

**COMMAND OF AERONAUTICS  
GENERAL STAFF OF THE AERONAUTICS**

**AERONAUTICAL ACCIDENT INVESTIGATION  
AND PREVENTION CENTER**



**FINAL REPORT  
A-022/CENIPA/2008**

**OCCURRENCE: AERONAUTICAL ACCIDENT**

**ACFT REGISTRATION: PR-GTD and N600XL**

**MODELS: B-737 8EH and EMB-135 BJ LEGACY**

**DATE: 29 September 2006**



## NOTICE

*According to the Law n<sup>o</sup> 7565, dated 19 December 1986, the Aeronautical Accident Investigation and Prevention System – SIPAER – is responsible for the planning, guidance, coordination and execution of the activities of investigation and prevention of aeronautical accidents.*

*The elaboration of this Final Report was conducted taking into account the contributing factors and hypotheses raised. The report is, therefore, a technical document which reflects the result obtained by SIPAER regarding the circumstances that contributed or may have contributed to trigger this occurrence.*

*The document is not focused on quantifying the degree of contribution of the different factors, including the individual, psychosocial or organizational variables that conditioned the human performance, and interacted to create a scenario favorable to the accident.*

*The exclusive objective of this work is to recommend the study and the adoption of provisions of a preventative nature, and the decision as to whether they should be applied belongs to the President, Director, Chief or the one corresponding to the highest level in the hierarchy of the organization to which they are being forwarded.*

*This Report does not resort to any proof production procedure for the determination of civil or criminal liability, and is in accordance with item 3.1, Annex 13 of the 1944 Chicago Convention, which was incorporated in the Brazilian legal system by virtue of the Decree n<sup>o</sup> 21713, dated 27 August 1946.*

*Moreover, one must stress the importance of protecting the individuals responsible for providing information relative to the occurrence of an aeronautical accident. The utilization of this Report for punitive purposes against such people maculates the principle of non-self-incrimination deduced from the right to remain silent, sheltered by the Federal Constitution.*

*Consequently, the use of this Report for any purpose other than that of preventing future accidents, may induce to erroneous interpretations and conclusions.*

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**ABBREVIATIONS**

AC	Advisory Circular
ACAS	Airborne Collision Avoidance System
ACC BS	Brasilia Area Control Center
ACC AZ	Amazonic Area Control Center
ADF	Automatic Direction Finder
ADM	Aeronautical Decision Making
AFTN	Aeronautical Fixed Telecommunications Network
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
ANAC	Agência Nacional de Aviação Civil (Brazilian Civil Aviation Agency)
APP	Approach Control (TRACON)
AQP	Advanced Qualification Program
ARINC	Aeronautical Radio, Inc
ASI	Air Safety Inspector
ASEGCEA	DECEA Flight Safety Advisory Office
ASV	Flight Safety Agent
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATCO 1	The first ATCO to control an aircraft in the sector
ATCO 2	The second ATCO to control the aircraft in the sector
ATP	Air Line Transport Pilot
ATS	Air Traffic System
AVOP	Operational Notice
BCT	Air Traffic Controllers' Basic Specialty
BRS	Brasilia VOR Designator
CAS	Calibrated Airspeed
CAT	Clear Air Turbulence
CCAM	Automatic Message-Commuting Center
CCF	Physical Capability Certificate
CCP	Company Chief Pilot
CFI	Certified Flight Instructor
CFS	Sergeant Formation Course
CFL	Cleared Flight Level
CFR	Code of Federal Regulations
CHT	Technical Qualification Certificate
CIAA	Aeronautical Accident Investigation Commission
CIEAR	Center of Specialized Instruction of the Aeronautics
CINDACTA	Air Defense and Air Traffic Control Integrated Center
COMM	Communication
COMAER	Command of Aeronautics

COMGEP	General Command of Personnel
COO	Chief Operating Officer
CPA	Aeronautical Accident Prevention Commission
CPG	Enlisted Personnel Promotion Commission
CRM	Crew Resource Management
CTR	Control Zone
CVR	Cockpit Voice Recorder
DAC	Civil Aviation Department
DECEA	Airspace Control Department
DEP	Design Eye Position
DEPENS	Department of Teaching
DFDR	Digital Flight Data Recorder
DIRSA	Health Directorship of the Aeronautics
DME	Distance Measuring Equipment
DOV	Operational Flight Dispatcher
DTCEA	Airspace Control Detachment
DTCEA SJ	Airspace Control Detachment of São José dos Campos
EAOF	Officialdom Adaptation Training
EASA	European Air Safety Agency
EB	Brazilian Army
EEAR	School of Specialists of the Aeronautics
EICAS	Engine Indicating and Crew Alerting System
ELT	Emergency Locator Transmitter
EO	Operating Specification
EPTA	Aeronautical Telecommunications Authorized Station
ERAU	Embry-Riddle Aeronautical University
ERC	Enroute Chart
ETA	Air Transport Squadron
ETO	Estimated Time Overhead
FAA	Federal Aviation Administration (USA)
FAB	Brazilian Air Force
FAR	Federal Aviation Regulation (USA)
FDR	Flight Data Recorder
F/E	Flight Engineer
FIR	Flight Information Region
FL	Flight Level
FLL	Fort Lauderdale
FM	Material Factor
FMA	Flight Mode Annunciator
FMC	Flight Management Computer
FMS	Flight Management System
FO	Operational Factor
F/O	First Officer
FPL	Flight Plan



FOQA	Flight Operations Quality Assurance
FRM	Formosa VOR
FSDO	Flight Standards District Office
FSI	Flight Safety International
FSS	Flight Service Station
FT	Feet
FTD	Flight Training Device
GAV	Aviation Group
GGCP	Product Certification General Management (ANAC)
GEIV	Special Group of In-Flight Inspection
GOM	General Operating Manual
GPS	Global Positioning System
GPX	Gavião Peixoto-SP Aerodrome
HF	High Frequency
HFACS	Human Factors Analysis and Classification System
ICA	Instruction of the Command of Aeronautics
ICAO	International Civil Aviation Organization
ICEA	Institute of Airspace Control
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Condition
INCERFA	Uncertainty Phase
IOE	Initial Operating Experience
IPA	Instituto of Psychology of the Aeronautics
IPV	Institute of Flight Protection (now ICEA)
IQCH	Indicator of Qualifications, Competencies and Skills
JAR	Joint Aviation Requirements
KFLL	Fort Lauderdale aerodrome designator
LESP	Special Leave
LNAV	Lateral Navigation
LOE	Line Operational Evaluation
LOFT	Line Oriented Flight Training
LOS	Line Operational Simulation
MAC	Midair Collision
MB	Brazilian Navy
MCA	Manual of the Command of the Aeronautics
METAR	Aviation Routine Weather Report
MFD	Multi-function display
MGO	General Operating Manual
MHz	Megahertz
MO	Operational Model
NAV	Navigation
NDB	Non-Directional Beacon
NM	Nautical Miles
NMAC	Near Midair Collision

NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board (USA)
OACI	International Civil Aviation Organization
PAI	Principal Avionics Inspector
PANS-ATM	Procedures for Air Navigation Service-Air Traffic Management
PAPAER	Project for the Aeronautics Personnel Adaptation
PC	Commercial Pilot
PCL	<i>Poços de Caldas</i> NDB
PF	Pilot-Flying
PFD	Pilot Flight Display
PIB	Preflight Information Bulletin
PIC	Pilot-in-Command
PIREP	Position reports/pilot weather reports
PLA	Airline Transport Pilot
PM	Pilot Monitoring
PMI	Principal Maintenance Inspector
PNF	Pilot-Not-Flying
POI	Principal Operations Inspector
PP	Private Pilot
PRIA	Pilot Records Improvement Act
QRG	Exact Frequency of Operation
RBHA	Brazilian Aeronautical Certification Regulation
RELPER	Danger Report (incident report)
RFL	Flight Level Requested
RICEA	Air Traffic Incident Report
RMK	Remark
RMU	Radio Management Unit
ROTAER	Air Routes Directory
RSV	Safety Recommendation
RVSM	Reduced Vertical Separation Minimum
SAR	Search and Rescue
SARSAT	Search and Rescue Satellite-Aided Tracking
SBBR	Brasília (Juscelino Kubitscheck) aerodrome designator
SBCC	Novo Progresso (Cachimbo) aerodrome designator
SBEG	Manaus (Eduardo Gomes) aerodrome designator
SBGL	Rio de Janeiro (Galeão) aerodrome designator
SBSJ	São José dos Campos aerodrome designator
SCO	Sub-Center of Operations
SFA	Aeronautical Fixed Service
SFAR	Special Federal Aviation Regulation
SGTC	Control Tower Management System
SIC	Second-in-Command
SID	Standard Instrument Departure
SIPACEA	Accid./Incident Investigation and Prevention Section of the Airspace Control
SISCEAB	Brazilian Airspace Control System

SJ GND	São José Ground Control
SJK	São José dos Campos
SMA	Aeronautical Mobile Service
SOP	Standard Operating Procedures
SPOT	Special Purpose Operational Training
SRPV	Regional Flight Protection Service
SSFDR	Solid State Flight Data Recorder
SSR	Secondary Surveillance Radar
STBY	Standby
STPV	Flight Plan Treatment System
STVD	Data Treatment and Visualization System
TA/RA	Traffic Advisory / Resolution Advisory
TAF	Terminal Aerodrome Forecast
TCAS	Traffic Collision Avoidance System
TF-1	Telephone Network (hot-line)
TF-2	Telephone Network
TF-3	Telephone Network
TGE	General Specialized Test
TMA	Terminal Area
TOC	Top-of-Climb
TOD	Top-of-Descent
TRM	Team Resources Management
TSB	Transportation Safety Board (Canada)
TWR	Control Tower
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
VHF COM	Very High Frequency Communications
VMC	Visual Meteorological Conditions
VMO	Maximum Operating Speed
VNAV	Vertical Navigation
VOR	VHF Omni directional Radio Range
VTE	Special Volunteer
XPDR	Transponder
3D	Three-Dimensional Radar
3S	Third Sergeant

## **SYNOPSIS**

This Final Report refers to the accident of 29 September 2006, typified as MID-AIR COLLISION, an occurrence that involved one regular air transport and one executive aircraft.

The regular air transport airplane was a Boeing 737-8EH, manufactured in the United States and registered in Brazil as PR-GTD, operated by the Brazilian airline company "Gol Transportes Aéreos S.A.". The executive airplane, an Embraer-135 BJ Legacy, manufactured in Brazil and registered in the United States as N600XL, was operated by the American company "ExcelAire Services, Inc."

The PR-GTD airplane was operating the regular flight GLO 1907, from Manaus (Amazonas State) to the city of Rio de Janeiro (Rio de Janeiro State), with a technical stop programmed for Brasilia International Airport/ President Juscelino Kubitschek, in the Federal District, under the rules of RBHA 121.

The executive aircraft N600XL was doing a ferry flight, from São José dos Campos (São Paulo State) to Fort Lauderdale, Florida, USA, with a technical stop programmed for Manaus International Airport/Eduardo Gomes, under the rules of RBHA 91.

The N600XL departed at 17:51 UTC from São José dos Campos/ Prof. Urbano Ernesto Stumpf State Airport, with two crewmembers, both of them American citizens, plus five passengers aboard.

Flight 1907 departed from Manaus /Eduardo Gomes International Airport, at 18:35 UTC, carrying 6 crewmembers and 148 passengers.

At 19:56 UTC, the two aircraft collided head on at flight level FL370, striking each other on their left wings, next to NABOL position, within the Amazonic Flight Information Region (FIR). They had been flying in opposite directions along airway UZ6, which connects Manaus and Brasília terminal areas.

N600XL lost part of the left winglet, and sustained damages in the left stabilizer and left elevator, but remained controllable in flight, and made an emergency landing at the military aerodrome of the *Campo de Provas Brigadeiro Veloso* (ICAO code SBCC), in Novo Progresso County, Pará State.

None of its occupants was hurt.

The PR-GTD airplane lost initially about one third of the left wing, which rendered the aircraft uncontrollable by the pilots. The aircraft started an abrupt spiral dive, and sustained a structural separation in flight before hitting the ground in the middle of the thick rainforest.

There were no survivors.

This accident, on the date of its occurrence, was considered the deadliest in the Brazilian aviation history, and will probably remain as one of the most complex scenarios to have been investigated.

The investigation of the accident was based on the following four focal points, considering the Human and Material factors:

**1) Operation of the Transponder and radio/navigation equipment of the N600XL airplane;**

- 2) **The degree of knowledge and preparedness of the N600XL pilots for the conduction of the flight in Brazil;**
- 3) **Aspects relative to the rules and procedures of the Air Traffic Control Systems currently in operation, both in Brazil and worldwide; and**
- 4) **The Communication and Surveillance Systems of the Brazilian Airspace Control System (SISCEAB).**

In the description of the Operational Aspect of the Human Factor, the aspects related to the pilots and the airplane are approached, corresponding to the first two focal points.

The aspects relative to the Brazilian Air Traffic Control organization, regarding the regulation, operation and infrastructure, which correspond to the last two focal points, are approached in the Psychological Aspect of the Human Factor.

Safety Recommendations (RSV) were issued, which deal with the following aspects:

- Preparation of the American pilots who fly overseas in sporadic missions like the one of the accident in question. Pilots who are used to another culture and to operating standards set up by the Federal Aviation Administration (FAA), which present peculiarities and differences in relation to the norms of the International Civil Aviation Organization (ICAO), of which Brazil is a signatory State and whose rules are followed in the national airspace.
- Level of requirement of the American regulatory authority concerning pilots assigned to missions in areas under the ICAO rules, in relation to the mentioned norms, as well as what is required for the pilot to be adapted, qualified and certified to operate a type aircraft under the rules of the 14 CFR Part 135.
- Improvement and installation of additional sound and visual signals in the alerting devices concerning the non-functioning (switch-off or failure) of required airborne anti-collision equipment and transponders. These alerts must be able to draw the attention of the crews, so that they maintain the situational awareness, relative to the perception of eventual failures or loss of functionality during the flight. Flight crews must be familiar with the alerting devices. Establishment of new premises and regulatory criteria applicable to future designs of the industry.
- Operational and organizational aspects of the Brazilian Airspace Control System (SISCEAB), aiming at perfecting the safety levels of the services provided to its users.
- Enhancement of the process of involvement of the Brazilian aviation inspecting authorities in the field of new aircraft delivery, as Brazil has an aircraft manufacturer of a considerable size, with the purpose of obtaining a higher level for the certification of the qualification, degree of proficiency and safety of the crews assigned to ferry flights and other types of flights over the national territory.

**SAFETY RECOMMENDATIONS (RSV)**

During the process of investigation, the following Safety Recommendations were issued:

**The DECEA shall, immediately:**

[RSV (A) 260/A/06 – CENIPA, on 22/Dec/2006] - Revise the AIP BRASIL, aiming at its updating, with an emphasis on the process of inclusion of the Brazilian air traffic rules and procedures.

[RSV (A) 261/A/06 – CENIPA, on 22/Dec/2006] - Instruct the air traffic controllers, as to the compliance of the prescribed procedures regarding the air traffic clearances to be transmitted to pilots, according to items 8.4.8, 8.4.9 and 8.4.10 of ICA 100-12 – RULES OF THE AIR AND AIR TRAFFIC SERVICES.

[RSV (A) 262/A/06 – CENIPA, on 22/Dec/2006] - Ensure that all SISCEAB controllers have the required level of English language proficiency, as well as provide the necessary means for that purpose, so as to comply with the prescribed SARP, as defined in ICAO Doc 9835 and Annex 1.

[RSV (A) 263/A/06 – CENIPA, on 22/Dec/2006] - Ensure that all air traffic controllers fully comply with the prescribed air traffic handoff procedures between adjacent ATC units and/or between operational sectors within the unit.

[RSV (A) 264/A/06 – CENIPA, on 22/Dec/2006] - Ensure that the prescribed procedures for air-ground communication failure are fully complied with by the ATC units.

[RSV (A) 265/A/06 – CENIPA, on 22/Dec/2006] - Ensure that all DECEA air traffic controllers participate in the specific refresher courses on SISCEAB regulations, also taking into account the recommendations of letters b, c, d and e of this document.

[RSV (A) 266/A/06 – CENIPA, on 22/Dec/2006] - Regulate and operationalize the use of OFF SET flight procedures in regions which present communication/radar coverage deficiencies.

[RSV (A) 267/A/06 – CENIPA, on 22/Dec/2006] - Implement, in the software used by SISCEAB, a new presentation (effective alert system) at the ATC radar screens, for information concerning the loss of the mode “C”, so as to increase the situational awareness of air traffic controllers.

[RSV (A) 97/A/07 – CENIPA, on 24/Sept/2007] - To make provisions so that the Brazilian aeronautical publications, including the AIP Brasil, AIP Brasil Map, AIP Supplement, ROTAER and NOTAM be made available through the electronic media, favoring the access to information via internet.

[RSV (A) 100/A/07 – CENIPA, on 24/Sept/2007] - To ensure the development of quality management programs for the air traffic control services in the various control units pertaining to SISCEAB.

RSV (A) 101/A/07 – CENIPA, on 24/Sept/2007 - To ensure that the procedures prescribed for the loss of transponder signal and radar contact, especially within RVSM airspace, be complied with by the ATC units.

[RSV (A) 102/A/07 – CENIPA, on 24/Sept/2007] - To ensure that the procedures prescribed for the transfer of position responsibility be complied with by the ATC units, and to analyze the possibility of setting up oversight and record protocols, through real time monitoring by means of audio and video recording of the relief and relieved controllers, which can be stored for more than 30 days, in complement to the RSV (A) 263/A/06 CENIPA of 22Dec06.

[RSV (A) 103/ A/07 – CENIPA, on 24/Sept/2007] - To make an analysis of the duties assigned to the regional supervisor, aiming at a redefinition of the activities to be performed and favoring the adequate management of the air traffic control operations both in the control sectors and in the region under his/her responsibility.

[RSV (A) 105/A/07 – CENIPA, on 24/Sept/2007] - To ensure that the air traffic control units systematize and monitor the processes and records relative to instruction and technical qualification.

[RSV (A) 107/A/07 – CENIPA, on 24/Sept/2007] - To make sure that all the frequencies listed in the aeronautical charts in force are duly activated in the pertinent consoles of the sectors.

[RSV (A) 108/A/07 – CENIPA, on 24/Sept/2007] - To ensure the adequate utilization of the emergency frequency, through its correct configuration in the consoles, including specific procedures in the Operational Model and in the trainings of air traffic controllers.

[RSV (A) 109/A/07 – CENIPA, on 24/Sept/2007] - To ensure that the air traffic controllers be trained in the utilization of the audio center and in the paging of its frequencies.

[RSV (A) 114/A/07 – CENIPA, on 24/Sept/2007] - To assess the current systematization of the operational routine, relative to the oversight of the compatibleness between the frequencies assigned to each sector, and listed in the charts, and the ones effectively selected for use in the consoles.

[RSV (A) 120/A/07 – CENIPA, on 24/Sept/2007] - To ensure that the initial and recurrent trainings in the STVD are conducted, with the objective of maintaining the minimum operational level required by SISCEAB and ICAO.

[RSV (A) 123/A/07 – CENIPA, on 24/09/2007] - To ensure that the preventative maintenance records are kept by the sectors concerned, so as to confirm that the maintenance activities were executed in accordance with the prescribed procedures and verified by the pertinent inspectors.

[RSV (A) 124/A/07 – CENIPA, on 24/Sept/2007] - To ensure that the procedures for the recovery of transportable radars are duly recorded and kept in their respective sites.

[RSV (A) 98/A/07 – CENIPA, on 29/Oct/2007] - To ensure the development of a continual operational training program, so as to guarantee the technical proficiency of the SISCEAB operators, including a revision of the yearly evaluation system for revalidation of the technical qualification certificate (CHT), and TRM courses, prioritizing supervisors, team chiefs and operational functions of a managerial level. The execution (ATCO) and high management levels will be dealt with as a second step.

RSV (A) 99/A/07 – CENIPA, on 29/Oct/2007 - To analyze the possibility of providing Chieftainship Preparation and TRM courses to the officers assigned to the command of the Airspace Control Detachments (DTCEAs).

RSV (A) 106/A/07 – CENIPA, on 29/Oct/2007 - To verify the adequacy of the ATM11 syllabus, as far as the operational needs are concerned.

RSV (A) 118/A/07 – CENIPA, on 29/Oct/2007 - To include alterations in the STVD, so that it records any occurrence of incompliance with the separation minima prescribed in the operational models (safety bubble) and, automatically generates a preventative report of the occurrence data.

RSV (A) 119/A/07 – CENIPA, on 29/Oct/2007 - To analyze the possibility of inclusion of features which enable the re-visualization software of the STVD to synchronize the audio and video of the selected console, while recording the operations performed by the controller in the area of commands, including the keys operated by him/her.

RSV (A) 122/A/07 – CENIPA, on 29/Oct/2007 - To ensure that the Aeronautical Mobile Service Plan of Frequencies guarantees the coverage of the emergency frequency 121.500 MHz in all the stations of the area under the responsibility of SISCEAB.

[RSV 202/A/08 – CENIPA, on 28 / Nov / 2008] - To include requisites in the STVD, relative to the installation of the Cleared Level Adherence Monitoring (CLAM), a functionality which verifies the conformity between the real flight level and the cleared flight level, and emits an alert in case of deviation from the standards, in order to improve the prescribed alerts that warn the controllers of the occurrence of a discrepancy between the received information on the real flight level of the aircraft and the level authorized for the segment.

**CENIPA shall:**

RSV (A) 268/A/06 – CENIPA, on 22/Dec/2006 - Conduct a Special Flight-Safety Inspection of the following organizations: GOL TRANSPORTES AÉREOS S/A, EMBRAER (SJC and EPTA-GPX), DECEA (CINDACTA 1 and 4, SRPV-SP, DTCEA-SJ, DTCEA-SP, DTCEA-CC and GEIV).

[RSV (A) 88/A/07 – CENIPA, on 24/Sept/2007] - To ensure, through a norm of SIPAER, the participation of a Human Factors accredited physician in the Team assigned for the Initial Action of Investigation of Aeronautical Accidents and Serious Incidents.

**To EXCELAIRE SERVICES, Inc., it is recommended:**

[RSV (A) 69/A/07 – CENIPA, on 24/Sept/2007] - To reassess the criteria for the selection and assignment of the flight crews to conduct ferry flights, both in the USA and abroad, giving priority to the technical-operational knowledge of the crewmembers, their experience in the equipment, as well as their mastering of the flight rules in force.

[RSV (A) 70/A/07 – CENIPA, on 24/Sept/2007] - To reevaluate the CRM Training Program of the company, and insert a plan for systematic recurrent training.

[RSV (A) 71/A/07 – CENIPA, on 24/Sept/2007] - To set up protocols to be executed by the pilots, and supervised by the Operations Sector, aiming at the strict compliance with the prescriptions of the company's General Manual of Operations relative to flight planning.

RSV (A) 72/A/07 – CENIPA, on 24/Sept/2007 - To set up protocols to be executed by the pilots, and supervised by the Operations Sector, aiming at the strict compliance with the standards of cockpit doctrine prescribed for all the flights conducted by the company.

RSV (A) 73/A/07 – CENIPA, on 24/Sept/2007 - To reevaluate the organizational structure of the company, aiming at the optimization of the work done by the Flight-Safety Sector, while assuring that the sector has independence in the accomplishment of its tasks.

[RSV (A) 74/A/07 – CENIPA, on 24/Sept/2007] - To revise and update the General Operations Manual of the company, as well as the ExcelAire Operative Specifications, in view of the acquisition of EMB 135BJ aircraft.



[RSV (A) 75/A/07 – CENIPA, on 24/Sept/2007] - To reassess the criteria for the operational evaluation of the pilots, relative to the application of the principles of Crew Resource Management (CRM) to the flight planning and all other phases of the flight.

[RSV (A) 76/A/07 – CENIPA, on 24/Sept/2007] - To reevaluate the criteria for the operational training of the pilots assigned to flights outside the USA, especially within airspace under the ICAO rules, concerning the preparation, planning and execution of the flight, aiming at keeping an adequate situational awareness through all the phases of the operation.

**DEPENS and DECEA shall:**

[RSV (A) 81/A/07 – CENIPA, on 24/Sept/2007] - To ensure, by means of a revision of the criteria used in the evaluation of the performance of air traffic controllers (BCT), relative to both basic professional formation and radar specialization courses, that they meet the proficiency levels required for the exercise of the activity.

**The Institute of Psychology of the Aeronautics (IPA) shall:**

[RSV (A) 82/A/07 – CENIPA, on 24/Sept/2007] - To reassess the criteria and the threshold point in the process of psychological selection for the BCT (air traffic control) specialty.

**To ANAC, it is recommended:**

[RSV (A) 83/A/07 – CENIPA, on 24/Sept/2007] - To conduct a Technical Inspection of EMBRAER, so as to verify the execution of procedures relative to the composition of crews and the activities of the Operational Flight Dispatch [Qualification and Certification of Operational Flight Dispatchers (DOV)], in accordance with the prescriptions of the legislation in force, in the process of aircraft delivery/receipt.

[RSV (A) 84/A/ 07 – CENIPA, on 24/Sept/2007] - To ensure the conformity of the certifications of the pilots working for the purchasing companies, in the process of aircraft delivery/receipt.

[RSV (A) 85/A/ 07 – CENIPA, on 24/Sept/2007] - To ensure the compliance with the protocols for the validation of licenses and certifications of the pilots working for the purchasing companies, so as to meet the legal prescriptions in force.

[RSV 205/A/08 – CENIPA, on 28 / Nov / 2008] - To evaluate, in coordination with DECEA, the current legislation concerning the utilization of aeronautical publications by aircraft operating in the Brazilian airspace, aiming at mitigating the risk of using outdated and/or incorrect data.

**To ANAC and DIRSA, it is recommended:**

RSV (A) 86/A/07 – CENIPA, on 24/Sept/2007 - To study the inclusion, through the updating of the pertinent legislation, of medical checkups of both civilian and military air traffic controllers, who get involved in aeronautical accidents and/or serious incidents, as well as the creation of specific protocols for these purposes.

RSV (A) 87/A/07 – CENIPA, on 24/Sept/2007 - To include, considering the pertinent legislation, the President of the Aeronautical Accident Investigation Commission in the list of authorities entitled to request medical checkups of military and civilian air traffic controllers involved in aeronautical accidents and/or serious incidents.

**To EMBRAER, it is recommended:**

[RSV (A) 89/A/07 – CENIPA, on 24/Sept/2007] - To revise the internal operational rules for the demonstration flights of their products, concerning the composition of the crew, in view of the Brazilian legislation.

[RSV (A) 90/A/07 – CENIPA, on 24/Sept/2007] - To promote regular meetings of the operational and safety sectors of the company, together with the DTCEA-SJ personnel, so as to update information and exchange experiences.

[RSV (A) 91/A/07 – CENIPA, on 24/Sept/2007] - To revise and update the “Qualification, Competence and Skill Indicators (IQCH)”, in order to adapt them to the operational reality of EMBRAER.

RSV (A) 92/A/07 – CENIPA, on 24/Sept/2007 - To conform the Aeronautical Telecommunications Authorized Station of Gavião Peixoto (EPTA – GPX), located in the countryside of São Paulo State with the norms of SISCEAB.

[RSV (A) 93/A/07 – CENIPA, on 24/Sept/2007] - To conduct regular audits of the Aeronautical Telecommunications Authorized Station of Gavião Peixoto (EPTA – GPX) and monitor the technical inspections of the station conducted by CINDACTA 1.

RSV (A) 94/A/07 – CENIPA, on 24/Sept/2007 - To hold courses for the granting and revalidation of Operational Flight Dispatchers (DOV) Certificates, in accordance with the Brazilian legislation, so that the sectors concerned may have a staff qualified and certified for the activity.

RSV (A) 95/A/07 – CENIPA, on 24/09/2007 - To ensure that the composition of the crews for the acceptance flights is in accordance with the legislation in force.

RSV (A) 96/A/07 – CENIPA, on 24/09/2007 - To ensure that the provision of Operational Flight Dispatch services and facilities to foreign crews be in accordance with the legislation in force and do not jeopardize the safety of the operation.

**The DTCEA-SJ shall:**

[RSV (A) 125/A/07 – CENIPA, on 24/Sept/2007] - Conduct an internal recurrent training for all air traffic controllers (operational model, operational agreements, CIRTRAF, ICA 100-12, etc.).

[RSV (A) 126/A/07 – CENIPA, on 24/Sept/2007] - To update the operational documentation used by the Detachment.

**To GOL TRANSPORTES AÉREOS S/A, it is recommended:**

[RSV (A) 130/A/07 – CENIPA, on 24/Sept/2007] - To reevaluate the SOP, “General Index of Chapters” / 1- General Procedures / 1.8 – Conversation in the Cockpit (Sterile Cockpit), and set up a protocol for cell phone utilization by crew members, when they are in the command cockpit of the aircraft.

RSV (A) 131/A/07 – CENIPA, on 24/Sept/2007 - To reevaluate the SOP and set up a protocol for the utilization of general electronic equipment by crewmembers when they are in the command cockpit of the aircraft.

RSV (A) 132/A/07 – CENIPA, on 24/Sept/2007 - To reinforce the facts that generated the proposals of RSV's in the "Safety Alert" of the company, during the operational recurrent trainings and in "safety" for all the company's personnel (technical crews, cabin crews, as well as the maintenance and support teams).

**COMGEP shall:**

RSV (A) 77/A/07 – CENIPA, on 29/Oct/2007 - Elaborate a plan for the re-manning of the air traffic control branch, setting up measures to be adopted in the short, medium and long terms, with the objective of meeting the need for human resources on the part of SISCEAB.

**DEPENS shall:**

[RSV (A) 78/A/07 – CENIPA, on 29/Oct/2007] - Establish a minimum level of proficiency relative to the English language, consistent with the requirements of the BCT specialty and with the aims of ICAO for 2008, as a criterion for the classification of CFS candidates at EEAR.

[RSV (A) 79/A/07 – CENIPA, on 29/Oct/2007] - In the CFS entrance exams, include specific criteria for the psychological (IPA) and medical (DIRSA) selections, as prerequisites for the classification of candidates in the BCT specialty.

**To the ICAO, it is recommended:**

[RSV 203/A/08 – CENIPA, on 28 / Nov / 2008] - To revise the provisions contained in the ICAO documents which deal with the procedures for communications failure, so that pilots and ATCOs alike have a clear understanding of the situation, and the procedures are harmonized worldwide.

**To the FAA, it is recommended:**

[RSV 204/A/08 – CENIPA, on 28 / Nov / 2008] - To evaluate the existing norms, in order to verify whether the training requirements for international flight operations under the 14 CFR Part 91, especially with high performance jets and VLJs, can be improved, so as to enhance the minimum levels of safety currently required by the legislation in force.

**To the Civil Aviation regulatory agencies, it is recommended:**

[RSV (A) 206/A/08 – CENIPA, on 28 / Nov / 2008] - To review their regulations concerning the man-machine interface in the aircraft flight control station and/or flight deck, in terms of the positioning of the instruments, warnings and alerts, so as to prevent that inadvertent interactions between the crewmembers and such devices affect the safety of the operation.

These revisions must be in accordance with the development of the requisites in progress in the aeronautical community, among them the Draft Rule § 25.1302 - Installed Systems and Equipment for Use by the Flight Crew, which includes aspects related to the interaction between the crewmembers and the positioning of the instruments, in order to prevent that eventual inadvertent actions affect the operation.

NOTE: The National Transportation Safety Board (NTSB) issued the Safety Recommendations referenced from A-07-35 to A-07-37, dated 2 May 2007, addressed to the Federal Aviation Administration (FAA), concerning the alerting devices of the functioning status of transponders and airborne anti-collision systems of aircraft in which they are required.

**DISSEMINATION**

- ANAC
- COMGEP
- DECEA
- DEPENS
- DIRSA
- DTCEA-SJ
- EMBRAER
- EXCELAIRE SERVICE, INC
- FAA
- Civil Aviation regulatory agencies
- GOL TRANSPORTES AÉREOS S/A
- ICAO
- IPA
- NTSB

<b>AIRCRAFT</b>	<b>Models:</b> B737-8EH / EMB-135 BJ <b>Registrations:</b> PR-GTD / N600XL	<b>OPERATORS:</b> Gol Transportes Aéreos S.A. ExcelAire Services, Inc.
<b>ACCIDENT</b>	<b>Date/time:</b> 29 Sept 2006 – 19:56 UTC <b>Location:</b> Airway UZ6; Flight Level 370; Coordinates: 22°38'40"S / 042°19'13"W <b>County, State:</b> Peixoto de Azevedo-MT	<b>TYPE:</b>  Mid-Air Collision

## 1. HISTORY OF THE ACCIDENT

The B737-8EH airplane was operating as flight GLO 1907, regular passenger transport, under the rules of RBHA 121. It had departed Eduardo Gomes International Airport (SBEG) in Manaus – Amazonas State, at 18:35 UTC, destined to Rio de Janeiro – Rio de Janeiro State (SBGL), carrying 6 crewmembers and 148 passengers. The aircraft was scheduled to make a technical stop at Brasilia International Airport (SBBR), in the Brazilian capital city.

The EMB-135BJ Legacy airplane, with 2 crewmembers and 5 passengers onboard, departed from São José dos Campos (SBSJ), São Paulo State, at 17:51 UTC, destined to Manaus (SBEG), from where it would later proceed to Fort Lauderdale (KFLL), Florida, USA.

The B737-8EH airplane made its last radio contact with the Amazonic Area Control Center (ACC AZ) at 19:53 UTC, and was instructed to call the Brasilia Area Control Center (ACC BS) at NABOL position, but the contact was not made.

At 20:14 UTC, the ACC AZ received a message from Polar Air Cargo 71, in relay for the Legacy airplane, stating that the N600XL was declaring emergency, having difficulties with its flight control system, and that it would proceed for an emergency landing at SBCC (military aerodrome of the Command of Aeronautics (COMAER), known as *Campo de Provas Brigadeiro Veloso*, in Novo Progresso county, Pará State).

After landing, the N600XL crew reported that their airplane had collided in flight with an unknown object. The airplane sustained damages at the left wingtip and left elevator.

The wreckage of the B737-8EH was found the next day, 30 September, in a region of thick forest, in the county of Peixoto de Azevedo, Mato Grosso State. All the 154 occupants of the PR-GTD had perished in the accident.

## 2. DAMAGE

### 2.1. INJURIES TO PERSONS

Injuries	Crew	Passengers	Third Parties
Fatal	06	148	-
Serious	-	-	-
Minor	-	-	-
Unhurt	02	05	-

### 2.2. TO MATERIAL

#### 2.2.1. To the Airplanes

The PR-GTD airplane sustained structural separation in flight, and was completely destroyed.

The N600XL airplane sustained serious damages in the left wing and in the left stabilizer/elevator assembly, but the recovery was considered as economically viable.

#### 2.2.2. To third parties

None.

## 3. ELEMENTS OF INVESTIGATION

### 3.1 INFORMATION ON THE FLIGHT CREWS INVOLVED

#### PR-GTD

a. Flight hours	PIC	SIC
Total .....	15,498:53	3,981:14
Total in the latest 30 days .....	75:30	64:25
Total in the latest 24 hours .....	04:20	04:20
B-737 (all versions) .....	13,521:20	3,081:15
B-737 in the latest 30 days .....	75:30	64:25
B-737 in the latest 24 hours .....	04:20	04:20

N600XL

a. Flight hours	PIC	SIC
Total .....	9,388:10	6,400:00
Total in the latest 30 days .....	Unknown	Unknown
Total in the latest 24 hours .....	03:30	03:30
EMB -135 BJ .....	05:35	03:30
This type in the latest 30 days .....	05:35	03:30
This type in the latest 24 hours .....	03:30	03:30

**b. Professional Formation**

N600XL – The PIC earned his *private pilot’s license* in 1985; the SIC earned his in 1992.

PR-GTD – The PIC earned his *private pilot’s license* in 1979; the SIC earned his in 1999.

**c. Validity and category of licenses and certificates**

The four pilots held Technical Certification for the respective types of aircraft and valid ATP licenses. All of them held valid IFR Flight ratings.

**d. Qualification and experience for flight type**

PR-GTD – Both pilots were qualified and experienced for the flight type proposed.

N600XL – Both pilots were qualified and certified for the flight type proposed; nevertheless, both of them had little experience in the EMB-135 BJ aircraft.

The N600XL SIC had about 300 flight hours in aircraft of the EMB-145/135 family, of regular air transport. As for the pilot, it was the third flight onboard an EMB-135 BJ, as a crewmember, with a total of 5 hours and 35 minutes. Both pilots were making their first enroute trip in the Brazilian airspace. It was also the first time they were flying together, as members of the same crew.

**e. Medical Certificate validity**

The pilots held valid Medical Certificates (CCF).

**3.2 INFORMATION ON THE AIRPLANES**

The PR-GTD, a low-wing, twin-jet aircraft, model B737-8EH, serial number 34653, was manufactured by the Boeing Company, USA, in 2006.

It had a valid Airworthiness Certificate.

The airplane had been incorporated to the GOL company fleet, less than a month before the accident.

As it was a virtually new aircraft, it had not undergone any comprehensive overhauling.

At the time of the accident, the aircraft had a total of 162 cycles (takeoffs and landings), with a total operation time of 202 hours and 28 minutes.

According to the technical maintenance records examined, the periodic inspections of the PR-GTD were up-to-date.

According to the Cargo Manifest, the distribution of passengers and cargo indicated that the aircraft was within the limits prescribed for weight and balance.

The N600XL, model EMB-135 BJ, a low wing, twin-jet aircraft, serial number 14500965, was manufactured by Embraer - Brazil, in 2006.

The aircraft Airworthiness Certificate was valid.

As it was a brand new airplane, it had not undergone any overhaul or programmed inspections.

At the time of the accident, the airplane had 11 total cycles (takeoffs and landings) with a total of 19 hours and 03 minutes of flight.

According to the technical maintenance records examined, the maintenance was up-to-date.

According to the Cargo Manifest, the distribution of passengers and cargo indicated that the airplane was within the limits prescribed for weight and balance.

### **3.3 EXAMS, TESTS AND RESEARCHES**

This topic has the objective of presenting the description and the results of the tests and evaluations conducted in the N600XL aircraft, in addition to describing the actions taken in relation to the flight recorders of the PR-GTD.

Less than 24 hours after the accident, a Go Team of CENIPA and EMBRAER representatives performed checks ("self-tests") in the avionics of the Legacy airplane. The two pilots were present during the tests.

On 7 October 2006, with the presence of the American accredited representative, the team performed, again, the same checks, downloading the test pages of all the avionics, besides checking the functioning of the TCAS, through the activation of simulated emissions of the Transponder. At the same time, at the Embraer labs, the information contained in the DFDR and CVR was copied – as a backup, because these components were to be sent abroad for readout.

With the purpose of going deeper in the investigation of the integrity of the N600XL avionics suite, the components listed below were sent to Honeywell (Phoenix, Arizona, USA), which is the manufacturer of the majority of the items, and responsible for the integration of the components manufactured by third parties, in its suite of avionics.



## Communication System

Component	Part Number and Serial Number
TCAS Computer Model-RT-951	P/N 7517900-55003 S/N 20008175
Communication Unit Model-RCZ-833K	P/N 7510700-665 S/N 0602A360
Communication Unit Model-RCZ-833K	P/N 7510700-665 S/N 0604A529
Radio Management Unit Model-RM-855	P/N 7013270-967 S/N 05084943
Radio Management Unit Model-RM-855	P/N 7013270-967 S/N 06035216

**Table 1a**

The flight recorders (CVR and FDR) were sent to the TSB in Canada for readout.

## Flight Recorders

Component	Part Number and Serial Number
CVR-Boeing-737- 8EH	P/N 980-6022-001 S/N 120-08600
FDR- Boeing-737-8EH	P/N 980-4700-042 S/N SSFR 12552
CVR- EMBRAER-135	P/N 980-6022-001 S/N 120- 08146
FDR- EMBRAER-135	P/N 980-4700-042 S/N SSFR 12092

**Table 1b**

The cockpit voice recorders and the flight data recorders were read out successfully at the Transportation Safety Board of Canada, in Ottawa.

### **3.3.1 Evaluations and tests (SBCC, 30 September 2006)**

On the day after the accident, a team composed of members of the Aeronautical Accident Investigation Commission (CIAA) and Embraer went to SBCC, where the N600XL airplane had landed after the collision. This team, with the participation of the two N600XL pilots, conducted complete operational tests of the Radio Navigation system of the airplane. These tests involved the Transponder and TCAS systems, according to the AMM 1770 Part II 34-43-00-5, TCAS – *Adjustment/Test* and the AMM 1770 Part II 34-52-00-5, *Transponder – Adjustment/Test*. None of the tests revealed any failure or abnormality.

Additionally, the FDR was downloaded, by means of a portable device, according to the AMM 1770 Part II 31-31-00-700-803-A, FDR Data Downloading. This procedure did not require the removal of the FDR unit from the aircraft.

The data stored at the CMC (Central Maintenance Computer), at the MFD (Multi Function Display) screen were verified by means of the procedure AMM 1770 Part II 45-45-00-970-801-A. The data stored at the CMC were read, according to the procedure AMM 1770 Part II 45-45-00-970-802-A CMC Downloading with the Personal Computer. The CMC data did not present any indication of failure associated to the mid-air collision with the PR-GTD airplane.

On the occasion, an external inspection was made so as to observe the structural damage sustained by the N600XL airplane. In summary, the following damages were seen: break of the left wing winglet (Figure 1), varied deformations on the left wing and a cut on the fairing of the left tip of the horizontal stabilizer, both on the left side (Figure 2).



Figure 1

Damaged tail and winglet, N600XL



Figure 2

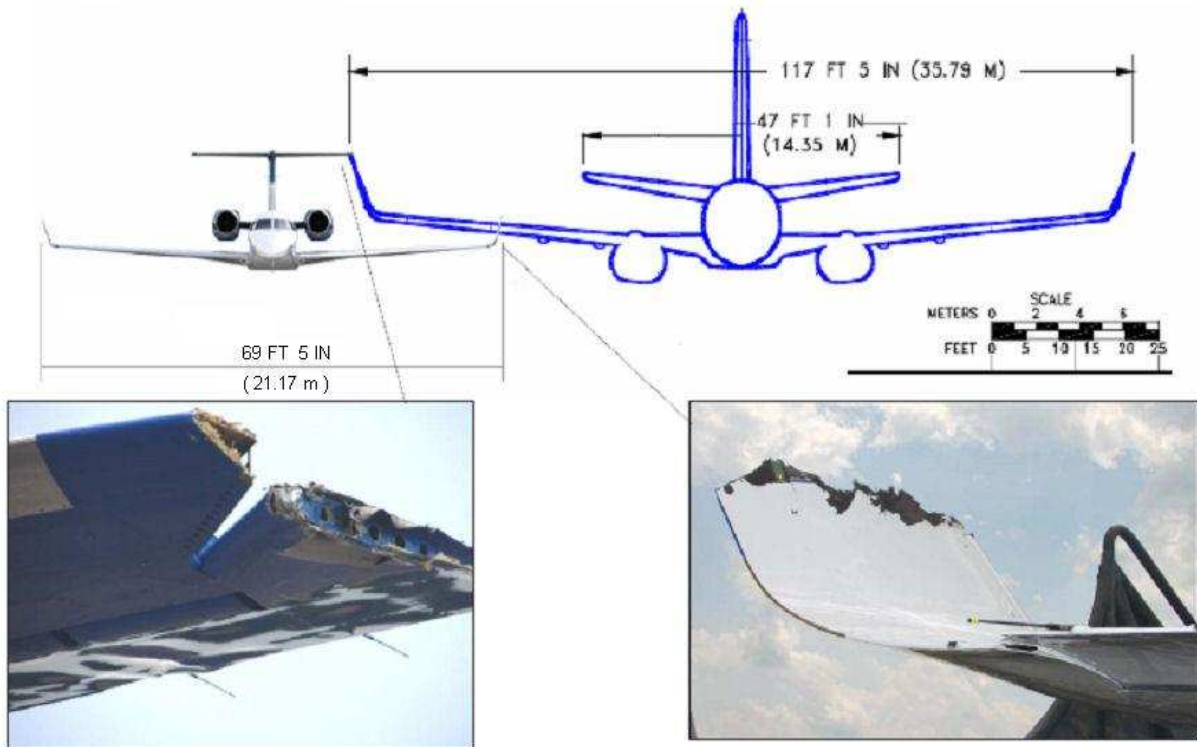
Damaged horizontal stabilizer, N600XL

On the occasion of this first visit, the PNs and serial numbers of the recorders installed in the N600XL were recorded, as follows: SSCVR (Solid State Cockpit Voice Recorder) Honeywell PN 980-6022-001 SN 120- 08146 and SSFDR (Solid State Flight Data Recorder) PN 980-4700-042 SN 12092.

### 3.3.2 Geometry of the collision between the N600XL and the PR-GTD

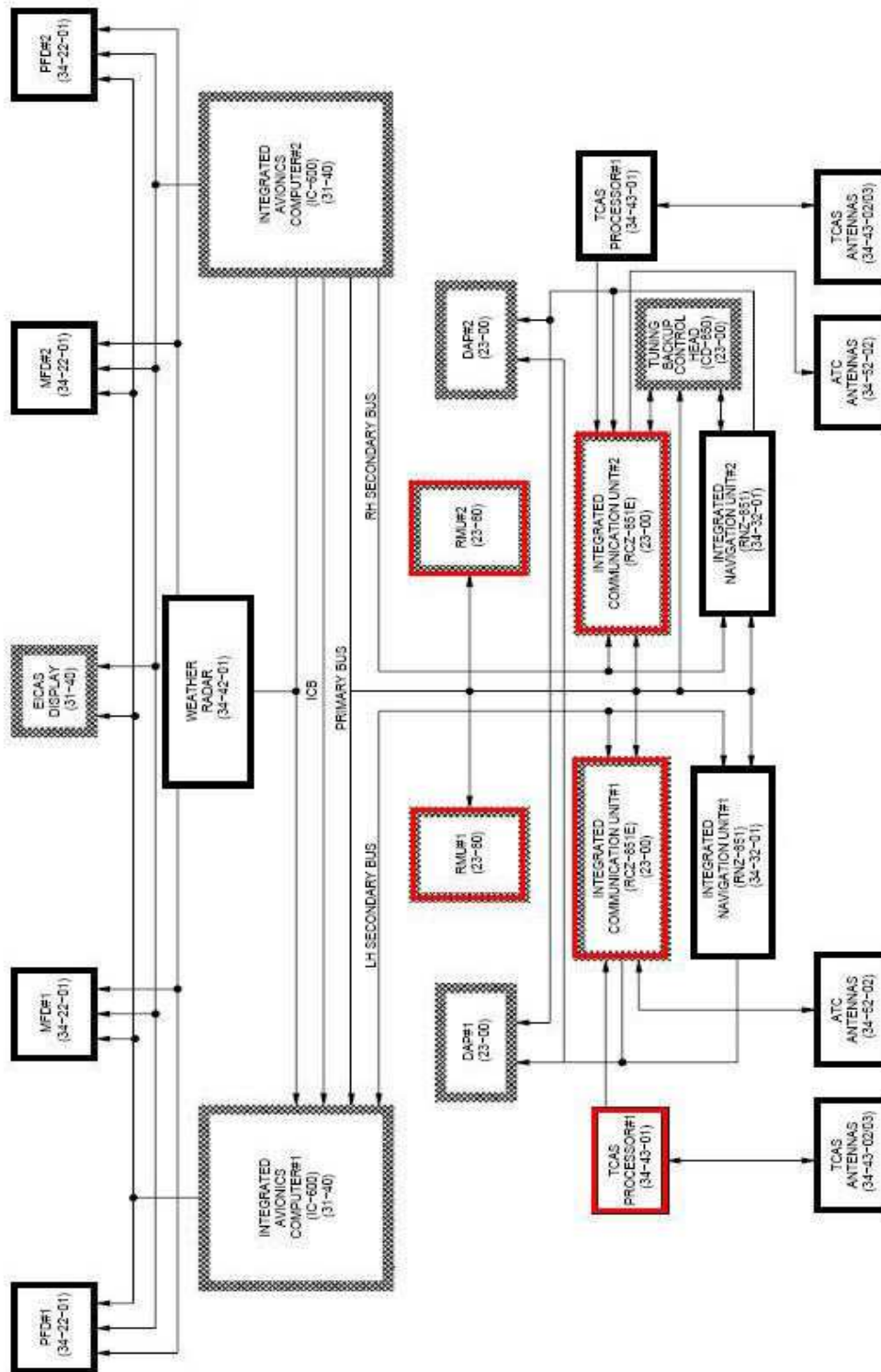
The evaluation of the damages sustained by the N600XL and PR-GTD airplanes allowed the elaboration of a representation of the probable relative position of the two aircraft at the moment of the collision, as shown in figure 3.

Figure 3



Geometry of the collision between the Legacy-600 N600XL and the 737-8EH PR-GTD

**3.3.3. Architecture of the Legacy-600 system of avionics (*Transponder* and TCAS)**



**Figure 4** – Simplified architecture of the Legacy-600 avionics, with emphasis on the TCAS and Transponder systems (in red color)

### 3.3.4. Tests (SBCC, 7 October 2006)

Initially, at SBCC, where the N600XL airplane had landed, tests were made with the intention of verifying the working condition of the Transponder system, (Mode A, Mode C and Mode S), the TCAS, and the VHF COM systems, in order to check, in particular, whether those systems were being operated according to the procedures prescribed in the production line of the EMB-135BJ design. The results of the tests showed that they were functioning properly and in accordance with the specifications of the EMB-135BJ airplane.

On the occasion of this second visit, additional tests of the Transponder, TCAS and VHF communication systems were performed, and the identification data of the components originally installed in the N600XL were recorded, as shown in Table 2:

Component - Position	Model	Part Number	Serial number
TCAS Computer	RT-951	7517900-55003	20008175
Communication Unit – Pos 1	RCZ-833K	7510700-665	0602A360
Communication Unit – Pos 2	RCZ-833K	7510700-665	0604A529
Radio Management Unit – Pos 1	RM-855	7013270-967	05084943
Radio Management Unit – Pos 2	RM-855	7013270-967	06035216

**Table 2**

Next, the non-volatile memory (NVM) of the TCAS unit was downloaded, by means of a portable piece of equipment (ARINC 615 *Data Loader*) and in accordance with the instructions of the unit manufacturer (ACSS), described in the document TNL-002 rev.C. For the execution of this procedure, the unit did not have to be removed. The result of the download was stored in a 3.5" disk, for further evaluation.

After the download of the TCAS, the RCZ 1 and RCZ 2 Communication Units, the RMU 1 and RMU 2 Radio Management Units were removed, in accordance with instructions provided by the Honeywell and the National Transportation Safety Board (NTSB), in order to preserve the NVM recordings of each unit. These recordings contain the history of failures of the components. The components removed were then separated, identified and photographed. Other units with equivalent PNs were installed so that the subsequent tests could be performed. The PNs of the units installed for the test are listed in Table 3.

Unit	Original Configuration	Test Configuration
RCZ 1	PN 7510700-665	PN 7510700-765
RCZ 2	PN 7510700-665	PN 7510700-765
RMU 1	PN 7013210-967	PN 7013210-967
RMU 2	PN 7013210-967	PN 7013210-967

**Table 3**

The objective of the tests of the Transponder, TCAS and VHF communication systems was to verify whether the installation (interfaces, wiring, connectors and antennas) of the N600XL airplane was working in accordance with the design specifications. According to pre-evaluation of the Embraer engineers, the difference between the PNs removed and those installed would not affect the validity and representability of the results.

Initially, the tests were the same as those operational tests carried out on the 30 September 2006, and the results obtained were similar, that is, no failure or abnormality was detected.

Then, other tests were made by means of measuring instruments, simulating the signals normally exchanged between the aircraft and the ground systems, besides simulating signals exchanged between the test aircraft and other airplanes, involving the Transponder, VHF communication and TCAS. These tests are equivalent to those normally conducted at the Embraer production line. Such tests were established and approved to exercise the main functions of these systems, in order to verify both the strength of the transmitted signals and the ability to receive and treat the signals.

The following documents were used as reference in the elaboration and conduction of the tests mentioned above:

- ACSS Pub. No.: A09-3841-001 – TCAS 2000: Traffic Alert and Collision Avoidance System – System Description and Installation Manual;
- ACSS TNL-002, rev. C: TCAS Event Team Update;
- Embraer AMM-1770-Part II - 23-12-00-5 - VHF System – Adjustment/Test;
- Embraer AMM-1770-Part II - 34-43-00-5 - TCAS – Adjustment/Test;
- Embraer AMM-1770-Part II - 34-52-00-5 - Transponder – Adjustment/Test ;
- Embraer Production Line Test Procedure PN 145-20109-703: VHF/COMM 1 and 2 Tests;
- Embraer Production Line Test Procedure PN 145-20114-703: TCAS 2000/XPDR 1 and 2 Tests;
- Embraer Technical Report 145-IN-020: Mode S Transponder and TCAS System Test Proposal, rev. D;
- Embraer Technical Report 145-IN-021: Mode S Transponder and TCAS System Test Results, rev. J.;
- Embraer Technical Report 145-IN-035, vol. II of V: Avionics System Description: Navigation, Communication and Identification Subsystems, rev. BD;
- Embraer Technical Report 145-NC-014, vol. II of XII: NAV/COMM System Test Proposal: Communication System Test Proposal, rev. T;
- Embraer Technical Report 145-NC-015, vol. II of XII: NAV/COMM System Test Results: Communication System Test Results, rev. N;
- FAA AC 20-151, Airworthiness Criteria of Traffic Alert and Collision Avoidance Systems (TCAS II) Version 7.0 and Associated Mode S Transponders; and

- Honeywell Pub. No.: A15-3800-001 – Primus II SRZ-85X Integrated Radio System: Operation and Installation Manual.

These tests did not reveal any failure or abnormality, and all the values obtained with the use of the instruments for measurement and simulation of signals were within the limits of tolerance specified in the procedures for testing at the production line, regarding the Transponder, VHF communication and TCAS systems. At no time was an uncommanded change of Transponder mode observed.

The units listed in Table 2 were duly protected against static, wrapped up and packed into boxes to be subsequently shipped to the Honeywell Company, in Phoenix-Arizona, USA, for bench tests, as Honeywell is responsible for manufacturing the majority of the items and for the integration of the TCAS unit (manufactured by ACSS) in the avionics of the Legacy-600.

### **3.3.5 Laboratory tests**

Two distinct batteries of tests were conducted. The first one, from 28 November to 1 December 2006, and the second, from 4 to 9 February 2007, the date on which the report of the tests was signed.

Basically, the investigators tried to rebuild all the operational environment of the accident flight. The focus was on the functioning of the avionics, so as to verify whether the Transponder/TCAS system had not sustained momentary failures, considering the collision involved two aircraft equipped with the most advanced airborne collision avoidance systems.

#### **3.3.5.1 Bench tests (Phoenix-Arizona, 28 November – 1 December 2006)**

The CIAA gathered at the installations of the Honeywell-Arizona, with the purpose of conducting bench tests in each of the units listed in Table 2 of item 3.3.4, which had been removed from the N600XL airplane in SBCC.

Initially, for each unit, external visual inspections were made, in order to identify any signs of fall or impact, as well as verify the condition of the interface connectors. No abnormality or failure was identified during these visual inspections.

Next, each unit was tested separately on its respective test bench, through the use of measuring equipment, according to procedures elaborated by the Honeywell for the RMU and RCZ units, and procedures elaborated by the ACSS for the TCAS unit.

Before the tests, the recordings of maintenance messages and fault codes stored in the NVM's of each unit were downloaded and analyzed.

For all the units, the results of the tests, including the analysis of the internal recordings of the units, did not indicate any significant failures or abnormalities.

In relation to the RCZ units, at no time was an uncommanded change of Transponder mode observed.

### 3.3.5.2. Integration tests (Phoenix-Arizona, 5-9 February 2007)

Checks were made to verify the integration of the pieces of equipment after they were installed, in order to list any possible failures between the TCAS and the Transponder, when in operation. For that purpose, a specific testing bench was prepared.

In the period from 5 to 9 February 2007, the CIAA gathered again at the facilities of the Honeywell-Arizona, USA, with the objective of conducting tests of integration of the RCZ, RMU and TCAS units removed from the N600XL.

In addition to the members of the CIAA, the tests had the participation of the accredited representative of the National Transportation Safety Board (NTSB, USA), the representative of the Federal Aviation Administration (FAA, USA), the representatives of Embraer, ExcelAire, Honeywell, and ACSS (manufacturer of the TCAS).

The integration bench of the Primus 1000/II avionic system was utilized, in addition to other types of measuring equipment. Integration tests are efforts made to exercise all the interfaces between the units, as well as to evaluate the integrated behavior of the functionalities associated to the Transponder and TCAS.

Besides, on the occasion, there was a quest for a better understanding of the operation of the Transponder/TCAS systems and their respective interfaces with the pilots (displays and control panels).

Prior to the beginning of the integration tests, Honeywell presented a specific proposal for the integration tests, which was discussed and jointly approved, with the participation of the members of the CIAA and other participants in the investigation.

The main objective of the test proposal was to exhaustively examine all the interconnections and buses between the TCAS, RCZ and RMU units, including a variety of normal and abnormal situations. The proposal also included exercising all the imaginable situations that could possibly cause the shift of the transponder mode to STANDBY, or the interruption of the transponder signal transmission.

The tests were divided into two distinct phases, and the first one consisted in validating the proposal of the test procedure. In order to conduct this validation, the team utilized other TCAS, RCZ and RMU units, all of them inviolate and tested by the Honeywell. These units were installed on the integration bench, whose software version was the same as the one of the N600XL airplane. The process of validation of the test procedures occurred satisfactorily, and, in the sequence, the readings of the non-volatile memories (NVM) of the TCAS, RCZ and RMU units were made.



The second phase consisted in the execution of the procedure already validated, this time using the TCAS, RCZ and RMU units removed from the N600XL. This phase was successfully conducted, and the results did not indicate any unexpected behavior, or in discordance with the technical specifications, which could affect the adequate transmission of the Transponder signals. No change of the Transponder mode of operation was identified.

In addition, it was confirmed that the system being tested did not present the problem associated to the subject addressed by the AD 2005-0021 issued by EASA “*Transponder Reversion to Stand-By Mode*”, and by the AD 2006-19-04 issued by the FAA “*To prevent transponder of the Honeywell COM unit from going into standby mode*”. The members of the CIAA and other participants had the opportunity to randomly apply successive commands in the control panels, mainly in the RMUs, trying to create an unexpected abnormal behavior. Nothing abnormal in the functioning of the equipment was observed.



Figure 5. Integration bench for the Primus 1000

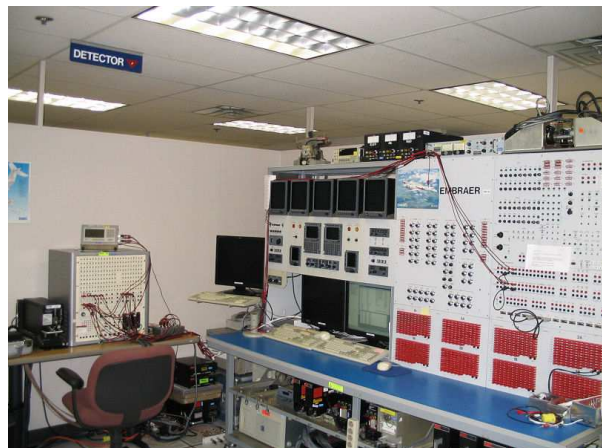


Figure 6. Integration bench - Primus 1000 and TCAS

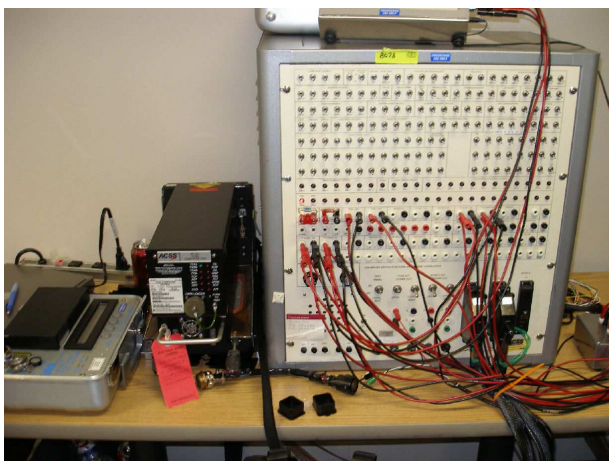


Figure 7. Bench for the TCAS



Figure 8. Bench for the Primus II (Radio Navigation)

### **3.3.6. Records of the N600XL technical history**

During the CIAA visit of Embraer, on 29 and 30 May 2007, in São José dos Campos - SP, the documents containing the N600XL technical history were collected. As the N600XL flights before the accident had been the production and acceptance flights, the technical history of the aircraft had been recorded in the documents associated with the process of production and delivery at Embraer.

The following documents were analyzed:

- Embraer – Final Inspection Report, N600XL, 14500965, manufac. date 28.Set.2006
- Embraer – Logbook No. 001/PT-SFN/2006, aircraft 14500965, 25.Sept.2006
- Embraer – Logbook No. 002/PT-SFN/2006, aircraft 14500965, 27.Sept.2006
- FAA Form 8130-3 Airworthiness Approval Tag PN 7517900-55003 SN 20008175
- FAA Form 8130-3 Airworthiness Approval Tag PN 7510700-665 SN 0602A360
- FAA Form 8130-3 Airworthiness Approval Tag PN 7510700-665 SN 0604A529

The Embraer report “Embraer – Relatório Final de Inspeção, N600XL, 14500965, *manufacturing date 28 Sept 2006*”, in the section “*Transponder Operational System Test*” contains the records of the transponder system final tests results conducted at the manufacturing plant through the Work Order No. 32701990, on 24 September 2006. These records indicate that the tests were successful, showing measurement results within the specified tolerances, according to the Certificate of Conformity relative to the N600XL radio navigation and communication systems. This certificate is contained in the Embraer report aforementioned.

Still in this document, page 27/31, there is the non-applicability of the AD 2005-0021 EASA “*Transponder Reversion to Stand-By Mode*” to the N600XL, since this aircraft was already equipped by the manufacturer with RCZ PN 7510700-665 units. These units already incorporate the required modifications as terminative action for the AD 2005-0021.

Similarly, on page 30/31, there is the non-applicability of the AD 2006-19-04 FAA “*To prevent transponder of the Honeywell COM unit from going into standby mode*” to the N600XL, since this aircraft was already equipped by the manufacturer with RCZ PN 7510700-665 units. These units already incorporate the required modifications as terminative action for the AD 2006-19-04.

The installation of the RCZs PN 7510700-665 units in the N600XL by the manufacturer was confirmed in accordance with Table 2, item 3.3.4.

In the Logbooks nº 001/PT-SFN/2006 and 002/PT-SFN/2006, it was verified that, in relation to the whole process of production and delivery of the N600XL, there were not any records of abnormalities involving transponder failure, uncommanded change of the transponder mode of operation, or any TCAS failure.

### **3.3.7. Interface between the Transponder and FMS systems in the N600XL**

The CIAA, with the advisory of technical members participating in the investigation, evaluated the interface between the FMS system and the transponder of the N600XL airplane, and concluded that it is not possible to change the mode of operation of the transponder by means of a command entered in the control panel of the FMS (Control Display Unit – CDU).

### **3.3.8. Summary of the results of the tests and evaluations**

After the execution of all the tests on the N600XL airplane, as well as the bench and integration tests of the units, no factual evidence was found that could explain the discontinuance of the transponder signal transmission, in terms of failure or abnormal behavior of the N600XL systems.

The technical history of the N600XL aircraft did not show any evidence associated with failures or abnormal behavior of the Transponder and TCAS systems. All the documentation pertinent to these systems was verified, and no indications of non-conformity were found relative to the systems investigated.

*The “Relatório de Testes dos Equipamentos de Radio Navegação da Aeronave N600XL” (N600XL Radio Navigation Equipment Test Report) was issued by the CIAA, through its Material Factor, on 28 February 2007. The following considerations are presented in the report just mentioned:*

*“The tests performed and presented in the Field Notes documents, of 1 December 2006 and 9 February 2007, confirmed the requirements of the descriptive documents of the Transponder, Communication and TCAS Systems, as well as their Certifications. Therefore, the N600XL equipment did not present design or integration error.*

The evaluation and more detailed results of the DFDR and CVR readings of the two aircraft will be dealt with in the items 3.11 “Flight Recorders”, 3.13 “Operational Aspect”, and, also, in item 4 “Analysis”.

As for the PR-GTD, since its transponder signal was received by the air traffic control units up to the last moment, a more detailed investigation of the wreckage was not necessary.

## **3.4 METEOROLOGICAL INFORMATION**

The meteorological conditions were determined and presented in the *Parecer (Opinion) 02/CNMA/2006*, dated 3 October 2006, in which the following documents were analyzed:

- Satellite imaging;
- SIGX PROG Chart, 29 Sept. 2006, 18:00 UTC – 21:00 UTC;
- En-route meteorological message, and
- WIND ALOFT PROG Charts, as of 18:00 UTC, FL 340/390.

The document mentioned above contains the following considerations:

*“Through the analysis of the documents, it is observed that there was no formation of significant clouds at the probable location of the collision, the wind was normal for the flight level, and there were not turbulence, icing or other significant phenomena.*

*After the analysis, it was possible to conclude that the meteorological conditions along the route were not contributing factors to the accident with the aircraft in question.”*

The photo shown below, a courtesy of the N600XL crew, was taken eighteen minutes before the collision (according to the CVR data), about a hundred and thirty five miles away from the point where the midair occurred. As the reports of the pilots and passengers of the Legacy do not tell of any changes in the meteorological conditions during the flight, one may conclude that the weather conditions and visibility were similar to those prevailing at the moment of the collision.



Figure 9 – Photo of the weather conditions along the route of the N600XL

According to reports of local dwellers, residing about 25 nautical miles from the accident area, there was no cloud formation present. Only in some sectors, the horizontal visibility was hindered by mist. It was even possible for one of the witnesses to sight the PR-GTD, from the moment of the collision until a little before its disintegration.

The collision between the two airplanes occurred close to the sunset, and, although the two aircraft were flying under IFR rules, the weather was VMC.

The sun, being near the horizon, possibly forced the N600XL crew to use the left side sunshade.

### 3.5. NAVIGATION

Neither accident airplane presented any indication of technical problems or failures in their navigation equipment.

They were latest generation airplanes, with integrated and redundant navigation systems, whose pieces of equipment are the most modern in use.

They were flying within type A controlled airspace, in which, in accordance with item 7.4.1 of ICA 100-12, only IFR flights are permitted, all flights are under air traffic control service, and are separated from each other.

The separation was being provided in RVSM (Reduced Vertical Separation Minimums) conditions, with both aircraft duly certified and equipped for this type of operation, complying with the sub item 1.11.1 of the item 1.11 "Crew Operational Procedures before Entering RVSM Airspace", of AIP-Brasil (ENR2.2-2) of 23 Nov. 2006.

The Operational Division of the First Air Defense and Air Traffic Control Integrated Center (CINDACTA I) provided the CIAA with a detailed sequence of the messages relative to the N600XL conveyed through the Automated Message Commuting Center of Brasilia (CCAM-BR), as shown below:

#### Messages relative to the N600XL aircraft on 29 September 2006.

##### **16:56:09 UTC**

The CCAM-BR received an FPL-type AFTN Message (Flight Plan Message) relative to the N600XL sent by "Gavião Peixoto Radio" (SBGPYSYX) to "São José AIS Office" (SBSJYOYX) and to "ACC-BS" (SBBSZQZX).

The CCAM-BR acknowledged the receipt with "Gavião Peixoto Radio" and transmitted the message to the "ACC-BS" and "São José AIS Office".

##### **17:09:58 UTC**

The CCAM-BR received an FPL-type AFTN message (Flight Plan Message) relative to the N600XL sent by the "São José AIS Office" (SBSJYOYX) to the ACC-BS (SBBSZQZX), "São Paulo APP" (SBSPZAZX) and "Eduardo Gomes Tower (TWR-EG)" (SBEGZTZX).

The CCAM-BR confirmed the receipt with the "São José AIS Office" and transmitted the message to the "ACC- BS", "São Paulo APP" e "Eduardo Gomes Tower".

##### **17:10:33 UTC**

The CCAM-BR received an FPVD type AFTN message (Automatized Departure Message) relative to the N600XL sent by the "ACC-BS" (SBBSZQZX) to "São José Tower" (TWR-SJ) (SBSJZTZX) and "São José " (SBSJZAZX).

The CCAM-BR transmitted the message to "São José Tower" (SBSJZTZX) and "São José APP" (SBSJZAZX).

**17:11:59 UTC**

The CCAM-BR received an FPVD-type AFTN message (Automatized Departure Message) relative to the N600XL, sent by "São Paulo APP" (SBSPZAZX) and destined to the "São José Tower" (SBSJZTZX).

The CCAM-BR confirmed the receipt with the "São Paulo APP" and transmitted the message to "São José Tower".

**17:52:52 UTC**

The CCAM-BR received a DEP-type AFTN message (Departure Message) relative to the N600XL, sent by "São José Tower" (SBSJZTZX), and destined to the "ACC-BS" (SBBSZQZX) and Curitiba Area Control Center, "ACC-CW" (SBCWZQZX).

The CCAM-BR confirmed receipt with "São José Tower" and transmitted the message to the "ACC-BS" and "ACC-CW".

The established protocol for the conveyance of messages was complied with as prescribed.

At 17:31:46 UTC, the N600XL crew asked for startup and taxi approval, without having received the IFR clearance yet.

At 17:34:51 UTC, SJ GND contacted the ACC BS and requested the IFR clearance.

According to the transcript, the dialog between the SJ GND controller and the ACC BS controller was as follows (translation):

**GND:** HI, BRASILIA! NOVEMBER SIX-ZERO-ZERO X-RAY LIMA TO EDUARDO GOMES, SÃO JOSÉ - EDUARDO GOMES, REQUESTING LEVEL THREE-SEVEN-ZERO.

**ACC BS:** THREE SEVEN ZERO, TRANSPONDER FOUR FIVE SEVEN FOUR, HEADING POÇOS.

**GND:** THREE SEVEN ZERO, HEADING POÇOS. WHAT IS THE FREQUENCY TO CALL YOU THERE?

**ACC BS:** ONE TWO SIX FIFTEEN, ONE THREE THREE FIVE.

**GND:** ONE THREE THREE FIVE. THREE SEVEN ZERO, HEADING POÇOS. OK, OK. BYE!"

The SJ GND controller said that the rule is to provide the entire clearance for the whole route, as specified in ICA 100-12. However, he pointed out that the controllers in São José are aware that the ACC BS has several clearance sectors.

He believed that the ACC BS controller would need further clearances from the other sectors of Brasilia, and also from Manaus, and said that, for this reason, he did not transmit the full clearance that should have been the following:

"N600XL cleared for Eduardo Gomes, level 370, direct *Poços de Caldas*. After Poços de Caldas, maintaining level 370 on UW2, up to Brasilia. After Brasilia, level 360, on UZ6, up to TERES position. After TERES, level 380, maintaining UZ6".

As the majority of the clearances are forwarded in an abbreviated manner, he believed that there were difficulties to transmit the entire clearance. He added that the Tower is

subordinated to the ACC and, therefore, if the ACC transmits in this manner, the Tower folks are supposed to comply with and not to question: "we must not either add or omit anything".

After the SJ GND had received the clearance from the ACC BS, the pilot called to get the instructions, and reported being ready for taxi. The taxi was approved to runway 15, and the SJ GND relayed, at 17:41:57 UTC, the partial clearance issued by the ACC BS:

"NOVEMBER SIX ZERO ZERO X-RAY LIMA, ATC CLEARANCE TO EDUARDO GOMES, FLIGHT LEVEL THREE SEVEN ZERO DIRECT POÇOS DE CALDAS, SQUAWK TRANSPONDER CODE FOUR FIVE SEVEN FOUR, AFTER TAKE-OFF PERFORM OREN DEPARTURE".

(transcript provided by the DTCEA-SJ)

In accordance with the item 8.4.9 of ICA 100-12 - CONTENTS OF THE AIR TRAFFIC CONTROL CLEARANCES, the clearances shall contain, in the sequence specified, the following:

- a) Aircraft identification;
- b) Clearance limit;
- c) Flight route;
- d) Flight level or flight levels for the whole route, or part of the route, and flight level changes, if necessary; and

NOTE: If the clearance for the flight levels involves only part of the route, it is important that the ATC agency specifies a limit point to which the clearance relative to the flight levels will apply.

- e) Necessary instructions or information, such as: transponder operation, approach or departure maneuvers, communications and time limit of the clearance.

Thus, it is possible to see that some indispensable pieces of information prescribed in the Instruction were missing in the clearance that was transmitted:

- 1) The clearance limit for FL370 (BRS VOR) was not informed in a clear manner;
- 2) It was not informed whether it was the only flight level for the entire route, or for part of the route. If it was for only part of the route, the other flight levels and their respective limits were not informed; and
- 3) It was not mentioned by the ATC whether the plan had been *cleared as filed*. This would certainly be fundamental to alert the pilots about where any programmed changes would occur.

According to the flight plan filed, the first flight level change was planned to occur overhead Brasilia (BRS VOR), where the aircraft was to descend to FL 360. The level changes had been programmed in the flight plan which was elaborated by the software of Universal, a company that provided this kind of service to Excelaire in the planning of the trips.

The N600XL received an incomplete initial clearance from the SJ GND, not specifying (as required by the norms) that the clearance limit for flight level FL370 was the vertical of BRS VOR. As a result, the pilots understood that FL370 was cleared up to Manaus.



In an interview to the CIAA, the pilots of the N600XL confirmed this understanding.

The N600XL climbed according to the instructions received, and reported reaching FL370 on airway UW2, at 18:33 UTC.

In Manaus, at 18:19:30 UTC, the SIC of the PR-GTD requested the IFR clearance to the Manaus Clearance Delivery, and asked for a change from the flight level FL410, initially proposed in the repetitive flight plan, to FL370.

The clearance delivery controller, after being informed of the intention of the GLO 1907 to fly at FL370, replied that he would coordinate the level change.

At 18:22:09 UTC, the ACC AZ controller issued the IFR clearance for the PR-GTD, authorizing FL370 up to Brasilia, via airway UZ6.

The instructions received were complied with accordingly, with no problems of understanding up to the last contact, at 19:52 UTC, when the PR-GTD crew was instructed to call the ACC BS when passing NABOL position. This position is located at the boundary between the Amazonic and Brasilia FIRs.

The last information received by the N600XL crew by means of a two-way radio contact with the ACC BS was at 18:51 UTC, when the ATC unit informed the aircraft that it was under Radar Surveillance, according to what is prescribed in item 14.11 of ICA 100-12/2006.

The provision of this type of service was informed by the controller after the pilots activated the IDENT feature of their transponder, whose code (4574) was assigned by the ACC BS, in compliance with item 14.11.2, letter a, ICA 100-12/2006.

In such a situation, it is the responsibility of the ATCO to issue instructions to the crew concerning a flight level change, since the crew will not make any level changes, unless authorized by the ATC.

Besides, under Radar Surveillance, the pilot does not need to report passing at fixes along the route, according to the sub item 14.19.1, letter a (item 14.19 – Position Reporting).

The control unit providing Radar Surveillance took no action to interfere with the vertical navigation of N600XL when the aircraft passed the vertical of BRS VOR at 18:55 UTC, and proceeded with a new heading (336°) on airway UZ6, a direction in which FL370 is considered non-standard. In the direction being flown by the N600XL, flight levels with even tens should be maintained, such as FL360, FL380, etc., in accordance with the air traffic rules applicable to the Brazilian airspace. Nevertheless, according to national and international rules, flexibility may exist for IFR flights, at the controllers' discretion, provided it is coordinated with the other ATC units involved. This coordination was not made.

The information transmitted by the Transponder was correct and available on the ATCO's screen, and so remained until 19:02 UTC, when the N600XL transponder stopped transmitting altitude information (Mode C) to the radars of ACC BS.

The loss of transponder information coming from the N600XL airplane occurred simultaneously in five different radars, while all other aircraft that were flying in the vicinity of the sector and had their transponders in operation, remained being normally received by the air traffic control units.



From that moment on, the Legacy transponder no longer transmitted any information until approximately 58 minutes later.

In such a situation, according to the norms in force, the controller had to inform the pilot that the signal of the transponder was not being received. Besides, the rules concerning the operation within RVSM airspace prescribe that the pilot has to inform the ATC about any inoperability of the transponder. If the transponder is not operating, the minimum vertical separation between the airplanes involved has to be changed to 2,000 feet.

However, even with the information displayed on the ATC radar screen and on the aircraft's panel, no action was taken either by the controller or the pilot to verify the condition of the equipment and, if necessary, increase the vertical separation. The maintenance of the vertical separation in accordance with RVSM rules was no longer possible, and an action had to be taken by the Air Traffic Control, but that did not happen.

Thus, the N600XL pilots, having not received any new instruction, maintained FL370, which was nonstandard for that direction on airway UZ6.

The ACC BS controllers assumed that the aircraft was maintaining FL360, although they were not receiving information from the N600XL transponder, and without confirming directly with the aircraft, by means of a radio contact.

At 20:02 UTC, after the collision, the Transponder equipment of the N600XL restarted transmitting and the signals were received by the ATC radar screens, including the original code that had been originally assigned to the aircraft.

As for the horizontal navigation, it was strictly maintained by both aircraft involved in the collision.

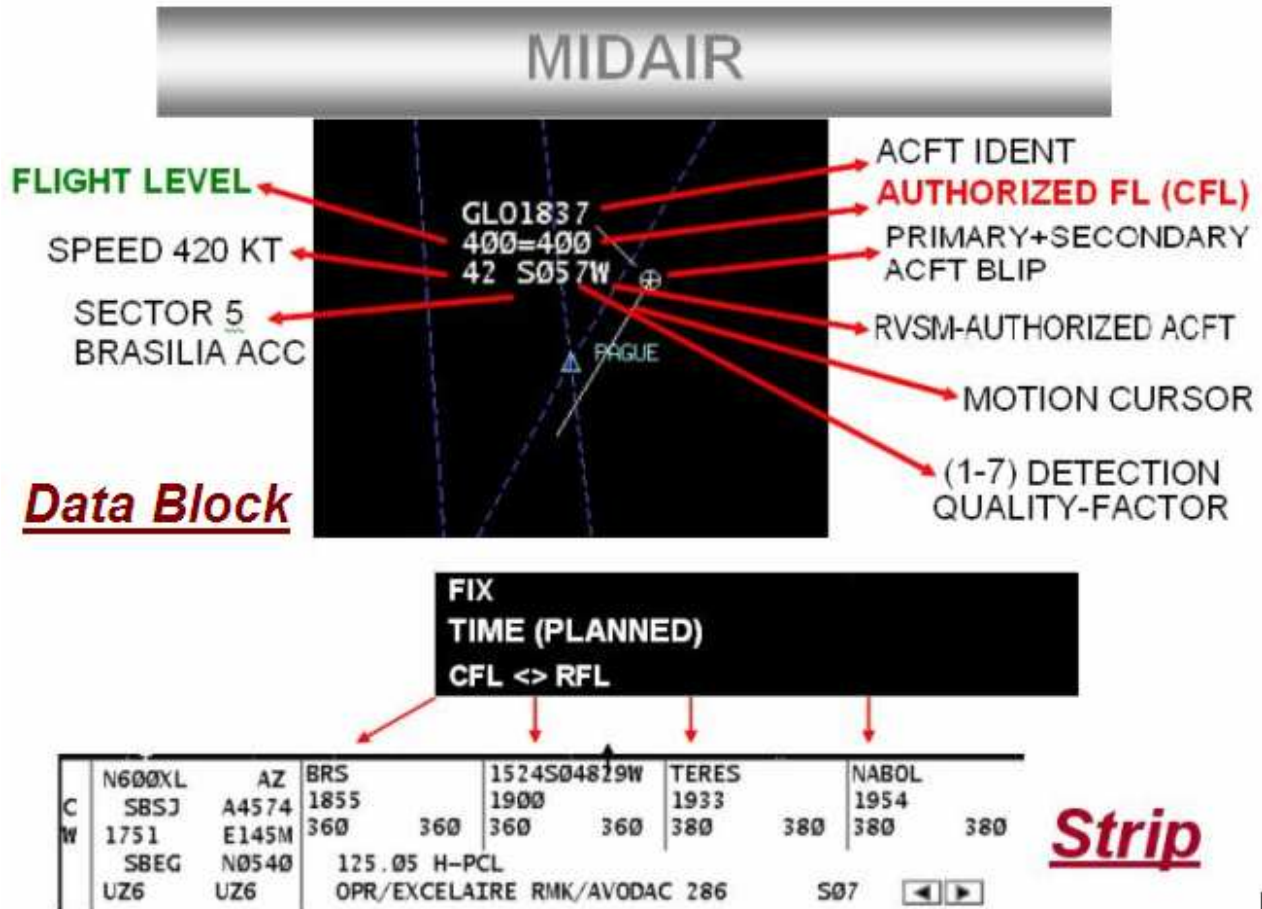
The Legacy airplane, after departing São José, flew direct heading to PCL (Poços de Caldas) beacon. Then, it joined airway UW2 en route to BRS VOR, crossing sector 5 of ACC BS. After the BRS VOR, the airplane joined airway UZ6 and, about 30 miles north of the BRS VOR, entered sector 7. Next, the airplane passed TERES position, and proceeded to NABOL, at the boundary between the Brasilia and Amazonic FIRs.

Since 19:26 UTC – about 30 minutes before the collision –, when the Air Traffic Controller responsible for sector 7 unsuccessfully tried to establish radio contact with the N600XL, it may be said that the Legacy airplane was no longer under effective Radar Surveillance, an air traffic control condition that had started 35 minutes before.

### 3.5.1. ATC Symbolology

The FPL, upon being received by the ACC BS, is processed by the software of the STPV (Flight Plan Treatment System), which analyzes the pieces of information contained in the flight plan proposed, and then generates the **electronic strip** at the console of the air traffic controller (item 3.2, Presentation of Electronic Strips, Controller and Assistant Controller Operations Manual, CINDACTA I ACC-Enroute Air Traffic System. C.A.006.13.D.TV.710.AT.T02.MO.001.01 of ATECH, distributed by CISCEA).

The Figure 10 below shows a **data block** and a **strip**, which are the main displays of information that the controller receives on his screen.



**Figure 10 - Presentation of a data block and a strip**

The position of an aircraft on the radar screen is represented by an icon. In the Manual of Operations of the Controller and Assistant-Controller of the Enroute Air Traffic System, ACC CINDACTA I. C.A. 006.13.D.TV.710.AT.T02.MO.001.01, item 3.1 “**Display of Aircraft Icons**”, table 3.1, there is a definition of each symbol associated to an aircraft icon.

The cross represents the current position of a primary-radar return.

The circle represents the current aircraft position obtained by the secondary-radar.

The cross inside a circle represents the position of associated primary and secondary radar returns relative to an aircraft.

It is worth explaining the utilization of the 3D radar:

The primary radar (2D) utilizes only two dimensions: azimuth and distance. For example, “the aircraft is at 340°, 20 miles”.

The 3D radar is a primary radar to which an altitude sweep information is added. For example, “the aircraft is at 340°, 20 miles, at an altitude of 10,000 feet”.

The information on the aircraft position is obtained by the radar by means of the return of the electromagnetic wave.

The secondary radars are utilized by the ATC for the provision of vertical separation, and there is an ICAO approved documentation for that purpose, especially in relation to the RVSM airspace.

The 3D radar does not have a documentation approved by the ICAO concerning its use for traffic separation.

The Brazilian ATC system does not use the 3D radar for the provision of vertical separation. It is used only for air defense purposes.

The Primary and Secondary radars are used, according to the ICAO rules, which define that the RVSM airspace requires a secondary radar and an operating transponder with mode C or S (AIP Brasil).

In the **Strip** shown in Figure 10, **the first rectangle** on the left shows:

- The aircraft call sign (N600XL)
- The adjacent ACC to which the transfer will be made (ACC AZ),
- Aerodrome of origin (SBSJ - São José),
- Transponder code (A4574),
- Estimated Off Blocks Time (EOBT) (1751 UTC),
- Aircraft type and wake turbulence (E145M- turb. medium),
- Destination Aerodrome (SBEG- Eduardo Gomes),
- Speed (540 Knots), and
- Airway (UZ6).

**The second rectangle**, from left to right of the **strip**, shows the fix that identifies the initial point of the segment to be flown, as may be observed, containing the following items of information:

- 1) The initial point of the segment (BRS).
- 2) The estimated time for the aircraft to fly over the point (18:55 UTC).
- 3) We see two fields, side by side (360 and 360): the **CFL** on the left, and the **RFL**, on the right.

These **two** fields will always be observed on the last line of each **rectangle**.

At the bottom **left** side, the **CFL** field (level authorized, from the point) indicates the level authorized by the ATC, from the respective point .

At the bottom **right** side, the flight level programmed to be **requested** for all the points of the route, the **RFL** (flight level requested for every point along the route).

All the definitions of mentioned abbreviations and fields in bold type are found on Page 3-14, sub item 3.2.1 **Format**, item 3.2 **Electronic Strips Presentation**, Controller and Assistant-Controller's Manual, En-route Air Traffic System, ACC CINDACTA I).

The **RFL** field **CANNOT BE CHANGED BY THE CONTROLLER.**

The **CFL** field MAY BE CHANGED BY THE CONTROLLER. And this may occur every time a new clearance is issued, after the controller, observing the RFL field, verifies whether he can or cannot authorize the level requested for that segment.

If there is a need to change the level, the controller will modify the CFL field of the strip, by means of his/her keyboard.

When the controller modifies this field, the CFL field relative to the level authorized/CFL on the right of the data block is also modified (Item 3.1.2, Controller's Operation Manual).

Therefore, when looking at the **data block**, the controller verifies the **level authorized/CFL** which was authorized by himself, or by the controller of the previous segment, on the right side, and the **flight level (NIV)** which is being flown, on the left side of the **data block**.

**NIV** means: “**mode C flight level (only for secondary icons, or correlated icons answering with the mode C) in hundreds of feet; 3D altitude, when mode C is not valid and 3D radar altitude is valid. Mode C** means, in this case, **transponder in operation**.”

The field **T** in the **data block** is located between the **NIV** and **CFL** (for example, 400=400 as seen in Fig. 10), and is the field of the **flight level evolution trend, represented by symbols**. The symbol **=** means that the altitude information is being received from a transponder operating in mode C. The symbol “**Z**” means that the altitude information is being received from a 3D radar.

Thus, the controller has just to look at the data block and compare whether the level presented is in accordance with the CFL. In case there is a discrepancy, an action must be taken by him/her.

However, there is a condition, in which the CFL flight level observed in the data block may refer to a flight level being requested, because the Field changes automatically. This change occurs when the aircraft is two minutes out of the next fix, over which a flight level change is forecast, warning the controller that he will have to analyze the change being requested and, then, after issuing the clearance to the aircraft, insert the level change in the CFL field of the strip.

It is worth pointing out that, in the initial processing of the flight plan, the RFL information of the strip is repeated in the CFL field. In other words, the CFL field, referring to a clearance that has not already been issued, is automatically filled with the RFL data, which is just a forecast.

There are two different definitions for CFL in the Controllers' Manual of Operation:

In item 3.1, 3.1.2 **Data block**, it means:

“**Flight level authorized in the flight plan for the segment being flown**, if the aircraft icon is correlated.”

In item 3.2, sub item 3.2.1 **Strip format**, it means:

“**Flight level authorized from the point .**”

(Definitions in bold type taken from the Controller and Assistant-Controller's Manual of Operation of the Enroute Air Traffic System – ACC CINDACTA I).

What has to be observed is that the Manual refers to flight level authorized, but does not mention the fact that such authorization will be provided by the controller responsible for the segment to be flown.

Therefore, the controller that receives a transfer of traffic must be attentive to interpret whether the flight level information contained on the right of the data block is the FL authorized by the controller of the previous segment to be flown along that segment, or it is the programmed FL to be requested.

Let us now take a look at the flight progress strips generated for sectors 5 and 7, relative to the flight in question.

#### In sector 5:

For the segment between São José dos Campos and Brasília, as seen on the strip below, the flight level requested is FL370 for all points, up to the vertical of Brasília.

First, the strip appears in green, in the pre-active condition, meaning that the airplane has not taken off yet.

The figure below (strip, at 17:10 UTC, in the pre-active condition) was shown on the console of the controllers that would control the aircraft between São José and the vertical of Brasília.

	N600XL	S01	SBSJ		PCL		VERME		2031S04652W	
	SBSJ	A4574	1730		15		6		2	
W	1730	E145M	370	370	370	370	370	370	370	
P	SBEG	N0540								
	UIR	UW2	OPR/EXCELAIRE RMK/AVODAC 286				S01			

Figure 11 – Strip for the first segment in the pre-active condition

Then, at the moment of departure, it changes the color to orange, and, instead of the flight time (in minutes) to fly along the previous segment for pre-active plans (green color, above), it shows the estimated time over the point (active plans).

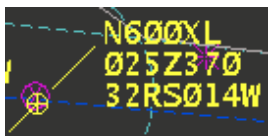
For the flight in question, the flight plan filed indicated flight level FL370 until the vertical of Brasília, FL360 from Brasília up to TERES position, and FL380 from TERES up to SBEG.

The processing occurred as expected, and the respective strips were generated for all sectors responsible for the control of the airspace through which the aircraft would fly along the proposed route.

Next, the pictures of the **strip** at 17:53 UTC, in the orange color active condition, and of the **data block** correlated after the departure, with the aircraft crossing 2500ft, from the recordings of the ACC.

**Figure 12** – Strip for the first segment of the flight in the active condition

	N600XL	S01	SBSJ		PCL		VERME	
			SBSJ A4574	1751		1805		1812
W	1751	E145M	370	370	370	370	370	370
R	SBEG	N0540	CLR1733	H-PCL				
	UIR	UW2	OPR/EXCELAIRE		RMK/AVODAC 286		S01	



In the data block, it is possible to see the correlated icon, valid 3D altitude (indicated by letter Z) beside the NIV (025). The information 025 means 2500 feet, climbing to FL370. The letter **Z means** Transponder mode C still not received, altitude information coming from the 3D radar. **370** is the CFL to climb to.

In sector 7: the Strip appears with forecast level changes (RFL):

	N600XL	AZ	BRS		1524S04829W	TERES		NABOL	
C	SBSJ	A4574	1855		1900	1933		1954	
W	1751	E145M	360	360	360	360	380	380	380
	SBEG	N0540	125.05 H-PCL						
	UZ6	UZ6	OPR/EXCELAIRE		RMK/AVODAC 286		S07		

↑
↑  
 (CFL)                      (RFL)

**Figure 13** – The Strip for the second segment of the flight in the active condition

After Brasilia, the flight level requested from the point (RFL) is FL360. However, on the left side, the flight level authorized from the point indicated (CFL) is repeated, due to a characteristic of the software, although the pilots were not instructed by the controllers to descend from FL370 to FL 360.

As can be seen, the CFL field is the field of the strip which is available to be modified by the controller at the console.

### 3.5.2. Radar Equipment

The radars which detected the airplanes on the day of the accident are shown below (Table 4):

Site	FIR	Primary Radar	SSR
Manaus	SBAZ	LP 23	Thales 970
Manicoré	SBAZ	-	Raytheon/Condor
Jacareacanga	SBAZ	-	Raytheon/Condor
Xingu	SBAZ	-	Raytheon/Condor
São Felix do Araguaia	SBAZ	-	Raytheon/Condor
SINOP	SBAZ	Lockheed Martin	
Tanabi	SBBS	TRS 2230	Thales 970
Gama	SBBS	TRS 2230	Thales 970
Três Marias	SBBS	TRS 2230	Thales 970
São Roque	SBBS	TRS 2230	Thales 970

**Table 4**

The radar maintenance reports presented by CINDACTA I and CINDACTA IV demonstrated that no failures had been found in the pieces of equipment.

### 3.5.3. Radar Integration and Presentation Applications

The systems of presentation of the Brazilian radars were developed after the transfer of technology from the French enterprise Thomson-CSF and were implemented in Brazil during the 1980's.

Concomitantly, the then Ministry of Aeronautics selected a company to monitor and receive the software, in view of the development of the national capability.

At the beginning of the 1990's, the first results of this investment were verified with the installation of the X-4000 System in the Area Control Centers of Rio de Janeiro and São Paulo.

Currently, the X-4000 system, formally known as Data Treatment and Visualization System (STVD, in Portuguese), has been revised and installed in the Area Control Center of Brasília. This version has the following functions:

- To process the information coming from external units and sensors;
- To provide the ATCOs of the ACC BS, in real time, with the data they need for the execution of their function of controlling and informing the users of the Enroute Air Traffic Control Services, within the Brasília FIR;
- To send and receive messages to/from the ACCs responsible for the ATC in the FIRs adjacent to the Brasília FIR, so as to allow the continuity of the provision of Air traffic Control Services in conjunction with these Centers;

- To send and receive messages to/from the APPs responsible for the ATC within the Terminal Areas located within the Brasília FIR, so as to allow the continuity of the provision of ATC Services in conjunction with these units; and
- To treat the keyboard commands entered by the Air Traffic Controllers, by means of the existing interfaces.

The STVD, according to the Systemic Specification of the ATECH company for the CINDACTA I, consists of hardware and software with the following functions:

- a) Radar Treatment;
- b) Flight Plan Treatment;
- c) Visualization and Treatment of Orders;
- d) Supervision;
- e) General Information;
- f) Rerun; and
- g) Database.

### **3.6. COMMUNICATION**

The communication systems comprised the communications of both the Aeronautical Mobile Service (SMA) and the Aeronautical Fixed Service (SFA), which will be described in this section.

#### **3.6.1. Aeronautical Mobile Service (SMA)**

The two airplanes possessed latest generation communication equipment. These systems have modern protections against interference.

The N600XL airplane was equipped with the PRIMUS II series of the Honeywell communications system. No indication or evidence was found that the aircraft communication equipment had presented any failures, even in the tests performed after the accident.

As for the PR-GTD airplane, the communication equipment did not present any failures during the all the flight, and all communications were monitored and recorded by the air traffic control units.

The control units at the Eduardo Gomes International Airport (Ground Control and Control Tower) utilize the transmitting and receiving equipment of the Airspace Control Detachment of Eduardo Gomes (DTCEA-EG), for communication with the aircraft within the aerodrome CTR, on the frequencies 121.9 MHz and 118.3 MHz, respectively. These control units established normal communications with the PR-GTD, without presenting any problems.

The Terminal Control of Manaus (TMA-SBWN) also utilizes the equipment installed at DTCEA-EG. Normal radio contacts were established with the aircraft, and there were not indications of any problems of communication with the PR-GTD airplane.

The Amazonic Area Control Center (ACC AZ) has communication sites equipped with VHF-AM transmitters and receivers manufactured by the Raytheon company.



For the connection between the communication sites and the ACC, most of the sites use satellite transmission-systems, except the site of Manaus, whose connection is made by means of a microwave system.

At the ACC AZ, the mobile and fixed communications are distributed to the controllers' consoles by means of an audio center.

The Table 5 below depicts the communication sites of the SMA of CINDACTA IV which were utilized in the communications with the PR-GTD airplane.

Site	Frequencies (MHz)	Remarks
Manaus	126.30	Designated to PR-GTD
Manicoré	134.70	-
Jacareacanga	134.70	-
São Felix do Araguaia	124.35	-
Cachimbo	126.45	Designated to PR-GTD

**Table 5** – Sites of the Aeronautical Mobile System of the FIR-SBAZ

The airport of São José dos Campos (SBSJ) has the following control units: São José Ground, São José Tower and São José Approach Control. These units utilize the communication equipment of the Airspace Control Detachment of São José dos Campos (DTCEA-SJ), and operate on the frequencies 121.9, 118.5 and 119.25 MHz, respectively. The communication equipment did not present any failures.

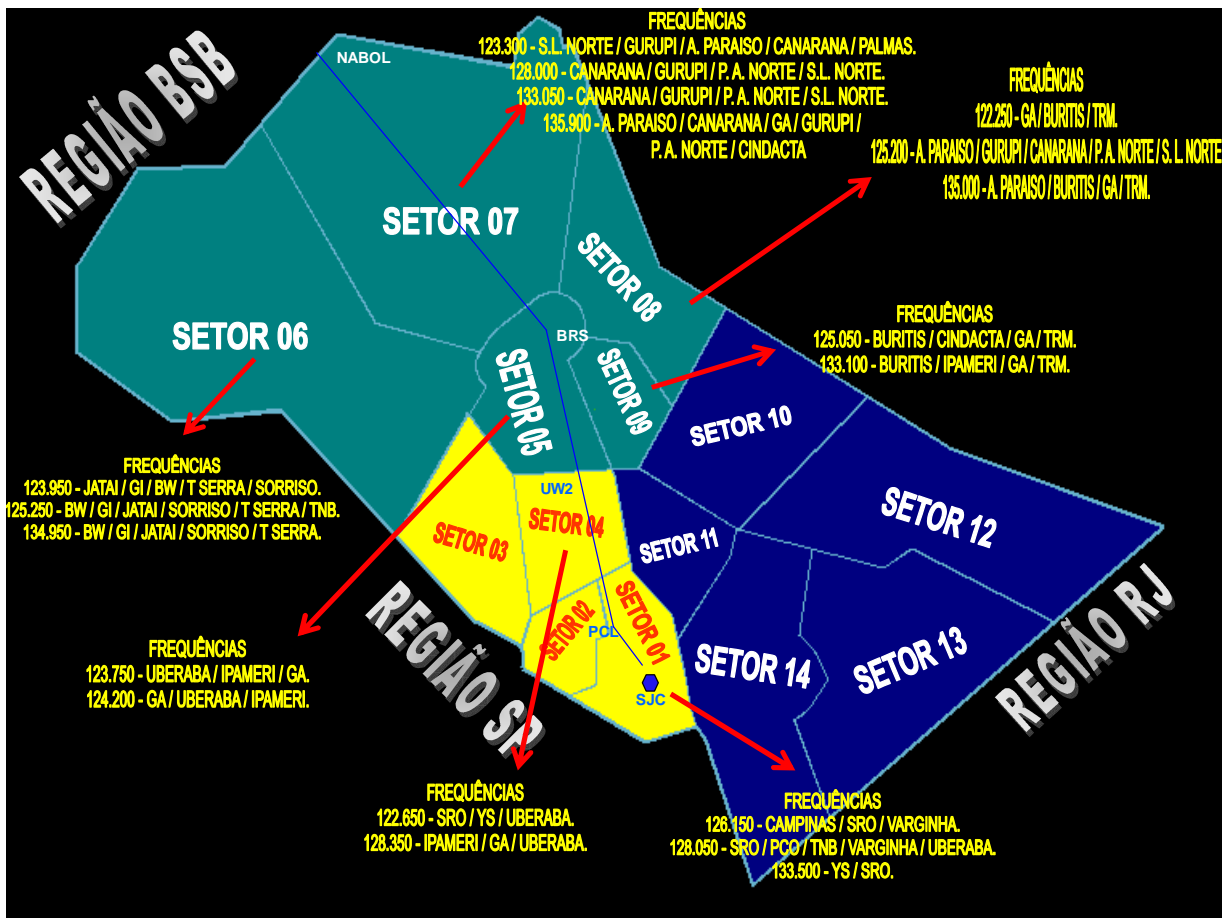
The ACC BS, responsible for the FIR-SBBS, has communication sites equipped with VHF-AM ParkAir systems.

In relation to the FIR-SBBS aeronautical mobile service, the investigation observed that:

- a) The frequency 128.000 MHz was not connected to the audio center;
- b) The frequencies 123.300 and 133.050 MHz were not selected in console 8;
- c) The frequency 134.700 MHz of the chart published by Jeppesen was incorrect; and
- d) The frequency 121.500 MHz was operational, but was not used.

The connection between the communication sites and Brasilia ACC is made by means of microwave (site of Gama), as well as commercial and satellite systems.

Figure 14 depicts the communication sites of CINDACTA I which support the various sectors of the FIR-SBBS. The blue line shows the flight path of the N600XL airplane.



**Figure 14** – Map of the frequencies for the sectors of FIR – SBBS

For the controller to have access to the frequencies and to the telephone service, an operating post of the SITTI company audio center is made available in each console. This operating post has several service pages, which can be configured by the controller.

The Aeronautical Mobile Service of DECEA includes an HF network, which was not used by the two airplanes involved in the accident.

### 3.6.2. Aeronautical Fixed Service

The Aeronautical Fixed Service of DECEA supports the communications between the ATC units, and has the following configurations:

- Hot Line (TF1) – it is not necessary to dial. The user just picks up the phone to get connected;
- Operational network (TF2) – a configuration of high availability, which connects operational ATC units only.

For the coordination of the PR-GTD and N600XL flights, the ATC units used the means of communication depicted in Table 6.

Originator	Addressee	Type	Remarks
SJ Ground	ACC BS	TF 1	N600XL IFR Clearance
ACC BS	ACC BS	TF 1	FIR-SBBS Sector-handoff
ACC BS	ACC AZ	TF 1	N600XL handoff
ACC AZ	ACC AZ	TF 1	FIR-SBAZ Sector-handoff
EG Ground	ACC AZ	TF 2	PR-GTD IFR Clearance
ACC AZ	ACC BS	TF 1	PR-GTD handoff

**Table 6 – Aeronautical Fixed Service utilized**

### 3.6.3. Analysis of the Communications

#### 3.6.3.1 Aeronautical Mobile Service

No communication failures occurred between:

- a) The SBEG control units and PR-GTD; and
- b) The FIR-SBAZ control units and PR-GTD.

These communications were carried out in the Portuguese language, without any difficulties, in terms of understanding between the parties involved.

Conversely, the communications between the control units and the N600XL crew presented failures, which were grouped as follows:

- a) Configuration of the controller's console;
- b) Standard phraseology (ICAO Doc. 4444);
- c) English language phraseology;
- d) Operational procedures (Doc. 4444, Operational Model of the FIR-SBBS, and AIP-Brasil); and
- e) Organizational problems.

An insufficient training of the standard phraseology and the English language was clearly observed in the communications between São José Ground and N600XL. This insufficient training was also noticed in other phases of the flight.

The transcript of the communication between the Ground Control and N600XL in Table 7 shows the non-observance of the operational procedures prescribed for the delivery of the IFR clearance.

**Table 7 – Transcript of communications between N600XL and São José Ground**

17:26:40	CAED 121,9 0	N600XL	SÃO JOSÉ GROUND ÉH NOVEMBER SIX ZERO ZERO X-RAY LIMA.
17:26:47		GND-C-SJ	NOVEMBER SIX ZERO ZERO X-RAY LIMA GO AHEAD.
17:26:51		N600XL	YES SIR (ININTELIGÍVEL) START ENGINES.
17:26:59		GND-C-SJ	ÉH, DID YOU REQUEST ÉH ABOUT WEATHER?
17:27:02		N600XL	YES SIR, WEATHER AND RUNWAY.
17:27:05		GND-C-SJ	ROGER. ÉH, SÃO JOSÉ OPERATING UNDER VISUAL CONDICTIONS, CELLING FIVE THOUSAND FEET, VISIBILITY ONE ZERO KILOMETERS, RUNWAY IN USE ONE FIVE, WIND TWO TWO ZERO DEGREES, EIGHT KNOTS, QUIU ENEITI ONE ZERO ONE NINER, TEMPERATURE TWO ZERO, TIME CHECK TWO FIVE.
17:27:37		N600XL	THANK YOU.
17:31:46		N600XL	GROUND, NOVEMBER SIX ZERO ZERO X-RAY LIMA LIKE TO HAVE PUSH BACK FOR A TAXI.
17:32:02		N600XL	GROUND, NOVEMBER SIX ZERO ZERO LIMA, X-RAY LIMA, LIKE TO GIVE READY, CLEAR TO PUSH FOR TAXI.
17:32:10		GND-C-SJ	AH, NOVEMBER SIX ZERO ZERO X-RAY LIMA, ÉH, CLEAR TO START UP, TEMPERATURE TWO ZERO. ÉH, ARE YOU READY TO TAXI?
17:32:24		N600XL	YES SIR, WE'LL BE IN TURN RIGHT NOW (ININTELIGÍVEL) TO THE TAXI BACK.
17:32:31		GND-C-SJ	ÉH REPORT READY FOR TAXI.
17:32:34		N600XL	REPORT READY TO TAXI, SIX HUNDRED X-RAY LIMA.
17:40:31		N600XL	SÃO JOSÉ GROUND, NOVEMBER SIX ZERO ZERO X-RAY LIMA READY TO TAXI.
17:40:38		GND-C-SJ	ÉH ROGER. ÉH, MAINTAIN POSITION, NOVEMBER SIX ZERO ZERO X-RAY LIMA.
17:40:44		N600XL	NOVEMBER SIX ZERO ZERO X-RAY LIMA MANTAINING POSITION.
17:40:52		GND-C-SJ	ÉH, NOVEMBER SIX ZERO ZERO X-RAY LIMA, ÉH CLEAR TO TAXI TO HOLDING POINT RUNWAY ONE FIVE. AND, REPORT HOW MANY PERSONS ON BOARD?
17:41:06		N600XL	SIX SOULS ON BOARD. ÉH, TAXI TO RUNWAY ONE FIVE, ÉH NOVEMBER SIX ZERO ZERO X-RAY LIMA.
17:41:15		GND-C-SJ	ÉH, COULD YOU CONFIRM, HOW MANY ON BOARD?
17:41:21		N600XL	AH, SO SORY WE HAVE SEVEN NOW (ININTELIGÍVEL) SEVEN SOULS ON BOARD.

17:41:26	CAED 121,90	GNDC-SJ	ROGER, SEVEN PERSONS ON BOARD. ÉH, CLEAR TAXI HOLDING POINT RUNWAY ONE FIVE AND REPORT READY DO COPY.
17:41:35		N600XL	CLEAR TO TAXI THE RUNWAY ONE FIVE, WE HAVE, WE'RE LOOKING FOR CLEARENCE. WE DON'T HAVE ONE YET (ININTELIGÍVEL).
17:41:50		GNDC-SJ	ARE YOU READY TO COPY THE CLEARENCE?
17:41:53		N600XL	AH, AFIRMATIVE, YES.
17:41:57		GNDC-SJ	<b>NOVEMBER SIX ZERO ZERO X-RAY LIMA, ATC CLEARENCE TO EDUARDO GOMES, FLIGHT LEVEL THREE SEVEN ZERO DIRECT POÇOS DE CALDAS, SQUAWK TRANSPONDER CODE FOUR FIVE SEVEN FOUR. AFTER TAKE-OFF PERFORM OREN DEPARTURE.</b>
17:42:26		N600XL	OKEY SIR, I GET (ININTELIGÍVEL), FLIGHT LEVEL THREE SEVEN ZERO (ININTELIGÍVEL), SQUAWK FOUR FIVE SEVEN FOUR, OREN DEPARTURE.
17:42:40		GNDC-SJ	AFIRMATIVE, ÉH BRASILIA CENTER FREQUENCY ONE TWO SIX DECIMAL ONE FIVE, IF ENABLE, CONTACT ONE THREE THREE DECIMAL FIVE.
17:42:57		N600XL	KEY, FREQUENCY ONE TWO SIX DECIMAL ONE FIVE, ONE THREE THREE DECIMAL FIVE FOR ALTERNATE. AND WHAT INITIAL ALTITUDE FOR CLEARENCE?
17:43:09		GNDC-SJ	AH, SAY AGAIN, PLEASE?
17:43:12		N600XL	(MENSAGEM COM INTERFERÊNCIA)ALTITUDE FOR TAKE-OFF?
17:43:19		GNDC-SJ	ÉH CLEAR TAXI TO HOLDING POINT RUNWAY ONE FIVE, AND REPORT READY FOR TAKE-OFF.
17:43:26		N600XL	OKEY, CLEAR TAXI TO HOLDING POINT ONE FIVE, SIX ZERO ZERO X-RAY LIMA.
17:45:06		N600XL	SÃO JOSÉ GROUND, NOVEMBER SIX ZERO ZERO X-RAY LIMA.
17:45:43		GNDC-SJ	ÉH, SIX ZERO ZERO X-RAY LIMA GO AHEAD.
17:45:47		N600XL	YES SIR, AFTER TAKE-OFF, WHAT ALTITUDE YOU'D LIKE (ININTELIGÍVEL).
17:45:54		GNDC-SJ	AFTER TAKE-OFF REPORT OREN DEPARTURE, OSCAR ROMEU ECHO NOVEMBER, TRANSITION POÇOS DE CALDAS.
17:46:10		N600XL	SIX ZERO ZERO X-RAY LIMA ROGER.
17:48:10		GNDC-SJ	NOVEMBER SIX ZERO ZERO X-RAY LIMA, SÃO JOSÉ GROUND CONTROL.
17:48:25		GNDC-SJ	NOVEMBER SIX ZERO ZERO X-RAY LIMA, SÃO JOSÉ GROUND CONTROL.
17:48:42	CAED	TWR-SJ	NOVEMBER SIX ZERO ZERO SÃO JOSÉ TOWER.
17:48:46	118,50	N600XL	SIR, GO AHEAD.
17:48:49		TWR-SJ	ROGER, AFTER TAKE-OFF, ÉH ÉH OREN DEPARTURE, TURN RIGHT ÉH ÉH, CLIMB INITIALLY TO FLIGHT LEVEL ZERO EIGHT ZERO.
17:49:01		N600XL	THANK YOU, OK, AFTER TAKE-OFF RIGHT TURN TO CLIMB INITIALLY UP TO ZERO EIGHT ZERO.
17:49:06		TWR-SJ	AFIRMATIVE. REPORT READY FOR TAKE-OFF.

From this transcript, it can be observed that the ATC unit did not comply with the prescriptions of ICAO Doc. 4444, Chapter 4, item 4.5.4 "Contents of Clearance". A main incompliance was the IFR clearance, delivered in an incomplete manner, not mentioning a clearance limit for the flight level FL370. As a result, the pilots understood that flight level FL370 was the only one authorized for the whole route.

Another problem identified relates to the English language phraseology. On two different occasions, the N600XL crew tried to learn the altitude to be maintained at the OREN SID, but the pilot did not get a correct answer from the ATC unit.

On the day of the accident, sectors 7, 8 and 9 of FIR-SBBS had been grouped in just one radar console (number 8), due to the reduced volume of traffic, and in accordance with the operational model of the ACC BS.

The audio center of the controller's console was operating with the configuration depicted in Table 8.

Freq. (MHz)	Sector	Remarks
125.05	9	Designated to N600XL.
128.00	7	-
135.90	7	TX in blind by ATC.
122.25	8	-
125.20	8	Designated to PR-GTD.
125.45	8	-
133.10	9	-

**Table 8** – Page activated at console nº 8 of CINDACTA I

It was observed that some of the frequencies of the sectors were not configured in subsequent pages. These pages should contain the frequencies of a given sector, to be selected by the controller, according to his operational needs. The operational model of the ACC BS neither defines this case, nor guides the controller and his supervisor.

At 18:50:19 UTC, ACC BS called the N600XL, but got no reply.

After a new attempt at 18:50:31 UTC, the N600XL answered the call.

At 18:50:37 UTC, the ACC BS transmitted the following instruction:

"...switch frequency one two five zero five, sir..."

At 18:50:41 UTC, the N600XL aircraft replied:

"...decimal one, I'll try **one two five decimal zero five**, good day, six hundred x-ray lima.

So, when the N600XL was handed off from sector 5 to sector 7, it was instructed to call on a frequency of sector 9. Another important fact to be considered was the point at which the transfer was made. The handoff was made before the aircraft passed BRS VOR, about 60 NM short of the sector limit.

The N600XL was instructed to call ACC BS on 125.05 MHz at the sector handoff.

It is worth pointing out that at the last two-way radio contact between the aircraft and

ACC BS, the pilots were informed that they were being provided with Radar Surveillance Service (radar monitoring).

Table 9 presents the transcript of the communication on 125.05, in support of the previous statements.

TRANSCRIÇÃO DE GRAVAÇÃO Nº 125, DE 29/09/06			FOLHA 01 / 01
REFERÊNCIA: Ocorrência entre o N600XL e o GLO1907.			AUDIOSOFT
DATA DA OCORRÊNCIA: 29/09/06		HORÁRIO: (UTC) Das: 18:51:07 às 19:27:17.	PARTES ENVOLVIDAS: N600XL/ACC BS
TRANSCRITA POR: SO AVOLIO		REVISADA POR: TEN CTA C. SOARES	
HORA (UTC)	OPR QRG	ANV. ÓRGÃO	TEXTO
18:51:07 18:51:13	125.05	N600XL	BRASÍLIA, NOVEMBER SIX HUNDRED X-RAY LIMA, LEVEL... FLIGHT LEVEL THREE SEVEN ZERO, GOOD AFTERNOON.
18:51:14 18:51:17	CJCF 135.9 / 125.2 125.05 / 133.1 122.25 / 125.45	ACC BS	NOVEMBER SIX ZERO ZERO X-RAY LIMA, SQUAWK IDENT, RADAR SURVEILLANCE.
18:51:20 18:51:20	125.05	N600XL	ROGER.
19:26:51 19:26:54	CGEE 135.9 / 125.2 125.05 / 133.1 122.25 / 125.45	ACC BS	NOVEMBER SIX ZERO ZERO X-RAY LIMA.
		N600XL	...(não contesta)...
19:27:12 19:27:17	CGEE 135.9 / 125.2 125.05 / 133.1 122.25 / 125.45	ACC BS	NOVEMBER SIX ZERO ZERO X-RAY LIMA, CONTACT ONE THREE FIVE DECIMAL NINE.
		N600XL	...(não contesta)...

**Table 9** – Transcript of the contacts made on 125.05 MHz

After this last two-way radio contact, both the N600XL and the ACC BS did not make any calls during the next 35 minutes.

The aircraft passed overhead BRS VOR, and the ACC BS controller took no action.

Another important fact was the loss of the secondary radar information, which, again, did not result in ACC BS contacting the N600XL, even though the aircraft was flying within RVSM airspace (FL 370).

At 19:26 UTC, the controller starts a series of seven calls to N600XL, on all frequencies.

It is worth pointing out that the calls were made simultaneously on the following six frequencies, which were selected at console 8:

- 135.90 MHz
- 125.20 MHz
- 125.05 MHz
- 133.10 MHz
- 122.25 MHz
- 125.45 MHz

**Table 10** – Transcript of the last five attempts made by ACC BS to contact N600XL, on six simultaneous frequencies (the frequency prescribed was 135.9 MHz).

TRANSCRIÇÃO DE GRAVAÇÃO N° 126, DE: 30/09/06			FOLHA 01 / 01
REFERÊNCIA: Ocorrência entre o N600XL e o GLO1907.			AUDIOSOFT
DATA DA OCORRÊNCIA: 29/09/06	HORÁRIO: (UTC) Das: 19:30:40 às 19:53:55.		PARTES ENVOLVIDAS: N600XL / ACCBS
TRANSCRITA POR:		REVISADA POR:	
HORA (UTC)	OPR QRG	ANV. ÓRGÃO	TEXTO
<b>19:30:40</b> 19:30:43	CGEE 135.9/125.2 125.05/133.1 122.25/ 125.45	ACC BS	NOVEMBER SIX HUNDRED X-RAY LIMA.
	125.05	N600XL	...(não contesta)...
<b>19:30:56</b> 19:30:58	CGEE 135.9/125.2 125.05/133.1 122.25/ 125.45	ACC BS	NOVEMBER SIX HUNDRED X-RAY LIMA, BRASÍLIA.
	125.05	N600XL	...(não contesta)...
<b>19:32:48</b> 19:32:50	CGEE 135.9/125.2 125.05/133.1 122.25/ 125.45	ACC BS	NOVEMBER SIX HUNDRED...
	125.05	N600XL	...(não contesta)...
<b>19:34:08</b> 19:34:12	CGEE 135.9/125.2 125.05/133.1 122.25/ 125.45	ACC BS	NOVEMBER SIX HUNDRED X-RAY LIMA CONTACT BRASÍLIA ONE THREE FIVE DECIMAL NINE.
	125.05	N600XL	...(não contesta)...
<b>19:53:39</b> 19:53:55	CGEE 135.9/125.2 125.05/133.1 122.25/ 125.45	ACC BS	NOVEMBER SIX HUNDRED X-RAY LIMA, BRASÍLIA IN BLIND, CONTACT AMAZONICO CENTER, ONE TWO THREE DECIMAL THREE TWO, IF UNABLE, ONE TWO SIX DECIMAL FOUR FIVE, NOVEMBER SIX HUNDRED X-RAY LIMA.
	135.9	N600XL	...(não contesta)...

Of these frequencies, only 125.05 MHz, 135.90 MHz and 128.00 MHz could be being used by N600XL. The frequency 125.05 MHz was the last one instructed by ACC BS.

The other two were prescribed frequencies for sector 7, shown by both the H1/H2 ERC published by DECEA, and the Jeppesen Chart used by the N600XL pilots.



Just after the transmission in blind from the ACC BS to the N600XL, the Total 5589 contacted the ACC BS and, then, there was communication with the TAM 3471, as shown in the table below.

Table11- Transcript of the communication with the TTL 5589 (Copy of the transcript n° 134, 05 October 2006)

19:53:38 19:53:55	CGEE 135.9 125.2 125.05 133.1 122.25 125.45	ACC BS	NOVEMBER SIX HUNDRED X-RAY LIMA, BRASILIA IN BLIND, CONTACT AMAZONIC CENTER, ONE TWO THREE DECIMAL THREE TWO IF UNABLE...AAH...ONE ...TWO... SIX DECIMAL FOUR FIVE, NOVEMBER SIX HUNDRED X-RAY LIMA.
19:54:02 19:54:04	135.9 125.2 125.05 133.1 122.25 125.45	TTL 5589	BRASÍLIA, BOA TARDE, É O TOTAL CINCO CINCO OITO NOVE.
19:54:09 19:54:11	CGEE 135.9 125.2 125.05 133.1 122.25 125.45	ACC BS	TOTAL CINCO CINCO OITO NOVE, PROSSIGA.
19:54:13 19:54:17	135.9 125.2 125.05 133.1 122.25 125.45	TTL 5589	PASSANDO...PALMAS, O CINCO CINCO OITO NOVE, MANTENDO O UNO MEIA ZERO.
19:54:24 19:54:32	CGEE 135.9 125.2 125.05 133.1 122.25 125.45	ACC BS	TOTAL CINCO CINCO OITO NOVE, CIENTE, MANTENHA NÍVEL...UNO MEIA ZERO E REPORTE CANA BRAVA, TOTAL CINCO CINCO OITO NOVE.
19:54:33 19:54:34	135.9 125.2 125.05 133.1 122.25 125.45	TTL 5589	OITO NOVE REPORTAR CANA BRAVA.
19:55:17 19:55:20	CGEE 135.9 125.2 125.05 133.1 122.25 125.45	ACC BS	TAM TRÊS QUATRO SETE ...(ininteligível)...CENTO E DEZENOVE CINCO.
19:55:21 19:55:21	135.9 125.2 125.05 133.1 122.25 125.45	TAM 3471	NOVE CINCO.

By means of a flight conducted by Special Group of In-Flight Inspection (GEIV) after the accident, it was verified that for the FL 370 on airway UZ6 a loss of contact with ACC BS occurred at the distance of 100 NM from BRS VOR and beyond, when utilizing the frequency 125.05 MHz. Thus, this was an operational and organizational failure of the ACC BS for having assigned a frequency to N600XL in an area of the airspace where the aircraft could not receive it. It is important to point out that the frequency 135.90 MHz, prescribed for sector 7, is operational all along the UZ6 airway.

After the last radio contact at 18:51:07 UTC, a new attempt by N600XL was only made 57 minutes later.

The crew was using a Jeppesen navigation chart, which listed the following frequencies for sector 7 of ACC BS:

SECTOR 7	
<b>123.3</b>	<b>128.0</b>
<b>133.05</b>	<b>134.7</b>
<b>135.9</b>	

#### Frequency Box of the Jeppesen Chart

According to the CVR data, the crew of N600XL started a series of 12 (twelve) unsuccessful calls to Brasilia ACC, in the chronological sequence shown below:

19:48:16 UTC	19:51:08 UTC
19:48:40 UTC	19:51:24 UTC
19:49:33 UTC	19:51:41 UTC
19:50:08 UTC	19:52:10 UTC
19:50:28 UTC	19:52:42 UTC
19:50:48 UTC	19:52:59 UTC

In the chart used by the pilots, a discrepancy was found which had influence on the communications. There was a frequency which was incorrect in relation to the Brazilian chart in force. The frequency 134.7 MHz was not indicated in the Brazilian standard chart.

The frequencies of the H1/H2 Brazilian chart were the same, except for 134.7 MHz. In its place, there was the emergency frequency 121.5 MHz.

At 19:53:39 UTC, N600XL received the last call (in the blind) made by ACC BS, telling him to call ACC AZ, but the crew was not able to copy the frequencies.

At 19:53:57 UTC, N600XL replied to ACC BS, requesting that the decimals of the first frequency be repeated, since he had not been able to copy them. However, the ACC BS did not receive the message.

A little later, N600XL made a series of 7 (seven) more calls to the ACC BS:

19:54:16 UTC	19:55:43 UTC
19:54:40 UTC	19:56:41 UTC
19:55:00 UTC	19:56:53 UTC
19:55:16 UTC	

Then, at 19:56:54 UTC, the collision occurred.

The CVR of N600XL recorded the voices and sounds in the cockpit, and also the calls made to ACC BS and ACC AZ. However, the frequencies on which the calls were made are not identified. The same is true for the transmissions received.

Nonetheless, by means of a logical sequence, if one takes the last frequency commanded as an initial reference, and follows the order that is in the chart used by the pilots, it is possible to establish some of the frequencies selected, by cross-checking the pieces of information with the recordings obtained at the ACC BS.

Below, it is possible to verify which frequencies were recorded (summary of the transcripts):

- 123.30 MHz – recorded in the CINDACTA I Recorder– attempt to contact by N600XL.
- 128.00 MHz – not recorded.
- 133.05 MHz – recorded in the CINDACTA I Recorder – attempt to contact by N600XL.
- 135.90 MHz – recorded in the CINDACTA I Recorder – attempt to contact by N600XL.
- 121.50 MHz – not recorded in CINDACTA I Recorder.

**ACC BS**

TRANSCRIÇÃO DE GRAVAÇÃO Nº: 132, DE 05/10/06		FOLHA: 01/ 01	
REFERENCIA: Ocorrência entre N600XL e GLO1907		AUDIO SOFT	
DATA DA OCORRÊNCIA: 29/09/2006		HORÁRIO: (UTC) Das 19:50:09 às 19:50:30	PARTES ENVOLVIDAS: N600XL / ACC-BS
TRANSCRITA POR: SO BCT JÉSUS		REVISADA POR: TEN CTA C. SOARES	
HORA (UTC)	OPR QRG	ANV ÓRGÃO	TEXTO
19:50:09 19:50:11	123.30	N600XL	BRASÍLIA NOVEMBER SIX ZERO ZERO X-RAY LIMA.
	123.30	ACC BS	... (não contesta)...
19:50:27 19:50:30	123.30	N600XL	BRASÍLIA NOVEMBER SIX ZERO ZERO X-RAY LIMA.
	123.30	ACC BS	... (não contesta)...
<p><b>“Esta transcrição constitui expressão fiel das comunicações estabelecidas entre as partes citadas, no período de 19:50:09 UTC às 19:50:30 UTC, incluindo todos os erros de linguagem e termos inadequados à fraseologia padrão”.</b></p>			

**Table 12** – Attempt made by N600XL to contact ACC BS on 123.30 MHz.

## ACC BS

TRANSCRIÇÃO DE GRAVAÇÃO Nº: 133, DE 05/10/06			FOLHA: 01/ 01
REFERENCIA: Ocorrência entre N600XL e GLO1907			AUDIO SOFT
DATA DA OCORRÊNCIA: 29/09/2006		HORÁRIO: (UTC) Das 19:51:42 às 19:51:45	PARTES ENVOLVIDAS: N600XL / ACC-BS
TRANSCRITA POR: SO BCT JESUS		REVISADA POR: TEN C SOARES	
HORA (UTC)	OPR QRG	ANV ÓRGÃO	TEXTO
19:51:42 19:51:45	133.05	N600XL	BRASÍLIA NOVEMBER SIX ZERO ZERO -RAY LIMA.
	133.05	ACC BS	... (não contesta)...
<p>“Esta transcrição constitui expressão fiel das comunicações estabelecidas entre as partes citadas, no período de 19:51:42 UTC às 19:51:45 UTC, incluindo todos os erros de linguagem e termos inadequados à fraseologia padrão”.</p>			

**Table 13** – Attempt made by the N600XL to contact ACC BS on 133.05 MHz

The recordings of the frequencies were correctly correlated with the data obtained from the CVR of the Legacy airplane.

The N600XL attempted contacts on the frequency 121.5 MHz.

At 19:59:57 UTC, the PIC made the **fourth** call on 121.5 MHz:

“Brasilia Radio, Brasilia Radio, November Six Hundred X-ray Lima, declaring emergency.”

At 20:01:05 UTC, he made the **fifth call**, no longer restricted to ATC units:

“...anybody on one two one point five zero: November Six Zero Zero X-ray Lima?”

On this fifth attempt, at 20:01:06 UTC, a commercial cargo aircraft, call sign POLAR 71, received the call and replied to the N600XL.

N600XL explained that they were in emergency and that they were descending.

POLAR 71 asked whether the N600XL needed to talk to Manaus.

POLAR 71 gave them two frequencies of Alta-Floresta, with whom it was maintaining contact at that moment.

At 20:01:45 UTC, the N600XL made the **sixth** call, using the call site of Brasilia. It was not possible to determine whether, for this call, they used the frequencies of Alta-Floresta provided by POLAR 71.

Finally, at 20:01:59 UTC, the N600XL pilots decided to select the 7700 transponder code, internationally used with the purpose of informing the controllers that the aircraft was in an emergency situation.

At 20:02:03 UTC, POLAR 71 began to attempt contacts with the ACC AZ, trying to help the N600XL to get in touch with the control units.

The N600XL crew made eight more calls to ACC BS on 121.5 MHz, getting no replies. When they passed flight level 170, descending, at 20:06:55 UTC, they received a new call from POLAR 71, who was still trying to help them to establish contact with the control units.

N600XL was then at 50 NM south of SBCC.

At 20:10:23 UTC, POLAR 71 finally manages to contact the ACC AZ, advising that N600XL was proceeding to SBCC.

At 20:15:17 UTC, POLAR 71 told the N600XL to call on 126.45 MHz. N600XL called Brasilia, but got no reply.

At 20:15:22 UTC, POLAR 71 called the N600XL again, informing that he was in contact with the ACC AZ.

Finally, at 20:16:34 UTC, the N600XL managed to contact the ACC AZ.

N600XL requested information on the SBCC aerodrome, but the ACC AZ did not receive his transmission.

N600XL gave up receiving the information, and just asked for the frequency of SBCC Tower.

At 20:17:37 UTC, the ACC AZ provided N600XL with the frequency 125.9 MHz of SBCC.

At 20:18:03 UTC, N600XL called the Tower of SBCC, and successfully coordinated the emergency landing.

At 20:23:00 UTC, the aircraft landed at SBCC. All the time, during the emergency, the aircraft had been flown by the SIC.

The frequency 128.00 MHz, prescribed in the H1/H2 ERC, as well as in the Jeppesen Chart, was only active in some of the communication sites of CINDACTA I. According to the audio recorder and the in-flight inspection after the accident, only in the proximity of Brasilia, the frequency was operational. In sector 7, this channel was not operational.

A similar problem occurred with the frequency 121.50 MHz: it was not operational in the area of the accident.

Despite having been recorded in the N600XL CVR, the calls made on 121.50 MHz were not recorded in the audio centers of the ACC BS and ACC AZ.

In both cases, transmitters and receivers had been installed in the communication sites, but the connections with the control center had not been concluded.

In the specific case of the ACC AZ, the system implemented did not have a primary and secondary channel for each frequency in use. The system had five frequencies, which were automatically prioritized, in case of equipment failure.

This kind of policy attributed low priority to the emergency frequencies, and in the scenario of the accident, they were not functioning.

The maintenance records of the ACC AZ VHF-AM systems confirmed this fact.

### **3.7. INFORMATION ON THE AERODROME**

The accident occurred outside the aerodrome area.

### **3.8. INFORMATION ON THE IMPACT AND WRECKAGE**

The PR-GTD airplane hit the ground at the coordinates 22°38'40''S / 042°19'13''W.

### 3.9. INFORMATION ON FIRE

The evidence of fire found in the left engine of the PR-GTD indicates the occurrence of an explosion resulting from the damage to the left wing, after the collision. No evidence of fire was found in other parts of the wreckage

### 3.10. ASPECTS OF SURVIVAL AND/OR EVACUATION OF THE AIRCRAFT

Taking into account that, during the fall, the abnormal attitude of the PR-GTD aircraft exceeded its structural envelope, the limits of human tolerability to the conditions created by the midair collision were also exceeded, not allowing for any chances of evacuating the aircraft and, consequently, of surviving. There was extreme fragmentation of the bodies, with dismemberment and the finding of naked bodies half-buried on the ground.

### 3.11. FLIGHT RECORDERS

#### 3.11.1 Reading of the CVR/FDR in Ottawa, Canada.

The units listed in Table 14 were sent to the TSB Flight Recorder Laboratory in Ottawa, Ontario, Canada, for readout:

Equipment	Aircraft	PN	SN
SSCVR Honeywell	737-800, PR-GTD	980-6022-001	120-08600
SSFDR Honeywell	737-800, PR-GTD	980-4700-042	12552
SSCVR Honeywell	Legacy-600, N600XL	980-6022-001	120-08146
SSFDR Honeywell	Legacy-600, N600XL	980-4700-042	12092

Table 14



Figure 15: Complete base of an SSCVR unit



Figure 16: SSFDR unit, PR-GTD



**Figure 17:** SSFDR unit, N600XL



**Figure 18:** SSCVR unit, N600XL

The process of data readout was successfully performed on all 4 units.

The recorders removed from the N600XL airplane did not show any signs of damage attributable to impact, and the reading of the data was done without difficulty.

However, the extreme conditions experienced by the DFDR and CVR of the PR-GTD need to be considered in detail.

The in-flight structural fragmentation of the PR-GTD airplane, which occurred at an altitude of about 8,000 feet, caused the loss of electric power supply to the recorders and, consequently, interrupted the recording of the data.

These damages, in addition to the external damage sustained by the recorders and their disposal on the terrain, allowed to indicate that, probably, when the structural rupture of the airplane occurred, these pieces of equipment detached from their fixation bases and surrounding structures, and sustained the deceleration of the collision with the terrain, without any protection other than its own structure.

The direct impact of the SSVR unit against a tree trunk or branch was sufficient for the protected cylinder containing the data (Figure 19) to detach from the rest of the set (Figure 20).



**Figure 19:** SSCVR protected cylinder, PR-GTD



**Figure 20:** Base of the SSCVR unit, PR-GTD



The protected cylinder of the SSCVR and its respective base were found in different places. This kind of separation was not normally observed in former CVR and FDR models, which had a rectangular box functioning as an external case for all the subcomponents.

The recording unit got buried about 20 cm in the soil, and it was virtually impossible to locate it with the naked eye.

Thus, when the conventional means of search proved unsuccessful, despite all the infrastructure of support to the accident site, professionals of the Brazilian Army were called to help.

Army units sent about two hundred troops to the area of operations, along with equipment originally designed for anti-mining missions, capable of detecting metal objects buried on the ground, at depths up to 70 cm.

The Units executed sorties in the wreckage site, during a period of almost 30 days, covering all the areas that had already been explored visually, besides other stretches of land that were of interest to the CIAA.

Finally, about 25 days after the accident, with the aid of the metal detecting devices mentioned, the recording unit was found.

The reading of data from the seriously damaged CVR/FDR equipment required support from laboratories located abroad, since there is not adequate infra-structure for that purpose in Brazil yet.

For the retrieval of the PR-GTD SSCVR cylinder data, the electronic board containing the memory chips was carefully removed from the cylinder (Figure 21), and the respective flat cable was recovered (Figures 22 and 23).

The electronic board was then installed in a complete SSCVR unit (Figure 24). Similarly, the protected cylinder of the PR-GTD SSFDR was removed and subsequently installed in a complete SSFDR unit.



Figure 21: Removal of the memory, PR-GTD SSCVR

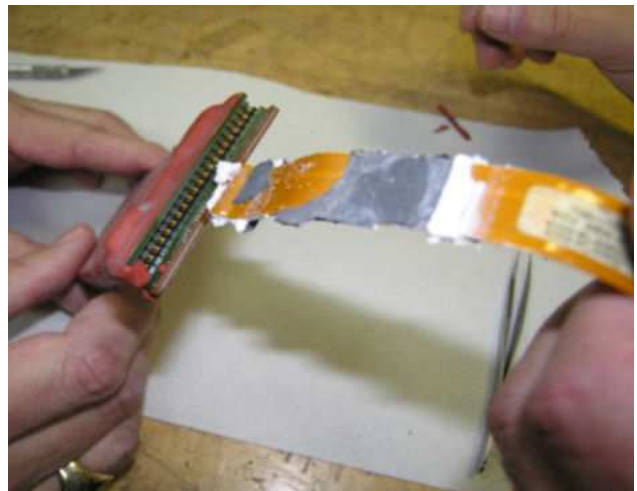


Figure 22: Memory board and flat cable, PR-GTD SSCVR





Figure 23: Flat cable recovery, PR-GTD SSCVR



Figure 24: Memory board reading, PR-GTD SSCVR

### 3.12. ORGANIZATIONAL ASPECTS

The investigation of the Human Factor (Psychological Aspect) includes the study of variables of individual, psychosocial and organizational nature which condition the human performance and can contribute to trigger off aeronautical accidents, incidents and ground occurrences, and are defined as follows:

- Individual variables: characteristics and processes typical of the human nature, such as: attitude, motivation, perception, memory, attention, emotional control, decision-making process, etc.
- Psychosocial variables: those that are established in the interaction of the individual with the work environment and outside it, such as: inter-personal relationship, communication, integration, cooperation, division of tasks, leadership style, etc.
- Organizational variables: those that instill certain directions or standards into the behavior of individuals or groups, such as: work organization, organizational atmosphere and culture, norms and regulations, work conditions, etc.

These variables interact and combine in multiple ways, weakening the defenses of the system and forming a favorable scenario for the occurrence of accidents.

Therefore, with the objective of permitting an integrated view of the contribution of the different variables in the context of the accident occurred between the PR-GTD and N600XL, the organizational aspects, including the ones associated to the air traffic control infrastructure, are dealt with in item 3.15.2 of this report, part of the section which refers to the psychological aspects.

### 3.13. OPERATIONAL ASPECTS

#### 3.13.1 General Considerations

The scenario of this accident involved the collision of two airplanes, both of them in level flight, flying in opposite directions on the same airway within controlled upper airspace and under RVSM.

The airplanes collided without receiving the expected alerts from their airborne anti-collision systems, due to the fact that one of the airplanes, N600XL, had discontinued the functioning of its own system, something that was not perceived by the crew.

Initial evidence pointed toward problems of communication between the N600XL airplane and the Air Traffic Control units, in addition to the operation of the Transponder/TCAS equipment aboard the aforementioned aircraft. For the investigation, these facts constitute the main focus of this Report.

All the relevant facts of the Operational Aspect that contributed to the occurrence of the accident have been considered.

The communications between the airplanes and the Air Traffic Control units were investigated, through the analysis of the recordings of the ATC units and airborne equipment, such as the CVR and DFDR (information of activation of the PTT key).

The operation of the Transponder/TCAS equipment was analyzed through the confrontation between the available data of the CVR/DFDR equipment and the video recordings of the radar consoles, the work stations of the controllers involved in the accident.

The reports of the pilots involved in the accident were analyzed, as well as the reports of some of the controllers of the ATC units, as the majority of the air traffic controllers and supervisors of the ACC BS, directly involved in the occurrence, refused to be interviewed by the Investigation Commission.

Various available sources of information were synchronized, such as the measured time of the N600XL CVR/DFDR, with one-second accuracy, and the time of the ATC units' transcripts. The time of the CINDACTA I transcripts was used as Time Measurement Reference.

All the work was done in accordance with the Annex 13 to the Chicago Convention.

In this report, the abbreviations *PIC* – “*Pilot In Command*” and *SIC* – “*Second In Command*” are used, in accordance with the definitions and deriving attributions of the *14 CFR Part 1 – “Definitions and Abbreviations”*.

When reference is made to “*FAA's regulations*”, the term “*14 CFR Part XXX*” is used, according to instruction of the FAA itself, in replacement of the widely known term “*FAR*”.

In subsequent references, only the term “*14 CFR Part XXX*” will be used, as in the example: *14 CFR Part 1*; *14 CFR Part 91*; *14 CFR Part 135*.

The profile of the N600XL crew (*PIC* and *SIC*) was analyzed exclusively from the perspective of the American legislation, as the career of both pilots was consolidated in the United States, following the career flow of that country, which is very similar to the Brazilian formation.

In order to duly detail the Operational Aspects, preserving the chronology of the facts, the subjects are presented within three main topics: **The Pilots, The Airplanes, and The Flight of 29 September 2006.**

### 3.13.2 The Pilots

#### 3.13.2.1 Applicability of the Legislations in the Investigation

The newly delivered airplane, already with the “N600XL” American registration, was flying between two Brazilian airports, with a planned navigation of 2 (two) airways of the national airspace.

Therefore, the flight of the aforementioned aircraft is considered as a flight of the General Aviation, under the rules set in the *RBHA 91 – “REGRAS GERAIS DE OPERAÇÃO PARA AERONAVES CIVIS”*, which is almost totally similar to the 14 CFR Part 91 – “GENERAL OPERATING AND FLIGHT RULES”.

The investigation of the Operational Aspect was conducted under the aegis of the RBHA 91, also taking into account the prescriptions set in the *14 CFR Part 91*, as well as other documents published by the *Federal Aviation Administration (FAA)*.

ExcelAire Services, Inc. operates in the realm of the General Aviation, whose definition is:

*“Although GA is typically characterized by recreational flying, it encompasses much more. Besides providing personal, business, and freight transportation, GA supports diverse activities such as law enforcement, forest fire fighting, air ambulance, logging, fish and wildlife spotting, and other vital services”.* **Source: NALL REPORT 2006 - AOPA**

Being a company of the General Aviation, ExcelAire is certified to meet the specifications set in *14 CFR Parts 91, 135 and 145*.

According to the Brazilian legislation, at the moment of the accident, the aircraft was doing a *repositioning flight* and, according to the American legislation, the flight is typified as “*FERRY FLIGHT*”, whose definition is:

*Ferry – “A non-revenue flight for the purpose of (1) returning an aircraft to base, (2) delivering an aircraft from one location to another, or (3) moving an aircraft to and from a maintenance base. Ferry flights, under certain terms, may be conducted under terms of a special flight permit”.* **Source: NALL REPORT 2006 - AOPA**

Before conducting the Ferry Flight on the 29 September 2006, the N600XL crew participated in the acceptance flights in Brazil and officially accepted the aircraft, after some necessary repairs and adjustments of non-conformities in the phase of finalization of the aircraft delivery, in accordance to what was prescribed in the purchase contract between the parties.

The CIAA analyzed all the pieces of information relative to the aircraft delivery phase, which were made available by Embraer and ExcelAire. Of this material, the logbooks are the most important documents for the CIAA, as they contain the latest data, up to the final declaration of acceptance of the aircraft by the client

It is important to point out that the airplane was accepted without any problem, failure, malfunctioning, lack of equipment or any other type of non-conformity associated to its main systems, such as: navigation, communication, electrical, electronic, anti-collision, sonorous and visual alert systems, as well as the integration between all of them.

Everything was functioning according to the specifications.

The PR-GTD airliner of the Brazilian company GOL Transportes Aéreos S.A., was operating a passenger transport flight between the cities of Manaus-AM and Rio de Janeiro-RJ, with a stop programmed for the city of Brasília, in the Federal District.

So, it was flying under the rules of RBHA 121, and was being conducted by a crew certified and qualified to comply with the protocols set in the regulation afore mentioned.

It must be pointed out that GOL is a company that does the maintenance of aircraft which are certified in accordance with the RBHA 145, Standard "C", Class 4, and is, therefore, entitled to do the aircraft maintenance services prescribed in the Company Homologation Certificate (CHE) number 0411-01/DAC, obeying the restrictions prescribed in the regulations in force, as can be observed in the Manual of Inspection Procedures (MPI) of the company.

In the elaboration of this report, the national and international legislations listed below were considered, on account of their applicability and focus:

- The RBHA 91, considering that the N600XL airplane was doing a ferry flight within the Brazilian airspace when the collision occurred;
- The 14 CFR Part 91, in complement to the RBHA 91, considering that the N600XL airplane was doing a ferry flight, according to the American legislation;
- The 14 CFR Part 91, in complement to the RBHA 91, considering that Excelaire is a company certified in accordance with this American legislation;
- The 14 CFR Part 135, considering that the N600XL pilots were selected, hired, trained, evaluated, certified and qualified at the FSI-Houston-TX, under the aegis of this regulation, as well as considering that Excelaire is also ruled by the same regulation;
- The RBHA 135, due to its correlation with the American document 14 CFR Part 135;
- The 14 CFR Part 61, considering the N600XL pilots' certification and qualification as ATP (Air Transport Pilot), qualified for IFR flight in type aircraft;
- The RBHA 61, considering the GOL PR-GTD pilots' certification and qualification as ATP, qualified for IFR flights in type aircraft;
- The RBHA 119, considering that the accident occurred within Brazilian territory;
- The 14 CFR Part 119, in complement to the RBHA 119;
- The RBHA 121, considering that the operation of the PR-GTD aircraft was under its rule;
- The RBHA 129, considering that the accident involved a foreign company and occurred within Brazilian territory;
- The RBHA 142, considering that the training of the PR-GTD pilots' was held at the Guarulhos CAE unit, in São Paulo State, Brazil;
- The RBHA 145, considering that GOL is also an aircraft maintenance company, as mentioned earlier;

- The 14 CFR Part 142, considering that the training of the N600XL pilots was held at the Flight Safety International (FSI) in Houston-TX;
- The RBHA 39, considering that the two aircraft involved in the collision are ruled by this regulation, and the fact that the accident is associated to items of equipment installed on both aircraft, certified by the civil aviation authorities of their respective countries;
- The 14 CFR Part 39, considering the validation of the RBHA 39;
- ICAO Annex 1 (Personnel Licensing);
- ICAO Annex 2 (Rules of the Air);
- ICAO Annex 6 (Aircraft Operation – Parts 1 and 2);
- ICAO Annex 8 (Aircraft Airworthiness);
- ICAO Annex 13 (Aircraft Accident and Incident Investigation);
- All the regulations issued by the DECEA (COMAER) relative to SISCEAB and associated with the accident;
- The analysis of the Pilot/Controller interface, in what refers to the utilizations of the rules set by the ICAO for communication and air navigation (CNS/ATM);
- The System Norm of the Command of Aeronautics number 58-01 (NSCA 58-01), which establishes the “Organization and Functioning of the Civil Aviation Flight Safety System), listing all applicable RBHAs to the Systems involved in the accident.

### **3.13.2.2 Pilots of the PR-GTD**

#### **3.13.2.2.1. Qualifications**

##### PILOT-IN-COMMAND (PIC)

The captain, PIC of the flight GLO 1907, earned his first license, Private Pilot (PPR), 27 years before the date of the accident.

On 29 September 2006, his ATP license was up-to-date and valid.

He had worked for the “Gol Transportes Aéreos S/A” since the date of foundation of the company, in 2001.

Up to the day of the accident, he had already participated in 4 (four) complete trainings of the Boeing 737-700/800 simulator, a type of equipment at which he was also a Flight Instructor.

For this reason, he was giving a flight instruction to the co-pilot, who was being re-qualified in the Boeing 737- 700/800.

As far as jet aircraft were concerned, the PIC of the GOL company had only flown Boeing airplanes throughout his career.

He had earned vast experience, which covered the Boeing aircraft 727-100, 737-300, 737-400, 737-700 and 737-800.

Besides the interviews with captains and co-pilots, other ones were held with his superiors of the Directorship level, in order to gather as much information as possible about the captain of the GLO 1907 flight.

At the same time, the Operational Formation Flight Sheets, the Simulator Flight Sheets, the Ground School Sheets, as well as all the available data concerning recurrent courses, were analyzed together with the records of the pilot in the GOL archives.

The comments and records analyzed by the CIAA highlighted the high level of his performance concerning the operation of the Communication, Navigation, Avionics, TCAS, Transponder systems, as well as his performance in the CRM, SOP, Checklist, General Flight Planning and Flight in RVSM Airspace.

Another point that was detailed in this analysis was the performance of this captain in the specific trainings at the Simulator, such as: CRM (practice), LOFT, utilization of the Transponder, utilization of the TCAS, evasive maneuvers (TA, RA, TA Only, TA/RA) and Recovery from Abnormal Attitudes (Upset recovery).

The PIC accomplished all the phases required for the operational progress of a captain in the company, up to the level of Flight Instructor.

The following internal documents of the operator were analyzed during the investigation, focusing on the selection, professional formation, training, evaluation and recurrent training of the PIC of the PR-GTD:

- General Manual of Operations (MGO) – Revision 4.2;
- General Manual of Maintenance (MGM) – Temporary Revision 03.01;
- Manual of Inspecting Procedures (MPI) – Revision 1.0;
- Standard Operating Procedures (SOP) B737 – Revision 16;
- Quick Reference Handbook (QRH) B737NG – Revision 16;
- Flight Crew Operations Manual (FCOM) B737NG – Revision 16;
- General Training Program of the GOL company.

It is important to highlight that the General Training Program of the GOL company prescribed instructions with annual recurrence for operation within RVSM airspace to all the company pilots, with theoretical and practical (Simulator) evaluation.

As a result of this analysis, we can affirm that the PIC of the PR-GTD airplane was adequately trained and prepared at a level of proficiency, to conduct the flight in question up to its destination.

Up to the moment of the collision, the PIC had complied with all the procedures, in accordance with the norms, manuals and air traffic rules.

### SECOND-IN-COMMAND (SIC)

The SIC earned his first license, Private Pilot (PPR), 7 (seven) years before the date of the accident.

On the 29 September 2006, his Commercial Pilot License (PCM) was up-to-date and valid.

He joined “Gol Transportes Aéreos S/A” company as a check-in clerk and, in June 2002, started to compose the board of flight crew members, as a co-pilot.

His performance at the Ground School” and at the Simulator was considered to be “very good”.

He had already participated in 1 (one) complete initial training at the Boeing 737-700/800 simulator, and 1 (one) initial training of the differences at the simulator of the Boeing 737-300, an airplane also utilized by the operator.

The SIC had started his flight crew member career in the operator, as a co-pilot of the Boeing 737-700/800. On this type of equipment, he flew 1,978 hours prior to being selected to fly the Boeing 737-300.

After the selection and training of the differences, the SIC flew 1,103 hours and 14 minutes on a Boeing 737-300. His being chosen to fly the Boeing 737-300 was on account of his distinguished quality among his peers. He was very studious and dedicated to the company, where he was considered a good aviator.

Upon completion of his participation in the board of Boeing 737-300 crew members, he was assigned by the Directorship of Operations to resume his activity as a co-pilot of the Boeing 737-700/800.

This was the reason why the PIC was training the SIC.

It was a re-qualification instruction for the co-pilot, concerning the Boeing 737-700/800 equipment.

The analysis of the SIC was the same applied to the PIC, except for minor differences on account of the functional distinction.

Besides interviews with captains and co-pilots, other ones were made with his superiors of a Directorship level, in order to obtain as much information as possible about the co-pilot of the PR-GTD.

Concomitantly, the Operational Formation Sheets, the Flight Simulator Sheets, the Ground School Sheets, and all the available data on recurrent trainings were analyzed, together with the records of the co-pilot in the archives of the operator.

As was the case with the captain, there were only commendations and other remarks highlighting his operational performance.

The CIAA analyzed the training performance of the SIC concerning the operation of the Communication, Navigation, Avionics, TCAS, Transponder systems, as well as his performance in the CRM, SOP, Checklist, General Flight Planning and Flight in RVSM Airspace.

Another point detailed in this analysis was the SIC's performance in the specific trainings at the Simulator, such as: CRM (practice), LOFT, utilization of the Transponder, utilization of the TCAS, evasive maneuvers (TA, RA, TA Only, TA/RA) and Recovery from Abnormal Attitudes (Upset recovery).

The SIC accomplished all the phases required for a co-pilot in operational ascent to become a captain of the operator.

As a result of this analysis, we can affirm that the SIC of the PR-GTD was adequately trained and prepared at a proficiency level, to aid the pilot to conduct the flight in question up to its destination, even though he was being re-qualified, as he possessed 1,978 hours of flight on that model.

Up to the moment of the collision, the co-pilot correctly complied with all the procedures established, in accordance with the norms, manuals and air traffic rules.

### 3.13.2.2.2. Requirements for the admission of pilots by the *GOL Transportes Aéreos S/A*.

The analysis of the admission processes of the PIC and SIC of the GLO 1907 flight revealed that the two pilots had undergone a strict selection process.

The PIC had been selected at the very beginning of the operator activities. He possessed vast experience in command, which had been obtained in an extinct big Brazilian company that operated under the rules of the RBHA 121. This was an important criterion adopted by the Directorship of the Gol company: as the company was new in the market, it opted for hiring experienced captains as an initial driving force.

The SIC had been hired more recently, but according to equally strict criteria, as there was a big number of candidates for the position of co-pilot of the Boeing equipment of the GOL company.

They complied with all the phases established after the admission until coming to the simulator, before the en-route instruction flight.

### 3.13.2.2.3 Knowledge and preparedness prescribed for the conduction of the flight

During the investigation, all the available consultation sources were researched, as well as the documents and instructions provided to the pilots of the GOL Company, with focus on the type of operations conducted, and the following data were selected, on account of their relevance for the investigative process:

- The PIC and SIC of the GLO 1907 flight were the flight crew of the number 304 airplane, Serial Number 34653 and Tabulation Number YK724, which was included in the Brazilian Aircraft Registration (RAB) as PR-GTD. This information is important because it was through these numbers that the airplane was inserted in the data processing system of the operator.
- The PR-GTD was a Boeing 737-800 Next Generation – Short Field Performance (SFP), and was doing a passenger transport domestic flight, in accordance with the RBHA 121. for this reason, the aircraft was being conducted by a simple crew, that is, 1 (one) captain, 1 (one) co-pilot, 1 (one) cabin purser, 3 (three) flight attendants, under the RBHA 121.391.

The Brazilian legislation determines the following limits for the working journey:

- Flight hours limit: 09hours 30min;
- Number of Landings limit: 05 landings;
- Working journey: 11hours.

All the crewmembers of the GLO 1907 flight were operating the PR-GTD airplane in accordance with the regulation in force in Brazil.



### **3.13.2.3. Pilots of the N600XL airplane**

#### **3.13.2.3.1. Qualifications**

Both pilots had technical qualification as Airline Transport Pilots (ATP), complying with the general determinations set in Subpart A – General, as well as the specific determinations set in Subpart G of the 14 CFR Part 61, specifically in what refers to sections §61.151, 61.153, 61.155, 61.157, 61.158, 61.159, 61.165, 61.167, 61.169, 61.171 [Reserved].

The 14 CFR Part 61 – “Certification: pilots, Flight Instructors, and Ground Instructors” which holds similarity to the RBHA 61 – “REQUISITOS PARA A CONCESSÃO DE LICENÇAS DE PILOTOS E INSTRUTORES DE VÔO”, is a legislation applicable in both countries, regulating the Certifications and Qualifications prescribed in the aeronautical legislation.

Similarly to what happens in Brazil, both pilots passed through a process of operational progress in their career of aviators.

So, in their country, they earned the following certificates: Student Pilot; Private Pilot; Commercial Pilot; Airline Transport Pilot.

The SIC also possesses the Flight Instructor Certificate.

The pilots, both of them qualified for the function of PIC, were hired by a company ruled by the 14 CFR Part 135, and had their competencies verified under the aegis of the sections § 135.293 and § 135.297, in accordance with section § 91.1065 and § 91.1069 of the 14 CFR Part 91, which regulates the training and verification flights.

The N600XL flight crew met the aeronautical experience requirements set in the Section § 61.159 “Aeronautical Experience: Airplane category rating”, also verified by the FlightSafety International (FSI-Houston-TX) where the Class D simulator training was conducted, in accordance to the prescription of the 14 CFR Part 142 – “Training Centers”.

It is worth pointing out that Section § 135.293 “Initial and recurrent pilot testing requirements” emphasizes the pilots’ knowledge of the aircraft systems (NAV and COMM), standard operational procedures (SCANFLOW, for instance), performance and limitations (weight & balance, for example), and en-route operation.

In another item of Section § 135.293, the FAA determines that the pilots have knowledge of the navigation and of the appropriate nav aids for the operation, including the instrument approach facilities and respective procedures and all that refers to the Air Traffic Control Procedures, IFR procedures included.

Also important in this section, is the determination by the FAA demanding the pilots to have appropriate knowledge of new equipment, procedures and techniques. The assertion “appropriate knowledge” which is cited in the American legislation means a proficient level, since the pilots are ATP.

It is worth remarking that Section § 135.293 is strengthened by Section § 135.297 “Pilot in command: Instrument proficiency check requirements”, which details what will be required from PICs at the IFR inspection flights: navigation by means of instruments, simulated emergency recoveries, etc.

### PILOT-IN-COMMAND (PIC)

The PIC assigned to the mission by the Directorship of the operator of the N600XL was considered an experienced, conscientious, conservative, well standardized, punctual, dependable, highly qualified captain, according to the Company Chief-Pilot (CCP) and the Chief Operating Officer (COO).

However, his experience in the installed avionics of the EMB-135BJ Legacy airplane was restricted to the hours spent in the simulator, plus the 5 hours and 35 minutes of flight time prior to the accident.

According to the CCP, the PIC had learned to fly with the "old instruments".

The PIC believed that the adaptation to the positioning of the buttons of another aircraft was a challenge to be overcome with study. Thus, he would place a photo of the aircraft panel in the cockpit so that he could study the lay-out of the differences.

The PIC had been requested by a client of the operator to be the captain of the EMB-135BJ Legacy and, then, as a result of this request, the PIC was sent to be trained in the Legacy.

The PIC obtained international experience, flying as a co-pilot and captain for the operator. He had made international trips, including trips to the Caribbean, Canada and Europe.

Along his career, he had gone through two abnormal situations while working for Excelaire: a failure of the steering system of a Gulfstream-III aircraft model and a windshield cracking on a Gulfstream-II. He managed well in both situations.

The training and the check ride for the new airplane were done at the FSI, Houston, Texas, in the period from 9 to 30 August 2006.

The qualifications of the PIC and the SIC were the same, except for Section §61.157 (Type Rating), since the PIC had never flown EMBRAER aircraft before (unlike the SIC).

The PIC was trained and evaluated for the PIC and SIC functions.

### SECOND-IN-COMMAND (SIC)

The SIC had been recently hired by the operator (25 July 2006). The flight of 29 September 2006 was officially his first flight as an effective pilot of the operator.

The SIC had the task of assisting in the planning of the ferry flight between São José dos Campos – SP (SBSJ) and Fort Lauderdale – FL (KFL) while getting updated with the international operation, ICAO rules, differences between the ICAO and FAA rules, operation of the aircraft systems, Flight in South America, simulated LFT flight in the rooms of the operator, etc.

At the American Airlines (AA), he had flown Boeing 727, as Flight Engineer and also as First Officer. He was trained to be a captain of the EMB-145 by the American Eagle Airlines.

He flew 51 hours as co-pilot of the EMB-145, and 317 hours as Captain, with a total of 368 hours in the EMB-145.

Although he was already certified in the EMB-145, the company decided to send him to the FSI, Houston, Texas, for a complete training program.

Although having never flown to Brazil before, the SIC had already flown as a Flight Engineer for the American Airlines (AA), to Colombia and Venezuela, in South America; to Nicaragua and EL Salvador in Central America; Aruba, Cayman Islands and the Dominican Republic in the Caribbean.

While working for the American Airlines, the SIC had received training on International Procedures.

He had graduated in Aeronautical Sciences at the "Embry-Riddle Aeronautical University (ERAU)", one of the most distinguished American universities in this area. It was at ERAU that he had contact with the subject of Flight Safety.

The SIC has a solid pedagogical formation, by means of a syllabus recognized in his country and abroad, since ERAU is an establishment renowned worldwide in the education of human resources concerning the airspace area.

He had accumulated a total of more than 6,400 flight hours on various different aircraft. He had more than 1,405 flight hours as flight instructor of basic and advanced aircraft, besides teaching IFR Flight, including jet aircraft IFR flight.

He flew several different jet aircraft, for almost 5 years as a co-pilot for the American Airlines, where he operated MD-82 and MD-83 aircraft.

His flights were between the USA and Canada (an ICAO Contracting State). As a co-pilot for the American Airlines, he flew under the aegis of the 14 CFR Part 121, a fact that gave him a higher level of aeronautical knowledge. The 14 CFR Part 121 is a lot more complex than the others and, undoubtedly, has a much higher level of operational requirements, when compared with the 14 CFR Part 91 and Part 135.

The SIC had flown as a captain of the EMB-135, EMB-140 and EMB-145, from January 2005 to July 2006, that is, a year and five months. He had no experience on the EMB-135 BJ Legacy, though.

The training and the check ride were done at the FSI, Houston, Texas, in the period from 9 to 30 August 2006.

The qualifications of the SIC were different from those of the PIC, because the former was already operational in the aircraft.

So, the SIC complied with the prescriptions of Sections §135.293a (2), §135.293a(3), §135.293b and §135.297, in addition to Section §135.247(a)(3)(ii)(D) relative to the 14 CFR Part 135.

The SIC was trained and evaluated for both the PIC and SIC functions.

The PIC and SIC were considered apt to operate the new Excelaire N600XL airplane, since they were considered by the company as being trained in their technical and operational competencies, as well as being evaluated by the competent authorities.

### **3.13.2.3.2. Conditions for admission of pilots by Excelaire**

According to data collected by the NTSB, the selection of pilots of the operator is always made with the participation of the Director of Operations, the Chief of the Pilots and the Chief Operations Manager.

The decision to hire is corporate, and the admission of pilots occurs with the unanimity of the members, in that, if one of them can not be present, the candidate will be judged on a subsequent date.

There is not a simulator check ride during the hiring process.

All candidates' documentation is verified to guarantee its legitimacy. If the candidate comes from another company, a Letter of Recommendation is required.

For the admission of Pilots, the operator considers not only the technical qualifications, but also the candidates' social behavior characteristics, in view of the company's clients.

In relation to the process of selection of the N600XL pilots involved in the accident, the operator made a verification of their background during the pre-hiring period.

Neither pilot had a history of accidents or incidents in the curriculum.

This kind of research is made by means of an interesting legal tool known as PRIA, or "*Pilot Records Improvement Act, of 1996*", a Law that allows the American aviation employer to access the antecedents of a prospective worker of the aviation field.

It was promulgated by the USA Congress on 3 October 1996, and made public on 6 February 1997.

The database of the pilots comes from the FAA, which, with the legal support of this Law, is authorized to provide, in response to a formal petition from the contracting company, all the individual data on a candidate, mainly the legal, technical and operational aspects of each one.

The pilots were experienced, certified as ATP, possessed a significant number of flight hours, were in good health and had prestige in the company, had already flown other high performance aircraft and were motivated.

### **3.13.2.3.3. Training at Excelaire**

One of the most important involvements of the Excelaire Director of Operations has to do with the Training Centers, which are ruled by the 14 CFR Part 142 - (*Training Centers*).

The Director of Operations manages the compliance with a full service-provision contract, which includes recurrent periodic training, complementary training, *Crew Resource Management (CRM)*, International Operation, and other types of training.

For that purpose, the operator selected the following training centers: SimuFlight, Bombardier or Flight Safety International, due to the diversity of equipment types.

The training of International Operations was provided by SimuFlight.

The policy adopted by the operator, according to the investigation, is to not assign two inexperienced pilots together to conduct international flights in any international trip, even for Europe.

The "Basic Doctrine" is taught by the Director of Operations, the Safety Manager and the CCP.

The operator affirmed that all its captains have international experience, either at the FSI-Houston-TX, at the Simuflight training, or on account of previous experience in other airline companies.

Originally, all the training of the operator was conducted by the FSI.

Then, it migrated to SimuFlight, as it was more advantageous economically.

In the case of the Legacy airplane, the institution responsible for the training was the FSI of Houston, Texas, because this training was included in the aircraft purchase contract. The Legacy training package was part of a contract between Embraer and FSI.

The SIC, although being certified in the EMB-145 model by the American Eagle Airlines, did the complete training, prescribed by the FSI for the EMB-145 and EMB-135BJ, due to a decision of the Company Director of Operations.

As already mentioned, the flight in question was defined as a ferry flight, in which the rules follow the 14 CFR Part 91, which is less restrictive in relation to the number of hours to be required for the crew. This allowed the crew operate the airplane hardly having any experience together as a crew, as they had just participated in 5 (five) short duration flights, in which they took turns to compose a crew with a manufacturer's pilot.

On account of the FSI refusal to receive the CIAA at its unit in Houston, Texas, there were significant difficulties in the progress of the research. However, through analogy, there is an internal administrative protocol of the Training Centers (more rigorous and controlled after the events of 11 September 2001), in which the purpose of the training is better explained, allowing for a monitoring of the training objectives by the Training Management and, especially, by the Principal Operations Inspector (POI) assigned by the FAA to that Center, mainly in relation to the operational issues (simulator training, syllabus and pilots being trained).

The operator, through its Director of Operations, as well as the FSI, regulated by the 14 CFR Part 142 (Training Centers), had operational tools to be used in the training of the PIC and the SIC, which could have enhanced the learning process of both pilots.

An example would be the training known as Line-Oriented Flight Training – LOFT - for the Class D simulator.

Considering the immediate demand situation of the operator, the Directorship of Operations could provide a LOFT session focused on the proficiency at the ICAO rules.

The operator demonstrated not to have any restrictions concerning investments in the training of its pilots.

At the various simulators of the aircraft that compose the fleet of the company, Excelaire always guaranteed all the training lessons prescribed for the operational formation of its PICs, and the operational formation and periodical trainings of its SICs.

The Excelaire Directorship was aware of the little experience of the N600XL crew in the new airplane, as well as of the fact that they had never flown together as part of the same crew.

The Excelaire Directorship of Operations underestimated the degree of difficulty of the flight to be conducted by its pilots, and should have treated the mission as a non-routine operation, since it was a sequence of acceptance flights, followed by the ferry flight of a newly purchased complex airplane, after the delivery by the manufacturer.

In this respect, the Section 91.711 of the RBHA 91 places the ferry flights to a new country of registration in the "SPECIAL RULES FOR FOREIGN CIVIL AIRCRAFT". Therefore, these flights can never be thought of as routine.

On the flight of 29 September 2006, evidence was found of inadequate procedures in the operation of the aircraft systems, in the application of the CRM concepts and in the International Operation.

The PIC and the SIC flew together as a crew for the first time, in the simulators of the FSI-Houston-TX.

Both in the USA, where they conducted the aircraft demonstration flight, and in Brazil, when they participated in 3 acceptance flights, the PIC and the SIC participated individually as crewmembers with a pilot of the manufacturer, and thus did not have the opportunity of getting experience working together before the accident flight.

Elementary doubts, such as the fuel system performance, were still being tackled during the flight of 29 September 2006, at the cruising phase, as well as the planning for the next leg, all in detriment of the flight management by the PIC and the SIC.

#### **3.13.2.3.4 Knowledge and preparedness for the conduction of the flight**

On account of the legal processes in progress in Brazil, the Excelaire attorneys instructed all the company's employees to not give any interviews directly to the Brazilian investigation commission, and only give clarifications to the NTSB, which would then pass the interviews to the CIAA.

The NTSB report mentions a Company Chief Pilot of the operator, although this function is not shown in the Manual of Operations (Air Carrier Operations Manual) of the company. The aforementioned manual shows the function of Chief-Pilot. According to the Excelaire Manual of Operations, at the final note of page 5, Chapter 4, the Chief-Pilot may take over the tasks of the Director of Operations, in case of temporary absence.

As the CCP is the supervisor of the Excelaire flight crews, on account of his responsibility, he should have advised the Director of Operations on the real technical and operational condition of the pilots, before they started the mission.

Here, it is important to highlight the direct role of the ASI designated by the FAA to exercise his authority at the Excelaire Company.

First, it is necessary, in general terms, to understand how the FAA works in relation to the airline companies, such as, specifically, Excelaire.

Excelaire is monitored by the USA Federal Aviation Administration, by means of the Aviation Safety Inspectors (ASI).

These FAA Inspectors develop, administer, investigate and verify the compliance with the safety regulations and with the standards for the production, operation, maintenance and modification of every aircraft which flies in the USA.

There are many different types of ASI. The four key-disciplines are:

- 1) Avionics;
- 2) Maintenance;
- 3) Production; and
- 4) Operations.

Our investigation focused on the key-discipline of OPERATIONS.

The research that was made in the legislation of the USA indicated that the “Aviation Safety Inspector - Operations” responsible for the Excelsior Operations Directorship has the duty of evaluating the pilots, their Training Programs, the equipment (aircraft) and installations.

Besides, the Aviation Safety Inspector – Operations investigates violations, incidents and accidents related to the 14 CFR, in the segment of the General Aviation and Public Air Transport, according to the investigation protocols established by law.

The CIAA researched the available documents of the American legislation, relative to the operational condition of both N600XL pilots, in order to ratify the line of investigation adopted.

This is being reported, because it involves the actions of the ASI of the FAA designated to audit Excelsior, after the moment the Director of Operations and the General Directorship of Excelsior communicated that a new type of a high performance aircraft would be incorporated to the fleet of the company.

The CIAA also conducted a specific research of the various AC’s, or, Advisory Circulars, published by the FAA and available in the Internet, whose compliance, sometimes compulsory, would have brought the desired effects for the prevention of the accident.

Our research of the AC’s starts with the “AC 120-54A – Advanced Qualification Program (AQP)”, dated 09 August 1991.

In its purpose, it is pointed out that the goal of the AQP is to reach the highest possible standard of performance of the individual crew member and the crew as a team, and its main objective is to provide an effective training to raise the professional qualifications to a level higher than the current standards established in the 14 CFR Part 121 and Part 135.

The AQP aims at reducing the probability of errors associated with the crew, by aligning the training and the evaluation requirements as close as possible to the known causes of human error.

As a tool of the CRM, in the AQP appears the Line Operational Simulation (LOS), which is a training session in the simulator, or “*Flight Training Device (FTD)*”, to be conducted in an airline environment, better known as Line Oriented Flight Training (LOFT), which is conducted with the use of flight crewmembers.

It is worth pointing out that the application of the Advanced Qualification Program (AQP) is on a volunteer basis, and the FAA-Flight Standards Service has encouraged the airline companies to participate in the Program.

There were not any records of the participation of Excelsior in the AQP Program. And it is important to consider that the training offered by the FSI-Houston-TX focused the EMB-145 airplane, with application of the training of the differences for the EMB-135BJ Legacy 600.

In the AC 120-51E – Crew Resource Management (CRM) Training, the CRM was conceived to prevent aeronautical accidents, by means of the improvement of the crew performance, and a better coordination between the crewmembers.

According to the FAA, the CRM training focuses on the situational alert, communication skills, teamwork, task distribution, and decision making, within a comprehensive structure of operational standards.

This AC correlates the success in the achievement of the objective directly with the actions of the management responsible for its application. In order to reach the CRM objective, the involvement of the highest levels of the company corporate management is essential.

This document states that the effective CRM starts at the initial training and gets consolidated in the Periodic Training which depends directly on the performance of the Directorships of Operations of the companies.

The analysis of the NTSB Field Notes provided by the NTSB to the CIAA points toward a company engaged in the application of the administrative management concerned with Flight Safety, as well as in the correct compliance with all the demands set up and recommended by the FAA and NTSB. However, the preparedness and the experience demonstrated by the pilots in the conduction of the flight indicated a low level of communications between the crew members and the high management staff (the General Directorship, the Operations Directorship).

The AC 120-51E still has other important points, as follows:

- LOFT sessions provide extremely effective means regarding the practice and reinforcement of the CRM skills.
- A CRM training is more effective within a training program based on Standard Operational Procedures (SOP).

In paragraph 16 of the AC 120-51E, the pilots are instructed to perform the monitoring of the flight, by means of the Cross Check. The critical role of the Pilot-not-Flying (PNF) as a monitor of the Pilot-Flying (PF) is emphasized.

In the accident, the SIC was performing the function of PNF, monitoring the flight of the PIC.

Such practice had a positive effect on flight safety, because it made the crewmembers work closer to each other, simply by placing the co-pilot in the loop of the cockpit management, as the expression PNF was conducive to the co-pilot getting away from the responsibilities of conducting the aircraft.

In the case of the N600XL, the SIC was a lot more experienced when compared to the PIC, and had accumulated 368 flight hours in EMB-145 aircraft.

The two pilots explained to the CIAA that when they passed over the BRS VOR they noticed the heading change, although not expressing verbally this perception to each other.

They explained that although the flight level was not compatible with the new heading to be flown after passing the BRS VOR, it was not considered by them a situation that had to be verified, since they were complying with the last clearance, whose content had not been modified by the controller.

No dialog between the crewmembers was recorded in the CVR that could indicate that the flight was being monitored by any of them.



Although the “AC 120-51E - Crew Resource Management (CRM) Training” provides guidance to crewmembers to exercise teamwork, employing the “Crew Monitoring and Cross-Checking” during the flight, the need of crew interaction is better detailed in the “AC 120-71A, Standard Operating Procedures (SOP) for Flightdeck Crewmembers” published on 27 February 2003.

After analyzing the AC 120-71A, we have listed below some of the data we considered relevant for the understanding of the accident in question:

- The SOP are universally recognized as standard procedures which are basic for the safety of air operations;
- The 2 (two) core CRM concepts (effective coordination between crewmembers and effective crew performance) depend on the crew sharing the same mental model regarding their tasks;
- As for the mental model, it is found in the SOP's, which have to be clear, easily comprehensible and available for being read;
- In the AC 120-71A, two significant changes appear: the replacement of the term PNF (Pilot-not-Flying) with the term PM (Pilot Monitoring), as well as the Appendix “**Crew Monitoring and Cross-Checking**”.
- The ICAO, also, has recognized the SOP importance for the safety of air operations. Recent addenda to ICAO Annex 6 establish that each State has to require that the SOP's concerning each phase of the flight, are duly contained in the Manuals used by the Pilots.
- The objective of an SOP is to ensure safety in the air operations, through the adherence to the prescriptions established in each of these SOP's.
- The FAA has issued a Note on the Appendices published in the AC, allowing for flexibility in the way of publishing the SOP's.

In Appendix 1 – “Standard Operating Procedures Template” we can read:

**Use of automation:**

- *Monitoring of automated systems and Flight Mode Annunciator (FMA);*
- *Cross checking of FMS routing with ATC clearance during preflight.*

**Communications:**

- *Primary language used;*
- *ATC;*
- *Keeping both pilots “in the loop”.*

**Flight deck discipline:**

- *PF/PM duties and responsibilities;*
- *Sterile cockpit;*
- *Maintaining outside vigilance;*
- *Monitoring/cross-checking.*

**Flight plans/dispatch procedures/takeoff and landing calculations:**

- *VFR/IFR;*
- *Fuel loads.*

**Crew Resource Management (CRM):**

- Crew briefings;
- Flightcrew;
- Weight & balance/cargo loading;
- Who is responsible for loading cargo, and securing cargo;
- Who prepares the weight & balance data form; who checks it;
- Copy to crew.

**Flight deck/cabin crew interchange:**

- Boarding;
- Ready to taxi;
- Cabin emergency;
- Prior to take-off/landing.

**Take-off:**

- PF/PM duties and responsibilities;
- Who conducts it;
- Briefing, IFR/VFR;

**Cruise altitude selection:**

- Position reports/pilot weather reports (PIREPs);
- ATC – including PIREPs of hazards such as icing, thunderstorms, and turbulence Company.

**Emergency descents.****TCAS.**

In Appendix 3 (examples) - "ATC COMMUNICATIONS and ALTITUDE AWARENESS" we can read:

**ATC Communications:**

SOPs should state who (PF, PM, FE/SO) handles the radios for each phase of flight, as follows:

- PF makes input to aircraft/autopilot and/or verbally states clearances while PM confirms input is what he/she read back to ATC.
- Any confusion in the flight deck is immediately cleared up by requesting ATC confirmation.
- If any crewmember is off the flight deck, all ATC instructions are briefed upon his/her return. Or if any crewmember is off the flight deck all ATC instructions are written down until his/her return and then passed to that crewmember upon return. Similarly, if a crewmember is off ATC frequency (e.g., when making a PA announcement or when talking on company frequency), all ATC instructions are briefed upon his/her return.

**Altitude Awareness:**

SOPs should state the company policy on confirming assigned altitude.

Example: The PM acknowledges ATC altitude clearance.

*If the aircraft is on the autopilot then the PF makes input into the autopilot/altitude alerter. PF points to the input while stating the assigned altitude as he/she understands it. The PM then points to the input stating aloud what he/she understands the ATC clearance to be confirming that the input and clearance match.*

*If the aircraft is being hand-flown then the PM makes the input into the Altitude Alerter/autopilot, then points to the input and states clearance. PF then points to the alerter stating aloud what he/she understands the ATC clearance to be confirming that the alerter and clearance match.*

*Example: If there is no altitude alerter in the aircraft then both pilots write down the clearance, confirm that they have the same altitude, and then cross off the previously assigned altitude.*

In Appendix 19 (examples) - "Crew Monitoring and Cross-Checking" we can read:

*Monitoring during high workload periods is important since these periods present situations in rapid flux and because high workload increases vulnerability to error. However, studies show that poor monitoring performance can be present during low workload periods, as well. Lapses in monitoring performance during lower workload periods is often associated with boredom and/or complacency.*

*Crew monitoring performance can be significantly improved by developing and implementing effective SOPs to support monitoring and cross-checking functions, by training crews on monitoring strategies, and by pilots following those SOPs and strategies.*

Considering, according to declarations, that the N600XL pilots did not perceive that the transponder had stopped transmitting and that, as a result, the TCAS was inoperative, it is possible to affirm that the focusing of the pilots' attention on planning factors during the flight resulted in a degradation of the flight monitoring strategies (poor monitoring), which became inadequate.

*A fundamental concept of improving monitoring is realizing that many crew errors occur when one or more pilots are off-frequency or doing heads-down work, such as programming a Flight Management System (FMS). The example SOPs below are designed to optimize monitoring by ensuring that both pilots are "in the loop" and attentive during those flight phases where weaknesses in monitoring can have significant safety implications.*

Coincidentally, the text above has a correlation with the situation encountered by the N600XL crew, which allowed themselves to remain distracted and work while keeping their heads down for a long time. The difference was that, instead of programming the Flight Management System, according to their own declarations and the CVR data, they were handling a laptop, that is, in the end the effect was exactly the same.

*In addition to modifying existing SOPs, operators may consider adding sections to the SOP manual to ensure that monitoring is emphasized, such as:*

*High-level SOPs that send an over-arching message that monitoring is a very important part of cockpit duties.*

*Examples:*

*A. Change title of "Pilot Not Flying" (PNF) to "Pilot Monitoring" (PM).*

*B. The SOP document could explicitly state that monitoring is a primary responsibility of each crewmember.*

Example:

### **Monitoring Responsibility**

*The PF will monitor/control the aircraft, regardless of the level of automation employed.*

*The PM will monitor the aircraft and actions of the PF.*

This citation demonstrates the importance of the flight monitoring task, as well as the distribution of the responsibilities between the PF and PM, focused on the maintenance of the "in the loop" concept in relation to their tasks, with a continuous monitoring of the whole Pilot operational environment, independently of the level of automation of the aircraft.

**"SOPs to support improved monitoring during vertical segments of flight** (also refer to Appendix 3 of this document, "ATC Communications and Altitude Awareness")"

Examples:

- *D. Many altitude deviations occur because pilots are not properly monitoring the level off. This SOP statement is to ensure that pilots concentrate on ensuring the aircraft levels at the proper altitude, instead of being distracted by or performing non-monitoring tasks.*

The flight proposed established different vertical segments for the whole route, but the clearance that the pilots received gave them the understanding that they had to fly the entire route at flight level FL370.

Although the pilots did not disregard any instruction relative to the maintenance of the levels prescribed, they got involved in activities other than flight monitoring, a fact that indicates a direct connection with the content of the AC relative to the SOP.

Additionally, the sub item A says that:

*A. Before flight, the routing listed on the flight release must be cross-checked against the ATC clearance and the FMS routing.*

The task of inserting the route of the flight had to be performed with both pilots seated on their seats in the cockpit of the N600XL airplane, but this did not occur. As described later on in this report, the PIC proceeded to the aircraft and did not participate in the delivery celebration dinner. The SIC, on the other hand, attended the dinner and later went to the delivery room in order to continue his familiarization with the performance calculations, while waiting for the FPL. This resulted in a separation of the crew at a crucial moment, without an adequate distribution of tasks. The initial operation of the FMS was conducted by the PIC (less experienced in the Legacy aircraft), without the presence of the SIC, who was more experienced in the aircraft made by Embraer.

In the case in question, the insertion in the FMS of the flight data contained in the FPL produced by the UNIVERSAL, if performed by the crew as a team, would have increased the situational awareness of the N600XL pilots relative to the required level changes, especially due to the fact that there were two planned level changes (FL 360 and FL 380). This could have worked as an additional defense.

The SIC remained loading his laptop with a program for weight and balance up to the last moment before the flight, in detriment of a preparation for the flight that should have been more carefully planned and detailed.

In the AC 90-48C "*Pilots' Role in Collision Avoidance*", published on 5 August 1980, the FAA shows its concern with the theme "Mid-air collision" (MAC) and "Near mid-air collision" (NMAC), on account of the statistics relative to these types of occurrences.

Its purpose is to alert all pilots in relation to potential hazards and to highlight the basic problems related to the human factor, where improvements in areas such as pilot formation and education, operational practices, procedures, as well as in the techniques of verification and surveillance are necessary for the reduction of the conflicts related to in-flight collision.

The FAA considers the "SEE AND AVOID" concept, which means that a continuous watch is to be maintained during all the flight time by each person operating an aircraft, no matter whether the operation is conducted under VFR or IFR rules. This would be applicable by both the N600XL and PR-GTD crews.

The AC 90-48C is a document that warns the pilots that they have to bear in mind their responsibility in maintaining a continued vigilance of the airspace outside the aircraft

The "International Operations" Training is given in one day, as an initial training, and in half a day, when it is a recurrent periodic training.

In this respect, the directorship of the operator possibly considered that all the experience earned by the newly hired SIC would be sufficient to compensate for the natural operational limitations of the other pilot who was assigned to be the PIC, the captain of the flight of the 29 September 2006.

The Excelsior Directorship and, especially, the Operations Directorship, did not have time for an adequate evaluation of whether the crew designated for the mission met the adequate technical/operational requirements for a safe conduction of the whole operation.

In relation to the knowledge and preparedness required for the conduction of an international flight, the CIIA considered that there were the following defenses for the prevention of the accident in question:

- The pilots themselves – because, by means of a self-evaluation, they could have learned that they had not reached an adequate level of proficiency for the conduction of the mission, mainly in relation to the management of the Legacy operational systems;
- The Directorship of the operator, in the process of Aeronautical Decision Making (ADM) - mainly because the Safety Manager and the Company Chief Pilot were directly linked to this Directorship, acting as direct advisors of the Director of Operations.
- The FSI-Houston-TX, which was the provider of all the training done by the PIC and the SIC on its premises;
- The ASI designated by the FAA for the Excelsior company; and
- The ASI designated by the FAA for the FSI-Houston-TX

For all the above mentioned, there were tools within their reach that could have been used as effective preventative barriers for Flight Safety.

### **3.13.3 THE AIRPLANES**

#### **3.13.3.1. The PR-GTD airplane**

The CIAA investigated the team responsible for the Operational Dispatch of the GLO1907 flight of 29 September 2006. They declared that the airplane had been dispatched with all its systems, components, parts and fuselage without any non-conformity.

Considering that the criteria for the flights within RVSM airspace area rather restrictive and that the Repetitive Flight Plan (RPL) of the GLO1907 initially programmed the execution of the leg at FL410, that is, an RVSM flight, the airplane was dispatched with its communication and navigation equipment in fully operational conditions, including the Transponder and the TCAS equipment.

#### **3.13.3.2. The N600XL airplane**

Before receiving its definitive American registration (Nationality and Registration Marking), in accordance with the prescriptions of the 14 CFR Part 45 – “Identification and Registration Marking”, the N600XL flew at Embraer with a “Provisional Airworthiness Certificate”, under the registration PT-SFN, according to what is prescribed by the Brazilian legislation.

The first employees of the operator that had contact with the aircraft were the pilots selected for the mission of monitoring the finalization of the airplane, conducting its acceptance flights, formally receiving the airplane from the hands of the manufacturer and, lastly, conducting the ferry flight, carrying the passengers invited by Excelaire, from São José dos Campos – SP to Fort Lauderdale – FL, USA, with a technical stop and overnight at Manaus – AM, still in the Brazilian territory.

The Director of Maintenance of the operator arrived in Brazil one day after the pilots, to receive the N600XL airplane on behalf of the president of the company.

The phase of final adjustments of the airplane, before the formalization of its delivery, was monitored by the N600XL crew in operational and logistic terms, and by the Director of Maintenance, who was in charge of the maintenance and administrative aspects. They had free access to Embraer during the period that preceded the final departure on 29 September 2006.

The acceptance flight is part of the protocol, and is conducted by crew members certified and qualified in the model. They verify whether the airplane and all its systems and subsystems are properly functioning.

The flight is conducted according pre-established standards. Safety during the flight is highly valued, and there is an aim at preserving the guaranty after delivery.

In the delivery phase, there is a sequence of checks, established by Embraer and approved in advance by the client. At these checks, there is a verification of the airplane both on the ground and in flight, with an analysis of the aircraft sections, parts, instruments, systems and subsystems, as well as their integrations. The monitoring by the client-buyer or by his/her agent is a *sine qua non* condition for the execution of the task.

There is not a limit for the number of acceptance flights. They are conducted until the client approves the functionality of the aircraft as a whole.

Up to 28 September 2006 (Thursday), the day before the accident, the N600XL had flown 16 (sixteen) hours and 33 (thirty-three) minutes, according to data collected at the "Export Airworthiness Certificate" number 2006E09-16.

This certificate defines the EMB-135BJ, SN 14500965 airplane as "New".

In the Logbook number 001/PT-SFN/2006 pertaining to the aircraft, there are not any records of failures that might have been found during the acceptance flights.

The only occurrence found in the Logbook refers to the weather radar of the aircraft, a problem that was soon corrected by Embraer still in the phase of delivery.

On 25 September 2006, Embraer drew up the Opening Term of the second Logbook of the PT-SFN (N600XL), number 002/PT-SFN/2006, and, according to the Brazilian legislation in force, still with the provisional Brazilian registration PT-SFN.

The second Logbook was closed on 27 September 2006 (Wednesday) and, in its records, nothing of relevance can be found relative to the delivery flights, suggestive of a malfunctioning of the aircraft and its systems, having as a last remark the acceptance of the aircraft: "ACFT ACCEPTED BY THE CLIENT."

The Quality Control of Embraer monitored, verified and approved all the phases established for the production of the aircraft number 14500965 which, on 29 September 2006, received the registration N600XL.

No records of malfunctioning relative to the airplane, including its avionics, navigation and communication equipment, were found in the Production Flights and, later, in the Acceptance Flights.

There was no indication that any component of the aircraft systems had been delivered to the operator by the manufacturer, in discordance with the airworthiness criteria.

The document "Certificate of Acceptance and Transfer of Title and Risks" was signed by the Excelaire Director of Maintenance, assuming the formal receipt of the aircraft on behalf of the Excelaire company, following the confirmation of the continued airworthiness of the N600XL, as non-conformities were not found.

In the content of the aforementioned document, the following statement is found:

*"After the aircraft has been inspected and found in good operating conditions, in accordance with the specified documentation."*

The Director of Maintenance, the Excelaire official responsible for the airworthiness of the entire company fleet, received from the FAA the document "FAA FORM 8100-2 – STANDARD AIRWORTHINESS CERTIFICATE, NO AIR-230", which represents the "Airworthiness Certificate" of the N600XL airplane.

The document of 29 September 2006, accepts the airplane as airworthy by the standards of the USA, in compliance with the requirements established in the 14 CFR Part 21, Part 43 and Part 91.

In complement to the information mentioned above, during the process of investigation of the occurrence, no records were found of any malfunctioning of the RMU/Transponder/TCAS/NAV/COMM set, relative to the flight period of 29 September 2006.

It is necessary to emphasize that the airplane, during the first part of the flight, flew across the TMA-SP, one of the busiest terminal areas in South America, showing only

normal indications, whether in relation to the return of the transponder signal, or in relation to the navigation and two-way communication.

### 3.13.3.2.1 Description of the Operation of the N600XL Transponder / TCAS

The *Transponder / TCAS* system of the Legacy is operated through two Radio Management Units (RMU), both located on the frontal instrument panel in the cockpit.



Fig 25

One RMU is located on the captain's side (left) and the other on the first officer side (right), as indicated by the red circles on the figure below.

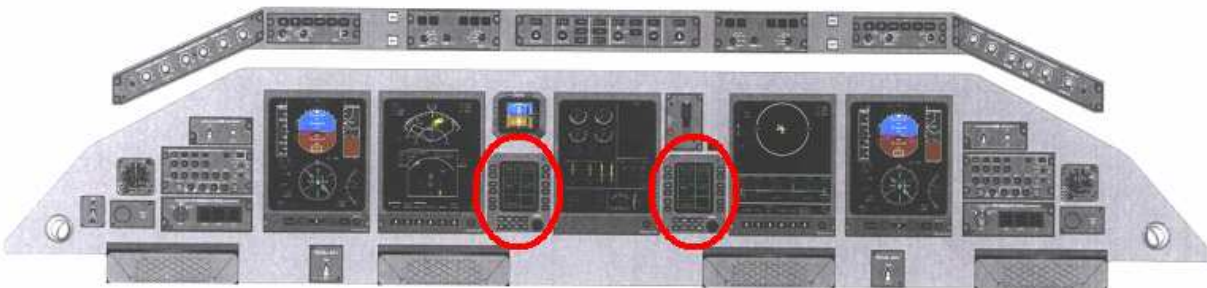


Fig 26

This positioning allows the crew to maintain direct visual contact with the RMUs during flight. This was verified during examinations and simulations, as well as during the reconstitution flight, which was conducted during identical time as the accident and with similar atmospheric conditions of luminosity and clouds.

In accordance with the Pilot's Manual for PRIMUS II – Integrated Radio System (Honeywell Pub. N°28-1146-50-03), on page 3-41 (Re v. 4), the operational modes are:

- ATC ON – Replies on Modes S and A, no altitude reporting.
- ATC ALT – Replies on Modes A, C and S, with altitude reporting.
- TA ONLY – The TCAS Traffic advisory mode is selected.



d) *TA/RA* – The TCAS traffic advisory / resolution advisory mode is selected.

In the *STANDBY* condition the *Transponder* does not reply. When the *Transponder* is set to *STANDBY*, a white message “TCAS OFF” appears on both pilots Primary Flight Display (PFD) windows, precisely at the front of the visual field of view of the pilots, as well as on the TCAS screen.

According to the PRIMUS II Integrated Radio System (RM-855 RMU) - Pilot's Manual, there are six operation modes in the Transponder: *STANDBY*, *ATC ON*, *ATC ALT*, *TA ONLY*, *TA/RA* and *TUNE ME*. Therefore, it is different from the documented mentioned (Honeywell Pub. N°28-1146-50-03), in which the *STANDBY* is not considered an operation mode but a condition.

The number 1/2 next to the TCAS mode is a reference to which *Transponder* (*ATC*) is being used (the aircraft has two independent systems, for the eventuality of failure or malfunction of one of them).

To change from *STANDBY* to the last selected mode:

- Press the line-select button to bring the cursor to the line related to the TCAS mode (fourth button from top to down on the left side).
- Once the TCAS mode is inside the box, press again the line-select button to return the mode to the last one used.
- If the line-select button is not pressed within 20 seconds, the cursor will return to the original position (*COM*).

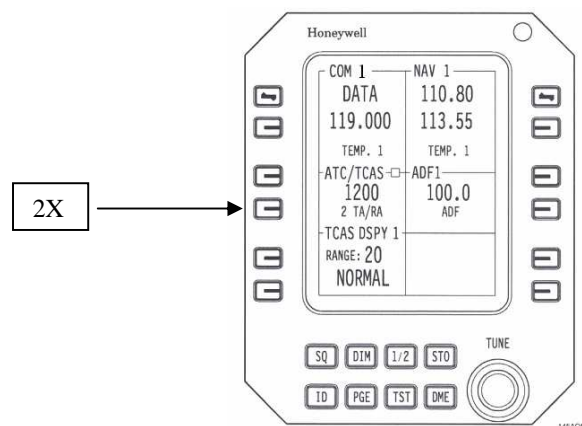


Fig 27

To change the TCAS mode:

- Press the line-select button to bring the cursor to the line related to the TCAS mode (fourth button from top down on the left side).
- Once the TCAS mode is inside the box, use the Tune Knob to change to the desired TCAS mode (*ATC ON*, *ATC ALT*, *TA ONLY*, *TA/RA*) or to *STANDBY*.

c) After 20 seconds without any input, the cursor will return to the original position (COM).

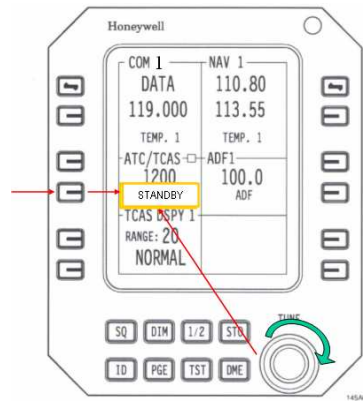


Fig 28

The normal mode of operation is in TA/RA which shall be selected at the time the aircraft receives authorization to ingress the runway for takeoff and shall stay until the aircraft leaves the runway after landing. The selection of this mode is a standard item of the Checklist Item (*cleared into position checklist*) as shown below.

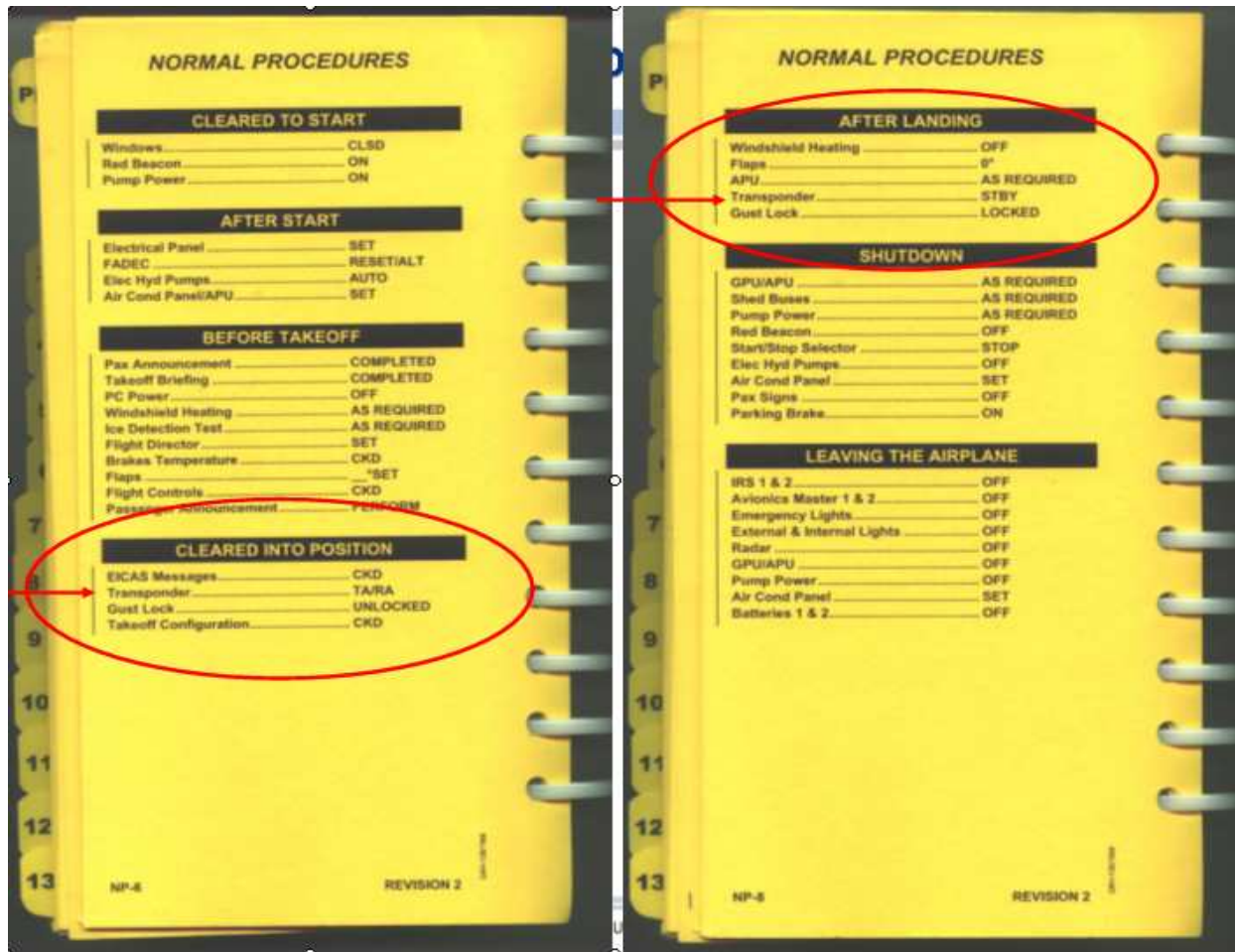


Figure 29

To change from TA/RA to STANDBY:

- Press the line-select button to bring the cursor to the line of the TCAS mode (fourth button from top to down on the left side).
- Once the ATC/TCAS mode is inside the box, press again the line-select button to change from TA/RA to STANDBY. Note: Pressing the line-select button only once will only move the cursor to the *Transponder* mode, therefore not changing the previously selected mode to STANDBY.
- If the line-select button is not pressed within 20 seconds, the cursor will return to the original position (COM).
- Once the mode selected is in STANDBY, a white message "TCAS OFF" will appear in both Primary Flight Displays (PFD) and also at the related TCAS screens.

### To change the *Transponder* Code:

- Press the line-select button to bring the cursor to the transponder code line (third button from top to down).
- Once the code is inside the box, use the Tune Knobs to select the desired code.
- After 20 seconds without any input, the cursor will return to the original positions (COM).

### In case of a *Transponder* Failure:

In case there is a *Transponder* failure, the operation mode and code selected are replaced by dashes in the RMU. An orange message “TCAS FAIL” will appear on both Primary Flight Displays (PFD) precisely in front of the visual field of view of both pilots, as shown by the pictures bellow.



Fig. 30



Fig. 31

## **3.13.4. The Flight**

### **3.13.4.1. Flight Planning**

The day initially selected for the ferry flight of the aircraft to the United States was 30 September 2006 (Saturday). However, the directors of the operator requested an anticipation of the flight to 29 September 2006 (Friday). According to declarations of the SIC, the intention was to depart in the morning of the 29 September 2006, in order to avoid flying over the Amazon jungle during the night.

The administrative process took the whole morning of 29 September, and then there was the delivery of the aircraft to the operator, a formal ceremony prepared by Embraer for every client who receives one of its products.

On the day of the ferry flight, the pilots passed the entrance gate of Embraer at 10 am local time (13:00 UTC), and the delivery ceremony started at 11 am.

The delivery ceremony began, and had speeches, filming, photos and a cocktail (approximately 40 minutes). The crew, then, got prepared to depart at 2 pm local time (17:00 UTC).

After the delivery ceremony, every one but the PIC participated in the dinner offered at the executive restaurant of the manufacturer. The PIC had his meal separately, and proceeded to the aircraft to deal with the preparations and pre-flight, assigning to the SIC the tasks related to the flight planning, which included the obtainment of the FPL.

After the festive dinner, the SIC went to the delivery room to resume the planning of the flight and the calculation of the aircraft weight and balance, utilizing a dedicated software and assisted by an engineer of the Embraer Flight Operations sector.

Meanwhile, aiming at complying with the departure time defined by the directors of the operator, the Embraer employee responsible for the administrative support to get the Flight Plan from the Universal, received the flight plan and submitted it to the SISCEAB unit.

At about 16:45 UTC, the flight plan was forwarded to the Air Traffic Authorized Station (EPTA), administered by Embraer and located in the county of Gavião Peixoto-SP. At 16:56:09 UTC, 29 September 2006, the Automatic Message Commutation Center of Brasilia (CCAM-BR) received the FPL type message originated at the EPTA-GPX/EMBRAER.

After being submitted to the SISCEAB, the FPL and other documents related with the meteorology and NOTAM were sent via e-mail to the Delivery Manager, who was in the same room where the SIC and the engineer of the Flight Operations sector were.

In spite of the proximity of the departure time, the SIC continued working with the Embraer engineer in the loading of the software in his notebook, and learning how to use it in the calculation of the aircraft weight and balance.

The Delivery Manager went to the aircraft where she was asked by the directors of the operator to call for the SIC, so that they could start the trip. Returning to the Delivery room, she advised the SIC, who then asked for more time to end the preparation work.

A little later, the SIC was interrupted by the Embraer Sales representative, who had come from the aircraft to reiterate the request made by the Excelaire directors. The SIC, then, interrupted his activities, and proceeded to the aircraft, without getting the FPL, which was handed to the PIC, at 17:15 UTC, by the engineer that had assisted the SIC in the utilization of the software.

As the delivery ceremony was held inside the hangar, the aircraft had not been refueled for the first part of the trip, due to safety reasons.

After the ceremony, the aircraft was towed out of the hangar for a complete refueling of all its tanks.

According to the pilots, they consider that the planning of the flight was made with the necessary advance for a safe conduction of the mission.

The most relevant moments, from the perspective of the investigation, were:

- 16:56:09 UTC, because it is the moment at which the "Gavião Peixoto RADIO" sends the FPL type AFTN message (Flight Plan Message) relative to the N600XL to the CCAM-BR;

- 17:52:52 UTC, because it is the moment at which the “São José TWR” sends the DEP type AFTN message (Departure Message) relative to the N600XL to the CCAM-BR;

The two moments shown above represent the understanding that everything, after the aircraft delivery ceremony, had been done with haste.

The PIC decided to stay in the cockpit of the N600XL airplane, to continue with the flight preparation phase (pre-flight execution) and data insertion into the FMS, while the SIC was in the Embraer Delivery Management sector dealing with the planning and studying the weight and balance calculation software.

By then, the pilots should have inserted the navigation into the FMS of the aircraft together. They were about to start a long duration flight, and for the first time without the assistance of an Embraer pilot (Safety Pilot).

Considering that the item “Flight Plans” of the “Air Carrier Operations Manual” mentions that it is the responsibility of the PIC the opening and closing of an FPL through the nearest Flight Service Station (FSS) or Aeronautical Information Service (AIS) facility, it can be observed that the PIC did not comply with this determination, as he transferred this responsibility for the FPL to the SIC.

Although the PIC and the SIC had received previous CRM training, the correct division of tasks did not occur in an adequate manner. Notwithstanding the natural lack of good interaction caused by the fact that they had little experience working together, the PIC allowed the crew to separate at one of the crucial moments of the mission: the elaboration of the FPL (including the planning of the flight), and at the conduction of the pre-flight of the airplane, during the phase that preceded the departure.

These facts were more significant, because that was their first trip with the N600XL, within an airspace under the ICAO rules, with which the pilots demonstrated not to be duly familiarized.

They still had some doubts, and there was information that needed to be assimilated by them, such as the performance calculations and fuel system differences between the EMB-145 and EMB-135BJ airplanes.

More attention should have been paid to the flight plan to be filed, as well as to the vertical and lateral navigation to be conducted, as they were concerned with the fuel and with the possibility to fly over the Amazon region during the night period.

With so many social protocols deriving from the delivery of the new aircraft, the pilots should have looked ahead for the accomplishment of the tasks related with the flight planning and pre-flight.

In the context mentioned above, it was observed that the activity of planning a long duration ferry flight mission, which normally requires a considerable time from the crew, was performed in less than two hours, with the crew dividing the tasks, in order to comply with the intended departure time.

Considering that the software had not been completely understood by the SIC yet, the finalization of the planning and the aircraft weight and balance calculations had not been concluded, with this activity being subsequently resumed in flight. This was the reason for the intense use of the notebook by the crew, as recorded by the N600XL CVR.

The flight plan was handed to the crew, when they were already inside the airplane, and the pilots did not examine it with the person that had elaborated it with the data received from the Universal.

The other items of information and the NOTAM were received by the pilots when they already were in the airplane.

It is important to bear in mind that other types of FMS equip the Legacy, among them, the Honeywell Primus. The EMB-135, EMB-140 and EMB-145, flown by the SIC at the "American Eagle Airlines", were equipped with the UNILINK FMS.

The SIC did not have previous experience in the Honeywell Primus, and was going to operate it on account of its similarity.

The CIAA did not get detailed information about the formal instruction the SIC and PIC received on the operation of the Honeywell Primus system.

Again, the decision of the FSI to not cooperate with the investigation was a hindrance for the work of the CIAA.

According to what was found, there were two distinct moments at which both pilots had contact with the operation of this model of FMS.

The first moment was when they flew in the segment Fort Lauderdale > Kansas City (leg conducted by the PIC) and Kansas City > Fort Lauderdale (leg conducted by the SIC). Although they occupied the left seat, the CIAA did not consider these flights as being formal instruction flights, that is, en-route flight instruction for Excelsior pilots.

These flights were considered as demonstration flights, according to what is described on the initial pages of the logbooks.

The second moment was during the acceptance flights. The acceptance flights were conducted with a specific purpose, and the situational awareness was focused on a pre-established type of task. Thus, we may deduce that, even if some time could be available for operational instructions on the correct use of all the functions of the Primus FMS produced by Honeywell, this probably did not happen during the three acceptance flights made.

Moreover, the acceptance flights do not have the same objective of a formal instruction flight. Even if we consider the allegation of the pilots of a delay in the delivery of the flight plan by the Embraer employee, they are not exempted from the task of foreseeing and managing possible delays relative to the flight preparations.

In the interview given by the pilots to the CIAA more than a year after the accident, there were neither complaints relative to the support provided by Embraer, nor a reference to a possible pressure on the part of the passengers to haste the departure.

However, it got clear in the interview that there were social protocols relative to the delivery of the aircraft they had to take part in, after which the ferry flight mission started, and, according to the pilots' standpoint, the flight plan took longer than expected to be handed to them.

In this interview, it got evident that there was a lack of specific guidance from the operator relative to systematic procedures to be followed by the pilots in the preparation of an international flight.

The PIC made decisions as the situations unfolded, without following any operational standard previously established. The pilots made the majority of their decisions following their own background and according to the unfolding of the facts, something that contributed to the failure of duly covering all the verifications, preparations and precautions that the conduction of this flight required.

Even considering the different versions about the moments and preparations that preceded the flight, it is possible to notice that the pilots were not sufficiently systematic and did not adequately plan the tasks that they had to do in person.

#### **3.13.4.2. The Flight Plan and the Clearance**

On the day before the ferry flight, the pilots of the N600XL requested the FPL from the Embraer employees. However, in the interviews given to the CIAA more than a year after the accident, the crew said they did not remember having met with the Embraer employee (Flight Support Manager) to discuss the flight plan (FPL). Also, they did not remember the moment at which they agreed to let the Embraer employee file the flight plan, although admitting that they did not take any action to the contrary.

The policy regarding the Flight Plan adopted by the operator was the following:

For the flights they utilized either FAA or ICAO Flight Plans, elaborated by an organization or facilities center, such as the Universal, which was responsible for sending the FPL, the weather briefing, winds aloft and other services to the crew, by means of a service provision contract. In the website, the Universal is identified as a support service provider for trips around the globe.

The PIC told the NTSB that a few days before the departure from SBSJ, he had contacted the Universal for the elaboration of a flight plan, according to a determination contained in the Manual of Operations of the operator.

The Universal offers three basic types of services: "Pre-Trip Support Services", "Active Trip Support Services" and "Post-Trip Support Services".

Considering that the N600XL airplane would depart, for the first time, as an aircraft of the American company Excelaire, the PIC requested the services of the "Pre-Trip Support Services", as shown below:

##### Pre-Trip Support Services

- Sample Flight Plans
- Route Weather or Flight Planning Briefing
- Security Briefs and Assessments
- Climatological Studies
- Preliminary Weather
- Passenger Weather
- Master Crew List (MCL) / APIS
- TSA Waivers
- Mexico Landing Permits
- Border Overflight Exemption



- Visa Waiver Program
- Visa / Passport Assistance

The utilization of this type of service is routine everywhere in the world, Brazil included.

The FPL may be filled out via telephone, and the company offers a variety of services.

The main office of the Universal is in the USA, and, as already said, it is specialized in providing flight support services before, during and after the trip, and utilizes the internet, telephone and fax, as the means of communication for the provision of this support.

So, there is not a direct (personal) interaction between the service provider and its clients. All the communication is remote, and the planning of the flight is normally made by computers, which process the data necessary for the execution of the flights.

In this scenario, the Universal forwarded, via internet, a sequence of operational and meteorological data spreadsheets relative to the flight of 29 September 2006.

The navigation presented by the Universal to the N600XL crew was rather unusual:

- 1<sup>st</sup> Leg: Climb to FL370;
- 2<sup>nd</sup> Leg: Descent to FL360;
- 3<sup>rd</sup> Leg: Climb to FL380.

The CIAA understood that this profile had been produced by the software of the Universal FPL program, which considered the winds aloft available at the several WIND ALOFT charts for the FL300, FL340 and FL390.

The flight plan activated had following cruising levels (FL):

- FL370, from SBSJ up to SBBR via UW2 (one-way);
- FL360, from SBBR up to TERES position, via UZ6 (two-way), with a heading change, from 006° to 335°;
- FL380, from TERES position up to SBEG, via UZ6 (two-way).

SJ Ground Control received the clearance from Brasilia in a shortened manner and transmitted it to the N600XL pilots, as already commented.

This incomplete initial clearance transmitted by São José Ground Control made the pilots understand that flight level FL370 was authorized up to Manaus, something which was confirmed in an interview given later by the crew to the CIAA.

Also, according to declarations of the pilots as to the influence of this first clearance, named "initial" clearance, it was understood as normal, with a clear message that the flight level authorized up to Eduardo Gomes Airport was FL 370, since no mention was made of a clearance limit.

This fact had influence on the situational awareness of the pilots in relation to the maintenance of the flight level FL370.

#### **3.13.4.3. Development of the flight**

These topics present the various facts involved in the accident, which represent a summary of the events. They focus, mainly, on the operation of the Transponder/TCAS of the N600XL.

The items of information are accompanied with comments and described chronologically, considering the most relevant events that could contribute to the elucidation of what happened with the Transponder and TCAS systems of the N600XL, during the flight that collided with the PR-GTD airplane.

### 3.13.4.3.1 Chronology of the Events

RMK: time sequence in accordance with the N600XL CVR.

17:41:44 UTC

- The N600XL FDR records the start of taxi.

17:41:57 UTC

CLEARANCE

- Initial Flight-Clearance: "N600XL, ATC clearance to Eduardo Gomes, Flight Level 370, direct Poços de Caldas, squawk transponder code 4574. After take-off, perform OREN Departure";

17:52:00 UTC

- Departure from SBSJ.

17:52:24 UTC

- After the aircraft departure, both São Paulo APP and São José APP received the normal signal of the transponder, code 4574, assigned to N600XL.

18:17:34 UTC,

- The Vertical mode of the auto-pilot (A/P) was selected to "Altitude Hold" when the N600XL leveled off at FL370. This flight level and this mode were maintained until the collision at 19:57:31UTC;

18:33:17 UTC

- Beginning of the recording of the N600XL CVR. The PIC and SIC were together using a computer (notebook) to calculate and obtain data of the landing and takeoff performance relative to Manaus. This computer was used until 19:13 UTC .
- As already commented, with an adequate planning of the flight, this task should have been finished on the ground before departure.
- Among the items of information that were not verified in advance, there was a NOTAM applicable to Manaus Airport, indicating that only part of the runway of that airport was available for landing and takeoff operations. This late perception about the NOTAM, with the resulting concern about the implications for the N600XL landing at and takeoff from SBEG, contributed to drawing the attention of the crew to the task of solving this problem, in detriment of the requisites of airmanship that would be

adequate for the flight. Only in flight did they use the documents received with the FPL, and, by means of the notebook, they checked the airplane fuel information.

Their attention was focused on the following issues:

- a) would they be able to make a safe landing at Manaus, with the existing weight of the N600XL, on a limited runway? And
- b) admitting that they landed safely at Manaus, would they be able to depart from the aerodrome to proceed to their destination with the load and maximum fuel to fly non-stop up to Florida?

18:33:26 UTC

- The SIC reported to BRASÍLIA Center (frequency 124.20 MHz): "November 600 X-ray Lima, Level, Flight Level 370";

18:33:49 UTC

- The ACC BS replied: "Roger, squawk ident, radar surveillance, radar contact";
- The PIC confirmed: "They just said radar contact".

18:33:57 UTC

- The SIC replied to the BRASÍLIA Center: "Roger, radar contact" and then said to the PIC: "I've no idea what (the h- - -) he said";
- The "squawk" relative to the N600XL transponder identification code was not received by the ATC at this moment.

18:44:38 UTC

- the SIC said "*just to let you know, on the landing, you might have to...*" and the PIC replied "jam on the brakes", and then "*it's a tiny runway*", an indication of some concern with the length of the landing runway at Manaus, on account of the NOTAM relative to works on the runway.

18:51:14 UTC

LAST RADIO CONTACT.

- The ACC BS informed: "N600XL - squawk ident, radar surveillance"

18:51:20 UTC

- The SIC replied: "Roger". It was the last contact.
  - The SIC recognized the instruction of "squawk ident" and said, at 18:51:20.6 UTC: "Oh (f.....) ... I forgot to do that ...". The PIC oriented him: "ID is there".
- It is a moment that denotes a difficulty or lack of familiarization of both pilots with the new airplane.

18:51:26 UTC

- The SIC then said: *"I think I did it. Yeah"*, and the ident feature of the transponder was then received by the ACC BS.

18:52:43 UTC

- The SIC said *"I don't know why it says we're gonna land with six thousand; this burn here is eighty-seven hundred. If we have sixteen thousand"*
- This moment indicates that he was working with the notebook, with his attention focused on the issues relative to the landing at Manaus.

18:54:52 UTC

- The PIC comments "well, let's just worry about takeoff first. I mean, let's see if we can do a takeoff since it's already there".
- This comment denotes once more that their attention was focused on the issues of the NOTAM relative to Manaus, on account of the restrictions it contained (this type of evaluation should have been made before departure, during the phase of mission planning).

18:57:54 UTC

- The N600XL passed over the BRS VOR/DME, turning (left) to intercept the course of airway UZ6, with the data block on the radar console of BRASÍLIA showing "370=360";
- There was not any action by the air traffic controller to verify the programmed level change to FL360, which was showing on his screen.
- The maneuver for the airway change was made smoothly by the autopilot and the aircraft passed from the UW2 (one-way) to the UZ6 (two-way).
  - The N600XL intercepted the centerline of airway UZ6, course 336°, and the crew did not discuss the progression of the flight in comparison with what was planned (heading change, next fix, fuel consumed, elapsed time, etc);
  - The N600XL passed BRS VOR, and no communication was made between the aircraft and ATC. The crew could have called the ACC BS to confirm FL370 in the opposite direction of the normal flow (UZ6, heading 336°), since the understanding was to remain at that level;
  - The PIC and SIC joined another airway, at the vertical of Brasília, but continued working at the laptop;
  - The N600XL was leveled at the non-standard FL370, flying in a direction opposite to the normal flow of airway UZ6, while the PIC and the SIC were busy with the calculations of the departure from Manaus;

18:59:17 UTC

- The PIC pointed at the computer and said (fragment): "... the burn's showing... 12,000 at seven eight... if we slow, if we fly at seven four".

18:59:35 UTC

- The PIC asked the SIC (fragment): "that tail work we did it at ...the ETO the Big One"
- The SIC agreed (fragment): "... try it...".

18:59:54 UTC

- The PIC appeared to be working on the situation of the fuel, and said (fragment): "So on this fuel here...".

19:00:01 UTC

- The PIC said: "...and it's all, that's it, all you have to do with that? But there was not a reply from the SIC, who was still working at the laptop.

Between 19:00:01.5 UTC and 19:01:44.3 UTC

#### INTERRUPTION OF THE TRANSPONDER TRANSMISSION

- The pilots confirmed that, at this moment, the SIC was with the laptop and worked on it alone during the two minutes; he neither passed it to the PIC, nor placed it next to the panel.
- The PIC, who had declared in his last interview not recalling exactly what he had been doing during this period of silence, may have been still focused on their calculation of the fuel for the departure from Manaus (seemingly) to check the current fuel status of the N600XL.

19:01:44 UTC

- At the end of this "period of silence", at, the SIC suddenly exclaims: "Naw! *We can do 48,884 ...*" (the aircraft weight that they could use at the departure from Manaus).

19:01:46 UTC,

- the PIC says: "*If we do ETO that's basically full fuel, isn't it?*" And, approximately at this moment (on account of a difference of some seconds in the synchronization between the CVR and the ATC radar) the Transponder/TCAS changed to a condition (possibly STANDBY) in which the transponder reply ceased being received by the ATC radar due to an discontinuance of the transmission of the mode **C**, without perception by the flight crew of the N600XL."

19:01:53 UTC (ATC time)

- The ATC radar showed that the N600XL Transponder was without signal a few seconds later, on account of the radar sweep time, when the transponder was possibly already at "STANDBY" (resulting in a TCAS OFF message)

19:02:30 UTC

What may have occurred:

- The PIC and the SIC were still working together on the calculations for Manaus, not realizing that the status of the Transponder had changed;
- When the Transponder changed to "STANDBY", the ATC radar lost the SSR signal of the N600XL, and reverted to the "Primary Mode";
- The "TCAS OFF" warning was shown on the displays of the two PFDs, and the "STANDBY" condition was shown on both RMUs;
- At that moment, neither crew member perceived the alerts showing the STANDBY condition of the TCAS system.
- With the N600XL at autopilot, and with the pilots focusing on the calculations at the computer, neither of them noticed the warnings on their RMUs and PFDs, because the only activity in the *cockpit*, minutes before and minutes after 19:02:08Z, was the PIC and the SIC working together at the *laptop*, calculating landing and takeoff parameters relative to Manaus.
- The altitude being received was the one measured by the available 3D radar, and the Transponder signal was not being received. Consequently, the altitude information was not as precise as the one provided by the transponder.
- It was necessary to contact the aircraft to confirm its altitude, request the crew to verify transponder, and assess the capability of the aircraft to continue under RVSM.
- The N600XL left Sector 5 and entered Sector 7 of the BRASILIA FIR. The ATC did not contact the N600XL to tell him to change from the frequency of Sector 9 (125.05 MHz) to the frequency of Sector 7 (135.90 MHz), in order to guarantee that the N600XL did not get out of the VHF coverage, as it proceeded into Sector 7.
- From 19:02:30 UTC on, the ACC BS did not contact the N600XL to question about the loss of the SSR signal ( the display showed "370Z360 ") and/or alert the aircraft about the reactivation of the Transponder.

19:13:00 UTC

- The CVR recording indicated that the laptop was only put away at 19:13 UTC. In the period recorded, it meant at least 40 minutes of use, without considering that it may have been used in the 42 minutes of flight prior to the beginning of the recording.
- The SIC said: "Want to turn this off, or leave it on?" and the PIC replies: "Uuhh, you can turn it off I guess", and then, at 19:14:09 UTC, he added: "Just put it in the bag there";

This means that they had stopped working at the notebook.

- As observed from the transcripts of the CVR, during this period of time, when the recordings indicate the use of the laptop, the crew focused on the calculation of the performance, without any conversation or comments that might suggest that the pilot in command was checking the information of the flight instruments at intervals. These circumstances denote a poor situational awareness on the part of the pilots.

Between 19:15:00 UTC and 19:18:00 UTC

#### CONTROL POSITION RELIEF.

- There was a control position relief at the ACC BS, and the relief controller was informed by the relieved controller that the N600XL airplane was at FL360 (wrong information, since the aircraft was at FL370).

- This control position relief did not comply with the prescription of the Operational Model of the First Air Defense and Air Traffic Control Integrated Center (CINDACTA 1). There is not, however, a recording of this procedure, and the controllers refused to be interviewed by this CIAA.

19:23:29 UTC

- The ACC BS transmitted an instruction to PR-LAM, telling him to monitor 123.75 MHz. This was the last time that the N600XL could hear a transmission (to other aircraft) from the ACC BS. The N600XL got out of the coverage – at a distance of more than 200 NM from the transceiver of the frequency 125.05 MHz. This same ATC transcript ( n° 134 dated 05 OCT 06) shows that, three minutes and twenty-two seconds later, the ACC BS made its first attempt to contact the N600XL, at 19:26:51 UTC.

Between 19:26:35 and 19:34:42 UTC

#### CALLS MADE BY THE ACC BS

- Three minutes and twenty-two seconds later, the ACC BS started a series of six calls on six different frequencies simultaneously, in an attempt to establish contact with the N600XL, but no reply was received, because the N600XL was already outside the coverage of the frequency 125.05 MHz.

- A seventh and last call, (“in the blind” at 19:53 UTC), was received by the N600XL on the frequency 135.9 MHz, but the frequencies informed in this transmission were not copied correctly.

19:30:40 UTC

- The ACC BS lost primary radar contact with the airplane, and a third attempt to call was made, when the aircraft was already at 248 NM from the BRS VOR, without radar contact with the ACC BS.

19:30:56 UTC

- Shortly later, a fourth attempt to contact was made, with the aircraft at a distance of 250 NM, still without radar contact and without replying to the calls.

19:32:48 UTC

- The aircraft reappeared as a primary radar contact, at 265 NM, without correlation of the icon, showing, instead of the previous data block, only speed and 3D radar altitude, which is not used for the maintenance of RVSM standard vertical separation.

19:36:48 UTC

- The N600XL passed the TERES position fix, maintaining the UZ6 airway centerline, heading 336°, on the way to NABOL, at FL370, instead of the required FL380.

19:39:00 UTC

- The N600XL continued flying on the centerline of the airway UZ6, at FL370, and its primary radar contact was maintained until 19:38:23 UTC.

19:39:50 UTC

- The PIC said: "I'm gonna take a whiz (sound of a yawn) ... your wheel" and the SIC replied: "Alright (followed by a cough)";
- From this moment on, the SIC stayed alone in the cockpit for approximately 16 minutes, as pilot in command. There is not evidence that he may have used the oxygen mask, as required when flying at very high altitudes. In an interview, the PIC alleged that the reason for his being away so long was that he tried to fix a problem in the lavatory..

Between 19:48:15 and 19:52:59 UTC

CALLS MADE BY THE N600XL.

- At 19:48:51 UTC, the SIC tried to make a radio contact with ACC BS on the frequency 125.05 MHz without success (because the N600XL was already more than 200 NM away from the transceiver of that frequency);
- While the PIC was away from the cockpit, the SIC tried to contact the ATC on different frequencies 11 times, but the calls were unsuccessful;
- To select the radio frequencies, the SIC possibly had his attention directed to the use of the RMU;

However, the SIC neither perceived the "STANDBY" condition, nor the lack of the reply light, information provided by the reply annunciator of his RMU, indicating that the Transponder /TCAS were OFF-LINE.

- In the interviews, the crew said they did not have any alert notice coming from the equipment relative to the "STANDBY" condition of the Transponder.

19:52:26 UTC

- The ACC AZ called the PR-GTD (flight GLO 1907) on 126.45 MHz and, after informing that the radar service was terminated, told the aircraft to call the ACC BS at NABOL position on the frequency 125.2 MHz, alternative 135.9 MHz. The frequency 125.2 MHz was one



of the frequencies used by the ACC BS in the simultaneous transmissions (135.9/ 125.2/ 125.05/ 133.1/ 122.25 and 125.45 MHz)

19:53:30 UTC

- The ACC BS Assistant Controller called ACC AZ by means of the fixed service, and handed off the N600XL at 19:53:45 UTC, not informing the loss of the Transponder SSR contact, the loss of mode C, and telling (incorrectly) that the N600XL was at level FL360.

19:53:39 UTC

- The ACC BS made a call "in the blind" to N600XL on the frequency 135.90 MHz, instructing the aircraft to change to 123.32 or 126.45 MHz. This call "in the blind" was received by the N600XL;

- The SIC called the ACC BS on 135.90 MHz: "Ah, just trying to reach you - what was the first frequency for N600XL - 123 decimal, I didn't get the last two?"

- Subsequently, the SIC repetitively tried to make contact with ACC BS and ACC AZ (Manaus) without success, as these calls were superposed by the transmissions of other airplanes, according to the confronted recorded data of the ACC BS and the N600XL CVR.

- This message was heard in the cockpit of the PR-GTD on the frequency 125.2 MHz.

19:55:16 UTC

- The N600XL continued flying on the centerline of airway UZ6 at level FL370, and without radar contact (occasionally, only a primary radar contact of the aircraft was seen on the screen).

19:55:46 UTC.

- The PIC came back to the cockpit after 16 minutes, and took over the command, saying: "Sorry", apparently apologizing for being away so long;

- The PIC, on this occasion, would have the opportunity to make a verification of the instruments as prescribed and expected from a captain, after coming back to the cockpit. Either this action was not taken, or he did not notice that the Transponder was not transmitting and, thus, the TCAS was not available.

19:55:51 UTC

- The SIC explained the situation to the PIC who had just come back to the cockpit.

- The SIC then made two more unsuccessful calls to ACC BS.

- After these two calls (19:56:41 UTC and 19:56:53 UTC), at 19:56:54 UTC, the collision occurred.

19:56:54 UTC

THE COLLISION.

- The CVR of the N600XL recorded the sound of the impact with the PR-GTD
- At the moment of the impact, both aircraft, N600XL and PR-GTD, were at flight level FL370, and were in the center line of airway UZ6, flying in opposite directions, at cruising speed;
- With the Transponder of the N600XL inactive, the Legacy could not be detected by the PR-GTD and vice-versa; as a result, there was not any TCAS alert or visual contact with the other aircraft. No evasive maneuver was attempted by the crews.
- The collision occurred within the airspace of the ACC AZ which was able to visualize the PR-GTD on the screen accurately.
- The ACC AZ had a primary radar contact, not correlated, of the N600XL, without accurate altitude information, and with the information received from the ACC BS that the aircraft was maintaining FL360.

Between 19:57:00 UTC and 19:58:00 UTC

- The SIC took over the commands of the aircraft and the control of the actions.

19:57:01 UTC

- The SIC started directing the captain:  
"All right, just fly the airplane dude."

19:57:04 UTC

- And again alerted:  
"Just fly the airplane".
- The SIC verified that there had not been any explosive decompression, and tried to calm the PIC.

19:57:14 UTC

- However, according to the CVR, the SIC noticed that the PIC was not comfortable to fly the aircraft, and asked:

"Do you wanna fly dude? Do you want me to fly it?"

- The PIC just answers:

What we got (f.....) hit?

- The SIC perceived the emotional unrest of the PIC and tactfully took over the command of the actions.

19:57:22 UTC

- The SIC said: "I don't know dude, just let me ah, let me fly it."
- The PIC accepted, saying:  
"You got it?"

- "Yeah" , answered the SIC, at 17:57:26 UTC, assuming not only the controls of the aircraft but also the command of the actions in the cockpit.

19:57:44 UTC

- The PIC tried, on two occasions, to declare emergency on the frequency 121.50 MHz, at 19:58:21 UTC and at 19:58:43UTC, but did not get any replies to his calls from the ATC;

19:59:13 UTC

- The recording of the CVR is very clear, the SIC released an exclamation of surprise, when he noticed that the TCAS was OFF.

"... Ahhh!... dude, you have the TCAS on?"

- The PIC replied, at 19:59:15 UTC :

"...yes, the TCAS is off "

19:59:17 UTC

- The DFDR recording showed that the page of the display of the TCAS was selected at the MFD2 of the SIC, right side, presumably to confirm that the TCAS system was OFF, precisely two seconds after the reply of the PIC, in a quick corrective action, typical of the profile the SIC showed all along the emergency.

19:59:25 UTC

- There was silence during ten seconds, in which the pilots said nothing, and, then, the co-pilot, reestablishing control of the situation, said:

"All right, just keep an eye for traffic. I'll do that, I'll do that, I'll do that .I got that"

- in the CVR, this last phrase may be indicative that the co-pilot was about to reactivate the transponder, or had just reactivated it.

Between 19:59:30 and 19:59:31 UTC

- The PIC says: "Why? Do you want me to fly?"

- The SIC answered (between 20:00:08 UTC and 20:00:12 UTC): "No, I can fly, just keep an eye out for traffic. We're descending. I want to get down";

19:59:50 UTC

THE TRANSPONDER RESTARTS TRANSMITTING

- In the rerun of the CINDACTA 4 radar, with images captured every 10 seconds by three different radar antennas, the appearance of the radar blip of the N600XL was observed, with the identification code 4574, presenting a correlated radar icon, with the aircraft crossing flight level 325, while the data block on the screen showed FL360, according to the change inserted by the second controller of the ACC BS;

- During the flight, the crew did not make any comments about failures or malfunctioning of the transponder and TCAS.

19:59:53 UTC

- The SIC said something like: "So much for TCAS!" , or "What's with TCAS" , or still "Watch your TCAS! ("There was no reply on the part of the PIC).

20:02:07 UTC

- The PIC said: "I'm gonna squawk 7700, that's Emergency..." , and the SIC replied: "Yeah ... squawk it";

- The shift from code 4574 to code 7700 was immediately observed on all radar console displays, as "Emergency Condition".

20:22:58 UTC

- the SIC conducted a visual approach to SBCC and, as he did not know the extent of the damage sustained by the aircraft, he waited until later to lower the landing gear (20:21:51 UTC) and asked for 9° of flap only during the "flar e".

- The N600XL landed safely on the SBCC runway, and the crew gradually applied the brakes, until the aircraft stopped;

20:33:00 UTC

- The N600XL followed the ground support vehicle to the designated parking area. The aircraft came to a stop and the engines were shut down.

22:35:07 UTC

- There was a phone contact between the captain of the N600XL and the Commander of CINDACTA IV, in which the crew member suddenly changed his answer to the chief of the control unit involved in the occurrence. On the occasion, the commander was trying to obtain information on the other aircraft, with which they had collided and that was still missing. The answer referred to the status of the Transponder at the moment of the collision.

(Below, follows part of the transcript of the communication between the commander of CINDACTA IV and the PIC, showing the question and the answer about the status of the Transponder at the moment of the collision (Table 15).

Table 15

2				TRANSCRIÇÃO DE GRAVAÇÃO N° 041, DE 29/09/06				3		FOLHA 01/05	
4				REFERENCIA: LRO DO ACC-AZ DE 29 SETEMBRO DE 2006				5		FITA N° 071	
6				DATA DA OCORRENCIA: 29/09/06				7		HORARIO: das 2235 às 2241UTC	
9				TRANSCRITA POR: 1S LISBOA				10		REVISADA POR: 1T ESP CTA RUBEM	
11		HORA	12	OPR. QRC	13	ANV ÓRGÃO	14	TEXTO			
		22:35:02 22:35:02	TF-3 310		PILOTO			HELLO!			
		22:35:03 22:35:04	CMT TF-3 310		CMT			HELLO, SIR. CAN YOU HEAR ME?			
		22:35:06 22:35:07	TF-3 310		PILOTO			YEAH, I CAN HEAR YOU.			
		22:35:09 22:35:16	CMT TF-3 310		CMT			OKAY, WE'RE TRYING TO GRAB AS MOST INFORMATION AS WE CAN. WOULD YOU MIND TO RESPOND SOME QUESTIONS?			
		22:35:18 22:35:18	TF-3 310		PILOTO			YEAH.			
		22:35:19 22:35:27	CMT TF-3 310		CMT			OKAY. DO YOU HAVE ANY IDEA HOW FAR FROM CACHIMBO YOU WAS WHEN THE COLLISION OCCURED?			
		22:35:32 22:35:32	TF-3 310		PILOTO			ABOUT A HUNDRED MILES.			
		22:35:33 22:35:34	CMT TF-3 310		CMT			ABOUT A HUNDRED MILES? OKAY!			
		22:35:37 22:35:42	CMT TF-3 310		CMT			OKAY. AHH... YOUR FLIGHT WAS LEVELED AT THAT TIME?			
		22:35:44 22:35:45	TF-3 310		PILOTO			AT THREE SEVEN ZERO.			
		22:35:49 22:35:50	CMT TF-3 310		CMT			LEVELED AT THREE SEVEN ZERO?			
		22:35:50 22:35:51	TF-3 310		PILOTO			LEVELED AT THREE SEVEN ZERO.			
		22:35:51 22:35:55	CMT TF-3 310		CMT			OKAY! THE TCAS SYSTEM WAS TURNED ON?			
		22:35:58 22:35:58	TF-3 310		PILOTO			NO.			

## FORMULÁRIO PARA TRANSCRIÇÃO DE GRAVAÇÕES

2		CONTUNUAÇÃO DA TRANSCRIÇÃO DE GRAVAÇÃO N° 041, DE 29/09/06				3		FOLHA 02/05	
4		REFERÊNCIA: LRO DO ACC-AZ DE 29 SETEMBRO DE 2006				5		FITA N° 071	
11	HORA	12	OPR. ORG	13	ANV ÓRGÃO	14	TEXTO		
	22:35:59 22:36:01		CMT TF-3 310		CMT		NOT?... HELLO?		
	22:36:02 22:36:03		TF-3 310		PILOTO		NO, IT WASN'T.		
	22:36:04 22:36:05		CMT TF-3 310		CMT		NO "TCAS"?		
	22:36:05 22:36:08		TF-3 310		PILOTO		TCAS WAS OFF.... THE TCAS WAS ON.		
	22:36:09 22:36:13		CMT TF-3 310		CMT		OKAY, WAS ON, BUT NO SIGNAL WAS REPORTED, ISN'T?		
	22:36:15 22:36:17		TF-3 310		PILOTO		NO, NO, WE DIDN'T GET ANY WARNING, NO.		
	22:36:18 22:36:21		CMT TF-3 310		CMT		OKAY! TCAS FOR SURE WAS TURNED ON, OKAY?		
	22:36:23 22:36:23		TF-3 310		PILOTO		OKAY!		
	22:36:24 22:36:45		CMT TF-3 310		CMT		OKAY! AND AH...(WHAT ELSE TO ASK?) HAVE YOU ALREADY PASSED TO AMAZONIC CENTER AT THAT TIME? OR YOU WAS FLYING WITH BRASILIA CONTROL AT THAT TIME?		
	22:36:52 22:36:56		TF-3 310		PILOTO		WE WERE ON ONE THREE FIVE DECIMAL NINE WITH BRASILIA CONTROLLER.		
	22:36:59 22:37:01		CMT TF-3 310		CMT		OKAY...AHNN...		
	22:37:02 22:37:12		TF-3 310		PILOTO		SO, TO SWITCH OVER TO ONE TWO THREE DECIMAL, IT CUT OFF, TRIED TO CALL THEM BACK THE REST OF THE FREQUENCY, WE'RE NEVER ABLE TO GET A RESPONSE BACK TO US.		
	22:37:13 22:37:20		CMT TF-3 310		CMT		OKAY! I UNDERSTOOD THE LAST CONTACT WAS IN ONE THREE FIVE DECIMAL NINE WITH THE BRASILIA CONTROL. IS THAT CORRECT?		
	22:37:21 22:37:21		TF-3 310		PILOTO		ONE THREE FIVE DECIMAL NINE YES, THAT'S CORRECT. LAST FREQUENCY WE HEARD THAT WAS ON.		

#### 3.13.4.4. Analysis and contributions of the Reconstitution Flight

The objective of the reconstitution flight was to provide a basis for the analysis and verify the factors that might have contributed to the interruption of the transponder transmission and, concomitantly, to the lack of perception of that interruption on the part of the crew.

In the reconstitution, the objective was to reproduce as close as possible all aspects of the reality of the flight of 29 September 2006, in relation to the environment and operational conditions in the cockpit during the accident flight..

For that purpose, the flight was conducted with an EMB-135BJ aircraft having the same configuration, fuel condition, flight level, day of the year (29 September 2007) and time of departure, complete route up to the point of impact, including the descent to the aerodrome of SBCC.

In relation to the meteorology, the weather conditions found on the day of the reconstitution flight were very close to the ones of the day of the accident.

In this reconstitution, all possible scenarios were researched that could explain the interruption of the Transponder signal. The following hypotheses were explored:

- Intentional Transponder switch-off by the crew
- Transponder failure (continuous or intermittent)
- Unintentional Transponder switch-off, through the handling of the Laptop
- Unintentional Transponder switch-off, through the use of the *footrest*
- Unintentional Transponder switch-off, during the familiarization with, or operation of, the RMU.

The evaluations carried out during the reconstitution flight revealed the following:



**Figure 33**

a) Use of the *laptop* by the SIC during cruise flight, leveled at FL370 and FL380. (Figure 33 shows the TCAS Box open, as should be expected):

- It can be observed that the control column is an obstacle for the contact of the *laptop* with the aircraft panel, hindering any type of inadvertent activation of the various systems;
- The *laptop screen* prevents the SIC from sighting the panel ahead and, thus, he cannot see the indications of the Transponder on the RMU and MFD;
- The red circle on the MFD, indicates that the TCAS box is in the “MANUAL” mode, not visible to the SIC, but visible to the PIC on the left-hand side seat, even considering the parallax;
- When the *laptop* is handled by the SIC, it is still possible for the PIC to maintain a normal visual contact with the panel ahead, sighting all the visual indications of the Transponder.

b) Use of the *laptop* by the PIC, (cruising level FL370 and FL380):

- Likewise, it was observed that the control column is an obstacle for the contact of the *laptop* with the aircraft panel, preventing any type of inadvertent activation of the various systems;
- The *laptop screen* prevents the PIC from sighting the panel ahead and, thus, He cannot see the indications of the Transponder on the RMU and MFD;



- When the *laptop* is handled by the PIC, it is possible for the SIC to maintain normal visual contact with the panel ahead of him, sighting all the visual indications of the Transponder, as well as the indications of the panel ahead of the PIC, even considering the parallax.



Figure 34



Figure 35

c) Handling of the *laptop* by both pilots, in a attempt to hit the RMU button related to the Transponder (cruising level FL370 and FL380):

- By handling the *laptop* with the screen open at a pronounced angle (close to horizontal), it is possible to hit the command Button of the Transponder. However, this unintentional action can be easily noticed, as the signals can be monitored visually. On the other hand, one has to consider that it is not logical to operate the *laptop* in such a position;
- All the time, it was possible to observe the indications of the transponder on the various displays, both for the SIC and the PIC. The use of the *laptop* is not capable of interfering in the sighting of the aircraft panel by both pilots at the same time.



Figure 36

d) During the reconstitution flight, while in cruise and level FL370, the PIC's foot was placed on the *footrest* and then subsequently it was attempted to strike the RMU1, as shown by figure 23:

- The *footrest* of the Legacy has a metal plate in the upper port, called *foot protector*, designed to keep the foot away from delicate instruments which could be damaged if contacted inadvertently.
- During the reconstitution flight, in order for the PIC to reach with his foot any of the RMU1 buttons, he had to move, with the leg raised, his seat to the backstop position and displace his foot to the right, outside the *footrest*, resting it at the edge of the *foot protector*. Then, he needed to twist the foot in such a way that the tip of the shoe touched the RMU buttons, in an angle not natural to the human being and in an intentional attempt to reach such buttons.

- Because of the discomfort to reach the buttons of the RMU, this action was considered as highly improbable to happen inadvertently. In order for the *Transponder* to stop transmitting, it is important to remember that the specific button (fourth, from top to bottom) on the RMU1 must be pushed two times consecutively in 20 seconds, which results in an extremely remote probability of this to happen inadvertently, as will be discussed in more details in another section of this report.
- The flight reconstitution indicated, therefore, that, for the buttons on the left side of the RMU to be reached with the right foot, it is necessary an intentional movement of the tip of the shoe forwardly, which was considered very uncomfortable due to the angle the foot must flex. With this in mind, the involuntary handling was considered an action with a high level of difficulty.
- No evidence was found in the ergonomic aspect, relative to the positioning of the RMU and the *footrest*, which could be considered as a contributing factor to the accident.

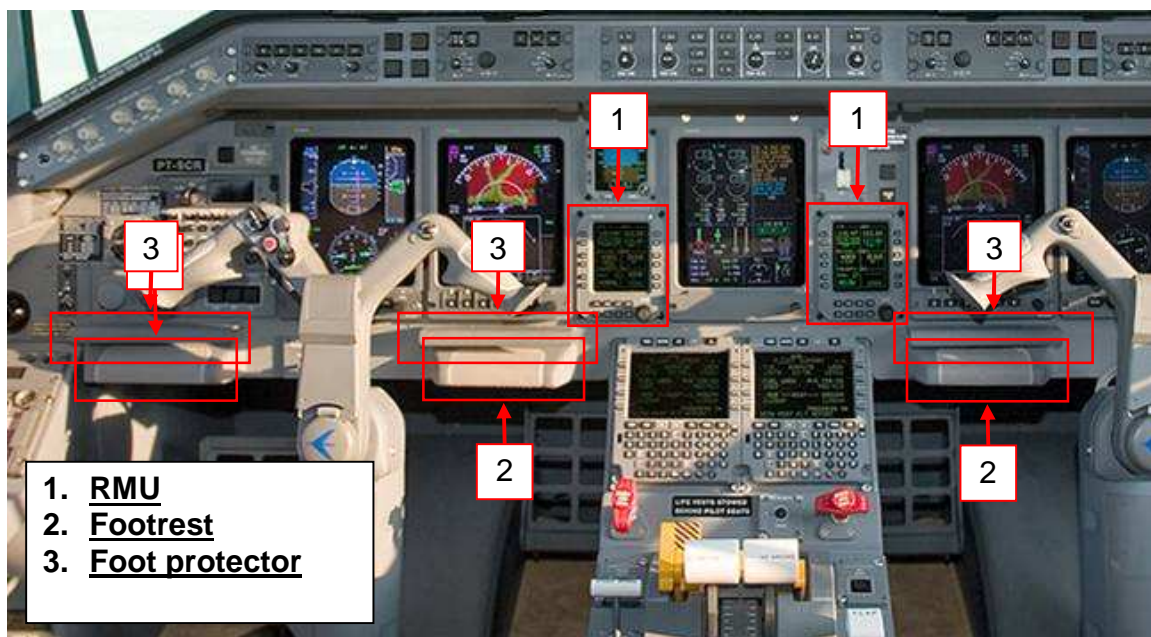


Figure 37

e) Ergonomic Aspects – Considering the positioning of the RMU1 and RMU2 in the instrument panel of the EMB-135BJ as in the picture above:

- With relation to “position”, the location of the RMU in the frontal panel of the aircraft is considered excellent when one verifies the angle of sight from both the PIC and SIC’s perspective.
- With relation to “luminosity”, the perception and understanding of the information of the RMU in the frontal panel of the aircraft were considered of easy interpretation, due to the size of the letters and distribution of colors, even with the intense luminosity present during the flight.





Figura 38



Figura 39

f) Using the RMU1 with simulation of a *Transponder* failure (by pulling the *Transponder Circuit Breaker*):

- The RMU1 was checked in flight in all of its functionalities and the responses in regard of the operation of all the equipment linked to the unit were within the expectations;
- The visual information bear by the RMU1 screen, during the operation were normally intelligible by the crew, without having any difficulty of interpretation;
- With this failure simulation of the *Transponder*, the RMU became “poor” of visual information, which increases the possibility that the indications related to the status of the *Transponder* will be noticed by the crew;
- While this test was being performed, all the visual messages of the *Transponder* status (TCAS FAIL) could be easily identified, both by the PIC and the SIC, while proceeding with the routinely in-flight scanflow, even considering the sunlight intensity at the time.

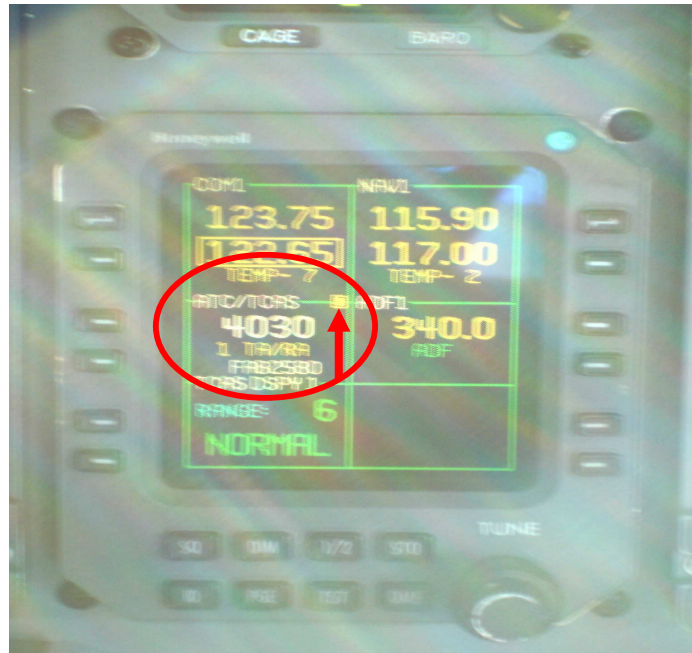


Figura 40

g) Visualization of *Transponder* indication on RMU1 (with a normal sunshine exposure, which corresponded to the same daylight hour as of the September 29, 2006):

- There was no degree of difficulty to note the visual information shown by the RMU screen, related to the *Transponder* modes of operation. As shown by figure 26, the ATC/TCAS mode is in TA/RA;
- The red arrow points to the rectangular box of the reply annunciator with its conspicuous blinking amber light, which indicates that the *Transponder* is replying to the interrogations from the ATC ground station, easily identified both by the PIC and the SIC;
- Also, it can be seen that the TCAS/DISPLAY has its range in NORMAL;
- At no moment during the reconstitution flight any interruption of the reply annunciator blinking light was observed, except when the CB related to the *Transponder*/TCAS was pulled;
- At all times during the flight, the indications of "TCAS OFF", "TCAS FAIL" on the MFD and the "TA/RA", "STAND BY" indications at the RMU, as displayed below, were visible for the normal attention levels by the reconstitution crew, especially if considering that they had the same lighting conditions experienced by the N600XL crew.

TCAS OFF  
TCAS FAIL

TA/RA  
STAND-BY

BLINK  
XTRD  
STAND-BY



Figura 41



Figura 42



Figura 43



Figura 44

h) Aspects related to the influence of the sun for the visualization of the aircraft panels and their respective instruments (without the use of the sunshades, with lateral views of the SIC and PIC, same magnetic headings and same flight time of the accident flight):

- It is possible to observe that the sunshine touches the SIC on the chest, in a area that is tangent to the chin is above the abdomen (Figures 41 and 42);
- The SIC reported a sensation of discomfort due to the intense heat on his chest;
- As the sunshine touches the SIC below his chin, his eyes end up being protected by the overhead panel, allowing a perfect visualization of the instruments, as they are not directly hit by the sunlight (Figures 38 and 39);
- Since the frontal panel of the PIC is also protected from the sunshine, it is possible for the SIC to visualize it normally (despite the parallax), in the same way he visualizes his own panel;
- For the PIC the conditions were similar, and, even with the sunlight coming from the left, the visualization of the instrument panel was not hindered (Figure 44). There is evidence of the use of the sunshade by the crew.



Figura 45



Figura 46

- i) Aspects related to the influence of the sunshine on the visualization of the aircraft panels and their respective instruments (with the use of the sunshade, lateral view of the PIC, same magnetic headings and same time of the accident flight):
- The aircraft possesses an amber color sunshade which proved efficient for preventing the incidence of the sunshine directly on the pilot or on the aircraft panels (Figures 45 and 46);
  - With the sunshade lowered, probably in the same position of the Day of the accident, the comfort of the pilot was rather improved, as the sunshine did not touch his chest directly (Figure 45);
  - The visualization of the instruments improved on account of the lower intensity of the sunlight in the cockpit (Figures 45 and 46).

The reconstitution flight allowed the commission to affirm that the interruption of the Transponder transmission was not on account of an inadvertent command resulting of the handling of the laptop, even if the two pilots handled it simultaneously.

The ergonomic of the aircraft, relative to the footrest and foot protector, as well as the position of the RMU, also discarded the possibility that an inadvertent command by the pilot's foot could have led to the interruption of the Transponder transmission. For that to occur, the movement of the pilot's leg would require effort and cause discomfort, resulting that his action would have to be intentional.

Both pilots were able to visualize the panels and read the information displayed, even in the presence of sunlight (without using the sunshade). All the visual items of information relative to the operation of the Transponder were available, and were understood coherently from both piloting positions.

Considering the hypotheses that would explain the interruption of the Transponder signal, only one of them is left: the possibility of an inadvertent switch-off during the familiarization with, or operation of, the RMU on the part of the pilots.

### **3.14. PHYSIOLOGICAL ASPECTS**

There is no evidence that any physiological factor in the crew of PR-GTD may have contributed, directly or indirectly, to the accident.

As for the crew of the Legacy, no stressing agent of a physiological nature has been identified that could be linked to any operational action taken during the flight in question.

In relation to the air traffic controllers involved, no stress inducers of a physiological origin have been identified that could justify any eventual operational failures.

In an overview, no physiological alterations were found that could be considered of relevance for the accident.

### **3.15. PSYCHOLOGICAL ASPECTS**

#### **3.15.1. Individual Variables**

##### **3.15.1.1. BOEING 737-8EH (PR-GTD)**

###### **3.15.1.1.1. The PIC**

The PIC was 44 years old, married for twelve years and had an eight-year-old son. He had a good financial standing.

Twenty seven years had elapsed since his graduation as a pilot at Luziânia Flight School, in Goiás State. He had joined Gol Airlines in 2001, as a Captain.

He was a flight instructor, and according to information, performed this activity in a didactic and standardized manner. As a Captain, he displayed a safe piloting, complying with the standards required by the company. Considered a sociable and communicative person, he was calm in his attitudes. He did not have a history of accidents.

The PIC had been scheduled to fly from Tuesday to Saturday. On September 28, he stayed overnight in Brasilia, where he lived.

###### **3.15.1.1.2. The SIC**

The SIC was single, and lived in São Paulo with his parents. He practiced physical activities regularly, especially the marathon race. He led a stable life, affectively and financially speaking.

He graduated at the Itápolis Aero Club, was checked for Private-Pilot at the end of 1998, and Commercial Pilot/PC in October 1999. He took up an Instructor course, and worked as such at the Itápolis Aero Club simulator. In 2001, he participated in a selective process for joining Varig, but ended up not being contracted, on account of a market retraction following the events of September 11, 2001. He joined Gol Transportes Aéreos as a "check-in" clerk and, in June of 2002, was promoted to co-pilot. His performance at the ground school and at the simulator was considered to be very good.

At the company, he was viewed as an extrovert, communicative and social person. As a professional, he was studious and perfectionist, being appraised by captains for the seriousness with which he dedicated himself to flight. According to the testimony of one of



the captains who participated in four flights with the co-pilot, he always showed discretion, tranquility, skill and prudence.

The SIC was being re-adapted to the equipment since June 2006, according to what is explained in item 3.13.2.2.1 – Qualifications. The captain of Flight 1907 was the instructor responsible for his re-adaptation, a fact that made the co-pilot very happy. The made a flight in July and flew during the month of September for approximately twenty days. The re-adaptation would be completed within two or three weeks, and the SIC was full of enthusiasm, because he was to go to Seattle (USA) to participate in a mission to receive a new aircraft for the company.

The co-pilot had been scheduled to fly from Tuesday to Saturday. On the 28th September, he stayed in Brasilia overnight and, in the morning of the day of the accident, he ran 10 km for exercise.

### **3.15.1.2. EMBRAER EMB-135BJ (N600XL)**

#### **3.15.1.2.1. The PIC**

At the time of the accident , the PIC was 42 years old, married, and had two children.

He has been a pilot since 1982, possessed 9,388 hours and 10 minutes of flight, 5 hours and 35 minutes of which in the Legacy. His longer experience was in the Gulfstream airplane. He worked three years as a flight instructor, three years as an airline pilot, and for eight years he made charter flights. He had joined ExcelAire five years before, and was happy with the company.

Although the pilot, in his first interview, stated that his international flight experience was restricted to the Caribbean, the information given to NTSB by ExcelAire says that he had international flight experience in Europe, Central America and Caribbean, but not in South America. According to the Director of Operations, the pilot had six to eight months international experience in Command. It is believed that he had some CRM training when he joined the company, although not in the Legacy.

In his first interview, he stated that he flew under the rules of the 14 CFR FAR 135, and that there was no routine in the missions he executed. The receipt of N600XL at EMBRAER was his first mission in Brazil. The criterion used by the company for his indication was, as he said, his experience in international flights, and the fact that he would be the pilot of the aircraft. Being happy with his indication, he considered the mission a routine flight. At the interview that was held at NTSB, he said he was enthusiastic about the fact that he was going to come back home flying a new aircraft.

According to the ExcelAire Chief of Pilots, the PIC was a very conscientious, conservative, good mood, disciplined, punctual and dependable person, who was always willing to travel. He was considered a good pilot in standardization, but his chief pointed out that the N600XL avionics were new to him.

### **3.15.1.2.2. The SIC**

At the time of the accident, the SIC was 34 years old, had been married for two years, and had no children.

Having been a pilot since 1990, he possessed 6,400 flight hours, 317 of which as a captain of the EMB-145, and 51 hours as a co-pilot.

He had been a flight instructor for three years at Embry Riddle Aeronautical University, a pilot for the Atlantic Coast Airlines for two years, a flight engineer for the American Airlines for five years, and a captain for the American Eagle for a year and a half.

As a pilot, he did not have missions abroad, but as a flight engineer, he had experience in Central America, the Caribbean and Venezuela. There were no records of previous accidents.

He was hired by ExcelAire approximately one month before the receipt of the aircraft, on account of his experience in EMB-145 aircraft.

The mission in which the accident occurred was his first flight for the company and to Brazil, as well as his first flight outside the United States, as a pilot.

According to the company Chief of Pilots, the information regarding the SIC showed that he was an excellent professional. During the job interview, he had perceived him as a polite and friendly person with a tidy personal look.

### **3.15.1.3. DTCEA-SJ**

#### **3.15.1.3.1. AIS Operator**

He joined the Brazilian Air Force in July, 1976. He was promoted to first class soldier and later to corporal, serving ten years at EEAR. He took up a mechanical engineering course. Before acquiring stability in the active service, he took an entrance exam for Special Volunteers in 1986. After succeeding, he took up the AIS course at the former IPV, now ICEA. He served in Campinas, state of São Paulo, up to 1991, and then was transferred to DTCEA-SJ on private interest. Since 2005, he had been the enlisted man in charge of the AIS Office, responsible for administrative activities and for personnel coordination.

#### **3.15.1.3.2. Ground Controller**

Having graduated at EEAR, he had been a controller for 33 years, and was transferred to DTCEA-SJ in February 1986. Since then, he had taken up the following courses: ATM 009 "Approach Radar Operator", at DTCEA-YS, in 1996; CTP 004, a one-week course on English phraseology for emergency situations, at SRPV-SP, in 2004, and a three-day course on the prevention of aeronautical accidents, with a focus on error management, at ICEA (AS001/ Team Resource Management Training), in 2006.

He related that he had not done English courses other than those offered by the COMAER, and that, considering that the test flights and flights of Embraer require the use of English phraseology, he would need a better mastering of that language.

### **3.15.1.3.3. Tower Controller**

The tower controller is a civilian of the DACTA group, and took the entrance exam in April 1979. She reported to DTCEA–SJ in February 1991, and worked as AIS up to 1998, when she started working at the TWR/APP. From 1980 to 1983, she worked at Brasilia ACC; from 1983 to 1985, at Campinas Tower, and, from 1985 to 1991, at the Campinas AIS Office.

After her graduation in 1980, she underwent an adaptation to Brasilia ACC, and also took up an eight-month air traffic English course at CINDACTA I in 1981. Currently, she is doing the ATM 006 (“APP Procedural Control”), at EEAR.

On the day of the accident she was coming back after a day off, and had been scheduled for the morning shift, but exchanged shifts with a workmate, to work in the afternoon.

### **3.15.1.3.4. APP Controller**

He graduated in 1987 at EEAR, and was transferred to DTCEA-SJ in 1992. From 1987 to 1992, he worked as an instructor at the Link Trainer, at the Brazilian Air Force Academy. He took up the basic radar operator course at SRPV-SP, in 1998, and the terminal area radar operator at ICEA, in 1999, as well as the Basic English course at CIEAR, in 2003. In that same year, he took up a three-day course on air traffic control management, with a focus on error management.

He stated he had requested an English course to his chief, and that his request was forwarded to SRPV-SP.

On September 29, he was on his second day of the shift. He had tried unsuccessfully to exchange the service, and for this reason he asked a workmate to remain on duty up to 17:00 UTC, when he finally took over his position at APP.

### **3.15.1.4. ACC BS**

#### **3.15.1.4.1. Supervisor 1 of the Brasilia Region (sectors 5 through 9)**

The Supervisor 1 of the Brasilia Region was 39 years old. He joined EEAR in 1985, and was appointed to the BCT specialty (ATC) on account of his interest and his results in the Psychological-Aptitude Evaluation. His certification in radar control was awarded to him in 1990.

At CINDACTA I, he took up the following courses: ATM 503 -Area Control Radar Qualification, and ASE 001 – Team Resource Management Training. At CENIPA, he did the ATC Flight Safety Control Course.

At ICEA, he did the following courses:

- OP-18 “Enroute-Radar Operation Techniques, from September 15 to October 16, 1997.
- ATM-011(ATC Unit Supervisor), concluded in October, 2003.
- At the last General Specialized Test (TGE), the result of his evaluation of the English language was “non-satisfactory”.

#### **3.15.1.4.2. Supervisor 2 of Brasilia Region (Sectors 5 through 9)**

The Supervisor 2 of the Brasilia Region was 36 years old. He joined EEAR in 1990, having been appointed to the BCT specialty (ATC), which was his second option, for his result at the Psychological Aptitude Evaluation, and for his interest. After graduation, he was assigned to CINDACTA I, where he took up the ATM 503 Course – Area Control Radar Qualification. He was certified as a radar controller in 1990.

At ICEA, he did the following courses:

- ATM 008, Enroute-Radar Operator.
- OP-90 (now ATM-011) – Supervisor Course, in the second 2001 class.
- At the last TGE, his result in the evaluation of the English language was “non-satisfactory”.

#### **3.15.1.4.3. ATCO 1 of Sectors 5 and 6**

The ATCO 1 of sectors 5 and 6 was 37 years old. He joined EEAR in 1988, and was indicated for the BCT specialty (ATC), his first option, for his result in the Psychological Aptitude Evaluation and for his interest. He received radar control certification in 2001.

At ICEA, he did the following courses:

- ATM 002, “Basic Radar Operator Course”.
- OP-17 (now ATM 007), “Terminal Area Radar Operation Techniques”, in the period from May 4 to June 19, 1992.
- OP-18 (now ATM 008), “Enroute-Radar Operation Techniques”, in the period from September 27 to October 28, 1999.

#### **3.15.1.4.4. ATCO 1 of Sectors 7, 8 and 9**

The ATCO 1 of sectors 7, 8 and 9 was 27 years old. He joined the Air Force in August, 1999, as a first class soldier, serving at the 2nd/6th GAV, in Anápolis, Goiás State. He took the entrance exam for the enlisted in 2001, and opted for the BCT specialty (ATC). He did his Psychological Aptitude Evaluation at IPA (Aeronautics Psychology Institute), and was considered “indicated” for the function. He passed the entrance exam, joining EEAR in the first 2002 class. After his promotion to Third Sergeant, he was assigned to CINDACTA I.

At ICEA, he did the courses ATM 015, “En-route and Terminal Area Radar Operation Techniques”, and ATM 016, “Formation in Radar”, having been considered “apt”. His Global Performance Information Card, filled in by the course instructor at ICEA, had the following comment:

“He has the necessary skills for his job as a radar controller. He had more difficulties as the volume of traffic increased. He also showed difficulty mastering the English language, with an effect on the use of the related phraseology. He has satisfactorily met the objectives proposed for this phase of the course”.

The controller completed the training for the radar control certification at CINDACTA I. Eight Operator Evaluation sheets referring to the period between July 16 and August 31, 2004, were presented, two of them with an “INAPT” result. The difficulties presented referred

to: secondary radar identification methods, establishment of priorities, guidance as to the need of taking notes on the electronic strips, poor emotional control, voice intonation and little agility in the “instructions”. In September 2004, he was forwarded to the Operational Council that was to take place in the month of December. The decision was that his certification as a controller would only be granted if he obtained an “APT” result in two further examinations. There is a gap in the records relative to this ATCO, up to April 2005, when an assessment was made with a comment of the instructor about the long time elapsed from the end of the instruction period and the taking of the test. The ATCO got an “APT” result. There is another gap, up to November 17, 2005, when the first of three evaluations were made, in which he was considered APT for the certification. He was certified in December 2005.

At the last TGE, his result in the English language evaluation was considered “non-satisfactory”.

#### **3.15.1.4.5. ATCO 2 of Sectors 7, 8 and 9**

The ATCO 2 of sectors 7, 8 and 9 was 27 years old. He joined EEAR in 1999, and his indication for the BCT specialty (ATC) was based on his interest. He completed the course in November 2000, and was assigned to CINDACTA I, where, in 2002, he was certified as a radar controller.

At ICEA, he did the following courses:

- ATM 003, “Controller Qualification Program”.
- ATM 008, “En-route Radar Operator”, in 2001.

At CINDACTA I, he did the basic and intermediate English courses.

At the last TGE, his result at the English Language test was “non-satisfactory”.

#### **3.15.1.4.6. ASSISTANT-CONTROLLER of Sectors 7, 8 and 9**

The Assistant ATCO of sectors 7, 8 and 9 was 26 years old. He joined EEAR in 2001, and was indicated for the BCT specialty for his own interest. He completed the course in June 2002, and was assigned to CINDACTA I.

In 2003, at ICEA, he did the courses ATM 015, “Enroute and Terminal Area Radar Operation Techniques”, and ATM 016, “Formation in Radar”, and was considered “apt”. He was certified as Assistant Radar Controller in 2004.

At CINDACTA I, he did the “Emergency Situations ATC Phraseology” course.

At the last TGE, his result in the English Language test was “non-satisfactory”.

#### **3.15.1.5. ACC AZ (AMAZONIC ACC)**

##### **3.15.1.5.1. The Supervisor of the Manaus Sub-Center of Operations (SCO)**

The Supervisor of the Manaus Sub-Center of Operations (SCO) joined the Air Force in 1989, as a Special Volunteer (VTE) of the BCT Specialty. He did the OP-30 “Basic Formation” course at ICEA, from June 12, 1989 to March 30, 1990.

He was assigned to CINDACTA III, in Recife, Pernambuco State, where he did the ATM 002 “Radar Operator Basic Course”. He served in Recife for seven years. Then he was

transferred to Florianopolis Air Force Base (Santa Catarina State), where he served for six years. He had been working at CINDACTA IV for four years. He had always worked in the ATC field.

He was considered a “competent, though polemical” professional by the chief of the ACC: “he gets scared and exaggerates the situations”. The chief of SIPACEA considered him one of the three best supervisors in the control unit.

In addition to his basic formation, he did the following courses at ICEA:

- OP-18 (ATM 008), “En-route Radar Operation Techniques”, completed on April 10, 1992.
- OP-17 (ATM 007), “Terminal Area Radar Operation Techniques”, completed on June 26, 1997.
- ATM-011, “ATC Agency Supervisor”, completed on October 28, 2005.

At CINDACTA IV, he did the ASE 001, “Team Resource Management Training”.

### **3.15.1.5.2. The ATCO of the Manaus Sub-Center of Operations (SCO)**

The ATCO of the Manaus Sub-Center of Operations (SCO) joined the Air Force in 1999, as a soldier, at Fortaleza Air Force Base. He passed the entrance exam for the EEAR Sergeant Formation Course in 2001, and was assigned to the BCT specialty, on account of his interest. After graduation, he was assigned to the SRPV/MN, now CINDACTA IV. In 2003, at ICEA, he did the courses ATM 015 “En-route and Terminal Area Radar Operation Techniques”, and ATM 016 “Formation in Radar”, having obtained an “Optimal” operational result.

His was considered by the chief of SIPACEA as an “excellent, safe, competent” operator, who “utilizes the standard phraseology”. The chief of the ACC described him as a calm controller.

### **3.15.2. Psychosocial and Organizational Variables**

#### **3.15.2.1. Gol Transportes Aéreos S/A**

##### **3.15.2.1.1. Organizational Structure**

The *GOL Transportes Aéreos* company is composed of a Presidency, Vice-presidencies (Institutional, Planning and Information Technology, Technical, Finance, Marketing and Services), a Directorship of Internal Audit and Compliance, a Directorship of Personnel and Airport Management, a Project Advisory, a Legal Advisory, SIPAER and a Secretariat. All the sectors are directly subordinated to the Presidency.

##### **3.15.2.1.2. Pilot selection process**

The process for the selection of pilots starts with an interview with the responsible for the Human Resource sector. Then, the candidates have to undergo a psychological evaluation, with interviews and role-play activities. Also, an English Test and an interview with the chief of the pilots integrate the selective process. After joining the company, the pilots do a month of “ground-school” and 10 four-hour sessions in the simulator. An instructor

is designated to develop a minimal program, which varies according to the performance of each pilot.

Upon getting a passing grade at the Company checkup, the pilot is then checked by ANAC. The pilot is re-examined every six months, alternating between simulator and aircraft. The pilots do courses on CRM, fire-fighting, jungle survival, first-aid, meteorology, International Air Traffic, with a high level requirement as far as the English language is concerned. The indication for the function of instructor is made by the Chieftainship of Operations, through the analysis of the pilot's profile, ethical aspect and way of operating.

### **3.15.2.1.3. Working Journey**

According to the interviewees, the company complied with the working journey regulations, although they considered the shift a little bit "tight", because the company was still getting stabilized in the market. There was a concern on the part of the Operations area, so that the limits are not exceeded, and the job done by the sector responsible for the flight shift is monitored. The pilots had eight respites per month, and at least one of them had a social nature. The flight hours varied a little each month. However, the Flight Safety Advisor said that the group was discontent with the amount of time they were flying, 85 hours per month, the maximum allowed by legislation.

### **3.15.2.1.4. Organizational climate**

The pilots interviewed said they felt supported by the company and free to make their decisions, prioritizing flight safety. They felt at ease to speak whether they did not feel fit for flying.

The communications within the company were easy and agile. The pilots had access to the work shift. They could ask for exchanges and adjust to meet their needs.

### **3.15.2.1.5. Flight Safety**

The Flight Safety Advisor said that his area was highly valued in the company. The Chief of Operations and the Technical Vice-President were Flight Safety Agents.

The Flight Safety Advisory was made up of a team of sixteen professionals with different backgrounds: captains, flight attendant, air traffic controller, airport personnel, flight dispatcher, and maintenance technicians. One of the flight safety agents collected information and sped up the proceedings in this area.

The reports concerning flight safety were forwarded via e-mail, telephone or anonymous letter. There was a statistical control concerning the data relevant for flight safety. The sector received between 1,100 and 1,200 e-mails per day, and answered all of them.

In the company, there were 172 employees, who were trained in Flight Safety by the *Air Safety*. Every year, 40 additional employees were trained. The integration training of the new employees included one day specially aimed at the subject. Every Wednesday, there were Flight Safety classes for pilots.

The Flight Coordination was always in contact with the Flight Safety Advisory. The company sponsored events in the area, while the team gave classes to the Air Traffic Control personnel at the CINDACTAs, and offered cockpit flights to the ATC operators.

Throughout the company, a Flight Safety Internal Bulletin circulated that brought alerts to the personnel. All the employees had their own e-mails, which were used for the dissemination of subjects of interest.

It was pointed out that the FOQA program generated some stress and a negative atmosphere among the pilots, but such a reaction was gradually diminished, as time passed. The Flight Safety classes began to be based on the presentation of case studies abstracted from the FOQA data.

#### **3.15.2.1.6. Behavior of the crew**

It was observed that up to the moment of the collision, the flight had gone by uneventfully. After the impact, the CVR shows that the pilots tried to control the situation, without indications of panicking.

#### **3.15.2.2. Excelaire Service, Inc**

##### **3.15.2.2.1. Organizational structure**

ExcelAire was founded in 1985 by its current President, to be an aircraft maintenance company. At the time of the accident, besides focusing on the maintenance activities (FAR 145), it also dealt with the executive aviation (14 CFR Part 91 and Part 135), operating the Falcon 900, Gulfstream, Cessna Citation and Lear Jet aircraft, in addition to helicopters.

ExcelAire managed a fleet of more than 20 aircraft, and had 190 employees, 48 of them pilots. The company was the owner of three aircraft. The other aircraft were private or a result of partnership. The pilots' turnover rate was low, and the work atmosphere was considered good. The majority of its operations were ruled by the 14 CFR Part 135, but some of its pilots flew only 14 CFR Part 91.

The company structure consisted of a Presidency, a Director of Operations, to whom the Safety Management, the Maintenance Directorship, the Chief of Fixed Wing Aircraft Pilots and the Chief of the Rotary Wing Aircraft Pilots were subordinated. The last two chieftainships mentioned were headed by the same pilot. The Safety Agent, who was also the flight inspector of the company, reported directly to the Director of Operations.

The company carried out operations all over the world, and common destinations were Europe, Central America and the Caribbean. There was not much activity in South America, with Aruba being the southernmost point reached by the flights. The trips to other countries represented 15% to 20% of the workload. The Chief Operations Officer stated that the company had already made technical stops in Brazil. According to the Chief of Pilots, the most common complaint of the pilots in relation to international operations was about language problems.

The company, on account of the nature of the activities, could not schedule its flights in advance. The pilots flew 17 days per month, on average. The shifts and schedules were the same as for any FAR 135 operation, sometimes intense, sometimes calm.

This was the first accident involving the company.



### **3.15.2.2.2. Pilot selection and hiring**

The pilots' hiring was made by a Commission, composed of the Director of Operations, the Chief of Pilots and by one of the partners, the Chief Operations Officer of the company. There were no simulator checks during the selective process. Only the pilot's documentation was analyzed.

The company's hiring policy was to try and obtain a good mix of airline, social and civil experience within the group of pilots. According to the Chief Operations Officer, the company needed pilots who were resistant to pressure of influent clients, while, at the same time, were capable of maintaining a close relationship with them. To reach the position of captain, it was necessary to have the abilities for dealing with the clients and the abilities related to flight. The company, in the process of hiring the pilots that were later involved in the accident, had examined their flight history, and had not found any records of accidents and incidents.

### **3.15.2.2.3. Training**

The training was done at the FSI, Simuflight or Bombardier, depending on the equipment. According to the Chief Operations Officer, ExcelAire had transferred all the training to the Simuflight three years before, because Simuflight had done a better job and had not committed errors of documentation, differently from what had occurred with FSI. However, the crew of the N600XL did the training at the FSI, because Embraer had included the training costs in the price of the aircraft purchased by Excelaire.

The company set agreements with the training centers, through contracts that guaranteed all the yearly trainings: refreshers, CRM, international operations, etc.

The CRM training was done at the company and, also, at the simulator. The training for international operations had the duration of one day at the initial training phase, and half a day at refresher trainings. According to the Director of Operations, there were three sources of international training: the classroom, Simuflight and CTS, a 6-hour computer program. At the basic training of doctrine, many educational aids were used, including a computer based training system.

### **3.15.2.2.4. Selection of the pilots for the operation in Brazil**

In special operations, the sector responsible for the pilots' assignment consults with the Director of Operations and the Chief of the Pilots regarding the crew. As a company policy, in the words of the Chief Operating Officer, ExcelAire never assigns two inexperienced pilots to international flights.

As for the criteria used in the selection of the crew for the operation in Brazil, considered a special one, the company informed that the PIC had been requested to be the captain of a client's Legacy and, thus, was assigned for training in the aircraft. The SIC, according to the PIC, had been because the company needed someone experienced in the Embraer aircraft. When the SIC joined the company, he underwent all the initial training at FSI, even if he had already been certified in that type of aircraft. If both of the pilots were approved in this experience, they would become the crew of the client's Legacy. The PIC and SIC would be the leaders of the development of the Legacy program at the company. Upon completion of the training, the pilots were asked to develop a checklist of the procedures for the aircraft.

The pilots were introduced to each other during the training at Flight Safety International (FSI).

#### **3.15.2.2.5. Operation planning**

The company had a dispatch sector. The domestic flight plans were filed through the ARINC, while the international ones were obtained through the Universal or Base OPS. The Flight Safety Agent informed that the flight plans were forwarded to the hotel through the "provider". The pilots neither expected to nor received any direct briefings during the phase of flight planning. They got the flight plan, and did not choose the routing.

It was informed that the captain was responsible for assuring that all operations were in accordance with the prescribed procedures.

In relation to the planning of the operation in Brazil, Excelaire informed that there were no previous discussions at the company about having an Embraer pilot aboard the aircraft on its way back to the United States, because the PIC was experienced in the company's procedures, as well as in international flights, and the SIC knew the aircraft, besides the fact that both of them had worked together as a crew during the training at FSI. Manaus was chosen as a technical stop.

The Chief of the Pilots informed that he was easy about the pilots' conditions for the mission. He said that, in the future, he would rather have the aircraft delivered with Embraer pilots aboard. The Chief Operating Officer informed that it was the first time the company brought an aircraft from a foreign manufacturer, and that now he would like to opt for a delivery made in Florida by Embraer pilots.

It was informed that the passengers on the N600XL did not have functions on board the airplane.

#### **3.15.2.2.6. Training and preparation of the pilots for the operation in Brazil**

The company informed that the SIC had undergone a doctrinal program at the company, with a two or three-day duration, which included a module concerning international procedures. The module consisted of a computer program and a discussion with the company's safety agent. According to the SIC's version, the PIC had trained him in relation to the company's *modus operandi*, including the international procedures.

The training for operating the Legacy was taken in August 2006 at FSI: ground school and simulator (28 hours). The training involved the utilization of the FMS in all simulator exercises. International procedures were not discussed. The differences between the simulator and the Legacy were approached, including the fuel system.

In the training of the communication systems, the SIC stated that the selection of frequencies was made through the RMU, and not through the FMS. There were no requirements concerning which type of equipment had to be used for selecting the radio frequencies.

In the training at FSI, there was at least one TCAS TA/RA scenario, in which they configured both displays at "down", in manual. Differently, in the acceptance flights, the Embraer pilots configured the right-side display at "up" and the left-side one at "down".

After the training, the pilots made a demonstration flight on the Legacy, with the Embraer pilots.

In the preparation of their coming to Brazil, the pilots studied the Jeppesen charts, and planned their return route. The pilot was familiarized with ICAO Annex 2, and had heard about AIP Brasil, but did not manage to find it in the web.

The SIC informed that, after the training at FSI, they started preparing a kit for the trip to Brazil. He mounted a folder which had material about all airports along the route, and reviewed the Jeppesen and ICAO material. This material was carried in his flight suitcase.

#### **3.15.2.2.7. Support systems**

The company did not have the international AIPs. Each aircraft had its own Jeppesen library, which covered all domestic, Canadian and Latin-American operations. The crew had a Travel Kit, to cover the trip back from Brazil. According to the Chief Operating Officer, the pilots, while getting ready for the trip, searched for the AIP Brasil, but could not find it.

The GOM ("General Operations Manual") of the company had a section concerning the PF and PNF attributions. The chief of the pilots thought that there was a section about the formal transfer of control, besides the crew briefings. There was a policy of seat-change, but the pilots have to be approved in the left-hand seat by the Chief of Pilots or by the Director of Operations. The document also specified how the checklists were read, the working journey limits and sterile cockpit below 10,000 feet.

The Flight Safety Agent informed, also, that the procedures for the loss of communication must be in the GOM or in the documents of the aircraft.

#### **3.15.2.2.8. Crew Behavior**

##### **a) Aircraft acceptance and delivery flights at Embraer**

The pilots arrived in Brazil on September 25, and were expecting to return to the United States on the 30. On the September 27, at Embraer, the return trip was advanced to September 29.

Three acceptance flights of the N600XL were made. Two Embraer pilots alternated as captains of the flights.

The first captain had met the pilots the day before the flight. On September 26, he made the first acceptance flight, which lasted 2h31min, according to the cockpit logbook.

As prescribed for the acceptance flights, a briefing was made, in which the Embraer captain pointed out that it would not be an operational "checkup", and that the pilots should not be concerned with either navigation or communication, because such activities could distract them from paying attention on the equipment of the aircraft, which was the focus of the flight. He presented the flight card, with the contents to be checked, the sequences and maneuvers that would be performed. He added that, since the maneuvers were not common in the routine of executive aviation pilots, they were free to decide whether they would make them or not.

The PIC was the first to fly the aircraft, while the SIC stayed in the passengers' cabin. The PIC had already informed that he would not perform the aircraft stall maneuver, but the SIC did it, after taking over the flight.

The Embraer captain said that the two pilots were easy and attentive to what was being checked, but he observed that the PIC was not adapted to the aircraft and, for this reason, he appeared more concerned getting to know it. He said that the PIC seemed to think, before activating a command, and did not move as quickly and automatically as would a pilot more familiarized with the equipment. The SIC, on the other hand, seemed to be better adapted and, thus, more attentive to the aspects of the acceptance flight.

The second Embraer captain affirmed that, on both flights, he took over the function of PNF (Pilot Not Flying), being responsible for communication and navigation. The American pilots took turns flying the aircraft, the SIC on the first flight, and the PIC on the second. The Embraer captain said that the pilots were "OK" and that they did not make any comments in relation to aspects of the flight or the aircraft. He reported that the checklist had been read and that the internal inspection of the aircraft had been extensive.

The ExcelAire pilots told they felt comfortable on the aircraft during the acceptance flights. They said that, on the first flight, there were problems with the control of the avionics, which were not switching off the PFD 1 and the MFD 2. The problem was solved, prior to the second flight. Also, a problem occurred with the anti-ice valve, but it was solved before the third flight. There were problems with the LED lights and with the bank angle indicator.

The Excelaire pilots informed that, when operating the radios during the flights, they utilized the RMU. The Embraer pilots did the radio communications on the acceptance and delivery flights, and the PIC does not remember having seen them tuning the radios through the FMS. They stated that, on the flights made, they utilized the TCAS, which was configured with the right-side display at "up" and the left-side one at "down."

## b) Flight Planning

According to information given by the ExcelAire pilots, Embraer was committed to provide them with the flight plan for the ferry flight.

The Delivery Manager of Embraer, who was assigned with giving support to the ExcelAire team, informed that, on Wednesday, September 27, she was told that the return trip, originally programmed for Saturday, would be advanced to Friday, the same day of the aircraft delivery ceremony. The pilots also advised that they would not fill the flight plan, and, thus, she requested the flight support manager of Embraer to elaborate the planning. The Delivery Manager said that many clients elaborate their own flight plans, through the Universal, while others consult with the dispatch administrator in order to discuss the flight plan. The ExcelAire pilots did not ask for the flight plan to be delivered on the day before the flight, contrary to what many pilots do.

The Flight Support Manager asked the Delivery Manager for the names of the pilots, the over-flight authorization and all pertinent data necessary for the elaboration of the plan (origin, destination, technical stop, type of aircraft and registration number). For the elaboration of the flight plan, he utilized the tool of the Universal, selecting the "best wind route" option.

In relation to the departure time that was chosen, one of the passengers, a Vice-President of the company, told in an interview to NTSB, that the departure time for Manaus was defined as 14:00 local time (17:00 UTC), so that they could fly over the Amazon region during the day.

At the initial interview, the pilots informed that they did not fly on the eve of the day of the accident, having planned the flight back to the United States, in the operational aspect. However, the delivery manager of Embraer informed that, during the initial contacts with ExcelAire, she was told that the PIC who would come to receive the aircraft had a cousin that worked for one of the companies of Embraer. A contact was made with this relative, and both pilots spent the Thursday with him. According to the entrance control of Embraer, the pilots entered the company at 12:34 local time, via gate F42, and, at 14:24 local time, left through gate F90 – Restaurant.

During the period they stayed in São José dos Campos, dinners were programmed for the ExcelAire team, according to the appointment book that was presented by the delivery manager. On Thursday, she attended the dinner, which was special, since it was the eve of the aircraft delivery ceremony. The pilots were present and, at the end, left with the engineer that was assigned to support the aircraft flight operations. The engineer said that, between midnight and 1am of September 29, he had left the pilots at the reception desk of the hotel at which they were staying.

The pilots informed that, on the day of the accident, they woke up at 08:30 am, after sleeping seven hours, and went to Embraer. They said that, after the aircraft delivery ceremony, they did not participate in the festive dinner with the rest of the group, having decided to eat at the manufacturing plant, in order to get ready for the departure.

The pilots got to Embraer at 10:01 am, according to the company's entrance control. The delivery ceremony was scheduled for 11:00 am, and the departure for 02:00 pm. After the end of the ceremony at 12:00-noon, according to information provided by Embraer employees, one of the pilots took part in the festive dinner, while the maintenance personnel dealt with the aircraft pre-flight.

The return from the dinner occurred at 01:15 pm, and the passengers proceeded to the aircraft, while one of the pilots and the Delivery Manager climbed to a room of building F-300, to pick up the flight plan. On that day, the Delivery Manager had already asked the Flight Support Manager to forward the plan by electronic means, and informed that the pilots would not come to his room. Then, she called the Support engineer, asking him to help the pilots to wind up the N600XL weight and balance, and verify the elaboration of the flight plan. The Support engineer asked a fellow engineer to aid the pilots, and went to the flight support office to verify the flight plan. The Flight Support Manager told him that the plan would be ready in 15 minutes. After this period, the Flight Support Manager informed having forwarded it to the Delivery Manager and to the Support engineer himself, by means of the company's intranet. The Flight Support Manager forwarded the file containing the briefing, with a copy of the flight plan, the meteorological information (graphic and non-graphic meteorology), NOTAM and the navigation data.

The Delivery Manager informed that she started to print the flight plan material and, because the amount to be printed was very big, and she had to go to the aircraft, she asked the engineer to hand it to the pilots, upon completion of the weight and balance. Upon her arrival at the aircraft, the passengers asked her to call for the SIC, as they wanted to depart immediately. She went back to the room to advise the SIC that he was being called on by the

passengers. The SIC replied that he still needed some clarifications about the differences of the aircraft fuel system.

The support engineer, while returning from the flight support manager's room to building F-300, came across the SIC and the other engineer calculating the weight and balance of the aircraft. Five minutes later, one of the passengers, an Embraer sales representative in Florida, came to the room and said that the aircraft owner had warned about the importance of finishing the job, in order to comply with the time prescribed for departure. At that moment, the elaboration of aircraft weight and balance was completed, and both the SIC and the sales representative proceeded to the aircraft. At the same time, the Delivery Manager handed a "bunch of papers" to the support engineer, remarking that it was the flight plan, and asked him to hand it in hand to the N600XL crew. The engineer descended immediately to the ramp of building F-300, climbed up the aircraft stairs and handed the papers to the PIC.

The information provided by the pilots differs from what was said by the Embraer employees about the period prior to departure.

At the initial interview conducted by the Psychological Aspect, the SIC said that there was a delay in the delivery of the plan by Embraer, and that he only received it a little before the departure. For this reason, he did not have time to analyze the plan in detail. He also said he took a quick look at the paper and asked a third party to hand it to the PIC, who was already on board. In the interview to NTSB, the PIC reported that both pilots climbed to pick up the flight plan, and added that there was a delay in its delivery, with the pilots having to ask for it repeatedly before it finally came to their hands. He reported that both of them returned to the aircraft and, later on, the PIC sent the SIC back to the delivery manager's room, in order to try and pick up the plan. He also said that he did the pre-flight, while the SIC was still in the Delivery Manager's room, working with the engineers, inserting data in his own lap-top, and that, finally, the Embraer sales representative got the plan and came to hand it to him.

#### c) Preparation for departure

The PIC reported that, before the flight, they had decided to use the Eagle checklist, as the SIC was more familiarized with that tool. He informed that he tested the TCAS, but does not remember the displays during the test. He initialized the FMS, but did not insert the flight plan.

The SIC reported that, upon arriving at the aircraft, he inserted the flight plan with the initial altitude necessary to initialize the program, but he did not program the subsequent climbs and descents, something which he planned to do later on. He pointed out that the FMS was little familiar to him. He compared it to a new radio in a car, with which one has to be more prudent as to what one presses, to not hit something inadvertently. He stressed that he felt comfortable using the FMS, within his needs, but that he felt more comfortable using the previous system, of the American Eagle.

The SIC also reported that the checking of the TCAS was performed a little before they entered the runway. The TCAS was in TA/RA, in the manual mode. In this mode, the TCAS display only appears on the MFD when the TCAS button is selected in the control of the MFD. When the TCAS page is presented on the MFD, other pages, including the system pages, are blocked, but can be selected if necessary.

The TCAS system has another option for selection called AUTO. If AUTO is selected through the RMU option, then the TCAS page will appear automatically whenever a Traffic Alert (TA) or Advisory Alert (RA) occurs.

Independently of the mode selected (MANUAL or AUTO), the message and sound alerts will be annunciated to the crew, and the PFDs will show the correct directions for the adequate adjustment of the flight path.

The SIV affirmed that the TCAS had been set in the least sensitive mode, because a display climbing and descending could be a source of distractions.

The pilots configured the TCAS with the displays at "down" (thus, not appearing on the MFD), because both of them wanted to monitor the fuel consumption. The SIC said that, since they were flying over a very remote region, he wanted to monitor the fuel, in order to confirm its transference.

The passengers got to the aircraft at 01:45 pm, but were advised that the takeoff had to be delayed, because the flight plan had had a delay. The pilots, according to one of the passengers, did not seem pressed for time or bothered, as delays are part of the charter operations nature.

There was no briefing for the passengers before departure, because the PIC regarded everyone as members of the company. However, he stressed that the briefing is a requirement of the company's General Operations Manual.

According to information provided by Embraer employees, the aircraft refueling had a delay, and the pilots stayed 40 more minutes in the cockpit. The aircraft was refueled with all passengers on board, and the takeoff occurred at 02:52 pm (17:52 UTC).

#### d) Clearance

The clearance was received while the aircraft was taxiing. In an interview to NTSB, the pilots commented that this was normal in the United States, although not being the best way, since it could generate an overload of tasks.

The clearance was reviewed and compared with the data within the FMS. There was not any change, except for the addition of the departure.

According to the SIC, the controller transmitted the "clearance" for FL370, destination Eduardo Gomes, but omitted the initial altitude. The co-pilot questioned the controller about that, but noticed that there would not be any answer. They passed to the control of the Tower, which confirmed that FL080 would be the level after departure.

The PIC said that the non-standard altitude given by ATC is not uncommon: "it is done all the time. Since the ATC informed 37,000 feet, that was our altitude". The SIC said the same, adding that they were en-route, with radar contact, and that they never expected a change from the ATC. He added that the clearance sounded correct: he was cleared to Manaus at FL370, and understood that he was to maintain this altitude up to the destination, unless otherwise directed later on.

In the initial interview, the pilots reported that, in the United States, when under radar monitoring, "there is not the custom" of asking for any change of level without the request of the control.

## e) During the flight

The SIC was responsible for the radio, and used the radio-2 for communication, operating the RMU on his side to change the frequencies. He stated that there were no changes in the Transponder, since they maintained the same code throughout the flight.

In an interview to NTSB, the PIC said that it is a task of the PF to monitor the aircraft and the navigation, while the tasks of the PNF were to operate the radios and to monitor the navigation. Both pilots can help each other with the communication, whenever necessary.

During the flight, the PIC understood the ATC, but reported that sometimes he experienced difficulties with the ATC use of the English language. At some points, the communication was poor, with echoes, a factor that bothered them. The SIC learned a little of Spanish with his family (his father is Argentinean, and his mother is Spaniard), but said that it is difficult for him to understand Portuguese through the radios. He stated that some frequencies were clear and some were not, and that he could hear Portuguese in the background.

The SIC said that he did not look at the TCAS display during the flight. It was not the TCAS that was selected in the display, but the fuel.

The pilots made use of the laptop during the flight, in order to analyze the airports and runways along the route. They said that the laptop, when being used, remained on top of the lap of this or that crew member, but never "supported" on the central console of the aircraft or on the pedestal. The SIC compared the data contained in the printed analysis that was prepared on the day before, with the results obtained in the laptop.

They said that the passengers who came to the cockpit did not sit on the jump seat, but kneeled, and that they did not distract the pilots.

At 18:34 UTC, the ACC BS made this request to N600XL: "*squawk ident, radar surveillance, radar contact*".

At 18:51 UTC, there was a new request from ACC BS for the aircraft to squawk IDENT, and, in the CVR, the following comment is heard: "Oh, (f.....)... *I forgot to do that! I think I did it*".

At 18:57:54 UTC, N600XL joined airway UZ6, without requesting or receiving any instruction from the ACC BS as to descend to level 360. The pilots reported that in the United States it is not the custom for the pilot to ask for a level change without being requested by the control. Since they were under Radar Surveillance (Radar Monitoring), they did not get aware of this need.

At 19:02 UTC, when the ACC BS stopped receiving the transponder signal from the aircraft, the N600XL crewmembers were discussing parameters of the departure from Manaus, and had a laptop open in the cockpit.

The SIC said that he believed that the radios were functioning all the time, and that he did not notice any kind of uncomfortable silence. Between 18:51 UTC and 19:26 UTC, there was no attempt to make contacts, either by N600XL or by ACC BS.

The PIC went to the lavatory and returned to the cockpit 16 minutes later, one minute before the impact. When the PIC returned, the SIC was trying to make contact with the air traffic control.



The SIC reported that he tried to contact the ATC, because he noticed that they were getting near the FIR limits, and he got concerned with the delay of the control to call the aircraft, so he decided to question them. When, at 19:39 UTC, the PIC left him alone in the cockpit, he looked at several frequencies in his chart, and decided to question ATC. He soon discovered that there was a problem, and started to call on all frequencies systematically. At 19:48 UTC, the N600XL started a series of twelve calls to the ACC BS. Finally, at 19:53 UTC, he received a message transmitted in the blind by the ACC BS, but it sounded as if there was no urgency in his voice. The controller just asked him to change the frequency. The SIC did not understand the decimals, and tried to clarify with the control, but there was no reply. Starting at 19:54 UTC, the N600XL made 7 more calls to ACC BS. At 19:55:46 UTC, the PIC returned to the cockpit and was told by the SIC that they were facing problems with the radio: "I got a radio problem here." In an interview to NTSB, he said that he did not feel as if he had lost communication, since he had a radio functioning, he could hear the transmissions, and found a frequency which worked. He said that, even if the radios failed, there still was the HF, and the satellite telephone.

In his attempts to communicate, the SIC used both radios. He thought that there could be a transmission problem, so he called on each frequency, first in the right-hand side radio, then in the left-hand side one. He did not use the HF.

As during that part of the flight the sun was ahead, the captain was wearing dark glasses, and a transparent protection screen was extended in front of him. He said he did not believe he would be able to see the other aircraft.

#### f) Collision and post-collision

The collision occurred at 19:56:54 UTC, and the first sign of abnormality in the cockpit was a heavy impact. The autopilot disconnected without having been commanded, and the aircraft started to roll. The PIC immediately grabbed the controls, recovered the control of the aircraft and kept it flying.

At 19:57:36 UTC, the SIC asked the PIC whether he wanted him to fly the aircraft, and received an affirmative answer. The PIC reported that he passed the control of the aircraft to the co-pilot, because the SIC had more flight experience in the aircraft. He also told the passengers to remain seated. From that moment on, his immediate objective was to lower the aircraft and look for a place to land. According to the SIC, the company directive establishes that the transference of control of the aircraft is at the discretion of the PIC.

The ExcelAire Director of Maintenance came to the cockpit and informed the pilots that the aircraft had lost part of the winglets. In the CVR transcript, it is observed that the crew, during the emergency, exchanged information about the procedures, place to land, reestablishment of communications, and damages sustained by the aircraft, besides questioning about what had happened and what they had hit.

They decided to proceed directly to the first aerodrome, and the PIC inserted it in the FMS. The aircraft was descending with no clearance. They transmitted in blind that the aircraft had a structural problem and that it was not able to maneuver. The PIC took over the radio-2, but the co-pilot helped him with his radio-1, by using the button on the yoke. He did not use the HF. The Captain used radio-1 to make the emergency calls, and the RMU to try a contact on the frequency 121.5 MHz. He managed to make contact with a Polar Air Cargo aircraft at 20:01 UTC, and at 20:22 UTC with the Control Tower of SBCC.

There was difficulty confirming the runway length with the ATC, but when they had the airport in sight, they agreed to land. The SIC decided not to use the flaps and proceed for a high-speed landing. The Embraer sales representative in Florida, a former jet pilot, who was helping the SIC to monitor the aircraft speed after the collision, was sent back to the cabin so as to prepare the passengers for the landing and evacuation, in case the pilots got incapacitated.

In an interview to NTSB, the crew stated not having changed the Transponder configuration after the collision, and that they did not alter the TCAS status. It can be observed in the CVR that, at 19:59:13 UTC, the SIC asked the PIC whether the TCAS was operating: "*dude, is the TCAS on?*" The PIC replied: "*Yes, the TCAS is off*". Soon after this conversation, at 19:59:47 UTC, the signal of the Transponder started to be received again by the control units. The Captain affirmed that, after the impact, he verified that the TCAS was not off: he did not see the PFD status; he remembered that the VSI was "blank", and that nothing in the display indicated the non-functioning. He also said that his answer ("no") was in relation to the display of the TCAS in the MFD, and that the TCAS had never been off.

The PIC reported that he put the code 7700 in the transponder, via RMU, and that he did not notice anything abnormal. According to him, in the RMU, he saw that the TCAS was in the TA/RA mode.

According to the CVR, at 19:59:47 UTC, the crew reactivated the transponder with the previous code 4574 and soon changed to code 7700.

After the landing of the N600XL, the Commander of CINDACTA IV made a contact with the pilots in SBCC, and asked them whether the transponder was on, and at which flight level they were flying. Their answer was YES, at flight level 370.

### **3.15.2.2.9. Comments on aspects related to the accident (by Excelaire)**

The Excelaire Flight Safety Agent stated that he defends the monitoring of the air-to-air frequencies so as to maintain the situational awareness in more remote regions, and that, generally, one of the pilots in the crew must be experienced in the route. In relation to the international procedures and loss of communication, he said that, after flying for more than 20 minutes without hearing anything, or when one is at the sector limit, one must verify about the existence of radio problems. However, when one hears other transmissions, there is nothing to be done. There was no "feedback" from company pilots about South America, because nobody had flown in the region before. He added that there were not records in the company about the pilots' international flights.

Based on the discussions about the CVR, the Chief of Pilots said that it was not exactly what he would be expecting from the pilots, in terms of performance, which seemed to be very informal and not professional. The Chief Operations Officer said that the pilots seemed to be much less qualified than they really are, and that, in the future, he is going to use the CVR as an aid for instruction, because the pilots must keep themselves fully professional at all times, and maintain a sterile environment in the cockpit.

### **3.15.2.3 EMBRAER**

#### **3.15.2.3.1. Organizational structure**

EMBRAER is an enterprise whose shares are traded in the Brazilian and American stock markets, and deals in the fields of Commercial, Executive, Defense and Government Aviation. Its administration is composed of an Administrative Council and a Statutory Directorship, composed of a Director-President and Vice-Presidents, each one with a specific focus and specific responsibilities.

EMBRAER works with documented processes and certified products. The area of Support Engineering monitors the product, and the area of Flight Safety participates in the process of monitoring the safety of the product. It has regional offices for the expediting of the related actions. These offices interact with the Flight Safety Agents of the clients and with the investigation authorities of each region.

The company works with flight safety internal committees, with the participation of safety technical representatives, most of them graduated as Flight Safety Agents by the CENIPA. The operational issues are dealt with by the agents in their areas, and the occurrences as well as the related actions are reported by the agents to the area of Flight Safety. The corporate activities of the company in terms of Flight Safety are documented in specific norms, such as the one that regulates the Embraer Flight Safety Program (PSVE), which is similar to the PPAA.

In relation to the N600XL process of quality, it was reported, as it can be confirmed, that the product was tested, approved and accepted by the client. All the airplanes are flown by specific pilots of the operations group. The flights are known as "production flights", because they are part of the productive process, and are conducted after authorization of the sector responsible for the quality. After the last production flight, the aircraft is ready for the acceptance and delivery flights.

#### **3.15.2.3.2. The planning of the N600XL delivery**

According to information provided by the Delivery Manager responsible for the N600XL, the aircraft delivery coordination includes, for each client, an engineer, a manager, and a delivery official. In the case of the N600XL delivery, her participation began after the signing of the contract, one or two months before the receipt.

According to her, ExcelAire had received another aircraft before, and the company Director of Maintenance had participated in the first delivery of a Legacy aircraft, which had been made by Embraer pilots at Fort Lauderdale, in February 2006.

For this second delivery, conference calls were made every week, in the period of a month, in order to plan the aircraft receipt details. For the first time, the participation of a journalist in the process was authorized. In relation to the ferry flight, ExcelAire informed that the involvement of Embraer pilots would not be necessary, since Excelaire had their own experienced and trained pilots available.

The schedule of the activities related to process of delivery is defined with the clients in advance, and forwarded to the several Embraer sectors that are involved.

She reported that the “start-up” of the pilots with the operation engineering personnel was programmed for Monday, Tuesday and Wednesday, when they would get in touch with the flight aids software. The acceptance flights were made on Tuesday and Wednesday.

She informed that the Excelaire Director of Maintenance was the inspector of the aircraft, and responsible for the formal acceptance and for the documentation of the aircraft (upon arriving at Embraer, the client has all the documentation at his disposal for analysis: logbooks, manuals, maintenance records). His routine was separated from the pilots', because his task was to inspect the aircraft and the papers, while the pilots complied with their own routine in the area of operations engineering.

She informed that, during the delivery process, the main focus of discussion was in relation to the cockpit internal lighting, and Embraer ended up signing an agreement letter, undertaking to solve the question.

### **3.15.2.3.3. Acceptance and Delivery Flights**

The acceptance and delivery flights for the client are made in the testing area, and have a specific protocol. Embraer suggests a one-hour-and-a-half flight with the team of pilots (testing pilots and pilots dedicated to the support of the client). However, the receipt card is discussed with the client on the occasion of the elaboration of the contract. Some clients want more tests than those prescribed, on account of their operation specificities.

The clients may refuse to perform a procedure suggested in the protocol, or they may want that the Embraer pilots fly the aircraft during fifteen days, for example. Some just make a short flight, because they already know the equipment and the manufacturer, due to having purchased other aircraft before.

In summary, the protocol is just a suggestion, with a basic standard for each type of aircraft, and the definition of the acceptance flights is at the client's discretion. From this phase on, the client is already accepting the responsibility for the aircraft.

The Embraer Test-Flight sector receives the aircraft receipt card and holds a briefing with the pilots of the company that is buying the aircraft. There is also the option of the airplane to be delivered by Embraer pilots at the final destination.

The routine of the acceptance flights includes the transporting of the team from the hotel to a delivery room of Embraer (usually at 08:00 am), where they stay the whole day, working on the verification of the documentation and specific needs. By and large, the first step in the acceptance process is the “introduction” of the aircraft software to the pilots. The weight and balance is verified, and the airplane physical analysis is performed. After this stage, the acceptance flight is conducted, and one or two days are set aside for an eventual trouble-shooting.

Then, one more day is necessary for the delivery ceremony. Thus, it is necessary that the period of stay at Embraer be flexible in relation to the date of return.

As for the N600XL, the whole process prescribed for acceptance flights was complied with.

#### **3.15.2.3.4. Elaboration of flight plans at EMBRAER**

According to information provided, EMBRAER does not do the planning of the flights of the companies receiving the aircraft, but acts as a “facilitator”, giving support to the clients through the operational flight support. Several clients use the services of firms certified for the provision of services within the aviation world. These firms elaborate flight plans, and take care of a range of subjects, from refueling to catering.

The professional who obtained the flight plan of the N600XL for the pilots by means of the Universal provider, had been working for five years at Embraer, and possessed a 20-year experience in the field. He was qualified in 1990 and had worked for the VASP and TRANSBRASIL airline companies.

In an interview, he informed that his responsibility was to support the flight activities of Embraer, and that he did not have to support the activities of other clients, except, perhaps, as a concession or courtesy.

He said that for the function of Flight Support Manager, Embraer required a professional formation in Operational Flight Dispatch (DOV, in Portuguese). However, ever since he joined Embraer, his license had not been renewed, and he justified the fact, arguing that he did not work as a DOV. Nonetheless, it was observed that the interviewee filed the N600XL flight plan with his ANAC code, although his DOV license had expired.

The IQCH was the document which regulated his activities at Embraer. It contained the necessary competencies, attitudes and knowledge, that is, the requirements to work in the function. According to information provided by him, the responsibilities were defined in generic terms, but the activity of flight planning was implied.

The interviewee worked in a section with nine people, each one of them performing flight support management activities. Four people performed that function, which was concerned with the planning of the flights pertaining to Embraer. The updating of these professionals is made by means of technical publications and eventual courses on the products at the company (flight support related software's, such as weight and balance).

He affirmed that he was not totally familiarized with the RBHA 065, and that the responsibilities of the flight dispatcher were in RBHA 121. In the period he worked for the airline companies, his job was based on the specific MGO of the company.

In his interview, the professional informed that there was a structure to meet the needs of the flights operated by Embraer: demonstration, administrative and ferry flights. The companies that come to pick up the aircraft generally either have a structure of their own or utilize the resources of Embraer, sometimes just meteorological information, indication of sector, airport infrastructure, etc. According to him, 90% of the clients elaborated their own flight plans.

Embraer had the following resources:

- Rede MET (DECEA's meteorological network for METARs, charts, TAFs);
- AIS Office at Gavião Peixoto - GPX (telephone and e-mail);
- Internet with access to site of the Universal; and
- CCAM.

When questioned about the reason why he did not use the AIS Office of São José dos Campos, he reported that he had already received a chart that did not provide information about volcanic ashes in the Caribbean.

According to him, the chart received from Universal displayed all kinds of information. For the flights in Brazil, he used the “*rede MET*”, although not for international flights, because those charts were out of date.

He explained that the Universal flight plan system is a kind of software that generates the product as a result of the insertion of the aircraft performance data. It is an “application program” with a friendly interface, with electronic forms filled in with origin and destination. It presents the option of plotting the route or not. The flight support manager did it manually, when the flight was in a period in which the NOTAM was restricted. He added that “manually, only on special occasions, so as not to disregard certain phenomena or situations”. In international operations, he utilized the resources of the Universal, which could forward the remote flight plan.

The traditional method (telephone or fax) was utilized for contact with the São José AIS Office. When the telephone was busy, he transmitted the plan via fax, or to the GPX, which retransmitted it to the system. Later, the Flight Support Manager informed that the GPX does not send the plan directly to the system, but, in fact, to the São José AIS Office.

The flight plan is forwarded electronically. The quality control occurs effected when the AIS Office verifies the data; in addition, there is the “sieve of the crew”.

When questioned about the reason of not using the São José AIS Office, he declared that this was on account of the difficulties of communication with foreign pilots, besides the distance and problems to access the room.

About the questionings of the problems that could arise from the fact that the pilots do not go to the AIS Office, he said that it is not possible to know whether the pilot had a briefing or whether he received the necessary information in the AIS Office and, besides, when the plan is delivered via fax or telephone, there are no guaranties that the pilot has had access to the necessary information, either.

He informed that he seldom has an interface with the clients and that the delivery managers generally make the contacts and can request a briefing. The delivery managers belong to a sector of the company that deals with the clients directly and gathers all their needs, so as to guarantee they are met and, within a pre-set protocol, they deal directly with the clients.

### **3.15.2.3.5. The N600XL Flight Plan**

The process concerning the elaboration of the N600XL flight plan is described in the item 3.15.2.2.8, letter b, of this report.

As for the flight plan itself, the Report no. 02/SO3, dated October 9, 2006, written by request of the Chief of SIPACEA of CINDACTA I, reads that “the cruise speed presented in the initial flight plan, which was of N0452 (four hundred and fifty two knots) was transmitted as N0540 (five hundred and forty knots)”. In addition, he points out that “the messages transmitted by the AIS Offices of Gavião Peixoto and São José contained errors of address and message transmission in the initial flight planning that was made by the flight safety

sector of Embraer”, because neither the address of CODA and COPM, nor the FIRs in which the aircraft was to fly included, as prescribed by ICA 100-15, item 6.2.1, sub item 6.2.1.1.

In a visit of Embraer, it was evidenced that the flight plan was correctly filled in by the flight support manager and flight support administrator, and that the aircraft speed was incorrectly typed at GPX.

Another important aspect that is cited in the report: “it is not possible to affirm, based on the information available, whether the flight support manager and flight support administrator participated in the process of flight planning, with the presentation of a briefing of NOTAMs and meteorological conditions along the route to the pilots”.

In its final considerations, the report reads that “it is necessary to have evidence of the provision of information concerning the NOTAMs relevant for the intended flight, by means of a Prior to Flight Information Bulletin (PIB) and of verbal instruction as established by the legislation of the Brazilian AIS”.

Embraer presented a copy of the e-mail forwarded by the flight support manager and flight support administrator to the delivery manager. It contained the meteorological information, NOTAM and flight plan. However, it became evident that there were no verbal instructions for the pilots.

It was also observed that the permit to function of the EPTA of GPX had expired on August 5, 2005. Although EMBRAER had requested for a renewal of the permit, there were pending issues without solution up to the date of the accident. Thus, the EPTA continued to access the system, in spite of the expired permit.

#### **3.15.2.4. DTCEA-SJ**

##### **3.15.2.4.1. Organizational structure**

The structure of the DTCEA-SJ consists of the Command and the following subordinate Sections: Administrative, Technical and Operational. The Air Traffic Controllers, the AIS operators, the weather men and the personnel of communications are under the jurisdiction of the Operational Section.

It is a Class 2 Detachment, as it does not have a radar controlled APP. It is commanded by a Captain or a Lieutenant.

##### **3.15.2.4.2. Work organization**

###### **a) AIS Office**

The AIS Office of the DTCEA-SJ was classified as category C, with a work volume of about 1,200 movements per month.

The AIS Office operators receive the flight plans and notifications, address them to the recipients, update the publications and manuals belonging to the AIS Office and to the Tower (whose alterations have to be made monthly), and receive the NOTAMs, which, lots of times, provide information concerning the flight charts, which have to be updated on a daily basis (when there is a lot of information, they select those pieces which are of local interest).

The flight plans may be received via telephone or fax, and there is not a need or an obligation for the pilots to go to the AIS Office. It is sufficient to write the DAC code of the pilot. The operator verifies whether the plan was filled in correctly and if the information contained therein is accurate. In case the pilot needs information about the meteorological conditions or about NOTAMs, he is asked to make the call using another telephone available, so as not to use the one that does the recordings. The plan receives the address of the units that will need the information and of the sector of communications which will transmit it.

The flight plans may be elaborated in other countries and be sent to Sao José AIS Office or Tower via AFTN. A few companies send them to São José, while other ones prefer to forward them to ACC BS. When there are errors in the plans, these are sent back, with indications for correction, as well as a contact telephone. Some foreign companies have agreements with Brazilian companies which are contacted in order to help correct the flight plans. The errors are more frequent in the plans elaborated by foreign companies which are used to operating with a standard different from the ICAO's. The most common errors are: indication of climb procedures, fixes and airways that have been altered, charts which are out of date, and a fail to request the diplomatic over-flight authorization. When the operators know that it is an Embraer flight, they call the company and ask about the diplomatic over-flight authorization.

The controller that was in the TWR position, during the shift in which the departure of N600XL took place, cited that some plans of foreign operators got in with wrong recipients or routes. There were companies which were Embraer's clients, whose plans came directly from the United States to the flight plan system, sometimes with an incorrect recipient or route. As a result, the controllers could not find the flight plan and, as the plans would only enter the system forty minutes before ETD, this fact was perceived at a moment very close to the estimated time of the flight. The pilots pressed the Tower to let them go, and the controllers called up Embraer, advising that the ATC cannot grant takeoff clearance. This factor is regarded as one that adds an unnecessary overload to the operators' routine.

The flight plans of Embraer testing flights and delivery flights were not elaborated in the AIS Office, but rather in Gavião Peixoto, where there was an aeronautical station managed by Embraer, which has a flight plan system that utilizes an exclusive recording telephone, whose number is in the ROTAER. The flight plans elaborated at Embraer were filled in correctly. The pilots of these flights never came to the AIS Office, especially if they were from other countries.

There were three work shifts: morning, 07:00h through 13:30h; afternoon, 13:30h through 21:30h; and night, 21:30h through 07:00h, followed by two days off. In each turn, there was only one operator in the AIS Office.

#### b) Control Tower

The service at the Tower was provided by controllers qualified for TWR and APP positions. There were five working teams, each one with, at least, three operators. In holiday periods or when there were courses being taken, there was difficulty manning the shifts. The shifts were the same as the ones of the AIS Office: morning, 07:00h through 13:30h; afternoon, 13:30h through 21:30h; and night, 21:30h through 07:00h, followed by two days off. As prescribed by MMA 130, the monthly work hours must be between 144 and 168. The civilians, by virtue of a judicial decision, had a maximum of 120 hours. The average was 18 shifts a month per controller and the number of monthly hours varied, on account of the



different duration of the shifts. There was an average of six overnight shifts per month for each team.

Because it was a small location which, normally, has little traffic, the work concentrated in the Control Tower, in its three positions: Ground (GND), which deals with taxi approval and clearance delivery: Tower (TWR) responsible for takeoffs and landings: and Approach Control (APP), which guides aircraft climb and descent procedures. The controllers themselves decided between them which position to take over when they started duty, as well as how the rotation between them would take place, since the teams did not have a supervisor. The respite period of the operators usually occurred when they occupied the GND position.

The work involved a lot of telephone and radio coordination, especially with Embraer, with a resulting accumulation of communications at the GND position. Thus, the same operator took over the functions of GND and Clearance Delivery. The APP covered the entire testing area, plus the CTR SJ (30 NM). The TWR position activities sometimes got more intense, when the flights required repeated touch-and-go landings. Although the volume of traffic was usually not intense, the diversity of aircraft and the maneuvers of the controlled flights in the SJ area demanded experience and preparedness from the controllers, especially at the APP and TWR positions. Besides, there were times in the year in which the volume of traffic increased (delivery of aircraft by Embraer, Testing-Flight Course, winter festival in Campos de Jordão, eve of holidays) in which the workload of the controllers increased.

The Control Tower had radar visualization, but the operation was procedural, that is, the controllers could not give vectors to the flights, and they worked with the information provided by the pilots. The radar information could not be used for provision of air traffic control service, because the equipment did not comply with the proper technical requirements.

The activities developed at the DTCEA may be summarized as follows:

- 1) The AIS Office operator (by means of telephone) forwards the flight plan to the GND operator, who jots it down.
- 2) The pilot, when the aircraft is ready for departure, calls GND through the radio, and requests the clearance, as well as the flight conditions.
- 3) The GND calls up CINDACTA and requests the clearance.
- 4) When the pilot requests taxi, the GND relays to him the clearance provided by CINDACTA, and gives him the frequency on which to contact the TWR.
- 5) The pilot calls TWR, and requests takeoff clearance.
- 6) After the aircraft takeoff, the TWR informs the APP frequency to the pilot.
- 7) The APP takes over control of the aircraft, and guides the pilot up to the moment the aircraft is handed off to the control of CINDACTA.

### 3.15.2.4.3. Personnel

The DTCEA–SJ personnel consist of 74 professionals, while the number prescribed by the TDP is 80 military people in total, including 20 controllers. The team of controllers at the time of the accident had 21 ATCO's, being 16 in the shifts, 1 in special leave, 2 out of the shifts, and 1 on holiday.

The team of controllers is made up of rather senior professionals, with only two Third Sergeants, and there has not been a significant renewal over the last years.

It was observed that there was a significant demand for proficiency in the English language, mainly focusing on expressions relative to the testing flights and on conversations not within the standard phraseology. As for the flight safety area, the person responsible for the development of the activities in the Detachment (OCEA) took up a course at CENIPA in 1984.

The Commander of the Detachment was a Specialist Officer, from the area of Electronics. Upon completion of the EAOF in 2001, he was assigned to DTCEA-SJ, where he took over the chieftainship of the Technical Section. In September 2006, he was designated for the Command of the Detachment.

The Chief of the Operational Section graduated in 1976, and served eight years at the Tower of the Air Force Academy; 10 years in the Instruction Section of the SRPV-RJ, elaborating tests and teaching classes; 5 years in the Operational Division of the SRPV-RJ, preparing manuals; and, 3 years at the Galeão Tower. In 2004, he did the EAOF and, in 2005, reported to the DTCEA-SJ. In summary, of the 30 years on active duty, he worked operationally for 13 years, in a discontinuous manner. His responsibility related to the four operational areas of the Detachment (ATC, AIS, MET, COMM), although, as he pointed out, with three of them he only had a superficial contact along his career. In the capacity of OCEA, he made incident investigations and wrote the preliminary reports.

### 3.15.2.4.4. The day of the accident

The AIS operator reported that the N600XL flight plan arrived by means of a transmission sent by Gavião Peixoto (GPX), via the CCAM fixed system. He verified the routes and fixes, and observed that the plan was filled in correctly. He included the address of SBBS, APP SP, and Eduardo Gomes TWR.

The SGTC system sends the flight plan to the Tower, via printer. The operator is not certain whether it was himself or the Communications specialist who forwarded the N600XL flight plan to the Tower. He said that when the Tower receives the "strip" from Brasilia, it comes without the route. When there is not a route, the Tower controllers call up the AIS Office. In the case of N600XL, the flight plan was transmitted to the Tower, via telephone.

The controller on duty at the Ground position (GND) in the afternoon shift knew that an INFRAERO simulated training, with a focus on aerodrome accidents, was programmed for 14:00 local time. There would be the involvement of a Bandeirante aircraft, two helicopters, Fire Brigade vehicles and an ambulance. Consequently, there were many aircraft and vehicles using the taxiways, a situation that increased the workload of the Tower positions. The simulation ended at 15:00 local time.

The GND received all the data concerning the N600XL flight plan from the AIS Office. The operator wrote these data on a flight progress strip. The flight plan was also received via electronic means (SGTC), but the route was incomplete, as it always happens when the itinerary of the flight covers a long distance. It just contained "level 370 DCT PCL UWZ".

The first contact of the N600XL with the GND was from the ramp of Embraer, at 17:25 UTC. On the frequency of GND, the pilot requested the operational conditions of the aerodrome. The GND operator informed the ceiling, visibility and runway in use. Later, the operator said that he understood the communication of the pilot well but, as there were other people talking at the work place (two controllers were in the Tower, helping with the coordination of the vehicles during the simulation), he experienced some difficulty communicating. Then, he waited until the aircraft requested clearance to startup the engines. In the meantime, the GND operator made contact with ACC BS, asking for the flight plan clearance.

As already seen, the IFR clearance transmitted by the ACC BS to the SJ GND, and by the SJ GND to the N600XL was not complete.

The GND said that, later on, when reading the transcription of the communications with N600XL, he noticed that the pilot did not understand "Poços de Caldas". He said that the phraseology allows two forms of communication: "Poços de Caldas" or "PCL radio beacon". Nevertheless, the pilot accepted the instruction, having not insisted with the GND, who, then, informed of Oren departure, transition Poços de Caldas, transponder code, and frequency to call Brasilia Center. Subsequently, he asked the pilot to report when ready for departure. As he had an extra takeoff instruction (restriction of level 80 after departure, so as to prevent conflict with the shuttle flights in Sao Paulo), he called N600XL twice, getting no reply. Thinking that the pilot might already be on the frequency of the Tower, he called him on that frequency, now successfully. He instructed the aircraft to climb initially, after takeoff, to level 080. The pilot read back, and that was the last contact of GND with the aircraft. The GND emphasized not having experienced any difficulty communicating or understanding in his contacts with N600XL.

Soon after the takeoff, the GND contacted the sector 3 of São Paulo APP, on account of an operational agreement, which establishes that coordination is required between the two agencies, whenever there is an aircraft taking off to the North Sector, the same heading of N600XL (confluence between aircraft departing from São José and Texas departure to the north of São Paulo). Depending on the situation, it may be necessary to transfer the aircraft first to the APP-SP and then to the Brasilia Center. The control in São Paulo informed that the aircraft could climb up to the level 200. The instruction was transmitted by the GND to the APP, who would relay it to the pilot.

The controller that took over the TWR position during the shift in question said that it was a Friday, a calm day in terms of traffic. There was an accident simulation at the aerodrome with the INFRAERO personnel, but without air traffic. When N600XL called TWR, the aircraft was given clearance to line up and take off, because there were no aircraft arriving. The pilot read back the instruction, passed the departure threshold and, then, informed the time of departure, as well as the APP frequency. She thinks that the pilot read back and said 'good-afternoon'.

The controller who took over the APP position said that, on arriving at the Tower, the environment was a little busy at the TWR and GND positions, on account of the INFRAERO simulation. However, the APP position was calm. After the takeoff of the N600XL, he gave

instructions regarding the climb of the aircraft, with the restrictions mentioned earlier. He said it was easy to understand the English spoken by the pilot, and that he even believed that it could be an EMBRAER pilot. Later, he cancelled the restrictions, but São Paulo control called, saying that there was another restriction of level. He transmitted the new restriction at level 200 to the pilot, and asked him to report when crossing level 110. At this point, he instructed the pilot to continue climb to level 200 and to call Brasilia.

#### **3.15.2.4.5. Flight clearances**

As for the flight clearances, the TWR operator interviewed said that they have to contain the destination, the level and the "SID" (departure procedure). She added that sometimes the route is informed but, considering that it is implied in the airway, this information is not transmitted. She also declared that, due to the fact that the distance from the ramp to the threshold of runway 15 is short, the pieces of information have to be transmitted quickly, because when the transmission of the clearance is completed, the aircraft is already in position for takeoff.

The APP operator interviewed said that the standard of the clearances delivered by Brasilia include only destination, heading and level. Regulations prescribe that the entire route has to be informed, including the level change. But the clearance is received from Brasilia in that manner, and he believes the reason is that a sector may not have a complete clearance. It would be necessary that three sectors of the ACC issued the flight plan clearance, and, even so, many alterations could occur along the itinerary of the aircraft. He added that a complete clearance could delay the clearance, as well as the taxi and departure. Besides, she said that "flight is dynamic, lots of things may change and it could be useless to issue a complete clearance". She also stated that, in São José, one cannot add anything to what is in the clearance issued by Brasilia, and the only one who could question the clearance was the pilot.

Another interviewee, a controller that was in the Tower on the day of the accident, assisting with the communications of the simulation coordinated by INFRAERO, reported that the clearance is always partial, containing the level, airway and "direction". He thinks that it would be unproductive to inform the whole route, since it could be implied that no alterations would occur along the "itinerary". The partial clearance concerns only the first sector, which is independent, differently from the other sectors. The pilot may ask for further information, and São José control has to contact Brasilia, in order to get it. He said that it is not common to request the whole route, and that even foreign pilots do not do it.

The Chief of the Operational Section said that he did not see anything abnormal in the clearance: "it was within the standard, everybody works that way; he retransmitted the clearance and covered all the instructions". He added that the clearance always comes in that standard, and that he did not know of any complaints from the pilots regarding the clearances.

It must be pointed out that, when the CIAA visited São José Tower, there was a notice posted on the console and signed by an ATC enlisted, informing that a coordination had been made with Brasilia Center, concerning a limit for the flight clearance, and the following example was given: "PT-XJO, cleared to FZ, flight level 370, via UW13, approved limit, Varginha radio beacon".

During the visit of DTCEA-SJ, the CIAA requested transcripts of the clearances transmitted by that control unit for long distance flights, with dates prior to the day of the accident, with the purpose of verifying the standard of the clearances.

The DTCEA provided a transcript, dated December 12, 2004, stating that it was the only one in the files, since the tapes earlier than September 29, 2006 had already been erased for having reached the time limit for their re-utilization, as established by the CIRTRAF 100-7, August 5, 2004, sub items 3.1.2 e 3.1.3.

The clearance is the following:

“GNDC: ÍNDIA UISQUI PAPA, CLEAR TO RECIFE, FLIGHT LEVEL THREE SEVEN ZERO, AFTER TAKE OFF RUNWAY ONE FIVE, TURN RIGHT PINO DEPARTURE, PAPA ÍNDIA NOVEMBER OSCAR, PINO DEPARTURE AND THERE IS A RESTRAINT FLIGHT LEVEL ZERO EIGHT ZERO UNTIL PINO INTERSECTION, (ININTELIGÍVEL) VICTOR GOLF OTEL, VARGINHA TRANSITION, SQWAK FOUR SIX THREE SIX AND AFTER FREQUENCY OF SÃO JOSÉ TOWER ONE ONE EIGHT DECIMAL FIVE AND AFTER DEPARTURE ONE ONE NINE POINT TWO FIVE AND AFTER BRASILIA CENTER ONE TWO EIGHT DECIMAL FIVE OR ONE TWO SIX POINT ONE FIVE. ÍNDIA UISQUE PAPA.”

#### **3.15.2.4.6. Post-accident**

The Commander of the DTCEA–SJ was informed of the accident by the Chief of the Operational Section, who had received the news from the Chief of the SIPACEA SP and from the Chief of the DTCEA-SP. The Chief of the DTCEA-SP asked him to protect all the material related to the communications of the N600XL. The next day, they had a meeting with the members of the Operational Section, with the objective of listening to the tapes and making the transcripts. According to the Commander, the atmosphere at the Detachment got uncomfortable. A week later, the Chief of the SRPV-SP had a meeting with the personnel to comfort them.

The Chief of the Operational Section was on duty the day after the accident and made contacts in order to gather the operators, so as they could collect the pertinent material, listen to the tapes and make the transcripts, over the weekend. He said that the Detachment had the support of the Commanders of the SRPV-SP and DTCEA-SP, who monitored the situation. The Chief of the Operational Section also had a meeting with his operators, to talk to them and to give them guidance concerning operational issues.

#### **3.15.2.5. CINDACTA I**

##### **3.15.2.5.1. Work organization**

Brasilia ACC is subdivided into three regions: São Paulo (sectors 1 through 4), Brasilia (sectors 5 through 9) and Rio de Janeiro (sectors 10 through 14). The Operational Model (MO) of Brasilia ACC establishes the criteria for the sectors grouping, in each of the regions, according to the number of consoles activated (one, two or three).

The work teams are composed in accordance with the following functions: Team Chief, Team Supervisor, Regional Supervisor, Controller and Assistant-Controller. The responsibilities of each function are specified in the MO (Operational Model).

The work shifts were the following: 06:30h to 14:00h, 14:00h to 21:30h and 21:30h to 06:30h. The peak time is between 16:30h and 17:00h. The controllers are used to working two hours before they make a rotation, so as to have a rest. The MO establishes the following: "the system shall provide sufficient personnel for activating all the positions required by the demand in the various shifts, with a number that makes it possible to assign three controllers to each of the existing controlling positions. With such a number of controllers, the rotation is guaranteed, so as to meet "sanitary", food and resting needs. Besides, it makes it possible to respond to the demand, with the activation of the system's full capacity, with all the control positions made available" (Item 5.6.2).

As for the maximum volume of traffic in the sectors, the MO establishes that until a new arrangement of the Brasilia FIR sectors is implemented, "in order to determine the volume of traffic per sector, provisionally, the maximum capacity of traffic absorption is stipulated to be 12 (twelve) aircraft controlled, when the sectors are grouped, and 14 (fourteen) aircraft, for ungrouped sectors". However, the Regional Supervisor can alter those limits, after analyzing the control sector, the controller's experience, and the estimate flow of traffic entering and leaving the respective region (Item 5.6.4).

The control position can be activated without the assistant controller, when a sector has, under normal conditions, less than six aircraft controlled, at the supervisor's discretion. The controller, in addition to his own duties, takes over the tasks of the assistant-controller (item 5.6.6). Whenever there is an expectation of a busy volume of traffic, the Regional Supervisor shall activate a further supervising position for every two operational positions activated (item 5.6.8). The Regional Supervisors rotate in their function, except during the peak times.

The operations are regulated by ICA 100-12, by the Operational Model, by the Operational Agreements with other organizations (Control centers, APP, TWR, EB, MB), and by the Operational Notices (AVOP) (which establish the immediate procedures).

The Chief of Brasilia ACC at the time of the accident reported that there is not a "Reference Manual" at the agency, although such a document is cited in the ACC Operational Model, dated June 10, 2004. It was informed that the Operational Model is being revised and that the new version does not mention the Manual.

Updated Operational Agreements are on the Supervisor's desk, within the premises of the ACC.

### **3.15.2.5.2. Personnel**

The officer who was the Chief of the ACC BS from March 2004 to January 2007 said that the biggest problem in the agency is the shortage of personnel, and added that, since 2005, he had been requesting an increase in the number of operators. He pointed out that it was not only the need to have operators in a number sufficient for maintaining the shifts: they are also needed for teaching and training purposes, as well as for qualifying the personnel for the operation. When a controller is taken out of the shift for any type of training, the already existing problem of personnel shortage is aggravated.

He said that the Aeronautical Accident Prevention Program (prescribed the TRM Team Resources Management) course several years ago, but its implementation has proved impossible. He pointed out that the TRM course has not been held for approximately two or three years.

It is important to point out that the Supervisors on duty at the Brasilia region of the ACC on September 29, 2006, have the ATM 011 Course, "ATC Agency Supervisor". This course, held at ICEA, which, at earlier times, was an "in-house" course and had duration of six weeks, but it was changed three years ago, and now it consists of a "distance" phase, plus another "in-house" phase of two weeks, with just an "affective" nature, as opposite to a practical one. It was informed that the contents of the course are not adequate for the activity itself, and that the course needs to be revised, so as to prepare the supervisor to really exercise his activities, especially concerning the flow control. In addition, it was remarked that the Operational Council should assess whether the controller has the necessary skills to be a supervisor, considering his experience, profile, and ability to manage the traffic.

It was also remarked that the function of the supervisor is loaded with administrative tasks.

The officer that headed the ACC BS was, at the same time, Chief of the Brasilia Region, besides participating in the shifts as Team Chief.

He reported the control of the operation quality is made by the supervisors in their daily practice, or by the Team Chief, but, whichever the case, not systematically. The officer also mentioned the Annual Technical Evaluations (TGE). The Operational Council analyzes the operators that have difficulties with the operation, be them related to personal relationship, to a psychological condition, or to the technical area, and takes the controllers away from their functions, whenever necessary.

He did not remember any previous involvement of the controllers on duty on the day of the accident in Operational councils or traffic incidents.

The importance of the function of the assistant-controller was also highlighted: it has to be very well performed, since he/she is responsible for traffic coordination, an aspect that reduces the controller's workload.

#### **3.15.2.5.3. Installations and equipment**

Brasilia ACC had eighteen consoles, sixteen of which are in working order. There had never been problems on account of a lack of consoles.

In 2002, a plan was developed to increase the number of frequencies of the ACC BS.

#### **3.15.2.5.4. The day of the accident**

According to the report written by the Supervisor 1 of the Brasilia Region, the Team Chief was not present at the ACC BS on the day of the accident, as he was on alert. There was no Team Supervisor, because the operator scheduled for that (an enlisted man) was away, due to being in mourning.

The accident occurred in the shift work period of 14:00h through 21:30h local time (17:00 UTC through 00:30 UTC).

In the São Paulo Region of the ACC BS, only one console was active, grouping the sectors 1, 2, 3 and 4, in accordance with the Operational Model (MO) of Brasilia ACC. The team was composed by the regional supervisor, the controller and the assistant-controller.

The assistant-controller delivered the clearance of the N600XL to the GND of São José dos Campos, in an incomplete manner, as already seen.

The controller of the São Paulo Region received the N600XL at 17:57 UTC and, at 18:33 UTC, handed it off to sector 5 of the Brasilia Region.

In the Brasilia Region, two consoles were active and, as prescribed in the MO, sectors 5 and 6 were grouped, as was the case of sectors 7, 8 and 9. There were two regional supervisors in the team, rotating in the function.

The Regional Supervisor 1 declared that, considering the concern of the previous team with the "terrain-mapping flight" (to be made by the "Guardião" and controlled by the Air Defense), he went to Air Defense Room, at 18:15 UTC, along with another controller of the work team, in order to coordinate the traffic evolution. There is no information in his report as to how long he stayed at the Air Defense. According to him, the regional supervisor position was occupied by the Regional Supervisor 2, from the beginning of the duty up to 19:15 UTC, when the Regional Supervisor 1 took over the position.

The Regional Supervisor 2 reported in his declaration that the afternoon team started duty at 17:15 UTC, and that he was responsible for consoles 7 and 8. He said that, at the very start of duty, he was informed about the "terrain-mapping flight" of an Air Defense aircraft, in the northeastern sector of Brasilia.

In the sectors 5 and 6, the team was composed by the controller and his assistant-controller. The controller performed the hand-off of N600XL from sector 5 to sector 7. The controller 1 of sectors 7, 8 and 9 was working without an assistant, because, according to information provided by the Chief of SIPACEA of CINDACTA 1, the volume of traffic permitted it, since the maximum limit of six aircraft was being maintained. The hand-off between sectors 5 and 7 was made at 18:51 UTC, about 12 minutes before the aircraft reached the limit between the sectors (19:03 UTC).

However, in his written report, the controller of sectors 5 and 6 reported that, as the N600XL had already crossed his control sector, he handed it off to the next sector, telling the aircraft to call the ACC BS on 125.05 MHz, and advised the controller of the next sector. The N600XL called the other sector, at approximately 60 NM to the south of Brasilia VOR, and pressed IDENT.

When questioned about the reasons the controller of sectors 5 and 6 might have had for handing off the traffic earlier than usual, the Chief of SIPACEA answered that as the controller was controlling two grouped sectors with a more intense flow of traffic (12\* aircraft), he probably wanted to transfer an aircraft to the other sector. (\* The rerun showed that there were nine aircraft at that moment).

As the handoff occurred before the N600XL passed BRS VOR, where a descent to flight level 360 was expected, the adequacy of the handoff procedure carried out by the controller of sectors 5 and 6 was questioned.

It was not possible to determine whether, when coordinating the flight of N600XL or handing it off, the controller of sectors 5 and 6 provided the controller 1 of sectors 7, 8 and 9 with the necessary information for those processes, as prescribed in the items 13.5.3.1, 14.21.3, 14.22.2 of ICA 100-12. In his written report, the controller just declared that he provided information of the frequency assigned to the aircraft.

As for the transfer of communications, considering the items 14.23.1 through 14.23.4 of ICA 100-12, it was verified that the hand-off of an aircraft can be made in advance, depending on the volume of traffic. The controller of sectors 5 and 6 handed off the N600XL



to the ATCO 1 of sectors 7, 8 and 9, approximately 12 minutes before the aircraft reached the boundary of the two sectors, a procedure that may be performed, if agreed by the controllers of both sectors, as prescribed in ICA 100-12. Nevertheless, the controller of sectors 5 and 6 had an obligation of providing the pilot with information on the existing restrictions, when the aircraft was still in his sector. According to the Chief of SIPACEA, no recording was made of the hand-off between sectors 5 and 7. It is likely that the coordination between the controllers was carried out verbally, without the aid of communication equipment, because the consoles are near each other, something that makes the recording unviable.

At the handoff of the aircraft to the controller of sector 7, the ATCO of sectors 5 and 6 instructed the pilots to use the frequency 125.05 MHz, which was a frequency of sector 9, and, therefore, inadequate for sector 7. As the sectors 7, 8 and 9 were grouped, the controller of the console could select the frequencies of all those sectors.

The controller 1 of sectors 7, 8 and 9 received the N600XL. A descent (from level 370 to level 360) was expected, still within sector 05, overhead Brasilia. According to information collected, the usual procedure is the pilots to request the level change. When they do not request the level change, the controller has to question them. In the case of the N600XL, the pilot did not make the request for level change, and the controller did not try to contact with the pilot.

The controller 1 of sectors 7, 8 and 9, in his written report, said that, in his first contact with N600XL, he asked the pilot to squawk ident. According to the rerun, this was at 18:51 UTC. Then, he remained observing the "Guardian" which was climbing to FL 300, roughly heading for FRM VOR. At this moment, TAM 3723 requested descent, and the ATCO 1 of sectors 7, 8 and 9 cleared him to FL 120, heading for FRM VOR. Thus, as he said, a doubt arose with regard to the track flown by the Guardian. He observed the evolution of the TAM 3723 and of the Guardian, and asked another controller of the team, who was involved in an instruction on a nearby console, to confirm the route of the Guardian with the Air Defense. After making a verification of all the plans, he saw that the flight plan of N600XL was indicating FL 360 overhead Brasilia, and that the data block was also indicating the same level. Noticing that everything was calm, he restarted to observe the evolution of the Guardian and the TAM 3723, besides communicating with the other airplanes. At about 19:15 UTC, he was relieved by the ATCO 2 of sectors 7, 8 and 9, and made him aware of all traffic, providing him with the information that N600XL was at FL 360, according to the flight plan.

In the period the controller 1 of sectors 07, 08 and 09 was controlling the N600XL, the following facts occurred:

- The aircraft passed the vertical of BRS VOR at 18:55:48 UTC, as shown at the rerun; it did not request a level change, "differently from what would be expected", and maintained flight level 370, while the flight plan indicated FL360. As confirmed at the rerun, this situation lasted from 18:55:48 UTC to 19:02:08 UTC, therefore, for about seven minutes. During this period, the N600XL data block on the controller's screen showed 370=360 (indicating that the aircraft had to change level at the point, according to the active flight plan).
- The ACC BS lost the SSR contact with the aircraft (according to the rerun, at 19:02:08 UTC; according to the recording presented during the visit, at 19:01:38 UTC, as reported in the RICEA 16.01). The aircraft icon no longer had the circle, and displayed only the symbol

“+”, while the symbol “=” in the data block was replaced by the letter Z: 370Z360. Later on, the aircraft altitude began to present variations.

- The service was received by controller 2 of sectors 07, 08 and 09, at 19:18:38 UTC (according to the RICEA, at 19:15 UTC), with the data block relative to the N600XL showing 385Z360.

So, as observed, the controller 1 of sectors 7, 8 e 9 failed to call the N600XL, when the aircraft had to change the flight level; failed to ask for a frequency change from 125.05 MHz, sector 9, to an adequate frequency of sector 7; and, supposedly, he did not perceive the loss of the Transponder mode C, failing to execute the procedures prescribed in ICA 100-12 (items 14.2, 14.6 and 14.11) , besides handing off the aircraft to the controller of sector 7, 8 and 9, with inaccurate information.

The Chief of ACC BS at the time of the accident reported that the controller had not presented operational deficiencies up to that day. As for controller's private life, the Chief did not know of any difficulties.

At 19:18 UTC, the controller 1 of sectors 07, 08 and 09 was relieved by the controller 2 (whose name is not listed in the work team, in the ACC BS Record-Book). The controller 2 took over the service together with his assistant controller (Assistant Controller of sectors 07, 08 and 09). As reported in the RICEA, the procedure utilized for the transference of function at the Operational Position did not comply with the prescription in the Operational Model of Brasilia ACC, and in item 5.3.1.1 of MCA 100-12, in relation to the “Check List”. Besides, it was observed the non-compliance with the item 5.1.4 of the Operational Model of Brasilia ACC, which establishes that the following situations must become very clear to the controller that is taking over the position: traffic without radio contact, traffic without transponder, with the transponder inoperative or with erroneous information.

In his written report, the controller 2 of sectors 07, 08 and 09 said that, when taking over the service, he questioned the controller 1 of sectors 07, 08 and 09 about the flight level of N600XL, after it had passed the vertical of Brasilia VOR, since the electronic strip of the X-4000, relative to that aircraft, indicated two different flight levels (FL 360 at Brasilia position, and FL380 at TERES and NABOL positions). The controller 1 replied that the aircraft was maintaining FL360 and, thus, the detection of any conflict for the route of the aircraft would not be possible. After analyzing the evolving traffic and conferring the altitude of N600XL, he noticed the lack of detection of the Mode C, which generated doubts about the flight level of the aircraft, that is, 360 or 380.

Still in his report, he informed that, until then, he had not had contact with N600XL, but the pilot had made an initial call on the frequency 125.05 MHz, to the controller 1 of sectors 07, 08 and 09. After additional observations of the traffic, he tried a contact with N600XL, unsuccessfully though, in order to verify the flight level of the aircraft, as well as the operational condition of the transponder. Some time later on, he tried another contact, again unsuccessfully, but on the frequency 135.90 MHz. After some time, the assistant-controller of sectors 07, 08 and 09, who had taken over at 19:40 UTC, made the coordination of the aircraft, providing the Amazonic Center with the information that N600XL was at level 360.

The controller 2 of sectors 07, 08 and 09 reported having tried again a last call, in the blind, next to the NABOL position, at the boundary between Brasilia ACC and Amazonic ACC, still within his control area, and requested the aircraft to call the Amazonic ACC on the frequencies 123.32 MHz and 126.45 MHz. There was no reply.

It was observed that the controller 2 of sectors 7, 8 and 9 altered the flight level in the flight progress strip of the N600XL, from FL 380 at TERES position (as indicated in the flight plan) to FL 360.

At the rerun, the following tentative calls made by the controller 2 of sectors 07, 08 and 09 were observed, as well as the radar contacts with the N600XL, and aircraft handoffs:

- 1) 1<sup>st</sup> attempt: 19:26 UTC;
- 2) 2<sup>nd</sup> attempt: 19:27 UTC;  
Primary radar contact loss: at 19:29:58 UTC, 246 NM from Brasilia;
- 3) 3<sup>rd</sup> and 4<sup>th</sup> attempts: 19:30:40 UTC;
- 4) 5<sup>th</sup> attempt: 19:32:48 UTC, (the primary icon appeared momentarily).
- 6<sup>th</sup> attempt: 19:34:28 UTC; with a request to contact on the frequency 135.90 MHz: Loss of primary radar contact: 19:38:23 UTC, (at 311 NM from Brasilia, according to the rerun, and at 29 NM from TERES, according to the time line).
- From 19:48 UTC to 19:52 UTC, the pilots of the N600XL tried to call the ACC BS twelve times (according to the communications time line, from 19:48 UTC to 19:50 UTC, probably still on the frequency of 125.05 MHz; according to the RICEA, on several frequencies not identified, except for 133.05 MHz).
- At 19:50:09 UTC, the ACC BS received two calls of the N600XL on 123.30 MHz, and did not reply.
- At 19:51:42 UTC, the ACC BS received another call on 133.05 MHz, and did not reply either.
- Last call (in the blind) made by the controller, at 19:53:39 UTC, telling the aircraft to call ACC AZ, on the frequency 123.32 MHz, alternative frequency 126.45 MHz. The pilots received the call, but did not manage to copy the digits of the frequency 123.32 MHz, and were not able to establish contact with the ACC BS.
- Hand-off of the GOL, from ACC AZ to ACC BS: 19:53 UTC;
- Hand-off of the N600XL, from ACC BS to ACC AZ: 19:54 UTC.

As mentioned earlier, the frequency provided to the pilots, on the occasion of the aircraft hand-off from sector 5 to sector 7 (125.05 MHz) belonged to sector 9, and it was not changed by the controller 1 of sectors 7, 8 and 9. Consequently, the controller 2 that relieved him in the position was not able to make contact with the aircraft.

The frequency 135.90 MHz, used by the controller 2 on the call made in blind, is a very busy frequency, and there could have been a frequency congestion in that period. In addition, on the page of the console 8 being used by controller 2 of sectors 7, 8 and 9, not all frequencies of sector 7 were programmed, as well as the emergency frequency (121.50 MHz), a fact that impeded the communication between N600XL and ATC.

The controller 2 of sectors 7, 8 and 9, being aware of the loss of the transponder and, later, of the primary radar contact loss with N600XL, attempted to contact the aircraft, but did not perform the procedures prescribed by ICA 100-12 for transponder and radar contact loss (items 14.2.1, 14.4.9, 14.4.10, 14.4.11, 14.6.3 and 14.6.4) and maintained the N600XL under

RVSM. It can be observed that when he had difficulty contacting the aircraft, he did not perform the procedures prescribed in ICA 100-12 (items 4.1.2, 7.14.1, 7.14.2 e 7.14.6).

The Assistant-Controller of sectors 7, 8 and 9 reported in writing that he started his function at about 19:40 UTC, and that he made the coordination of the N600XL with the Amazonic ACC. He said that, on the occasion, the aircraft was no longer within an area with radar coverage and, thus, he informed the Amazonic ACC of the flight level which was on the strip, that is, FL 360.

The handoff of the N600XL was made, according to the following dialog:

“ACC AZ: Oi, Brasilia.

(hi, Brasilia)

ACC BS: November meia zero zero x-ray lima, tem?

(November six zero zero x-ray lima, do you have it?)

ACC AZ: Tem aqui...

(I have it, here)

ACC BS: Tá entrando na tua área já aí.

(it is soon entering your area, there)

ACC AZ: Tenho sim, tenho sim.

(I have it, I do have it)

ACC BS: Beleza, três meia zero tá te chamando aí.

(ok, three six zero, it is calling you there)

ACC AZ: Ta beleza!

(ok)

ACC BS: Valeu.

(thanks)

ACC AZ: Valeu, falou.”

(thanks, out)

As for the events that preceded the coordination of the N600XL handoff from Brasilia ACC to the Amazonic ACC, there is no information on the reports in relation to the communication made between the controller 2 of sectors 7, 8 and 9 and his assistant controller, but it is a fact that the assistant controller coordinated the handoff of the N600XL with Amazonic ACC, without advising the loss of the Mode C, the loss of primary radar contact, and the difficulties experienced trying to communicate with the aircraft, in disagreement with the prescribed in ICA 100-12 (items 14.4.10 and 14.21.3), besides CIRTRAF 100-21 (item 6.1).

In addition, there is evidence that the information concerning the situation of the N600XL was not transmitted to the supervisors that were on duty at the moment.

In the reports of the controllers 1 and 2 of the sectors 7, 8 and 9, there are no descriptions of the participation of the supervisors in the events concerning the control of the N600XL. This fact suggests that the supervisors were not monitoring the evolution of the problems presented by the aircraft, and that the controller 2 of sectors 7, 8 and 9, who was knowledgeable of the difficulties relative to the N600XL, did not appeal to the supervisors in order to get help to deal with the abnormal situation.

The Supervisor 1 of the Brasilia Region said, in his report, that he took over his position at 19:15 UTC, and declared not having noticed any kind of irregularity in the "running" of the service of the region, although the controller 2 of sectors 7, 8 and 9 that had taken over the service at 19:18 UTC, perceived the loss of mode C, and initiated his attempts to contact the N600XL, at 19:26 UTC. He stressed having kept paying attention to the evolution of the flight of the Guardian. Then, he said that one of the controllers of the work team, who was teaching at console 7, reported to him that an aircraft had transmitted the information that the N600XL had made a call on the emergency channel, telling they would make an emergency landing in the area of the Amazonic ACC, and that the operators of that region had already been advised. He passed the information to the Brasilia SAR, which called him back, advising that the aircraft had landed at SBCC. Some minutes later, the assistant controller of sectors 7, 8 and 9 showed concern with the Gol 1907 estimate, as the aircraft had not called. He contacted Manaus, confirming the information, and requested the Brazilian air force aircraft that was flying in the region to try and make a relay with the GOL. The attempt was unsuccessful, and then he received the information that the N600XL had collided into something. When he perceived the similarity between the routes of the GOL and the N600XL, he passed the information to the Brasilia SAR, to the Air Defense, to the Team Chief and to the Chief of the Brasilia ACC. He requested the help of Supervisor 2, and provided for the substitution of the controllers involved, asking for an increase of the team, as well as for an anticipation of the team that would be working in the night shift.

The written report of the Regional Supervisor 1 informed that, at about 18:40 UTC, the N600XL entered sector 5 (console 7), showing no irregularities in its mode C. *... "However, at approximately 30 NM to the northwest of Brasilia, it began to show failures in its mode C, with the altitude varying significantly"...* The aforementioned report says that the aircraft was maintaining FL370, as authorized by the São Paulo Region. *"However, when the aircraft passed Brasilia, the system itself changed the level in the flight progress strip to FL360 for the vertical of Brasilia, and to FL380 for TERES position, in accordance with the flight plan filed".* According to the supervisor's written report, *"this fact would have generated a doubt about the level the aircraft was flying, after having passed Brasilia, since at 30 NM to the north of BRS VOR there was a loss of the aircraft mode C concomitantly with the change to FL360, in accordance with the filed flight plan".* The controller, perceiving that the mode C was not operating, made several calls to the N600XL in order to check its flight level, unsuccessfully. He said that the assistant controller coordinated with the Amazonic ACC, passing the information of FL360, and not the FL380 that the Amazonic Center had received.

The Supervisor 2, in his report, said that he monitored the running of the events concerning the N600XL. However, he only provided information on the procedures adopted by the controller and his assistant in sector 7, and there was not any description of his own participation in the process.

As reported earlier, the Team Chief, as well as the Team Supervisor, were not present at the Brasilia ACC, during the period in which the accident occurred, and the Supervisors of the Brasilia Region did not participate actively in the facts concerning the control of the N600XL, aspects that are in disagreement with the prescriptions of the Operational Model of the control unit.

### **3.15.2.6. CINDACTA IV**

#### **3.15.2.6.1. Work organization**

There was an Internal Notice of CINDACTA IV (AVOP 002A, dated August 25, 2006) still in force, defining that a controller was authorized to control up to seven aircraft; with an eighth aircraft, it would be necessary to request an assistant from the team; the pair of operators would be able to control up to 14 aircraft, and above that number, a new sector would have to be opened. According to information collected at the CINDACTA, those numbers were based on a recommendation of DECEA, which concluded, after studies of time and motion, that a controller could operate up to 10 aircraft. Having considered the vast extent of the area controlled by the Amazonic ACC, CINDACTA IV decided to establish its own limits.

At the time of the accident, the work shift consisted of seven controllers per round (07:00 through 14:30; 14:30 through 22:00 and 22:00 through 07:00 - local time -, the latter being the period of the highest volume of traffic). While four operators worked, the other three were at rest.

Of the three sub-centers (Belém, Manaus and Porto Velho), two of them routinely opened their consoles (Porto Velho, only occasionally). Each sub-center had five consoles but, in general, only three were opened.

#### **3.15.2.6.2. Installations and equipment**

The Chief of the ACC said that the problems of infrastructure encountered were due to the characteristics of the Amazon region, on account of its great extent, and the complicated logistics necessary in terms of monitoring and maintenance.

However, no aspects relative to the installations and equipment were found that could have contributed to the accident.

#### **3.15.2.6.3. SIPACEA**

The Chief of SIPACEA took over his function in the beginning of 2005. He reported having a full support from the CINDACTA Commander, who knows and understands the system, and that is making efforts in order to solve the difficulties of the ACC, by reconditioning consoles and frequencies. He has made inspections at all the units subordinated to CINDACTA, verifying the operational conditions and promoting meetings.

#### **3.15.2.6.4. The day of the accident**

There are discrepancies between the written report of Supervisor 1 and the information provided by him in the interview. According to the report written by the regional supervisor (supervisor 1), the work team on duty at the time the accident occurred was composed in the

following manner: at the sub center of Belém, there were four operators, two of them working at the consoles, and the other two standing by to help when needed; at the sub centers of Manaus and Porto Velho, there were five controllers and a trainee, with three active consoles. There was no need of assistant controllers, in accordance with the AVOP in force. In his interview, the supervisor declared that four operators were at their positions, while one was standing by for relief purposes; he also said that, despite the fact that an assistant was required due to the volume of traffic, they were operating alone. As the operation was progressing smoothly, the supervisor 1 focused on the administrative tasks (reading of operational e-mails, as well as of the "logbook" of previous shifts), in addition to the instruction of the trainee supervisor taking part in the team.

The Supervisor 2 (Belém sector), after the accident, went to the Manaus sector, and stood behind the console, with Supervisor 1, to help in whatever was needed.

The controller that made the coordination of the GOL, and received the N600XL, reported having arrived at the ACC at 17:00 UTC, attended the briefing and participated in the work-team change. As the operation was sectorized, he took over the southern region of Manaus sub center. According to his information, the service progressed normally. He was controlling about nine aircraft, and no supervisors were close to the operation: supervisor 1 was instructing the supervisor trainee, while the Supervisor 2 was dealing with the Belém sub center.

As he had been advised at the initial briefing that the secondary radar of SINOP was inoperative, he was terminating the provision of radar service earlier than usual.

The controller stated that he had terminated the radar service for the GOL aircraft. According to information provided by the supervisor 1, the controller handed off the GOL airplane with 12 minutes, instead of 15 minutes, at 19:53:00 UTC, according to the time line. As shown in the transcripts, the communications concerning the handoff of the GOL airplane started at 19:48:23 UTC. The supervisor 1 declared that Brasilia made a late handoff of the N600XL (at 19:53:30 UTC, according to the transcripts).

The handoff of the GOL from the Amazonic ACC to the Brasilia ACC occurred as follows:

"ACC BS : Oi Manaus.

*(hi, Manaus.)*

ACC AZ : Oi, eu tenho pra você...ôôô...deixa eu vê quem eu tenho aqui, Gol uno nove zero sete.

*(hi, I have here for you... er... let me see, whom I have here, Gol one nine zero seven).*

ACC BS: Onde?

*(Where?)*

ACC AZ: Lá em Nabol.

*(There, at Nabol)*

ACC BS: Só um minuto.

*(Just a minute).*

ACC AZ: Ta Okey.

*(It's OK)*

ACC BS: Nível e hora do Gol.

*(Level and time of the Gol)*

ACC AZ: Okey, três sete zero, aos cinqüenta e nove.

*(OK, three seven zero, at fifty nine)*

ACC BS: Beleza, copiado.

*(OK, copied)*

ACC AZ: Valeu”

*(out)*

The handoff of the N600XL was made, according to the following dialog:

“ACC AZ: Oi, Brasilia.

*(hi, Brasilia)*

ACC BS: November meia zero zero x-ray lima, tem?

*(November six zero zero x-ray lima, do you have it?)*

ACC AZ: Tem aqui...

*(I have it, here)*

ACC BS: Tá entrando na tua área já aí.

*(it is soon entering your area, there)*

ACC AZ: Tenho sim, tenho sim.

*(I have it, I do have it)*

ACC BS: Beleza, três meia zero tá te chamando aí.

*(OK, three six zero, it is calling you there)*

ACC AZ: Ta beleza!

*(Alright!)*

ACC BS: Valeu.

*(OK)*

ACC AZ: Valeu, falou!

*(OK, out)*

When the controller received the coordination relative to the N600XL, he noticed a primary radar position symbol (RPS) on the screen and thought it was the aircraft. The controller declared that, at first, they thought they were not receiving the secondary of N600XL because SINOP was inoperative but, later on, they learned that, at that moment, the radar had already been reestablished.



According to the Chief of the SIPACEA of ACC AZ, the N600XL appeared on the screen as a primary radar contact at 19:58 UTC.

There are doubts in relation to the expression used by the controller in his dialog with Brasilia ACC: “tenho sim, tenho sim” (“I have it, I do have it”). In the interview, it was understood that the controller stated that he could see the primary RPS on the screen, and thought it was the N600XL. The Chief of the SIPACEA of ACC AZ believes that the aircraft had not appeared on the screen yet (first primary icon at 19:58 UTC), and that the controller was talking about the aircraft electronic strip.

It was observed that the controller of the Amazonic ACC accepted the aircraft with little or no advance to question the conditions of acceptance. The information was incomplete, and the aircraft identification was doubtful, because, according to him, he noticed just a primary radar blip, and believed it was the N600XL.

According to the Chief of the SIPACEA of the ACC AZ: the estimate of the pilots' call to the ACC AZ was 19:54 UTC; the controller has to wait for the call of the aircraft to initiate radar service; the collision occurred at 19:56:54 UTC; the N600XL appeared on the screen as a primary radar contact: first RPS at 19:58 UTC; the N600XL Transponder restarted transmitting at 19:59:47 UTC; the controller accepted the aircraft and made the first call at 20:00:30 UTC; the N600XL declared emergency at 20:02:40 UTC (according to the time line, at 19:59:47 UTC, shortly after the reactivation of the Transponder).

The controller declared having made two calls to the aircraft, with no replies. He added that this is normal to happen, as the pilot could have been changing the frequency, and some were inoperative. The supervisor 2 said that there were problems in the frequencies of the region, and that, sometimes, when entering the area, the pilots were not able to contact the ATC.

There are not recordings of those attempts of the controller to call N600XL. According to the transcripts, the Amazonic ACC started the calls to N600XL at 20:00:30 UTC, followed by five other calls between 20:10:40 UTC and 20:13:44 UTC, that is, after the aircraft had declared emergency. From 19:53:30 UTC, the time when the handoff of the N600XL was made, up to 20:00:30 UTC (07 minutes) there are no recordings of any attempt to call on the part of the controller.

According to the Chief of the SIPACEA, the legislation prescribes that, after thirty minutes without contact, the alert phase is characterized. He stated there is not a specific time for the ATC to make contact with the aircraft. If the aircraft does not call, the ATC tries to contact it, seeking information with the center to verify whether the aircraft was directed to call, in other words, they try to find the aircraft.

In the legislation, specific directions were not found which might concern a time limit for the controller to call the aircraft when it has not made the initial call. The ICA 100-12, in item 12.2, relative to the emergency phases, sub item 12.2.1 defines as one of the situations that characterize an aircraft in the uncertainty phase (INCERFA): when the ATC agency “does not have communication from the aircraft after the 30 minutes following the time at which such a communication was expected, or following the moment at which one tried unsuccessfully to establish communication with the referred aircraft, whichever comes first”.

At 19:55:40 UTC, the ACC AZ lost primary radar contact with the N600XL. The collision occurred at 19:56:54 UTC. The signal of the transponder started to be received again by the ACC AZ at 19:59:47 UTC, with the code 4574, which later changed to 7700.

It was verified that the aircraft did not appear on the screen for almost four minutes and, during this period, the controller did not take any action. The ICA 100-12, in item 14.6.3, establishes that: "the controller shall advise the pilot, whenever the radar contact is lost". There are doubts about the responsibilities in relation to the aircraft: the coordination had already been made and the ACC AZ had accepted the handoff, but it was waiting for the aircraft to call.

The controller declared that, at no moment did he imagine that the N600XL might not be at the flight level 360, as informed by Brasilia. He noticed the Transponder as it appeared on the data block and, next, the emergency. He called the Supervisor 1, who took the following provisions: he asked that another call be made to the aircraft, to try a relay through another aircraft in the sector, and call the aircraft on the emergency frequency.

At 20:07:27 UTC, the controller contacted ACC BS, asking whether the frequency of the sector had been passed to the aircraft, because it was in emergency. At 20:13:39 UTC, the Polar 71 made a contact with ACC AZ, advising that N600XL was in emergency and that it would land in Novo Progresso. The N600XL only managed to contact the ACC AZ at 20:16:43 UTC.

There was a communication failure on the emergency frequency (121.50 MHz), since there were not any recordings of transmission or reception on that frequency by the ATC. In addition, there were not any calls between the N600XL and the controller of the ACC AZ, on the HF frequencies available.

At 20:33:23 UTC, the ACC BS contacted ACC AZ, and asked about the PR-GTD airplane, forty minutes after it had been handed off. The ACC AZ immediately realized what had happened with both aircraft.

### 3.15.3. Analysis of the Psychological Aspect

Taking into account the complexity and diversity of the systems involved in the collision of the PR-GTD and N600XL airplanes, the analysis of the Human Factor – Psychological Aspect was founded on the model developed by James Reason (1997), since it provides a basis for the comprehension of the contributing factors of the "organizational accidents", which characterize themselves with multiple causes involving various operators, at different levels of their respective organizations. The Reason Model permits to follow the development of a sequence of failures, starting from the organizational and managing decisions, passing through the work conditions at the various work posts, and getting to the personal and situational factors which lead to the rupture of the work process.

From the facts gathered by the investigation, some active failures were extracted which, according to the approach adopted, are the ones produced by the operators in the execution of their tasks and that generate an immediate adverse effect. The **active failures**, when occurring within complex systems, are in general the result of a set of **latent failures** which result from measures adopted and decisions made well before the occurrence of the accident, and whose consequences may remain hidden for a long period. The **latent failures** are subdivided into two categories:

- 1) **Local work conditions**, which influence the efficiency and the reliability of the human performance at a certain work context, and refer to the mental and physical status of the operators, to the task and its physical, technological and social environment.

- 2) **Organizational influences**, related to the resource management, organizational processes and organizational climate.

The investigation activities made it possible to discover the latent failures, present in the various systems involved, which were classified in the levels defined in the Reason model.

#### **3.15.3.1. PR-GTD**

The data that were the foundation for the analysis of the psychological aspects involved in the operation of the PR-GTD were collected by means of a briefing with the members of the high management staff of the company, interviews with the Flight Safety Advisor, captains and co-pilots, recording and transcription of the CVR and of the communications with the air traffic control.

No active failures have been identified on the part of the crew, as well as no latent failures in the system.

#### **3.15.3.2. N600XL**

The analysis of the data concerning the operation of the N600XL was based on the following sources of information: interviews with the pilots, held on October 3, 2006, at the "*Centro de Medicina Aeroespacial*" (Airspace Medicine Center), in Brazil; answers of members and pilots of ExcelAire to the enquiries forwarded to the NTSB representative, since the scheduled interviews of the Psychological Aspect were not held, due to the recommendation of the company's attorneys; the document "Operations/Human Performance Advisors to the U.S. Accredited Representative" (Group Chairman Field Notes), dated January 11, 2007; CVR recordings and transcripts of the communications with the air traffic control.

As for the crew of the N600XL, the following active failures were identified: non-execution of the flight planning and lack of attention to the flight plan provided by the EMBRAER operator, using tool of the UNIVERSAL company; non-execution of a briefing before the departure; unintentional change of the transponder mode of operation, failure in prioritizing attention; failure in perceiving the non-functioning of the transponder; a delay in recognizing the problem of communication with the air traffic control; and the non-execution of the procedures prescribed for communications failure.

The aspects that favored the occurrence of the failures described above are located in the two levels of latent failures.

##### **3.15.3.2.1. Local work conditions**

- a) Attitude of the pilots relative to the operation.

The pilots of the N600XL declared that they considered the operation of acceptance and the ferry flight of the aircraft from Brazil to the USA as 'routine'. However, the operation involved a series of aspects which were new for the crew: it would be the first time they would fly the Legacy, after the training in the simulator; the first time they would fly to South America, and the first time they would fly as a crew on a real flight. For the co-pilot, it would also be the first flight he would make for the company; his first international experience, as well as a return to the position of co-pilot, after having flown 317 hours as captain of an

aircraft of the same type of the Legacy. It could be observed that the captain was little familiar with the aircraft, possessing an experience of only five hours of flight in the simulator.

The attitude of considering the operation as routine permeated throughout the behavior evidenced by the pilots in the planning of the flight to Brazil, in the preparation for the departure, and in the conduction of the flight. "Attitude" can be defined as a lasting organization of beliefs and cognitions in general, provided with a affective charge for or against a defined social object (people, groups, situations), which predisposes to an action consistent with the cognitions and affections relative to the object. In other words, it means the willingness or the preparation to act in a certain manner.

It has to be stressed that the data collected during the investigation did not allow analyzing the origins or purposes involved in the adoption of such an attitude by the pilots. However, when they felt the operation as routine, they disregarded the unprecedented aspects mentioned earlier, which favored the lowering of the level of anxiety that would be needed in order to deal in a conscious and proactive manner with the different requirements inherent to the situation. Taking into account the Motivational Cycle Theory, the unprecedented aspects, if considered, would function as stimulants for the pilots, breaking the steady state, thus generating a tension state, which would lead to behaviors directed to the satisfaction of this need, so as to "promote" the return to the original steady state (Chiavenato, 1998). The behaviors generated from this cycle could be more appropriate for the real and objective features of the situation experienced by the pilots.

b) Influence of habit relative to the planning of the flight at ExcelAire.

According to the official responsible for the Flight Safety of the company, the flight plans were forwarded either to the hotel or to the airport by the provider, and the pilots neither expected nor passed through direct briefings about their flight planning. As for the ferry flight of the N600XL, the pilots did not take part in its planning; they requested EMBRAER to elaborate the flight plan; they did not ask for it to be delivered in advance; and on the day of the departure they said they would not go to the Flight Support Manager's office to get it.

The behavior adopted by the crew of the N600XL reflects the informal procedure, usual in the company, according to what was reported by the Flight Safety Officer. This aspect denotes the influence of acquired habits concerning the planning of operations, especially on the part of the Captain, which had been working four years for the company. Considering the concepts relative to the theories of learning, the interference of habits occurs because old habits are transported to the new situations, at which they prove inadequate (Bond, Bryan, Rigney e Warren, 1968). As described in the previous item, the crew considered the operation in Brazil as routine, an aspect that strengthened the adoption of behaviors based on habits acquired by the pilots in their daily activities

According to Isaac and Ruitenbergh (1999), the information actively generated through one's own efforts is more easily remembered than the one received in a passive manner. The flight planning, the briefings, the exchange of experiences with pilots that have flown in similar conditions are activities which induce the creation and the strengthening of the mental models referring to the operation: "each pilot will have a different way of creating the mental image or model to be referred to and as they do so they create an action memory trace which is essential to decisions made in the flying environment"; and, also, "the more 'active' association one has with the creation of the mental model, the stronger the mental model will become".

The fact that the pilots did not do an adequate planning of the flight constituted a fact of extreme relevance, because it contributed to reduce the crew situational awareness during the operation. As a first consequence of such a behavior of the crew, it can be highlighted the impossibility of the pilots to question the GND of the DTCEA-SJ regarding the clearance which was transmitted in an incomplete manner: if they did not participate in the planning of the flight, and were not knowledgeable of the flight plan filed, they would not have reasons for raising any doubts concerning the message transmitted by the GND.

c) Haste to depart/ pressure from the passengers.

From the moment the decision was made to anticipate the ferry flight of the N600XL for the same day of the aircraft delivery ceremony, there was a reduction of the time available for the execution of all the activities scheduled for the period before the aircraft departed. The pilots had been out with a relative of the PIC on the eve, and the final arrangements were, then, made on the day of the trip. The planning of the flight was not made in advance and, thus, in the morning of September 29, besides participating in the aircraft delivery ceremony and in the “festive dinner” , which was over at 01:15 pm (local time), the pilots still needed the flight plan, as well as to clarify some doubts with the Embraer engineer, in relation to the software of weight and balance of the aircraft, leaving only 45 minutes for all those activities, besides the execution of the pre-flight.

Thus, the period which preceded the departure of the N600XL was characterized by haste, and the situation got worse, on account of the pressure of the passengers for the takeoff to take place at the estimated time, the receipt of the flight plan at the aircraft, and the delay of the refueling which took place with the passengers on board.

This aspect is relevant, because, during the preparation of the flight and during the departure, it influenced the mental state and the behavior of the pilots significantly. The flight crew, besides not having made the planning of the flight, were not familiarized with the flight plan elaborated by Embraer, and did not receive a briefing with the information concerning the operation, either. The sequence of actions during the pre-flight and the departure was hampered: the pilots did not execute the procedures together, there was not a briefing for the passengers, and the standard sequence of the communication procedures with the GND of São José was modified, with the clearance being transmitted as the aircraft was taxiing for departure.

It is also important to point out that the sequence of the events that occurred in the period before the takeoff, as well as the attitude of the pilots relative to the operation and planning of the flight, constitute significant elements – “precursors” - for the loss of the crew situational awareness concerning the flight.

d) Little experience in the aircraft avionics.

On the occasion of the acceptance flights, the Captain showed little familiarity with the aircraft, as he seemed more concerned in learning about it. In the transcription of the CVR, it can be observed that, at 18:51 UTC, at the request of the Brasilia Center to “squawk ident”, one of the pilots says: “I don’t know how to do that! I think I did it”. This comment is an evidence of the little familiarity with the equipment. Still in relation with the avionics, in an interview to the NTSB, the SIC said that he had felt comfortable using the Legacy FMS, within his needs, but that he felt more comfortable with the former system. This little familiarity with the aircraft and its avionics may have favored the involuntary switching off of the Transponder.

e) Experience as PIC.

The PIC had worked as captain of Gulfstream aircraft for one year, while the SIC had 317 hours as captain of aircraft of the same type of the Legacy. It can be observed that both pilots were used to the position of captain, and that it was the first flight they were working together as a crew. It can be inferred that both displayed a conditioning relative to PIC tasks, according to their more recent and significant flight experiences. Consequently, the SIC was not accustomed to working in this capacity, and to performing the right seat routine functions, one of which was the RMU operation and monitoring. This factor could have favored the non-perception of the changes that occurred in the transponder during the flight, as well as the difficulties presented by the pilots concerning the crew resource management.

f) Lack of knowledge concerning the calculation of weight and balance.

Before the departure, as mentioned earlier, the pilots requested support to wind up the weight and balance of the N600XL, and were aided in the task by an EMBRAER engineer. According to the CVR, it was observed that the pilots dedicated themselves to the investigation of the weight and balance software that had been inserted in the Captain's laptop, an aspect that distracted them from the prescribed tasks of aircraft monitoring, navigation and communication.

g) Crew dynamics.

The crew is a group of people who interact in the quest for reaching a common objective. The group dynamics is influenced by some factors that may either favor or hinder the accomplishment of the task and the reaching of the intended objectives.

From the analysis of the dynamics of the N600XL crew, the following aspects were relevant: the pilots did not do the flight planning together, the PIC initiated the pre-flight while the SIC was absent, there was no briefing before the departure, both pilots configured the TCAS with the displays at "down" (not being shown on the MFD screens) because they wished to monitor the fuel consumption, and maintained their attention focused on the software of the weight and balance calculation, and on the planning of the next day flight, using a laptop in the cockpit. Besides, the informal atmosphere of the cockpit can be observed up to moment of the collision, not to mention the "chat" with the passengers during the flight, and the absence of the Captain from the cockpit for 16 minutes. The most significant results of those aspects for the occurrence of the accident were the lack of monitoring of the instruments and flight parameters, as well as the lack of concern with the air traffic control communications.

In summary, the facts just related are evidence that inadequate interaction was established between the pilots who did not assume and did not exercise the specific roles of PF and PM, hindering the division of tasks, and the employment of the resources in an efficient manner. The crew dynamics favored the loss of situational awareness in the cockpit and, consequently, the lack of perception of the shutting off of the transponder.

h) Lowering of the situational awareness.

According to Isaac and Ruitenberg (1999), the concept of situational awareness refers to the ("cognitive state or process associated with the assessment of cues both past and present in a dynamic situation. It may refer to a person's knowledge and reference to their status within a space and time continuum (pilot) or an individual prediction within a known and specified space/time continuum (air traffic controller) ").

In accordance with CENIPA (2007), the situational awareness may be defined as: “the precise perception of the facts and conditions that affect an aircraft and its crew during a certain period”. In a simplified manner, the situational awareness means to be conscious of what is going on around, and with the thought ahead of the aircraft. It is the perfect coincidence between the situation as perceived by the crew and the real one.

This perception is affected by several factors, such as: stress, inexperience, interpersonal conflict, expectations, fatigue, lack of interest, workload and complacency.

In the case of the N600XL crew, it is possible to affirm that a number of factors contributed for the loss of their in-flight situational awareness: the initial attitude of the pilots, when they considered the operation as a routine, their non-participation in the flight planning, as well as the crew dynamics, as described earlier.

As a result, the pilots did not monitor the instruments and parameters of the flight, besides being late to realize that there were problems of communication with the air traffic control. It has to be pointed out that, only when alone in the cockpit did the SIC focus his attention on the real situation of the flight, noticing that they were getting to the limits of the FIR and that the control had not called them for a long time. The pilots flew 57 minutes without establishing or receiving any control communication, and the SIC attempted a contact for seven minutes, finding out, at this point, that they had a problem, but there was no time for discussions about the procedures that should be adopted, because the PIC had just come back to the cockpit and, a little later, the collision occurred.

i) Technological environment: alert relative to the non-functioning of the TCAS.

When there is a commanded switch-off of Transponder, the information “TCAS OFF” appears in white letters on the TCAS page of the MFD and PFD, and the expression “STAND BY” appears in green color, in the RMU. In case the Transponder fails, the information “TCAS FAIL” appears in amber color in the MFD and PFD.

The functioning of the transponder and TCAS is fundamental for the RVSM flight. In case of an involuntary switch-off, or of Transponder failure, it is necessary that this information be made available for the pilots quickly and precisely, so that they can adopt the necessary procedures right away.

The visual display of information is preferably used, among other criteria, when the transmitted message does not require an immediate action. Besides, for the information to be noticed, it is necessary that the operator focus his resources of attention and selection on the informative device. Stokes et al. (as cited by Stanton and Epworth, 1990), state that the audio alarm systems seem to alert the operators more quickly than the visual devices, and do not depend on the position of the head or of the eyes to be noticed, and they add that (“[...] because we cannot ‘shut our ears’ in the same way that we can our eyes, our hearing tends to act as a natural warning sense”).

### **3.15.3.2.2. Organizational influences**

a) Scheduling of the crew

The technical competence of the crew is an important defense for dealing with and overcoming situations that could jeopardize the safety of the air activity. Thus, the decision concerning the selection of the crew has to comply with clearly defined criteria relative to the peculiarities of the activity and to the qualification necessary for the accomplishment of the

operation, so as to guide the elaboration of the shifts and the adequate allocation of the crew.

In relation to the crew of the Legacy, it was observed that the ExcelAire company, in order to execute the ferry flight of the aircraft, chose a captain that was inexperienced in the aircraft, although experienced in international flights, but again not in South America, and a just-hired co-pilot, experienced in the command of aircraft similar to the Legacy, little familiar with the FMS of this equipment, and not experienced in international flights. These aspects, besides the inexperience of the company in South America routes and the inexistence of records concerning international flights of the N600XL crew, point towards the fragility of the supervising activity of the company in the identification of the knowledge and skills necessary for the execution of the ferry flight of the N600XL.

b) Training.

The identification by the organization, of the knowledge and skills necessary for the crew to monitor the aircraft systems, to understand the events observed, to detect problems, to interfere at the right time and in an adequate manner, to fully use the available resources in the operational context, as well as of the definition of the criteria to be met in the performance of the activity and the establishment of evaluating measures constitute fundamental actions for the implementation of training programs compatible with the specificity of the operations that were executed.

The incorporation of those aspects, both in the trainings that aim at the integration of the new members with the organization, and in those concerning the maintenance of operational proficiency, and the adoption of new operational equipment and procedures constitute an important resource for the reduction of performance deficiencies, and reveal aspects of the company culture regarding the safety of operations.

In relation to the N600XL crew, ExcelAire informed that the SIC underwent a doctrinal program at the company, with a two or three-day duration, which included a module about international procedures, consisting of a computer program and a discussion with the company safety agent. According to the SIC, the pilot trained him in relation to the *modus operandi* of the company, including the international procedures. On account of the inconsistency of this information about the initial training taken up by the SIC at the company, one can assume that such training was not executed in a systematic manner, thus hindering the preparation for the activity, as well as the evaluation of his skills and knowledge by the company.

It was also observed that the company had two contracts with training centers for the execution of annual trainings of the CRM, as well as refreshers, and that the training for the operation of the N600XL was provided to the crew by EMBRAER, at the FSI. The difficulties presented by the crew at the pre-flight and at the ferry flight indicate that the mechanisms developed by the company to supervise the efficiency of the training taken up by the pilots were inefficient regarding the prevention of the performance deficiencies shown by the crew of the N600XL.

The validation of a training program takes place as the knowledge acquired by the pilots proves sufficient for the execution of all the functions necessary for the accomplishment of the mission, as well as makes it possible to detect any problems with the necessary anticipation for the implementation of corrective actions.



The performance of the pilots in the ferry flight evidenced that the trainings for the operation of the aircraft, international procedures and CRM were not enough and/or adequate for the accomplishment of the mission in Brazil. The pilots demonstrated a lack of knowledge on the ICAO flight rules, little familiarity with the aircraft and avionics, and failures at the crew resources management.

c) Routine of the company regarding the planning of the flights.

The planning of the flight contributes for the creation of a crew's mental model, in which the various stages of the mission are integrated according to time and space. This activity facilitates the monitoring of objects and procedures established, the assessment of the time and resources available to accomplish the mission, and it contributes for the maintenance of the situational awareness.

In the routine of the company, the flights plans were forwarded to the hotel and to the airport via the internet service provider. The pilots neither expected nor had a briefing about the planning, they did not choose the route, they received the flight plan and implemented it. This procedure adopted by ExcelAire, the unavailability of the AIP Brasil for the crew, and lack of concern of the crew regarding the flight plan are factors that favored their lack of involvement in this phase of the flight and, consequently, contributed to their loss of situational awareness.

d) Safety culture.

According to the ICAO "Circular" 247-NA/148, the culture defines values and predisposes to attitudes, exerting a permanent influence on the behavior of a certain group. In companies where the culture is oriented towards safety, the ones responsible for the decisions of high management, as well as the supervisors, have a fundamental role in the dissemination of values and attitudes compatible with safety in the operational environment, and must ensure that the policies, processes and procedures are designed and applied so as to favor optimized safety levels.

Thus, the aspects concerning the planning and programming of the acceptance and repositioning operation of the N600XL, the characteristics of the trainings taken up by the crew of the aircraft for the operation in Brazil, and the procedure adopted by ExcelAire for the planning of their flights, mentioned earlier, are indications of the existence of a culture of informality, which weakens the defenses available for the organization to manage the risks of the operation.

e) Provision of flight support services.

EMBRAER informed that it does not do the planning of the flights for the companies which receive the aircraft, but acts as a "facilitator", supporting the clients occasionally through the flight support sector, by means of professionals of this area known as Flight Support Managers (Flight Support Office). In the case of the N600XL, EMBRAER elaborated the flight plan, a task which is the responsibility of the pilots.

### 3.15.3.3. SISCEAB

The analysis of the aspects relative to the units of the SISCEAB involved in the accident was based on data collected from the following sources of information:

- Interviews with Commanders, chiefs and controllers of the organizations involved;

- Interviews with the controllers of the work teams on duty in the period of the accident (except the controllers of Brasilia ACC);
- Testimonies written by the Brasilia ACC controllers on duty;
- Visits of the control rooms;
- Rerun of the radar visualization;
- Communications' Time Line;
- Transcripts of the units involved;
- Consultation of the Legislation of SISCEAB and of the Control Units (Operational Model);
- Consultation of the RICEA data collected over the last years;
- Research of performance in selective, formation and specialization processes, in "on-the-job training" for certification, general specialized test (TGE), English language evaluations, and annual performance evaluation of the controllers involved.

The following non-conformities were identified in the area of Air Traffic Control:

- Assistant-controller of the Brasilia ACC (São Paulo Region): transmission of the flight clearance in an incomplete manner from Brasilia to São José dos Campos (SJC).
- GND of the DTCEA-SJ: transmission of the flight clearance in an incomplete manner from SJC to N600XL.
- Controller of sectors 5 and 6 of Brasilia ACC: failure to provide the controller 1 of sectors 7, 8 and 9 with the necessary information when coordinating and handing off the N600XL.
- Controller 1 of sectors 7, 8 and 9 of Brasilia ACC: failure to contact N600XL for a level change; failure to change frequency from sector 9 to sector 7; failure to notice the loss of the mode C on the part of the N600XL; judgment error, assuming that N600XL would be at level 360; non-execution of the procedures prescribed for loss of transponder in RVSM airspace; and non-execution of the procedures prescribed for control position relief, with transmission of wrong information.
- Controller 2 of sectors 7, 8 and 9 of Brasilia ACC: non-execution of the procedures prescribed for loss of transponder and for radar contact in RVSM space; non-execution of the procedures prescribed for communications failure; and failure of communication with the assistant-controller.
- Assistant-controller of sectors 7, 8 and 9 of Brasilia ACC: non-execution of the procedure prescribed for the aircraft hand-off to the Amazonic ACC, with transmission of wrong information.
- Controllers 1 and 2 of sectors 7, 8 and 9 of Brasilia ACC: failure to communicate with the supervisors of Brasilia Region.
- Supervisors of Brasilia ACC: non-involvement in the events concerning the control of N600XL.
- Controller of the Manaus Sub-Center of the Amazonic ACC: deviation from standard procedure at the hand-off of the PR-GTD and acceptance of the N600XL; wrong

confirmation of the existence of the N600XL traffic; and non-execution of the procedure prescribed for loss of radar contact.

The fact that the controllers of Brasilia ACC involved in the accident refused to take part in the interviews hindered the precise identification of the individual aspects which contributed to the occurrence of active failures (attention, memory, motivation, expectations, attitude, knowledge, etc.). As a result, those aspects remain in the field of hypotheses.

The data collected at the SISCEAB units involved in the accident, and at other organizations which deal with the selection, training, and qualification of the operators favored the identification of aspects concerning the levels of latent failures of the Reason Model.

### **3.15.3.3.1. Local work conditions**

#### **a) Controllers' aptitude, knowledge and professional experience.**

It was observed that the controllers, in various work positions and agencies, presented failures in the provision of air traffic control service, related to a deficient communication and to the non-execution of the prescribed procedures, both in routine and abnormal situations. It was verified that the controllers involved were not able to realize and to adequately interpret the information, to assess the risks present in the situation, to make adequate decisions, and to execute procedures which are prescribed in the legislations that regulate the activity. The action of the supervisors did not follow the standard which was expected and prescribed in the manuals. In consequence, it was necessary to research data concerning the aptitude and the technical capability of those controllers.

In relation to the psychological selection for classification in the BCT specialty (ATC), only the data pertaining to the 3S (third sergeants) involved in the occurrence were researched, as, according to specific legislation, those data are destroyed five years after being collected. Only one of the sergeants involved had been selected by the Aeronautics Psychology Institute (IPA), by means of a "test battery" of BCT specific abilities. The other ones were selected for the rank of sergeant (military ability), and classified as BCT at the Aeronautics School of Specialists (EEAR). The controller selected was considered "apt", although showing a performance lower than the average of the group at some of the tests for specific abilities. The other third-sergeants did not take a psychology test of the abilities, with their own manifested interest in the specialty being the criterion used by EEAR for their classification as air traffic controllers.

There was a research of the performance of all the controllers involved in the accident, in the formation and specialization courses of radar control and supervision, and no evidence of difficulties and deficiencies were found in the results they had obtained. However, it was observed that one of the controllers involved in the accident, the same that had evidenced a low performance in some of the results of the psychological selection, had completed the course of specialization in radar control with difficulties concerning both the English phraseology and the control with a more intense volume of traffic.

Efforts were also made in order to analyze the performance of the third-sergeants at the "on-the-job trainings" done at CINDACTA I, so as to verify the presence of specific difficulties that might have contributed to the failures presented. The data of three controllers involved were made available, although only two contained information prior to the accident.

The controller who had completed the radar specialization with some restrictions, also showed difficulties during the “on-the-job training” at CINDACTA I, with his certification as radar controller being dependent on two extra evaluations which were held one year after such a decision of the Operational Council.

The ACC BS controller responsible for the issuance of the N600XL clearance completed his basic formation, in 2005, and the radar control specialization course in 2006. At CINDACTA I, he was considered “apt” for certification as an assistant controller on September 4, 2006, after 128 hours of training.

The controllers from the DTCEA-SJ, ACC BS and ACC AZ involved in the accident passed their last annual theoretical evaluation (General Specialized Test – TGE) which had been taken before the occurrence of the accident.

The last English test of the DTCEA-SJ controllers was held in 2003. From the ACC BS controllers involved in the occurrence of the accident, five obtained a “non-satisfactory” result, and one received a “satisfactory within minima” at the last evaluation of the English language.

The DTCEA-SJ controllers that were on duty when the accident happened had graduated more than nineteen years before (between nineteen and thirty three years), and had not taken refresher courses since their graduation. All of them reported difficulties in the English language.

It was verified that the third-sergeant controllers of the ACC BS and ACC AZ who were working at the consoles, had between one and four years of experience in radar control, while the assistant had less than a month experience in the position, the first sergeants had an experience between eleven and sixteen years as radar controllers, and between one and five years as supervisors.

It is important to point out that, in the interviews held during the investigation and in the data of performance evaluation kept by the Enlisted Promotion Commission (CPG), no evidence of problems was found in relation to the controllers’ operational performance.

b) Informal procedure standard relative to the transmission of clearances.

The DTCEA-SJ controllers interviewed, although being knowledgeable of the procedures prescribed in ICA 100-12, declared that the flight clearance of the N600XL was provided in the usual standard, in the way it is transmitted by the Brasilia ACC, including destination, heading and level. According to them, it is not up to them to question the clearances which are issued by the Center, and they believe that there are reasons for the transmission of “partial” clearances. It was also observed that a specific standard of clearance, different from what is prescribed in the legislation, is being adopted by the controllers at Brasilia ACC and DTCEA-SJ.

It was not possible to specify the aspects which led the controller of Brasilia ACC to transmit an incomplete clearance of the N600XL to the GND of DTCEA-SJ, because the controllers of the Brasilia AC refused to participate in the interviews. It was not possible either, to confirm whether the standard of transmitting incomplete clearances is a widespread behavior at Brasilia ACC.

The investigation of the accident between the PR-GTD e N600XL aircraft made it possible to identify a deviation of procedure concerning the transmission of clearances, originated at the ACC BS, and disseminated at DTCEA-SJ, as a result of the daily practice,

from a localized and specific logic, in replacement of what is prescribed in the legislation. The reception and transmission of incomplete clearances are unduly configured as normal, routine and rationally justifiable practices within the DTCEA-SJ and, possibly, within the ACC BS.

In the case of the accident, the incomplete clearance transmitted to the crew of the N600XL, led the pilots to understand that they had to maintain the level 370, up to SBEG.

c) Low situational awareness

It was verified that the controller of sectors 5 and 6 handed over the N600XL to the controller 1 of sectors 7, 8 and 9 of the Brasilia ACC, well before the limit between sectors 5 and 7, using a frequency of sector 9, while there was a level change to be made still in sector 5. In the report written by the controller of sectors 5 and 6, there are no references to these aspects of traffic in his sector. The controller just informs to have handed over the N600XL to the next sector, providing the receiving the receiving controller with the information of the frequency assigned to the aircraft.

Endsley (as cited by Isaac and Ruitenbergh, 1999) discusses three cognitive levels involved in the concept of situational awareness: the perception of the situation, the understanding of its meaning and, finally, its projection to the future, so as to favor the elaboration of effective plans for dealing with the situation.

Taking into account the definition of situational awareness, the information that was passed by the controller of sectors 5 and 6 indicates that he did not have a precise perception of the factors concerning the traffic of N600XL in his sector, and that his priority in relation to that aircraft would be a quick hand-over to the next sector. It was not possible to specify the reasons for such an early hand-over of the aircraft, on account of the refusal of the Brasilia ACC controllers to be interviewed by the members of CIAA. A hypothesis that can be raised is that sector 5 could be presenting a higher volume of traffic at that moment, in a way that could exceed the limits prescribed for the grouping of sectors, making it necessary to open another console.

His failing to transmit important information concerning the N600XL traffic in sector 5 to the controller 1 of sectors 7, 8 and 9, contributed for the lowering of the situational awareness of the latter controller in relation to the aircraft. As a result, this controller was not aware of the need to change the flight level, as well as the frequency, which was inadequate for the sector the aircraft would enter. It is also possible that this controller judged that the controller of sector 5 had already told N600XL to perform the descent to the authorized level at passing the vertical of Brasilia VOR.

d) Distraction

Among the facts gathered by the accident investigation, the information concerning the loss of mode "C", following a characteristic of the software of the STVD, was presented to the controller 1 of sectors 7, 8 and 9 of the Brasilia ACC. The controller refused to be interviewed by the members of CIAA, but his written report, made on the day of the accident, permits to raise the hypothesis that his attention, at first, had been distracted from the N600XL and directed to the other aircraft that were under his responsibility.

According to information provided by the controller, in his first contact with the N600XL, he requested that the aircraft squawk identification and, then, kept observing the traffic of the Brazilian Air Force airplane (call-sign "Guardião"). He authorized the descent requested by

TAM 3723. While he observed the progress of TAM 3723 and of the “Guardião”, he asked another controller of the team to confirm the track of the “Guardião” with the Air Defense. This part of his testimony indicates that his attention was directed to these aircraft. Nothing, however, that could indicate something different from the normal routine of verification or an excessive workload.

e) Technological environment: Alert on the STVD.

As mentioned before, the information on the loss of mode “C” was presented in the way programmed in the STVD: the RPS of the aircraft no longer showed the circle, only the signal (+), and the signal (=), in the label was replaced by the letter Z, like this: 370Z360. Later on, the altitude of the aircraft began to show variations. Such indications apparently were not enough to attract the attention of the controller to a situation which was extremely critical, considering the importance of the functioning of the transponder, as far as ATC is concerned, especially in RVSM airspace.

There are human limitations in the area of attention and perception, and the loss of the mode C requires immediate actions on the part of the ATCOs.

f) Perception failure/ judgment error/ complacency.

Despite the hypothesis of distraction on the part of the controller 1 of sectors 7, 8 and 9 of Brasilia ACC, it is a fact that, at a certain moment, this controller visualized the label of the aircraft, as indicated in his written report: “While I was doing the checklist of all the plans, I saw that the plan of the N600XL was indicating FL360 overhead BRS VOR, and that the RPS was also indicating FL 360. I noticed that everything was calm, and again I resumed observing the evolution of the Guardian and TAM 3723, besides monitoring the other aircraft”. Such a comment denotes that the controller did not identify the information presented in the label of the aircraft, an aspect that raises the hypothesis of lack of knowledge on his part in relation to the indications of transponder loss.

On the other hand, it may be supposed that the controller had perceived the loss of mode C, but after verifying the altitude prescribed in the plan, concluded that the aircraft was complying with the planned flight level from the vertical of the Brasilia VOR onwards, that is, FL 360. Such an inadequate judgment would have calmed him, making him disregard other possibilities relative to the aircraft situation, as well as the risks resulting from inaccurate information of altitude. Thus, he would not have felt “impelled” by the situation at least not to the point of adopting the prescribed procedures for transponder loss.

If the controller, even though perceiving and correctly identifying the information contained in the data block of the N600XL, did not know the prescribed procedures or preferred to not adopt them, it may be supposed that he showed an attitude of complacency, which can be defined as the condescension towards acts or facts that have to be controlled. It must also be considered that the controller, when faced with the difficulties of the situation, could have requested support from the regional supervisor, but this did not happen.

The complacent attitude could, also, have influenced his behavior on the occasion of the rotation, when he was superseded by controller 2 of sectors 7, 8 and 9, in which he failed to inform the non-functioning of the N600XL Transponder, and transmitted an inaccurate piece of information about the altitude of the aircraft, as if it were accurate information.

In relation to the deficient judgment of the controller concerning the aircraft altitude, it is important to point out that, according to Isaac and Ruitenbergh (1999), a poor judgment adds

to the probability that another poor judgment will come next. This occurs because a wrong judgment increases the availability of false information which can negatively influence the next judgments. "As the poor judgment chain grows, the alternatives for safe controlling decrease. If a controller selects one poor alternative among several, the option to select the remaining good alternatives may be lost. The longer the poor judgment chain becomes, the more probable it is that an incident will occur, as the alternatives for safe controlling become fewer"). In the occurrence of the accident with the PR-GTD and the N600XL, it was observed that the assumption that N600XL was at FL 360 was the basis for the making of a series of inadequate decisions and of the taking of ineffective actions on the part of the controllers.

g) Decision making error/ low situational awareness/ poor judgment/ complacency.

The controller 2 of sectors 7, 8 and 9 perceived the loss of the mode C of the N600XL and, eight minutes after he had taken over the position, he started a series of six attempts to call N600XL within an 8-minute period (from 19:26 UTC to 19:34 UTC), unsuccessfully. During the next nineteen minutes, there are not any recordings of call attempts, up to 19:53 UTC, when the controller made a last call, in the blind, to the aircraft. During this period, the controller did not perform the prescribed procedures for the loss of transponder and radar contact in RVSM space, and did not perform the procedures prescribed for communications failure, either.

Although the controller had perceived and identified the loss of the mode C early enough to adopt the necessary adequate provisions, he made use of ineffective procedures to solve the problem, initially concentrating his action on the attempts to call the aircraft, during a short period, and remaining inactive for nineteen minutes.

In relation to the difficulties establishing contact with the aircraft, it was observed that the controller did not realize that the frequency assigned to the N600XL was inadequate for the sector the aircraft was in. In his report, he does not refer to the impossibility of establishing contact as an aspect indicative of communication failure. It can be guessed that the controller was not able to detect, identify and diagnose the situation correctly and, in consequence, he did not adopt the prescribed procedures.

The hypotheses for the inadequate action taken by the controller include the poor judgment concerning the situations dealt with, and the level of risk involved in them. The attitudes of passivity and complacency displayed by the controller may have been generated by the false expectation that N600XL was maintaining FL 360. Such an expectation is corroborated by the attitude of the controller, when he altered the strip of N600XL, changing FL 380 to FL 360, from TERES onwards. The impossibility to contact the aircraft, and even the fact that the flight plan filed by the N600XL indicated a level change to FL 380 at TERES, at 19:30 UTC, were not sufficient stimuli for the controller to request support from the regional supervisor to deal with the problems, and to ask the assistant to advise the Amazonic Center of the aircraft condition.

h) Lack of communication between the controllers and supervisors involved.

The lack of communication, verified in the context prior to the accident, occurred mainly at the transmission of the incomplete flight clearance, procedures of coordination and aircraft handoff between sectors, as well as between Control Centers, and service transfer at the controllers' position relief. The documents that regulate the air traffic control activity present norms and standards for each of these situations, concerning the type of information and the way it must be transmitted, establishing specific procedures and phraseology.

The lack of communication also occurred in the context of the dynamics of the work team, especially at the Brasilia ACC, between controllers and supervisors. These were not informed by the controllers on the problems they were experiencing in the control of N600XL, an aspect that negatively influenced the decision making, which occurred in an isolated and individual manner, resulting in inadequate and ineffective actions, indicative of a poor coordination of the team resources.

i) Poor resources coordination (TRM).

The work team on duty in the air traffic control is a group of people who interact in order to reach a common goal. Such a group dynamics is influenced by some factors which may favor or hinder the accomplishment of the task. The integration of the team is a fundamental aspect for an efficient and effective performance, because it refers to the commitment with which all members collaborate, exchanging information and resources, while promoting a cooperative climate.

It was observed that the decisions and actions at the Brasilia ACC originated from individual initiatives, denoting a lack of communication, integration and cooperation between the members of the work team. In this sense, it is necessary to question the reasons which led the controllers to deal so individually with the critical situations they experienced.

In relation to the regional supervisors, the Operational Model (MO) of the Brasilia ACC establishes that, among other responsibilities, they have to supervise the provision, by the controllers under their responsibility, of the air traffic control services in their sectors of jurisdiction, and correct mistakes, omissions, irregularities or inadequate employment of ATS procedures, by means of performing frequent verifications of the data presentations (flight progress strips, radar visualization, aeronautical and meteorological information, as well as of the utilization of the control sectors' communication channels (phraseology and coordination). Notwithstanding the fact that the controller did not appeal to the supervisors, according to the prescription of the MO, they had to have been able to perceive and identify the critical aspects of the operation concerning the N600XL, and guide the controllers on the procedures to be adopted.

It was not possible to define the aspects which contributed to the non-involvement of the supervisors in the events, since there was a refusal to give interviews. It was verified in the work shift in which the accident occurred that the Team Chief was on the alert from 20:00 UTC on, while the Team Supervisor was off duty, due to mourning. Thus, the supervisor 1 of the Brasilia Region took over these functions, besides his own responsibilities, after taking over the position at 19:15 UTC, when Supervisor 2 retreated for his period of rest.

j) Lowering of the situational awareness/ poor judgment/ complacency.

The ACC AZ controller received and accepted the coordination of the N600XL from the ACC BS, with incomplete information and without enough time to question the conditions of acceptance. He made a doubtful identification of the aircraft from a primary RPS on the screen. It was also observed that from 19:53:30 UTC, time at which the hand-over of the N600XL was completed, up to 20:00:30 UTC (07 minutes), there are no recordings of attempts to call on the part of the controller. The aircraft had not been under radar contact for almost four minutes, and, during that period, no procedure was carried out.

The controller did not consider those conditions as critical, and did not feel uncomfortable with the situation, having judged that the primary radar detection was due to the unserviceability of the SINOP radar, and that the lack of communication with the aircraft



was on account of the frequency problems in the region, since the pilots sometimes did not call control when entering the area. The pre-concepts of the controller led himself to an erroneous interpretation and diagnosis of the situation, which resulted in his non-compliance with the procedures prescribed.

### **3.15.3.3.2. Organizational influences**

#### **a) Qualification/Training**

To guarantee that the controller possesses the knowledge and skills necessary for the safe and efficient performing of his activities is one of the fundamental resources for achieving the air traffic control system reliability.

The selective process permits that only the individuals with a favorable prognostic of adaptation join the organization, and the initial formation period has to function as a complementary sift, either confirming or opposing the initial prognosis, guaranteeing that those who complete the course succeed in the subsequent phases of their formation, as well as in the performing of their functions.

Taking into account that the reduced number of professionals (of the SISCEAB units involved in the accident) hinders the maintenance of the continued training of the personnel, by means of periodical recurrent courses, TRM trainings, English courses, and also the supervisor course, there is a situation of shortage of opportunities for technical updating and professional improvement. The last results at the English evaluation obtained by the controllers involved in the accident, as well as the deficiencies presented in terms of deviations from the prescribed procedures, communications and teamwork reflect the difficulty experienced by the control units involved in the occurrence for the continuity of the process of qualification of their controllers.

Considering, also, that the controllers of the DTCEA-SJ, ACC BS and ACC AZ passed their annual theoretical evaluation (General Specialized Test – TGE, in Portuguese) prior to the occurrence of the accident, and on account of the failures presented by those controllers in the situation of the accident, it can be observed that this evaluation has not been effective, in the sense of aiding the identification and diagnosis of the controllers performance deficiencies, thus failing to subsidy the process of identification of the training needs.

#### **b) Supervision**

The supervision systems are designed to ensure the existence of adequate defenses against latent lack-of-safety conditions. The defenses can be of a diverse nature, including regulations, legislations, safety inspections and audits for the identification of systemic deficiencies. According to ICAO (2002), "In many ways, accidents can be viewed as the ultimate manifestation of deficiencies in safety oversight systems". Besides, human errors can be indicative of safety system failures. Thus, the supervision systems have to be capable of identifying and correcting systemic safety failures, especially those that affect the human performance.

All the air traffic control operation is regulated, and the procedures are defined in various documents (COMAER Publications, Operational Models, Operational Agreements and Operational Notices), all of them in concordance with the ICAO documentation. However, in the actions taken by the controllers involved in the accident, several deviations from the prescribed procedures were observed, both in routine and abnormal situations.

During the investigation of the accident, the research of the controllers' professional profile was hampered by the shortage of records, at the units involved, concerning the instruction of the controllers. The systematization and monitoring of the processes and records related to the instruction and technical qualification of the operators are fundamentally important for the assurance of those processes and, consequently, for an efficient and safe operational performance.

### c) Personnel planning

According to information collected at the control units involved in the accident, the existing personnel shortage hindered not only the structuring of the operational shifts but also the instructional activities related to the operation, as specified in the item concerning the qualification/training in this report. This factor also hindered the activities of a management level, due to the many functions assigned to the chiefs.

At the ACC BS, personnel shortage was also cited as the worst problem experienced, not only in relation to the maintenance of the shifts, but also in relation to the qualification of the operators. There are significant effects at the managing level, as the chiefs were overloaded with activities and functions, and were not able to exercise management effectively.

As for the ACC AZ, the same problem of personnel shortage had always been a critical one, aggravated by the high rate of transfers, because the military operators along with their families experienced hardships adapting to the city, on account of the high cost of living, awaiting four to five years to be granted a house by the military institution, as well as the distance from the states of origin, together with the costs of travel. After five years serving at the agency, the majority of the controllers request a transfer, being replaced by the newly graduated operators, a fact that caused an overload in the instructional activities and hindered the participation of the senior controllers in courses and recurrent trainings.

The effects of the personnel shortage are perceived in the quality of the services, since they contribute to the degradation of the controllers' performance and/or technical qualification. The occurrence of the accident put these effects in evidence, owing to the series of deficient communications and inadequate actions taken by the controllers involved.

## 3.16. ERGONOMIC ASPECTS

In addition to the reconstitution flight, to substantiate technically the evaluation performed during that flight, the investigation commission (CIAA) requested to the Legacy aircraft manufacturer a study of the ergonomics of the aircraft in relation to the positioning of the footrest and RMU. This study had the objective of clarifying questions raised by the CIAA in relation to a scenario of the inadvertent touching of the RMU buttons with the foot while using the *footrest*, considering the various positions of the pilot's seat, with focus on the pilot seating on the left side (PIC).

This study was performed based on the actual dimensions of the EMB-135BJ cockpit and utilizing a virtual human model, with the basic estimated measurements from the PIC of the N600XL, which are equivalent to the percentile 59%.

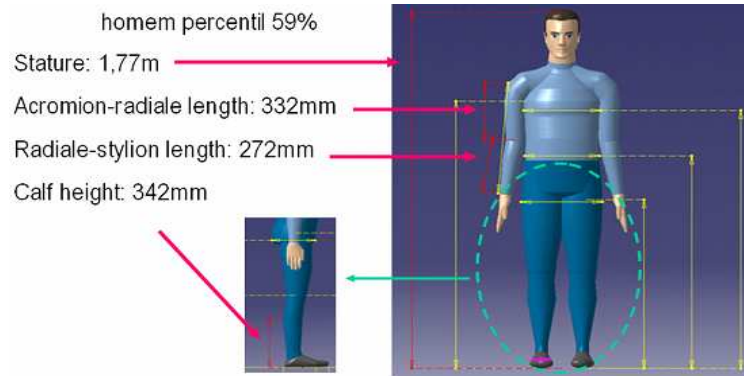


Figure 47

During this evaluation 3 seat positions were taken into account:

- PIC positioned for takeoff and at the DEP (Design Eye Position -adjusted with the references for flight), and with the seat reclined 10°;
- PIC with his seat moved back 5 cm (2") from DEP, still with full access to the flight controls (control wheel and pedals);
- PIC with his seat moved back 5 cm (2") from DEP, still with access to the flight controls (control wheel and pedals) and with the seat reclined 10°;
- PIC seated with the seat all the way to the back.

The main parameters utilized from every angle of comfort of foot and leg articulations, necessary to the PIC to utilize the *footrest* were:

- Thigh Flexion;
- Thigh Abduction;
- Thigh Rotation;
- Leg Flexion;
- Leg Rotation;
- Plantar Flexion;
- Inversion (foot).

Additionally, the following picture shows the movements the PIC should perform so as to get his foot reaching the RMU1:

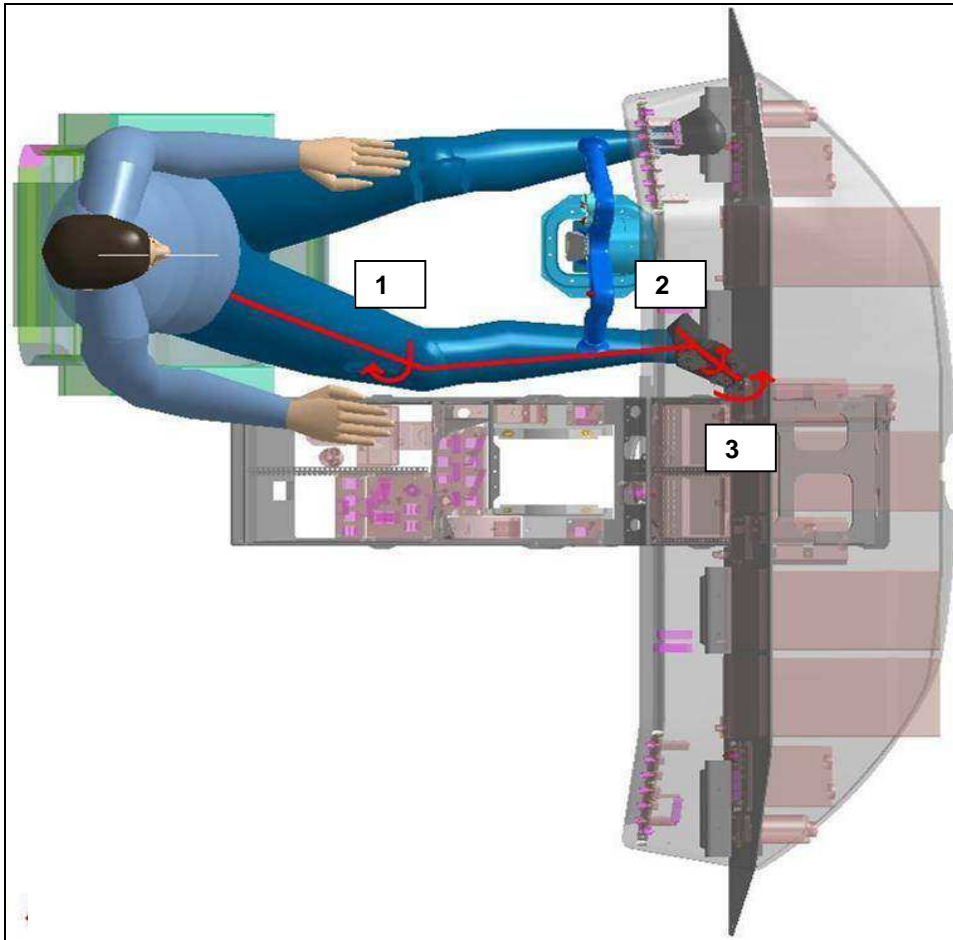


Figure 48

- (1) – Thigh lateral rotation
- (2) – Foot Inversion
- (3) – Plantar flexion.

**Situation (a):** Figure 49 represents the position of the virtual human model, equivalent to the PIC, in the normal flight condition (DEP), using the *footrest* with the seat reclined 10°.

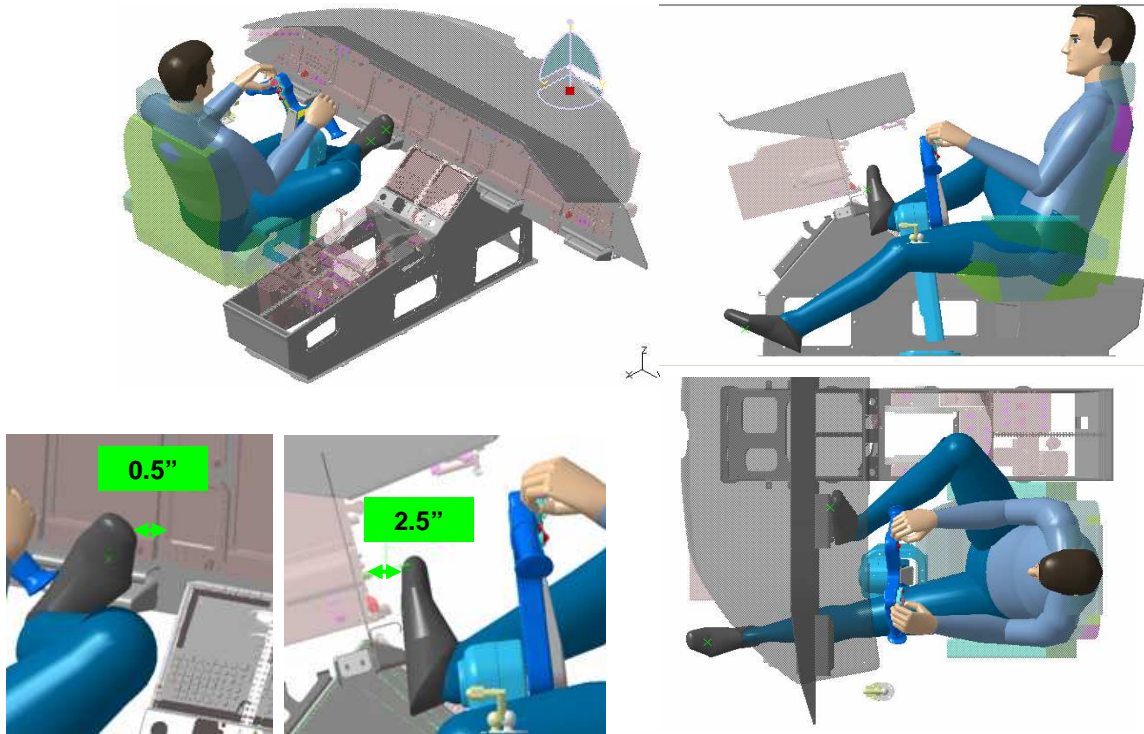


Figure 49

Table with measured angles in reference to the necessary movements to attain the posture of the pilot:

	Simulation Foot on footrest	Simulation attempt Foot on RMU	Comfort Range
Thigh Flexion	112°	113°	60° to 85°
Thigh Abduction	44°	50°	0° to 20°
Thigh Rotation	-30.13°	- 40°	-15° to 15°
Leg Flexion	112.5°	104.5°	45° to 85°
Leg Rotation	16°	-14°	-5° to 5°
Plantar Flexion	38°	19.5°	0° to 25°
Inversion	19.7°	17.5°	0° to 13°

Table 16

From this Table, it can be observed that all the angles measured in the simulation exceed the comfort limits. The posture of the pilot in this position is unnatural and uncomfortable, this being the same for any attempt to reach the RMU with his foot. These

measurements eliminate the possibility of an inadvertent command from the foot on the RMU.

**Situation (b):** Figure 50 represents the position of the virtual human model, similar to the PIC, trying to utilize the *footrest* with the seat moved 2" back from DEP without reclining the seat and still having access to the primary flight controls (control wheel and pedals):

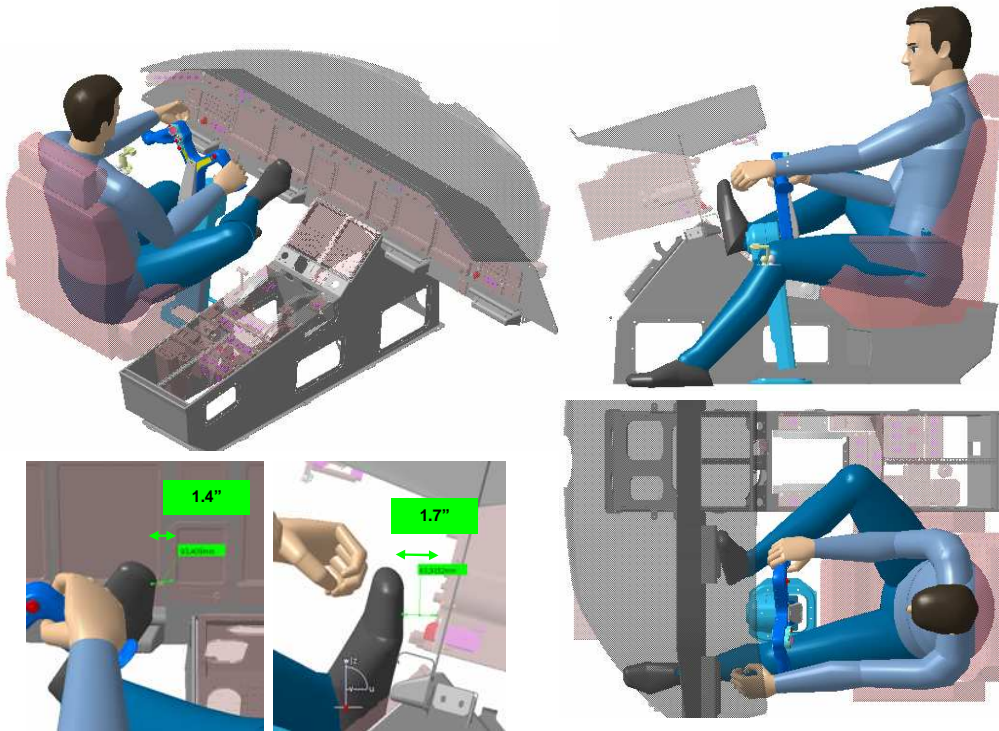


Figure 50

Table with measured angles in reference to the necessary movements to attain the posture of the pilot:

	Simulation Foot on footrest	Simulation attempt Foot on RMU	Comfort Range
Thigh Flexion	112.7°	113°	60° to 85°
Thigh Abduction	42°	45°	0° to 20°
Thigh Rotation	-36.2°	- 45°	-15° to 15°
Leg Flexion	100,7°	89.4°	45° to 85°
Leg Rotation	20°	12.1°	-5° to 5°
Plantar Flexion	26,3°	- 4.2°	0° to 25°
Inversion	7°	20°	0° to 13°

Table 17

From this table, the posture of the pilot in this position eliminates the possibility of an inadvertent command from the foot on the RMU, because it is unnatural and uncomfortable.



**Situation (c):** Figure 51 represents the position of the virtual human model, similar to the PIC, trying to utilize the *footrest* with the seat moved 2" back from DEP (i.e., without reclining the seat) and keeping access to the primary flight controls (control wheel and pedals), and now with the seat reclined 10°.

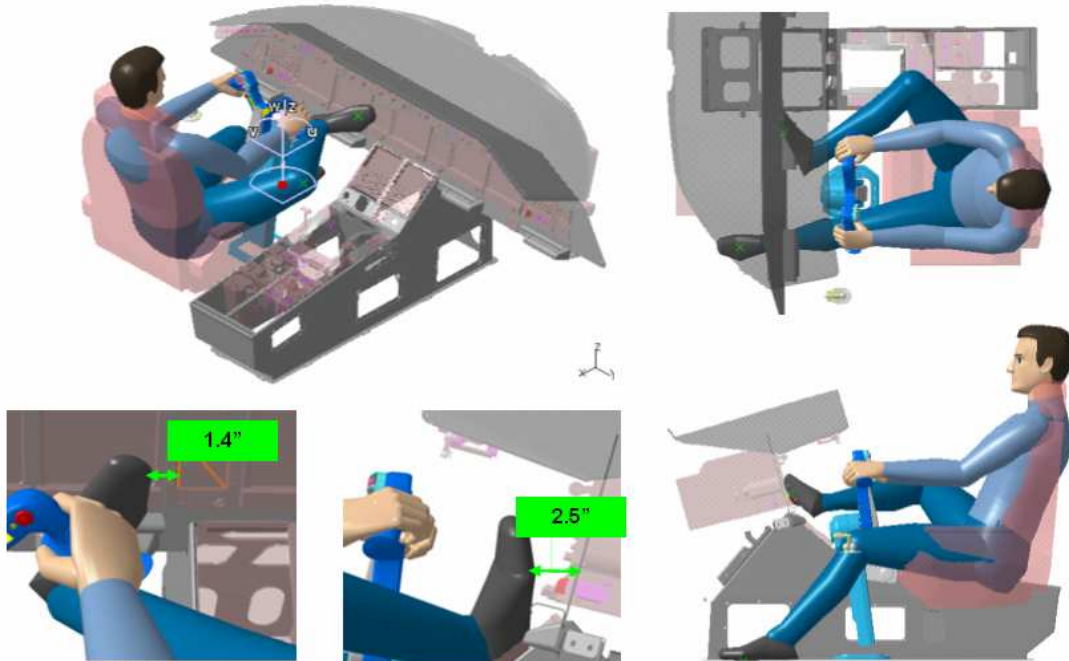


Figure 51

Table with measured angles in reference to the necessary movements to attain the posture of the pilot:

	Simulation Foot on footrest	Simulation attempt Foot on RMU	Comfort Range
Thigh Flexion	98.6°	103°	60° to 85°
Thigh Abduction	44°	42.8°	0° to 20°
Thigh Rotation	- 43°	- 44.9°	-15° to 15°
Leg Flexion	98°	94°	45° to 85°
Leg Rotation	31.4°	-13.7°	-5° to 5°
Plantar Flexion	28°	12.2°	0° to 25°
Inversion	7°	9.8°	0° to 13°

Table 18

From this table, the posture of the pilot in this position remains unnatural and uncomfortable, which also eliminates the possibility of an inadvertent command from the foot on the RMU.

**Situation (d):** Figure 52 represents the position of the virtual human model, equivalent to the PIC, trying to utilize the footrest with the seat all the way to the back and without reclining the seat:

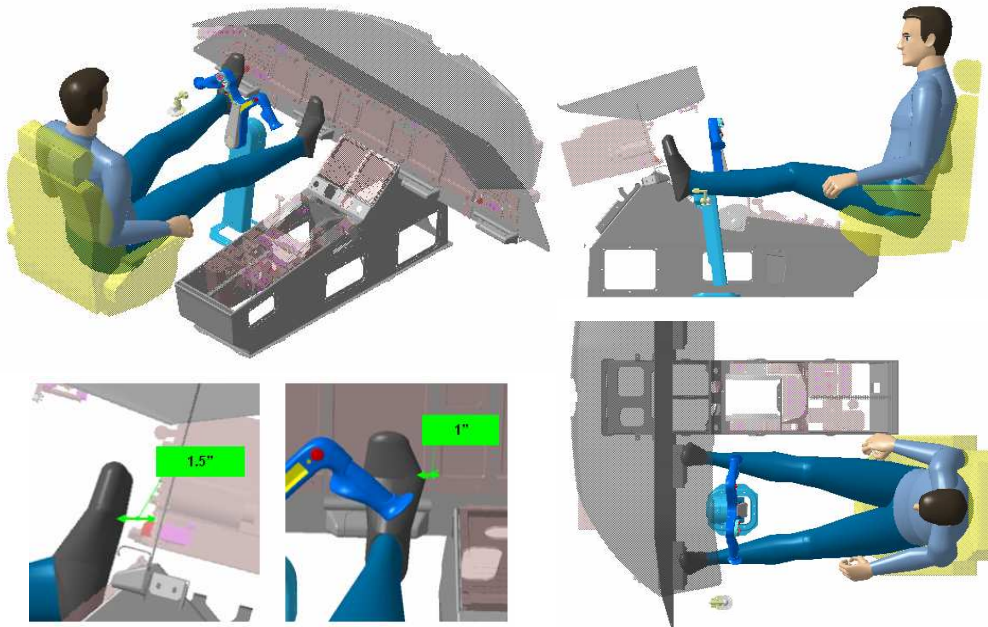


Figure 52

	Simulation Foot on footrest	Simulation attempt Foot on RMU	Comfort Range
<b>Thigh Flexion</b>	74,8°	80.3°	60° to 85°
<b>Thigh Abduction</b>	6,5°	10.4°	0° to 20°
<b>Thigh Rotation</b>	0°	<b>-23.8°</b>	-15° to 15°
<b>Leg Flexion</b>	<b>17°</b>	<b>19.8°</b>	45° to 85°
<b>Leg Rotation</b>	0°	<b>-17.6°</b>	-5° to 5°
<b>Plantar Flexion</b>	-13,9°	<b>-45°</b>	0° to 25°
<b>Inversion</b>	0°	3.3°	0° to 13°

Table 19

(with measured angles in reference to the necessary movements to attain the posture of the pilot)

From this table, the posture of the pilot in this position remains unnatural and uncomfortable, mainly for the leg flexion and rotation. As the pilot has short legs and need to stretch to reach the footrest, to get his foot touching the RMU would require an intentional action. Therefore, the possibility of an inadvertent command from the foot on the RMU can be eliminated.



### Considerations about the Ergonomic Evaluation

Comparing the values of the body angles required to utilize the footrest in the three conditions evaluated, it can be drawn that the comfort in the utilization of the footrest is inversely proportional to the proximity of the seat with the DEP, as follows:

	DEP Position	Position 2" back no reclining	Position 2" back reclining 10°	Seat all the way back
Thigh Flexion	112°	112.7°	98.6°	74,8°
Thigh Abduction	44°	42°	44°	6,5°
Thigh Rotation	-30.13°	-36.2°	- 43°	0°
Leg Flexion	112.5°	100,7°	98°	17°
Leg Rotation	16°	20°	31.4°	0°
Plantar Flexion	38°	26,3°	28°	-13,9°
Inversion	19.7°	7°	7°	0°

Table 20

On the other hand, if comparing the angles for the necessary movements to attempt to reach the RMU with the right foot of the PIC in the evaluated conditions, the results indicate that it is necessary to go beyond the comfort limit in the majority of the angles involved, as follows:

	DEP Position	Position 2" back no reclining	Position 2" back reclining 10°	Seat all the way back
Thigh Flexion	113°	113°	103°	80.3°
Thigh Abduction	50°	45°	42,8°	10.4°
Thigh Rotation	- 40°	- 45°	- 44.9°	-23.8°
Leg Flexion	104.5°	89.4°	94°	19.8°
Leg Rotation	-14°	12.1°	-13.7°	-17.6°
Plantar Flexion	19.5°	- 4.2°	12.2°	- 45°
Inversion	17.5°	20°	9.8°	3.3°

Table 21

The utilization of the footrest with the seat in the flying position for the evaluated conditions, from the ergonomic point of view is extremely uncomfortable and therefore not usual or practical if we consider that the PIC would be looking for comfort while resting his right foot on the *footrest*.

Also, with the ergonomic evaluation it was possible to understand that in order for the pilot to reach any button on the RMU (whichever button) with his seat in the DEP position or next to it, he will need to move his leg up and twist his foot in such a way for him to rest his foot out of the footrest and over the lateral border of the foot protector. These movements imply in the inappropriate use of the footrest, and 'forcing' the tip of the foot forwardly would require a movement that is not natural and that would presumably be intentional.

The study also showed that the *foot protector* does not allow the pilot's foot to touch the instrument panel, when the foot is placed inside the delimited area for the *footrest*, therefore fully complying with the SAE recommendation 4101 – Flight Deck Layout and the 14 CFR Part 25 (section 25.777) requirements.

The cockpit ergonomic evaluation provided the conclusion that the normal utilization of the footrest assures the non occurrence of any inadvertent touching of instruments on the instrument panel with the pilot's foot.

Although considering that the scenario of the inadvertent command of the RMU1 button by the PIC's right foot has been completely discarded, the Commission, after researching about the existing requirements and the ones under improvement, related to Cockpit Ergonomics, obtained information about the Draft Rule § 25.1302 - Installed Systems and Equipment for Use by the Flight Crew. This document is the result of the work developed by the Human Factors Harmonization Working Group coordinated by the FAA, EASA and Transport Canada, with the participation of the Industry.

As this Draft Rule § 25.1302 is still under the rulemaking process, the Commission considers timely to recommend the inclusion in its provisions, the aspects related to the interaction of the cockpit crew with the physical positioning of instruments, messages and warnings, so as to avoid that the eventual inadvertent interaction of the crew with these cockpit devices may affect the safety of the operation.

### **3.17. ADDITIONAL INFORMATION**

The circumstances in which the accident occurred, namely: an in-flight collision over the forest, a long way from any resources, at a location difficult to be reached, associated with the inexistence of an adequate medical investigation infrastructure, except the one established for the process of identification of the corpses, determined a practical impossibility of identification of the causes of the injuries and of their correlation with the aeronautical accident.

The swiftness of the fall, associated with the accelerative charges generated by the abnormal attitude assumed by the aircraft, and its resulting structural separation, which caused an abrupt decompression with all its effects, with exposition to the intense cold and to the wind at an extreme speed, allows to affirm that there was a generalized daze which probably did not let the victims realize the approach of imminent death.

The ELT (*Emergency Locator Transmitter*) did not work automatically.

#### **ELT Description**

The function of the ELT (Emergency Locator Transmitter) is to make the aircraft search and rescue operations easier, facilitating aircraft location. The ELT provides automatic transmission of the standard swept tone and encoded digital message sent to a satellite

(COSPAS - Cosmicheskaya Sistyema Poiska Avariynich Sudov) - SARSAT (Search and Rescue Satellite-Aided Tracking)) in the event of a crash. The emergency locator transmitter sub-subsystem transmits signals through emergency frequencies of 121.5 MHz, 243.0 MHz and 406.025 MHz.

The ELT automatically activates during a crash and transmits the standard swept tone on 121.5 and 243.0 MHz. Every 50 seconds for 520 milliseconds (long message protocol) the 406.025 MHz transmitter turns on. During that time an encoded digital message is sent to the satellite.

The crash force activation sensor or G-Switch is designed to activate according to the plot time versus longitudinal G force as shown by the Figure 1. For short impact the G force to activate the ELT is much higher than a relatively long impact.

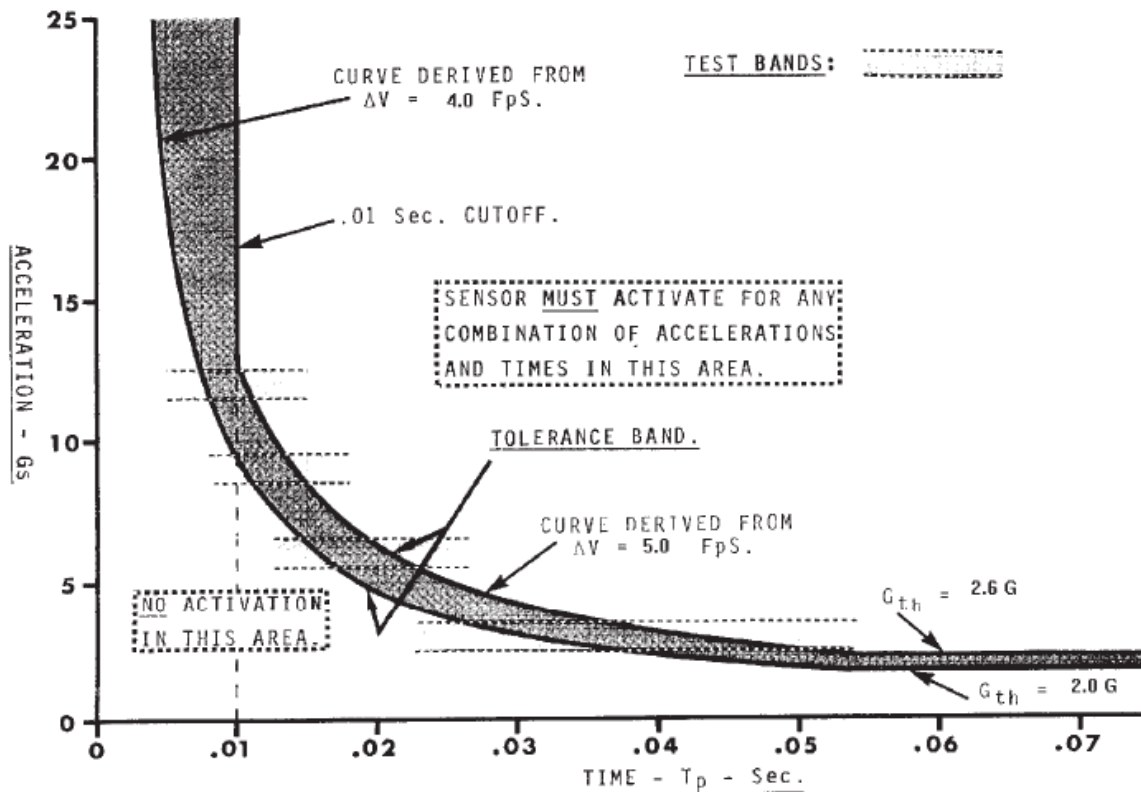


Figure 53

## Aircraft Installation

The ELT installation includes a fuselage mounted antenna (Figure 2). If the cable between ELT unit and respective antenna is damaged, the transmission of the signal will not occur.

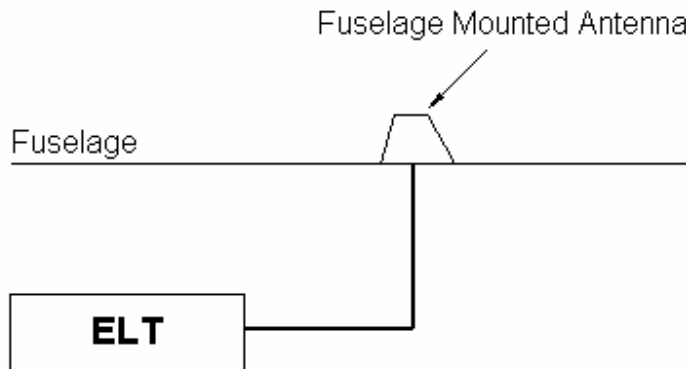


Figure 54

### Probable explanation for lack of transmission from PR-GTD ELT after impact

After the N600XL and PR-GTD collision, no signal from the PR-GTD ELT was received by COSPAS/SARSAT system to help the search and rescue effort. While the PR-GTD was already in a spiral dive and before it suffered the in-flight breakup, the recorded FDR information revealed that the longitudinal acceleration did not exceed 0.5 G. This value was not sufficient to activate the ELT, according to figure 1.

After the in-flight breakup of 737, probably the connection between the ELT unit and respective antenna was damaged or the tail crashed vertically, preventing any possible signal transmission.

## 4. ANALYSIS

On 29 September 2006, the EMB-135BJ (N600XL) and the Boeing 737-8EH (PR-GTD, regular flight GLO 1907) had different ETD's from their respective aerodromes of origin.

According to their flight plans, the N600XL ETD from SBSJ was 17:30 UTC, while the GLO 1907 ETD from SBEG was 18:30 UTC.

Normally, the two aircraft would cross each other at some point between Manaus and Brasilia, controlled by the Amazonic Center (ACC AZ), within a class A airspace, flying under the rules of Reduced Vertical Separation Minimums (RVSM), in which the minimum vertical separation is 1,000 feet (300 m).

However, the airplanes collided while flying enroute at flight level 370, along the axis of airway UZ6.

#### 4.1. THE PREPARATIONS OF N600XL

In São José dos Campos, the week of the delivery of the N600XL was dedicated to the final arrangements regarding the aircraft and its documents, so that it could be delivered to the foreign client.

There was not much to be done in the airplane, but a few Embraer technicians did some finishing of the painting and internal furniture of the N600XL to be delivered to ExcelAire.

Some details needed corrections, such as an adjustment of the door opening system and a final touch in the painting (everything prior to the aircraft acceptance and delivery flights).

The Excelaire pilots chose to get the flight plan for the ferry flight through Embraer, as it was a habitual practice of Excelaire in the arrangements for that kind of flight. So, a request was made to the Flight Support Manager to make the necessary provisions.

The Embraer Delivery Manager designed to give support to the Excelaire team said that, on Wednesday, September 27, she had been notified that the return trip, originally scheduled for Saturday, would be advanced to Friday, the same day of the aircraft delivery ceremony. The pilots, in the interviews, said they did not remember any change of the schedule.

For the PIC, it was the first time that he would receive an aircraft directly from a manufacturing plant in a foreign country. In the past, he had already received a smaller and less sophisticated airplane in his own country.

As for the SIC, that flight would be his first in the executive aviation. His previous experience had been in the regular aviation, under the aegis of 14 CFR Part 121, in which the preparations for a flight are usually more systematic, simplifying the job of the flight crew, since there is a significant flight dispatch structure.

There was not any standard operational procedure (SOP) for the Embraer Legacy at Excelaire, because the aircraft was new to them.

In this respect, according to the Operational Aspect, the participation of the ASI designated by the FAA to audit ExcelAire has, among other points, the responsibility of verifying the SOPs of the company, in coordination with the Safety Manager, the Flight Safety Manager and the Inspector of the company. The FAA ASI allowed the repositioning of the airplane to occur without a specific SOP, something that resulted in the lack of standardization of the pilots.

The Embraer Delivery Manager said that many clients elaborate their own flight plans, through the UNIVERSAL, and that there are clients that ask for the advisory of the Embraer Flight Support Manager.

The Excelaire pilots, differently from what usually occurs, did not request the flight plan to be delivered on the day before the date of departure.

The Flight Support Manager asked the Delivery Manager for the names of the pilots, the overflight authorization, and all other data necessary for the elaboration of the flight plan (origin, destination, technical stop, aircraft type and registration marks).

For the elaboration of the flight plan, he utilized the tool of Universal, selecting the “best wind route” option.

The vice-president of Excelaire, who was aboard the aircraft, said in an interview to NTSB, that the time of departure for the trip to Manaus had been defined as 14:00h local time, because they wanted to fly over the Amazon region during the day.

The pilots declared that, on the day before the trip, they worked on the planning of the return flight, and that most of the time they stayed at Embraer.

However, the EMBRAER Delivery Manager said that, according to records of the gates of the manufacturing plant, they entered the manufacturing plant at 12:34 pm, via gate F42, and exited at 02:24 pm. Therefore, on the day before the flight, they spent most of their time away from Embraer.

Still on Thursday, a special dinner was offered, as it was the eve of the day of the aircraft delivery ceremony. The pilots attended the dinner and, at the end, went out with the engineer assigned with the support to the aircraft flight operations. The engineer said that he dropped both pilots at the hotel where they were staying, between midnight and 01:00 am, 29 September.

The pilots said that, in the morning of the flight, they awakened at 08:30 am, after seven hours of sleep, and proceeded to Embraer.

They also said that, after the delivery ceremony, they did not take part in the festive dinner with the rest of the group, because they had decided to have lunch at the manufacturing plant, in order to get ready for the departure.

The pilots arrived at Embraer at 10:01 am, according to the entrance records. The delivery ceremony was due to take place at 11:00 am, and the departure was programmed for 02:00 pm.

After the end of the ceremony, at midday, according to information provided by Embraer employees, one of the pilots attended the festive dinner, while the other one monitored the aircraft pre-flight.

The return from the dinner was at 01:15 pm. The passengers proceeded to the aircraft, and the SIC, together with the delivery manager, went to a room of building F-300, in order to continue preparing the flight.

During the interviews with the pilots, it became clear that the procedures concerning the preparation of the flight, including the receipt of the flight plan, meteorological information and NOTAM that had to be analyzed by the crew, were not performed systematically.

As we have seen, the reasons for the lack of participation of the pilots in the procedures were partially a result of the following aspects:

- Delivery of a new aircraft to the operator.
- The operator did not have standard operational procedures established for the pilots, regarding this type of situation or this type of aircraft.
- In his career, the PIC had received only one considerably less sophisticated new aircraft and in his own country.

- The SIC was a novice in flights of the executive aviation, and had come from the regular aviation, ruled by 14 CFR Part 121, in which all procedures are systematically complied with, with the support of a big flight-dispatch structure.
- The non-existence of standard procedures set by the operator for the receipt of a new aircraft, to be performed by the crew, made the pilots divide their tasks according to their own experience, and react as the situations unfolded (a confirmation of this fact was the declaration of the captain that he did not remember the moment or the reasons that led him to accept that the flight plan would be prepared by the Embraer delivery manager).
- The presence of high staff members of the company directorship on board, although not being cited by the pilots, influenced their decisions and the management of the situations.
- The fact that, apart from the simulator, the pilots had never worked together as one crew in a real flight, contributed to a natural difficulty getting a smooth and fluid division of tasks.
- The pilots' concern with the data relative to weight and balance of the flight, as well as the fuel transfer system, which in the real airplane was different from the simulator used for their training, all contributed in one way or another to the deviation of the attention that had to be dedicated to the management of the flight.
- The lack of a better planning did not allow an early evaluation of important operational information, such as a NOTAM relative to the reduction of the runway length available at the Eduardo Gomes airport, their destination for that leg.
- Even the mentioned delay in delivering the flight plan and other data of the planning on the part of Embraer, alleged by the pilots, does not excuse them from their responsibility to forecast and manage possible delays in the preparation of the flight, especially for being in a place and under circumstances they had never experienced before.

In the interview given by the pilots to the Commission, more than a year after the accident, there were no complaints relative to the support provided by Embraer, and not a mention of a possible pressure on the part of the passengers to hasten the departure.

In the interview, it became evident that there was a lack of specific guidance on the part of Excelaire, operator of the aircraft, in relation to systematic procedures to be performed by the pilots in the preparation of an international flight.

The lack of a written operational routine established by the operator deprived the crew of a procedure standardization, which would have thoroughly covered all the verifications, preparations and care required for the conduction of the N600XL ferry flight.

It is important to point out that the pertinent legislation does not set requirements for this type of operation, in terms of flight dispatch.

The pilots were certified and did the training required by the legislation, but it did not prevent them from getting to the moment of departure with some lingering doubts about the aircraft weight and balance calculation software, which was only installed in the laptop of one of the crewmembers, shortly before the take-off.

When one considers the different versions about the moments and preparations prior to the flight, one gets to the conclusion that the pilots did not work methodically enough, did not prepare themselves for tasks they had to do by themselves, and transferred the responsibility for those tasks to other people. Contributed to this the fact that the operator did not have

standard procedures established to cover all the nuances that involved the receipt of a new aircraft, mainly in the case of executive flights, in which the scenarios are varied.

The ceremony and protocols degraded their attention to the details of the flight planning, resulting that the operational needs of a long distance ferry flight were underestimated, since it was the first time the pilots were going to operate the fuel system of the Legacy, which was different from the system presented in the simulator used by the pilots for their training.

It seems to be evident that the pilots did not deliberately fail to plan their flight, but they considered the mission as routine and ended up not being able to process all the necessary items of information within the time available.

As an example, both pilots were concerned over the fuel system and the weight and balance of the airplane.

It is not common for pilots who intend to fly an aircraft with which they are not accustomed, to be trying to solve doubts up to the last moment before departure, to the detriment of the time necessary to study the planning for the conduction of the flight to be initiated.

Likewise, it is not common for pilots to spend a great deal of flight time on a personal computer to study and plan the operation at the destination aerodrome and later stages of the flight.

The Legacy is a modern aircraft with sophisticated systems. Modern aircraft are designed to make their flights in such a way that a maximum of information is gathered and processed by the Flight Management System (FMS).

Thus, the mastering of the FMS operation by the crew is the vital condition for the completion of the flight planning, for the insertion of data relative to the flight, for the conduction and management of the proposed navigation.

There are not records about the PIC's degree of knowledge of the Honeywell FMS-Primus utilized in the Legacy.

A deeper analysis of the aspects of the training at the simulator of the FlightSafety International, in Houston, USA, was hindered because the FSI did not receive the CIAA, possibly for fear that the information collected relative to the training provided to the pilots, might be used in the law suits that were in progress.

On account of its importance for the flight management, the correct use of the FMS is enhanced by means of a modern tool known as CRM, that is, the Crew Resource Management, which today is a compulsory course for pilots.

The CRM doctrine is so deep-rooted in the air operations, that it is applied to almost all aviation segments around the world.

The captain (PIC) assigned to the mission and responsible for the flight would need the assistance of the co-pilot (SIC) along all the phases of the flight. On the other hand, the SIC, who was more experienced and had operated aircraft of the EMB-145 family, would be responsible for assisting the PIC, so that they could, together, accomplish the tasks regarding the preparation of the aircraft, the receiving of the proper briefings and the operation of the FMS.



There was a low situational awareness concerning the full application of the CRM doctrine, at the phase of planning and preparation for the flight, although the pilots of the N600XL had taken CRM courses.

Although the pilots had enough professional experience for the accomplishment of the mission, they did not perceive that the procedures adopted were short of what was required by the operational environment.

The aircraft had not been refueled before the "Delivery Ceremony", because the solemnity took place inside the Hangar of EMBRAER (where refueling operations are not allowed).

As the aircraft would be refueled at its maximum capacity, it had to be parked in the ramp, due to its heavy weight after the refueling, besides the fact that it was supposed to depart as soon as practical (after the refueling and flight plan clearance delivery).

The ceremonies, celebrations, the little time left for a proper study and analysis of the information relative to the flight, in addition to passengers and bosses concerned with the time of departure made the flight start differently from what should have been for a new plane in a foreign country.

The fact that one of the pilots was a little more experienced in the operation of aircraft of the EMB-145 family could not be interpreted as an assurance of proficiency in the Legacy, even though they are similar aircraft requiring the same rating from the pilot.

Although the SIC had been hired by Excelaire on 25 July 2006 (just two months before the mission), he was more qualified to operate the aircraft under a psychomotor perspective, that is, the ability to fly the new airplane.

The PIC, despite working at the company for almost 4 years and 11 months, did not have any experience piloting the new model, and had accumulated a total of 5 hours and 35 minutes in the type.

The organizational influence appears in the management of the resources at the disposal of the company, as well as in the organizational climate and organizational process.

All may be summarized in the haste to send pilots that had never worked together as a crew before, to fly an aircraft which they did not master in technical and operational terms.

The crew was **operationally unprepared** to fly the equipment.

**Such operational unpreparedness** refers to the fact that they had not flown together before the trip to Brazil; that they had studied the new aircraft together, but not deeply enough (in detail); and that they were not aware that the repositioning of the new aircraft, which the PIC had never flown before, would not be a routine flight..

The coordination of the cockpit preflight procedures contributed to the pilots not acquiring a perfect situational awareness, relative to the flight plan which had been submitted to the airspace control units.

They got to the moment of departure with doubts and expectations relative to the functioning of the system of fuel transfer from the extra tanks of the aircraft, a feature that was not present in the simulator used in their training.

At the moment of departure, they had not duly evaluated the consequences of the weight and balance on account of the reduction of the runway length available at the

destination airport, informed by a NOTAM, something which was highly distracting to them during the flight, in detriment of the monitoring of the aircraft systems with which they were not well familiarized.

These factors made the pilots focus their attention on the fuel system, since it was a long distance flight, a considerable part of which over the Amazon rainforest.

Consequently, they decided to configure the fuel system on the MFD screens of both sides.

They could, for example, have selected the TCAS system on one of the sides, as a way of protecting and monitoring the airspace.

During the acceptance flights conducted with the Embraer pilots, the standard procedure was to always select the TCAS screen on one of the sides.

It is worth pointing out that the TCAS screens of the MFD are programmed to be automatically selected in case a traffic alert appears, but the fact that it was not selected suppressed one of the indications of the TCAS operation mode available to the pilots.

## **4.2 THE CLEARANCE**

### **4.2.1. The clearance as it was received (scenario onboard the N600XL)**

The safety of the air traffic is ensured by established procedures which require a previous knowledge on the part of the professionals involved in the operation, including the pilots and air traffic controllers, in which every one has their own obligations to comply with. It depends on a perfect coordination of the tasks that each one has to execute.

The planning of the flight is the first of them, since there will be a right time for each event to occur.

The tools used for the accomplishment of the tasks according to the established procedures also guarantee the safety of the flight. Examples of these tools are the planes, the radio communications and the radars. The radars send signals that are processed by the software, and the resulting information is displayed on the air traffic control consoles, before the eyes of the controller.

In this scenario, when a pilot files a flight plan, the air traffic control units study the viability of the route proposed and the flight levels to be flown, aiming at authorizing it as filed or, in case there is a conflict, they try to solve it, resulting that the active flight plan is as similar to the flight plan filed as possible.

Therefore, a perfect communication between the pilot and the control units along all the phases of a controlled flight is essential, as far as safety is concerned.

A flight has to be initiated with a complete understanding of what has to be done by each of the parties involved.

A copy of the flight plan that had been filed was only handed to the pilots less than half an hour before departure.

It is interesting to point out that this does not represent any abnormality or violation of procedures.

The use of flight dispatchers to fill out flight plans and to go through the proper procedures is a widespread practice in the world aviation. It is up to the crew to learn the information contained in the FPL, in accordance with the specific legislation of each country.

However, it is always advisable that the flight crew set enough time aside to study adequately what has been proposed for their flight.

The study, the analysis and the previous knowledge of all the peculiarities relative to the navigation are fundamental for the comparison between what was proposed and what was approved by the control unit, so as to verify its feasibility.

The time span covered by the cockpit voice recorder (CVR) represented the last two hours of the aircraft under electrical supply, as expected. However, the time elapsed between the beginning of the electric power supply to the aircraft in the aerodrome of origin, and the arrival in Cachimbo was about three hours and forty minutes, resulting that all the procedures of departure and about 46 minutes of flight were not in the CVR anymore.

Thus, it was not possible to retrieve the dialogs of the N600XL occupants in the period from the receiving of the flight plan form, as the crew was already on board, up to 18:37 UTC, time at which the recording begins, when the N600XL was about 220 NM from SBSJ, leveled at FL 370.

The first call made by N600XL to São José Ground was at 17:26:40 UTC. In this contact, São José Ground provided information on the aerodrome conditions and runway in use.

The second call occurred at 17:31:46 UTC, when the aircraft requested push-back. The Ground granted approval for start-up, and asked the aircraft to report when ready for taxi.

The third call occurred at 17:40:31 UTC, with the aircraft reporting ready for taxi.

Initially, the Ground instructed N600XL to hold position, and subsequently approved the taxi, asking for confirmation of the number of persons on board.

The SIC answered, not adhering to the standard English phraseology: "six souls on board".

The controller asked for confirmation, the SIC apologized and corrected the information to "seven souls on board".

Despite the phraseology, the controller understood the number, and read back "seven persons on board", confirmed the taxi approval and asked the pilot to report when ready to copy the clearance.

N600XL read back the taxi approval for runway 15, and immediately reported being waiting for the flight plan clearance, as they did not have one yet.

At 17:41:50 UTC, the controller asked whether N600XL was ready to copy the clearance, getting an affirmative answer.

At 17:41:57 UTC, the following clearance was transmitted:

NOVEMBER SIX ZERO ZERO X-RAY LIMA, ATC CLEARANCE TO EDUARDO GOMES, FLIGHT LEVEL THREE SEVEN ZERO DIRECT POÇOS DE CALDAS, SQUAWK TRANSPONDER CODE FOUR FIVE SEVEN FOUR. AFTER TAKE-OFF PERFORM OREN DEPARTURE.

OKEY SIR, I GET (UNREADABLE), FLIGHT LEVEL THREE SEVEN ZERO (UNREADABLE), SQUAWK FOUR FIVE SEVEN FOUR, OREN DEPARTURE.

*(This was the transcript presented by DTCEA SJ).*

This was the first failure in the communication between the pilots and the air traffic control.

At several moments, the pilots demonstrated that they were not familiarized with the ICAO rules. For example, they could not interpret the item 18 of the flight plan, which describes the route in the ICAO form, a fact that was confirmed in the interview held in Brazil shortly after the accident.

In their latest interview, the pilots confirmed that, upon receiving the flight plan, they checked the route with the careful attention that modern FMS-equipped aircraft normally demand: maximum attention to the insertion of the navigation way points (lateral navigation) and less focus on the proposed flight levels along the route (vertical navigation).

The reason why they paid more attention to the lateral navigation was that it meant the correct itinerary of the flight, which is defined by all the points that have to be over flown, and whose insertion in the FMS takes longer and are more difficult to revise en route, besides being less prone to be changed by ATC instructions.

As for the flight levels, they are more likely to be changed in relation to the flight plan filed. They are simpler to modify and subject to more restrictions and modifications during the en-route flight.

The crew commented that, in their previous analysis of the flight, they paid more attention to the way-points than to the flight levels.

Relatively to the flight in question, there was confidence that they were within controlled airspace and that there were not any major elevations along their route.

The pilots did not show much concern with the fact that they were flying within an area under the ICAO rules, nor demonstrated to be aware of the differences and peculiarities of the forms used.

They did not realize that more attention had to be paid to all the prescribed procedures, especially in relation to the navigation and the planning of the flight as a whole.

As for the influence of the first clearance, the initial clearance, according to the interviews, was understood by the pilots as a normal one, with a clear message that the flight level authorized up to Manaus was FL 370.

They only felt that a first altitude restriction was missing in the ATC message, since the chart of the OREN SID only showed the minimum flight level over the PCL (Poços de Caldas) fix.

Then, they requested an instruction concerning the initial altitude, but the controller did not understand the question.

As the ATC message did not mention either a clearance limit or whether the flight plan had been cleared as filed, the resulting understanding was that the flight level to be flown all the way to the Eduardo Gomes Airport, in Manaus, was FL 370.

As a matter of fact, the way the message was transmitted by the São José Ground Control, authorized the pilots of the N600XL to fly at flight level FL370 up to Eduardo Gomes International Airport, in Manaus.

This fact influenced the situational awareness of the pilots in relation to the maintenance of flight level 370.

However, this failure will be added to various other ones that occurred in the existing protections of the ATC system that could have prevented errors of this kind, as we will see later on.

#### **4.2.2. The ATC clearance, as it was transmitted (ATC scenario).**

During the investigation of the human factor, psychological aspect, the ground control operator at São José dos Campos affirmed that the whole clearance is prescribed to be delivered for the entire route, as specified in ICA 100 -12. However, he pointed out that the controllers of São José are aware of the fact that there are various sectors for authorization in Brasilia and, sometimes, they issue a clearance in an abbreviated manner, as described and analyzed in the item 3.5 Navigation, of this report.

The pilot questioned about his first or initial altitude, showing his concern as to the first limit.

The controller did not understand, but asked the pilot to repeat the question.

The pilot asked again about the first altitude to be maintained after takeoff.

The controller, either due to having misunderstood or because he did not feel comfortable to ask the pilot to repeat, replied that the aircraft was authorized to taxi up to the holding point of runway (threshold) 15 of São José airport.

Once more, the pilot called the ground control and asked about the altitude he should initially maintain after the takeoff.

SJ Ground confirmed the climb and the first fix, but did not confirm the first altitude.

Two minutes later, the ground controller made two calls to the aircraft, which was taxiing, but there was no reply.

While they were taxiing, a low situational awareness could be observed on the part of the pilots, possibly due to their paying attention to other tasks in the cockpit, without being attentive to the radiotelephony.

Finally, SJ TWR called N600XL, and informed the aircraft about the first level to be maintained.

The GND controller declared that, later on, when reading the transcription of the communications with N600XL, he noticed that the pilot did not understand the expression "Poços de Caldas".

He said that the phraseology allows two forms of communication: "Poços de Caldas" or "PCL radio beacon". Nevertheless, the pilot accepted the instruction, having not insisted with the GND, who, then, informed of Oren departure, transition Poços de Caldas, transponder code, and frequency to call Brasilia Center.

Another factor to be considered: in the uses and customs involving the phraseology and jargons commonly used in two-way radio communications within the Brazilian airspace, it is not unusual that, when referring to a certain stage of a flight, with many changes in the vertical or horizontal navigation, the personnel involved – ATS units and flight crews – describe those changes in generic terms, normally mentioning the final destination and the first flight level – with each party assuming that the other is aware of the details.

Notwithstanding the fact that the ATS units may choose to transmit an abridged clearance, the key issue is that, at the beginning of the clearance, it announces whether the clearance is “as filed” or, if otherwise, what has been kept of the previous planning, as well as what has been modified – which is called the clearance limit.

As for the flight of N600XL, it can be said that the flight plan was cleared with no clearance limits regarding the flight levels proposed. However, this was not made verbally clear to the crew of N600XL.

The ATS unit did not comply with the prescription of the ICAO Document 4444, Chapter 4, items 4.5.4 “Contents of Clearance”, mainly in what refers to the IFR clearance, which, on account of not being complete, did not indicate a clearance limit.

In summary, a flight plan which was cleared as filed; a clearance that was not correctly transmitted by the ACC BS to SJ Ground, which, in turn, did not transmit it to the N600XL crew correctly: all of this resulted in that the N600XL flight crew understood that the flight level FL370 was authorized up to Manaus.

The clearance message transmitted conveyed information that was different from the flight plan that had been activated by the ATS units.

#### **4.2.3. The flight progress, according to the understanding of the clearance.**

A clearance delivered in an incomplete manner, and pilots that did not have enough time to analyze the flight plan filed, on account of a lack of proper anticipation of the procedures concerning the preparation for the flight, the N600XL ended up departing with situational awareness incongruent with the plan activated by ACC BS.

The pilots receive, evaluate and usually follow the instructions given by the controller, but this is not an impediment for them to confirm the instructions with ATC.

If there is an international rule concerning headings and flight levels, and if it was understood that the instruction meant to join an airway at a non standard flight level, the pilots could have questioned the air traffic controller as to the maintenance of flight level 370 after the vertical of Brasilia VOR.

It is common that, when duly authorized by ATC, aircraft maintain flight levels different from the recommended standard and, provided there is not a conflict, controllers may authorize such procedures for the benefit of the traffic flow. Therefore, flying in a direction opposite to the normal traffic flow would not be incorrect, provided a coordination was made by the controllers and pilots, prior to performing such a procedure.

According to what was recorded in the CVR, at the moment of heading change overhead Brasilia VOR to join the UZ6 airway, there is not any comment made by the pilots about the navigation, since the crew’s attention was focused on the performance data of the landing at and departure from Manaus, a task relative to the planning that should have been dealt with before the flight.

At that moment, the strips of the active flight plan were already getting to the air traffic controllers of the sectors through which the aircraft would fly. The strips contained flight level changes not realized or expected by the pilots.

During the 79 minutes and 34 seconds recorded in the N600XL Cockpit Voice Recorder before the collision, there was not any comment by the pilots concerning levels, level changes or airway changes.

Since there is not anything before the beginning of the CVR recording, which started at 18:33:17 UTC, it was not possible to determine whether the planning factors of the flight plan submitted – in which there were three distinct flight levels for the entire route – had been previously and duly discussed by the flight crew.

What can be said is that, according to the interviews, the flight crew showed a lack of attention to the flight plan and was not able to interpret the routes and flight level changes prescribed in item 18 of their ICAO flight plan form.

As was confirmed in an interview given by the pilots a year after the accident, more attention was paid to the lateral navigation than to the vertical navigation (levels). As already commented, this is common in the programming of the FMS for long routes. However, the lack of pre-established procedures on the part of the company for this type of operation contributed to the pilots' diminished attention to this aspect.

According to the data obtained from the CVR, the N600XL crew was excessively concentrated in studying the systems and performance characteristics of the new aircraft, and in the planning of the operation to be carried out in SBEG, which was restricted by a NOTAM.

It is not good practice to be involved, while flying, in any type of task that demands too much attention that, otherwise, would be paid to the adequate operation of the aircraft systems or to the navigation being conducted.

It would have been wiser if those tasks and more detailed planning's had been carried before the flight, in the phase of planning, so that they did not demand so much time and attention during the enroute flight, which would have rendered the pilots more attentive and with a more adequate level of situational awareness.

It can be considered that, except for the understanding of the flight level FL370 as being for the entire route, everything went by normally, from the takeoff, at 17:52 UTC, up to the last two-way radio contact between the aircraft and Brasilia ACC, on frequency 125.05 MHz, at 18:51 UTC.

All communications occurred normally, on seven different frequencies, in accordance with what is prescribed for the various sectors, as shown in the table below:

CLEARANCE	17:26 UTC	SJ GROUND	121.9
-----------	-----------	-----------	-------

DEPARTURE	17:51 UTC	SJ TWR	118.5
INITIAL CLIMB	17:54 UTC	SJ APP	119.25
CLIMB	17:57 UTC	ACC BS	126.15 SECTOR 1
CLIMB	18:13 UTC	ACC BS	122.65 SECTOR 4
LEVEL	18:33 UTC	ACC BS	124.20 SECTOR 5
LEVEL	18:51 UTC	ACC BS	125.05 SECTOR 5 (last contact)

According to the CVR, there was no comment on the route or flight plan management or on the status of the equipment and the aircraft in general. There was an informal comment of a passenger that was helping the pilots with the planning of the operation in Manaus, about the overflight of Brasilia, but it was not technical, and did not refer to the airway, headings or altitudes.

#### 4.3. THE PREPARATIONS OF FLIGHT 1907

In Manaus, at the Eduardo Gomes International Airport, the PR-GTD flight crew was in the cockpit preparing for their flight, receiving the papers relative to the flight planning and navigation.

Considering that the criteria for flying in RVSM airspace are rather restrictive and that the Repetitive Flight Plan (RPL) of the GLO 1907 prescribed the conduction of the leg at the flight level FL410 (initially), i.e., an RVSM flight, the airplane was dispatched in perfect condition, with the communication and navigation equipment in fully operational condition (Transponder and TCAS).

According to the interview with the team of the GOL Company of the Manaus base, in charge of the Operational Dispatch of the GLO 1907 on 29 September 2006, the airplane was dispatched with all the systems, components, parts and fuselage without any non-conformity.

At 18:19:30 UTC, the SIC of the PR-GTD requested the clearance from Manaus Clearance Delivery.

Over the radio, the controller, who was already aware of the Flight 1907 repetitive flight plan with a FL 410 cruise level, asked the SIC whether that was their intended level. The SIC replied by asking whether FL370 would be possible, but, before the controller could say anything, immediately added that FL410 would be alright.

Finally, the controller, knowing that FL370 was the crew's preferred level, replied that he would try to coordinate that level as a first option.

At 18:22:09 UTC, the controller issued the clearance for the GLO1907 to fly at FL370.

The controller opted for accommodating the crew's request for a lower flight level, considering that the pilots would have had their technical reasons.



It was a technical and opportune decision considering the flight conditions. Logically, the crew's request for a lower level is a routine decision that may be motivated by a number of factors, such as aircraft weight, meteorological conditions along the route, winds forecast for the levels, clouds, etc.

#### 4.4 THE EARLY HAND-OFF OF THE N600XL

At 18:50:19 UTC, ACC BS called the N600XL, but got no reply.

After a new attempt at 18:50:31 UTC, the N600XL answered the call.

At 18:50:37 UTC, the ACC BS transmitted the following instruction:

"...switch frequency one two five zero five, sir..."

At 18:50:41 UTC, the N600XL aircraft replied:

"...decimal one, I'll try **one two five decimal zero five**, good day, six hundred x-ray lima.

The hand-off of the aircraft was made with the message above from the controller of sector 5 to the controller of sector 7.

The flight level change was scheduled to occur over the BRS VOR, still inside the sector 5.

The controller of sector 5 handed off the traffic to the controller of sector 7, while the aircraft was still in his sector, and did not make any mention either to the receiving controller or to the N600XL pilots, of a possible flight level change a little further, and, therefore, did not set a limit to his clearance, not complying with the item 11.4.2.6.2.2 a and c, ICAO Doc 4444 (PANS-ATM) - Procedures for Air Navigation Service-Air Traffic Management.

There was not any mention regarding a sector change or a clearance limit for flight level FL370.

The controller of sector 7 received the traffic still outside his area of responsibility, confirmed flight level FL370 and the provision of radar surveillance service to the N600XL.

The aircraft was about 52 NM south of BRS VOR, a navaid marking out the vertical of Brasilia and the transition from the UW2 to the UZ6 airway.

The border between the sectors 5 and 7 was about 30 NM northwest of Brasilia VOR.

Therefore, the aircraft handoff to the next controller took place while the aircraft was still in sector 5, well before the vertical of Brasilia.

Upon calling sector 7, the N600XL pilot reported maintaining flight level FL370.

It was the first contact with sector 7, and would be the last contact with ACC BS (Brasília Center).

#### 4.5 THE LAST CONTACT

#### 4.5.1. Onboard the N600XL

At 18:50:19 UTC, the ACC BS called the N600XL, but the pilots were so busy with the destination weather forecast that neither of them identified the call.

The controller called them again, and then they answered.

The ACC BS told them to change frequency to 125.05 MHz.

According to the CVR, the PIC, sitting on the left, repeated the frequency as if, at the same time, he were selecting it in the RMU. The SIC thanked him.

The PIC commented:

..."could have done it from my side but...that, that'd be too hard."

It was a reference to the SIC, who was busy with the computer on the lap.

The SIC, who continued to select the fields of the flight planning software, inserted in the laptop, that were to be filled in, commented that he never knew how to address the control, in a reference to the Brasilia ACC call sign.

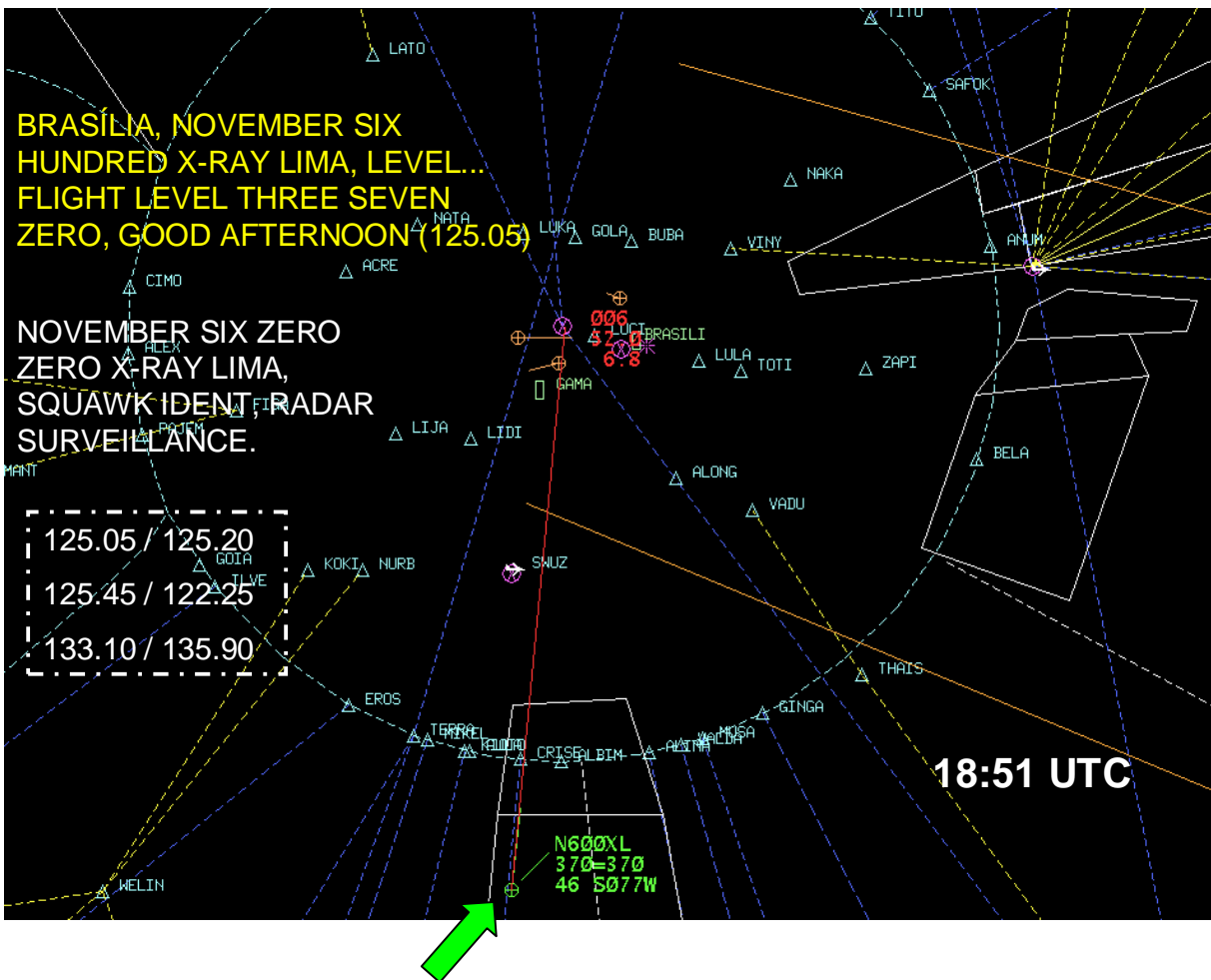
The little familiarity of the crew with the flight in Brazil was evident, as well as the fact that the crew did not try to counterbalance it with a more detailed preparation concerning the frequencies, routes, flight plan and, for instance, the call signs themselves.

At 18:51:04 UTC, the crew made the last radio call that would be heard and answered by the ACC BS, which instructed the crew to squawk the identification code.

At 18:51:14 UTC, the ACC BS transmitted: "November six zero zero X-ray Lima, squawk ident. Radar surveillance."

At 18:51:20 UTC, the N600XL replied: "Roger."

It was the last two-way radio contact between the aircraft and ACC BS.



**Figure 55**

Figure 55 above depicts a view of the data block at the moment of the last two-way radio contact with Brasilia Center, sector 5, on the frequency 125.05 MHz.

After telling the aircraft that he was aware of the flight level 370 reported, the controller asked the N600XL to squawk the identification mode of the Transponder.

On his screen, the controller saw the respective indication of the aircraft and on account of that, to comply with ICA 100-12/2006, item 14.11.2, letter a, he informed that the aircraft was being provided with radar surveillance service.

Although the aircraft was still in sector 5, the controller who assumed control of the aircraft was the one responsible for sectors 7, 8 and 9, operating at console 8.

Immediately after acknowledging the message, the pilots made comments about how to activate the ident mode of the transponder, once again showing that they were not adequately adapted to the aircraft, and that they were not certain about the handling of the communication and navigation equipment.

This was confirmed by the CVR data, which contained the following dialog:

18:51:20.6 UTC

(HOT-2) - OH!...(bad word). I forgot to do that.

18:51:22.0 UTC

(HOT-1) – ID is there.

18:51:26.8 UTC

(HOT-2) - I think I did it. Yeah.

18:51:33.2 UTC

(HOT-2) - I think you see that. Oh! (bad word)

18:51:37.7 UTC

(HOT-2) - Twenty five oh five. That's why I write it down.

18:51:39.3 h UTC

(HOT-1) – yeah.

18:51:39.8 UTC

(HOT-2) - a technique I saw when I was uh doing international with uh some of the Captains.

18:51:44.9 UTC

(HOT-1) - yeah, I don't see any uh...

18:51:52.9 UTC

(HOT- 1) - we don't, we don't have any data link. It's gotta be set up.

18:51:55.9 UTC

(HOT-2) - what is our alternate let's see here?

18:51:57.9 UTC

(HOT-1) - they put, they put it in there, right?

18:51:59.0 UTC

(HOT-2) - B-V-V.

18:51:59.4 UTC

(HOT-1) – yeah.

18:52:12.1 UTC

(HOT-2)\_ - sky at twenty five hundred. I don't know what TX thirty five means...TN twenty five. I got to learn this (bad word) international (bad word).

From 18:51 UTC to 19:48 UTC, 57 minutes elapsed without any attempt to contact the ATC units.

From the moment of the last two-way radio contact onwards, everything that occurred was a result of the interaction between the N600XL crew (with the aircraft communication/navigation systems) and the ACC BS.

#### **4.5.2. At Brasilia ACC**

The ACC BS is located at the CINDACTA I, in Brasilia, the federal capital of the country.

This ACC covers a large area that contains the three busiest regions within the Brazilian airspace (Brasilia, Rio and São Paulo).

For the Brasilia Region, two supervisors and seven controllers were assigned, taking turns in their respective positions.

On account of the light flow of traffic during that period, the five sectors of this region (5, 6, 7, 8 and 9) were grouped into two consoles (07 and 08), according to the legislation in force. Sectors 5 and 6 were grouped into console 07, and sectors 7, 8 and 9 were grouped into console 08.

As already seen, the route planned for the N600XL passed through the sectors 5 and 7 of the ACC BS.

The Legacy airplane, after departing from São José, flew direct heading to PCL (Poços de Caldas) beacon. Then, it flew along the UW2 airway, crossing the sector 5, up to BRS (Brasilia) VOR.

After Brasilia, the aircraft entered sector 7 flying along the UZ6 airway, passed TERES position and proceeded to NABOL position, located at the boundary between the Brasilia and Amazonic FIRs.

The flight progressed uneventfully up to the vertical of BRS VOR, with the data block showing flight level 370 on the right, as the flight level authorized for that segment, and, on the left side, the **real** flight level (**NIV**) maintained by the aircraft, in this case, **FL 370**, informed by the mode C of the N600XL transponder equipment, in what is called a correlated aircraft icon.

The aircraft **was cleared** by the ACC BS to reach FL370, at 18:10:50 UTC (frequency 126.15 MHz, sector 1).

At 18:12:41 UTC, the aircraft was transferred to frequency 122.65 MHz (sector 4), still during the climb.

At 18:33:00 UTC, the aircraft was transferred to frequency 124.20 MHz (sector 5), and the pilot informed having reached flight level 370. Brasilia ACC replied by informing that they were under radar contact, and corrected the information by saying that the aircraft was under radar surveillance.

At 18:50:19 UTC, Brasilia ACC called N600XL, and instructed the aircraft to change to frequency 125.05 MHz.

At this moment, the responsibility for monitoring the aircraft passed from the controller who was working at console 07 (sector 5) to the controller of console 08, responsible for three grouped sectors, among them sector 7.

This early handoff brought up consequences for the passing of the aircraft on the vertical of BRS VOR.

#### 4.6 PASSING OVERHEAD BRASILIA VOR

At 18:55 UTC, the aircraft passed overhead Brasilia, joining the UZ6 airway, maintaining flight level 370.

As we have seen, in the **NIV** field of the data block of the correlated aircraft icon, the controller had the information of FL 370.

“ Mode C flight level (only for secondary radar returns or associated radar returns replying in mode C) in hundreds of feet; 3D altitude, when mode C is not valid and 3D mode is valid”. (Item 3.1.2 Controller’s Operations Manual).

This information confirms that the aircraft was maintaining FL370, according to authorization given by the controller of the previous segment.

According to an operational feature of the software, known to the controllers, when the aircraft approached BRS VOR, which is a route fix marking out the vertical of Brasilia, the data block of the aircraft, by means of an automatic change of the CFL field, began to display the information that, from Brasilia on, there was a programmed flight level change to FL360, according to the active flight plan.

The **CFL** field changes from **authorized flight level** to **requested flight level**, about two minutes before the point where the expected level change is supposed to occur.

According to the concept of the system, the flight level FL360 was the one cleared for the next segment of the route, and the controller simply had to analyze it and call the aircraft to instruct about the necessary level change.

Looking at the data block, the controller notices a discrepancy between the flight level shown in the **NIV** field and the one of the **CFL** field , with the equality sign (=) connecting them both. The **NIV** field shows the current aircraft altitude, informed by the transponder mode C, if the aircraft icon is correlated, or by a 3D radar, in case it is available.

However, the previous controller (sector 5) did not issue any instruction to the aircraft relative to level change.

As a feature of the system, there are two kinds of information that may be displayed in the same field.

The same **CFL** field may indicate either authorized flight level 370, as it did in sector 5, or requested flight level 360 (programmed for the next segment, in accordance with the active flight plan), as was the case about two minutes before the aircraft passed BRS VOR, heading for sector 7. However, there is neither a reference to this double function of the **CFL** field in the item 3.1.2 (Data Block) of the Controller’s Manual, nor any recommendation for the controller to be aware of such change. Nevertheless, these features are taught and practiced with the controllers during the **ATM-15** course.

This automatic change does not warn the controller, in any special way, that the **CFL** field now requires an action, and it is up to the controller to observe that the equality signal (aircraft stabilized) in the T field of the data block, which indicates the tendency of the level evolution, now shows the discrepancy between the levels in the **NIV** and **CFL** fields.

The **NIV** field was receiving information from the aircraft **mode C**, so it was perceptible that the FL 370 maintained by the aircraft was in discordance with the FL 360 indication, which was then a requested flight level.

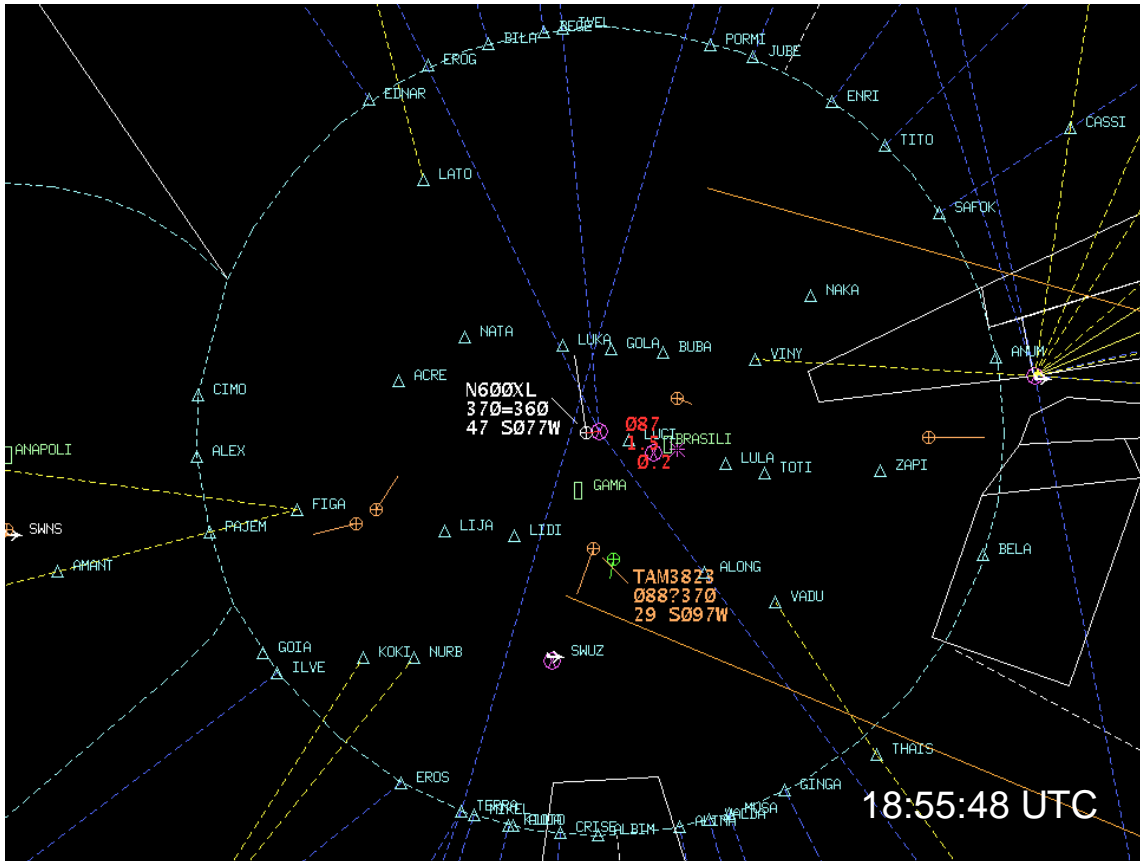
This situation remained for **seven minutes**.

The aircraft maintained FL 370, and the controller in charge did not make any calls.

The data block displayed FL 370 as the current flight level, informed by mode C, while the field “flight level authorized according to flight plan” began to indicate FL 360 (flight level requested), when the aircraft was two minutes out of the vertical of BRS VOR which, in fact,

was a flight level to be authorized by the ATCO for the next segment, as a flight level authorized in accordance with the active flight plan.

The information of the data block was that the aircraft, from that point on, **was flying at a flight level that was different from the flight level requested in the active flight plan**, as shown in Figure 56 below.



**Figure 56**

The frequency maintained by the aircraft was the one of the last radio contact, 125.05 MHz.

For the aircraft to proceed through sector 7, at that moment, actions on the part of the controller in charge would be necessary, both on account of the need to coordinate the flight level change authorized by the active flight plan, and the need of a more adequate frequency for that sector.

According to the active flight plan, there was a request for a level change from FL370 to FL360.

The flight level 370 would be non-standard for the new heading 336°, now being flown, after a 30° turn to the left. This would require an action to be taken by the controller, since radar surveillance service was being provided, within category A airspace, with RVSM separation.

The detection equipment worked in accordance with their expected and habitual characteristics.

The controller's failure to act may have been caused by a lack of perception or a mistaken perception of the information conveyed by the data block.

There were only five more aircraft in the sector, a fact that is not an indication of a lack of perception caused by stress, on account of excessive workload.

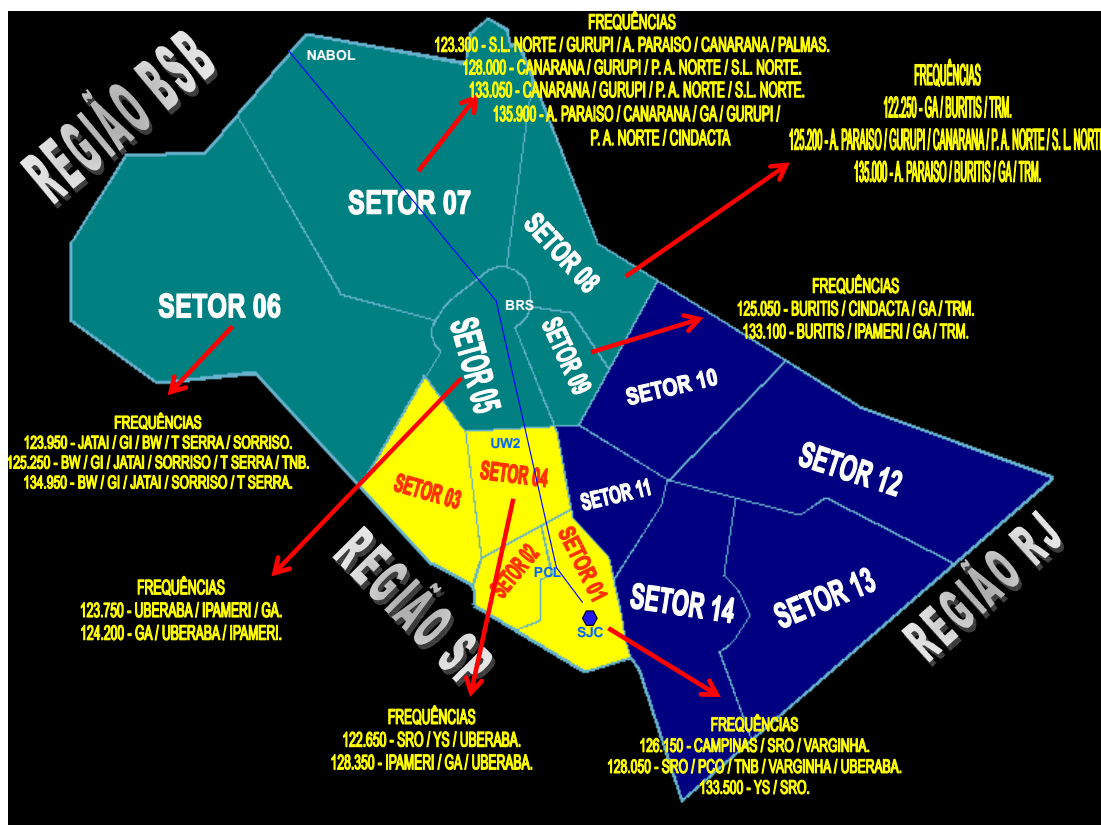
The failing to act, on the part of the controller, leads us, then, to the possibility of an inadequate situational awareness to react correctly to the pieces of information presented by the equipment, something that contributed to the N600XL maintaining of the FL370 after passing BRS VOR.

#### 4.6.1 Handoff from sector 5 to sector 7 – prescribed actions for controllers and pilots

As already commented, the controller of sector 7 received the N600XL from sector 5, on the frequency 125.05 MHz.

When the controller verified the aircraft entering sector 7, to the north of Brasilia, he had to have instructed the aircraft to change frequency to 135.9 MHz, in accordance with the sector frequency table (Figure 57), besides analyzing and deciding about the adequate instruction regarding the change to FL360 authorized by the active flight plan.

As it was a category A controlled airspace, and the flight evolved under RVSM conditions, it was not compulsory for the pilots to report that fix and, according to the understanding of the initial clearance, they were authorized to maintain FL370 and, if necessary, they would receive a new clearance from the ACC.





## Figure 57

The maintenance of the FL370 on the part of the N600XL pilots was in accordance with the last instructions received from the ACC BS.

During the seven minutes after the aircraft passed the vertical of the BRS VOR, the actions required were the responsibility of the ACC BS.

### 4.7 THE INTERRUPTION OF THE TRANSPONDER TRANSMISSION

At 19:02 UTC, seven minutes after the aircraft passed over the vertical of BRS VOR, the transponder of the N600XL airplane stopped transmitting its signals to the radars of the ACC BS, interrupting the mode C altitude information, resulting that the controller did not have precise altitude information any longer.

This event contributed to the lack of accurate information relative to the flight level maintained by the N600XL, after passing BRS VOR.

The loss of information occurred, simultaneously, in five distinct radars, and all the other aircraft in the vicinity that had their transponder operating, continued with their transmissions of the mode C being received by the ACC BS.

#### 4.7.1. In the cockpit of N600XL.

The analysis of the CVR showed that the atmosphere in the cockpit was rather relaxed, and with a low situational awareness. There were various examples pointing to a lack of attention to details, from the beginning of the recording (when forty minutes after takeoff had already elapsed) up to the moment of the collision, with the pilots working with the laptop.

According to the CVR data, the pilots did not make any comments concerning the flight management, such as, for example, the thirty-degree heading change to the left (from 006° to 336°) at the vertical of BRS VOR. There were no comments about the joining of the new airway, or the possibility of a flight level change. The left turn was made automatically by the autopilot, and the CVR did not record any supervising action by the crew at that moment, denoting a poor airmanship.

This expression "*airmanship*" is very much used in aviation, and is understood as the skill or knowledge applied to the air navigation, similar to the "*seamanship*" of the maritime navigation. "*Airmanship*" covers a broad spectrum of desired behaviors and skills of an aviator. It is not only a measurement of techniques and skills but also the conscience of the pilots relatively to the airplane, to the environment in which they are operating the aircraft, as well as their very capability to operate it.

There were not any recordings of comments that might suggest that the pilot-in-command (PIC) was checking the information displayed by the flight instruments at periodic intervals.

The pilots were busy, making use of a laptop in the cockpit, for calculations and for obtaining data relative to the landing at and takeoff from Manaus, in the software provided by Embraer for performance and weight and balance calculations.

If they had planned the flight more properly, that task would have been accomplished still on the ground, before departure, mainly due to the fact that there was a NOTAM for

Manaus airport, informing that just part of the runway was available for landing and takeoff operations. This aspect will be commented later.

When, at an interview, the crew was asked about having entered a wrong flight level for the heading they were flying, they said it is not uncommon to receive non-standard levels from the air traffic control. According to them, they were flying en route, under radar contact, and did not receive any instruction from the control unit whose frequency they were monitoring. They were in accordance with the last instructions received.

From the analysis of the exact moment, recorded in the CVR, at which the N600XL Transponder stopped transmitting, we have a period of silence in the cockpit, with duration of about one minute and forty two seconds (from 19:00:01.5 UTC to 19:01:44.3 UTC).

According to the information available, the loss of the Transponder signal on the screen of the air traffic controller occurred around 19:02 UTC, indicating that the STANDBY feature of the transponder had probably been selected.

For the Standby mode to be selected, it is necessary to press the fourth top to bottom left button, in one of the RMUs (it has to be pressed twice in a 20-second interval).

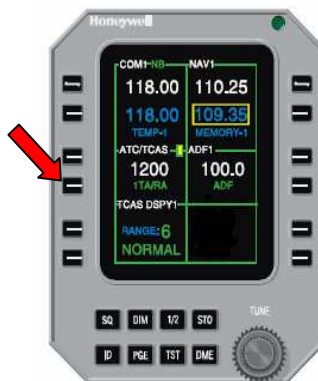


Figure 58

It is worth pointing out that all the tests of the N600XL transponder and TCAS, as well as of the units and pieces of equipment associated to them, showed that no technical problems had occurred in any of the components.

During that period, the SIC continued using the laptop for landing and takeoff calculations, while the PIC would have the aircraft panel in front of him, with numerous possibilities of actions.

In his interviews, the PIC declared that he was then monitoring the instruments, having touched only the button of the fuel transfer on the overhead panel, therefore at a distance from the RMU, where the modes of operation of the transponder are selected.

The possibilities of what may have happened will be dealt with later on.

According to the interviews with the pilots conducted by the NTSB, which were forwarded to the Brazilian investigators, as well as according to information collected in direct interviews with the CIAA, the SIC provided the following information:

- The transponder code was not changed, and remained the same during all the flight
- Said that the TCAS was checked before they entered the runway.
- Said that the TCAS was set to the TA/RA mode (manual). In manual, the TCAS does not appear on the MFD (Multifunction Flight Display), except when there is an intruder.
- Said that when the TCAS appears on the MFD, it blocks the page of the systems, on account of not having an integrated display.
- Said that the aircraft TCAS was set to the least sensitive mode of operation, since every time the TCAS screen goes up and down on the MFD, it can distract the pilots.
- The TCAS was set to the manual mode as soon as they arrived in the cockpit and so remained.

The PIC provided the following information:

- They used the TCAS during the acceptance flights, and it was usually raised on the right-hand side display and lowered on the left-hand side one. He believes that the reason why the EMBRAER pilots did so was to allow for a constant monitoring of the pages concerning the fuel and hydraulic systems.
- During the training at FSI, there was at least one TCAS training of an occurrence of TA/RA. On the FSI simulator, they normally configured both displays at down, and he believes they were set to the manual mode. However, he said that, no matter what is configured in the display, the TCAS screen will rise to inform either TA or RA.
- He said that he tested the TCAS but does not remember the screens' status during the test.
- During the flight, they configured the TCAS with the screens at down on both sides.
- They both wanted to have the fuel system displayed on their respective sides. The fuel page was shown on both displays.
- The fuel for the flight was not critical, but both pilots wanted to see the fuel transfer in progress, to be certain that the functioning was normal.
- According to him, at the moment of the test, the RMU display appeared normal, and he saw the TA/RA shown on the screen.

Additionally, the FDR data indicated that during the flight, the pilots never selected or maintained the MFD screen for the TCAS open, something that would have enabled them to monitor contingent traffic during the flight.

It is worth pointing out that the continuous monitoring of eventual traffic through the use of the MFD screen for the TCAS – which would immediately warn them that the TCAS was not operating – is a provision usually made by pilots. This provision was not consciously used by the N600XL flight crew.

According to declarations given in the interviews, both pilots decided to focus their attention on the fuel on both screens of the MFD, as they were not confident in relation to the aircraft fuel transfer system. This could be explained by the fact that their training had been done at a simulator which was different from the aircraft, as far as the fuel transfer system was concerned. The time available was short to solve doubts and adequately learn about the new system.

It was observed that the pilots lacked knowledge of basic parameters of the aircraft, such as, for instance, its weight, which they certainly should remember very clearly, since they had just completed ground school.

The CVR recorded that the laptop was only put away at 19:13 UTC. Considering just the time recorded, it represented at least 40 minutes of use, not to mention that it may have been used during part of the 42 minutes of flight, prior to the beginning of the recording.

Back to the NOTAM of Manaus, this issue is relevant because the N600XL crew, already in flight to the destination, learned later than could be expected (about 18:45 UTC) of the important restrictions concerning their landing at Manaus and mainly their departure on the next day to Florida.

There was a distraction from the focus of the routines relative to the monitoring of the flight progress, which made the crew direct their attention to the search and analysis of the available data relative to the remaining fuel, as well as the information contained in the software of the notebook, during a long time, possibly longer than the one that was recorded in the CVR.

Such a doubt and its urgent solution involved them thoroughly and, on account of the little experience of the PIC in the aircraft, it is possible that he searched for information about the fuel consumed on the fuel page of the RMU, a moment at which, trying to leave the page and pressing the pertinent buttons, he may have inadvertently changed the Transponder from the TA/RA condition to STANDBY, thus interrupting the mode C altitude information.

The subject of the NOTAM (and the drawing of the attention of the crew to it) was only solved at 19:13 UTC (closing of the *notebook*), approximately 11 minutes after the *Transponder* had stopped transmitting.

As the CVR demonstrates, the pilots had all their attention drawn by the issues related to the NOTAM of Manaus, as soon as they understood its importance for the completion of the flight and for the landing at that airport. As part of their conversations during the flight, even with passengers that came to the cockpit, they talked about technical issues for the execution of the landing such as, for example, the lack of a Glide Slope for a night-time landing, aspects of the meteorology, the need to make a non-precision approach, and whether the PAPI had been moved from its position.

Even after the laptop was put away, there was no discussion or comment on the part of pilots which might suggest that they were monitoring the parameters and information relative to the flight.

At 19:16:35 UTC, the CVR indicated a course deviation consistent with an enroute weather area avoidance. The deviation was confirmed by the pilots, who said that they did not call ATC, because it was a minor deviation of just a few degrees away from the route.

Any course deviation should have been communicated to the Air Traffic Control (poor *airmanship*).

The last radio contact between the crew and ATC had been at 18:51 UTC.

Again, the point was not only the deviation they made without coordination with the Air Traffic Control, but also the fact that the pilots were flying 25 minutes without communication with ATC, in a foreign country. This was an indication of the pilots' poor *airmanship* – even if we take into account that they were maintaining FL370, in accordance with the last instruction received.

During the deviation, it could certainly be expected that the crew would monitor the existence of other traffic, by selecting the TCAS screen on the MFD – another chance for the pilots to notice any discrepancies on the screens of the PFD or RMU, such as, for example, TCAS OFF on the PFD.

During the period from 19:22 UTC to 19:39 UTC, there was some chat in the cockpit, about various subjects.

They talked about the operation of a certain item of the airplane equipment, the Moving Map system/(entertainment), with which neither pilot seemed to be acquainted.

As they were approaching TERES position, there was some discussion about whether they were really passing over the fix. In fact, the discussion originated from a request of one of the passengers who asked for the name of a big river that could be sighted on the ground.

Again, not a mention was made of any periodic verification of the airborne equipment or instruments, with the exception of the amount of fuel.

An adequate airmanship environment would imply the decision by the pilot to compare both the consumed and remaining fuel with the amount of fuel received before departure. This would involve verification of the flight plan and of the fuel page.

There was neither any attempt to contact ATC nor a questioning between the pilots, although 43 minutes had elapsed since they last communicated with the ACC BS.

Then, the SIC commented with the captain that the fuel had been selected from the fuselage to the tail. The fuel transfer was confirmed by the PIC.

Once again, this would imply the necessity of verifying the fuel page in detail, which would have meant another opportunity for the pilots to see that the TCAS was OFF, and that the transponder had been set to STANDBY.

By looking at the fuel page, their attention would also have been directed to the general instruments of the panel, where the lack of the green light glow, which indicates the return of the transponder identification could have alerted them that it was not transmitting.

Even if verification had been made at the moment of the aircraft leveling-off, any operational standard for executive aviation flights would require a thorough instrument verification to be made at least every hour. There is no evidence in the recording of the CVR that this was done, and the pilots continued flying the airplane with the Transponder at STANDBY and, consequently, with the TCAS inoperative.

#### **4.7.2. At ACC BS (interruption of the N600XL transmission)**

All that has been analyzed so far aims at the understanding of what was going on aboard the executive aircraft during the period that involved the interruption of the Transponder transmission.

Now, let us analyze the same event, from the perspective of the air traffic controller.

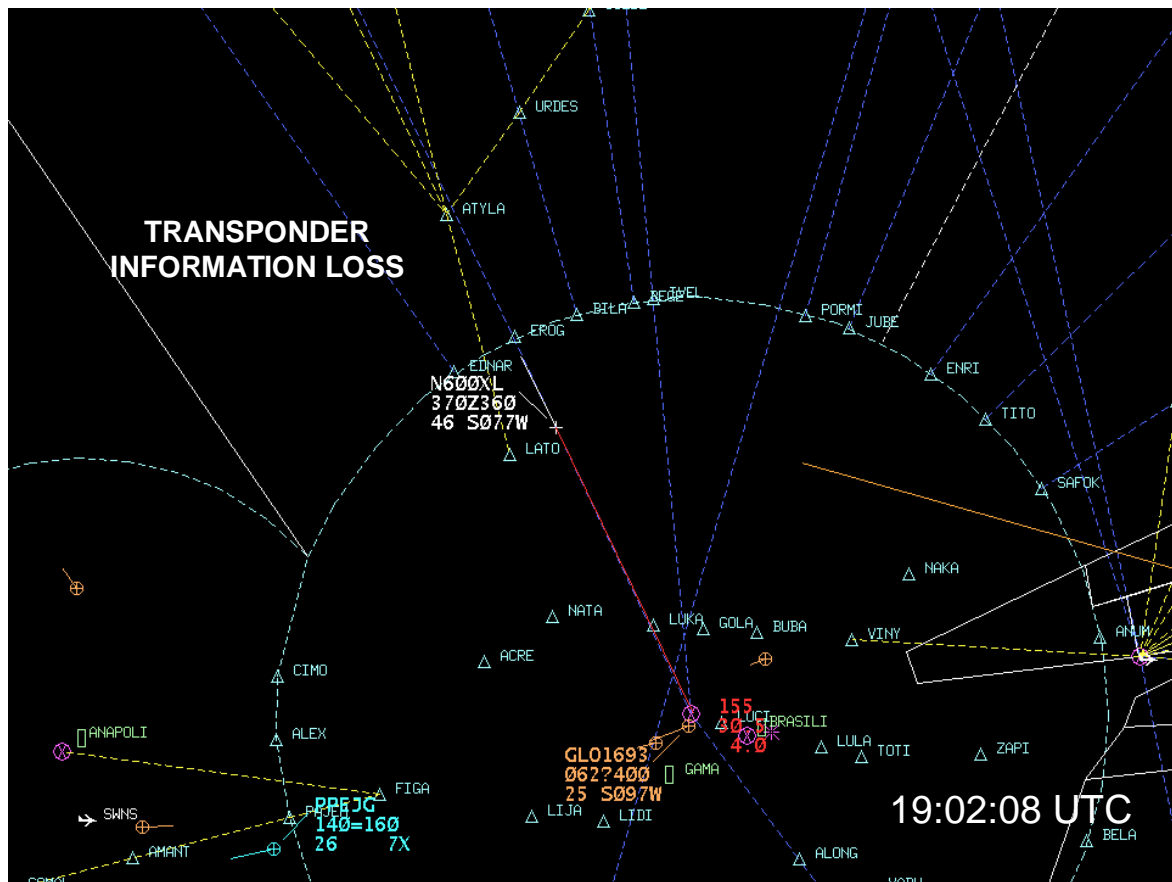


Figure 59

As seen in figure 59, the white data block pertaining to N600XL displays a letter Z between the two levels earlier identified as NIV and CFL, according to the ATECH Controller's Manual already mentioned, meaning **aircraft with a valid 3D altitude**. This meant that, from that moment on, the altitude information relative to that aircraft **was being obtained by 3D primary radar equipment and not from the transponder mode C** any longer.

The display of the N600XL icon on the screen is now just a white cross associated to a vector line, as seen in the picture depicting the data block. It was **different from the previous icon, which consisted of a cross inside a circle, as detailed in item 3.5.1 of this report**.

In this case, from that moment on, the air traffic controller had an indication, which was in accordance with his manual of operation, that the detection of the aircraft was being obtained by primary radar, and that the source of altitude information was then the 3D radar, and not the C mode of the aircraft transponder, via secondary radar.

#### 4.7.3 Actions prescribed for Controllers and Pilots in the event of transponder failure

Both air traffic controllers and pilots must constantly verify the functioning of their respective pieces of equipment.

The transponder failure is considered, according to ICAO Doc. 4444, Chapter 5, item 5.2.2, a degradation of the aircraft performance:

### 5.2.2 Degraded aircraft performance

Whenever, as a result of failure or degradation of navigation, communications, altimetry, flight control or other systems, aircraft performance is degraded below the level required for the airspace in which it is operating, the flight crew shall advise the ATC unit concerned without delay. Where the failure or degradation affects the separation minimum currently being employed, the controller shall take action to establish another appropriate type of separation or separation minimum.

When the controller observed that the transponder signals were not being received, it was his duty to call the aircraft and request a verification of the equipment.

In case the crew informed that they were not able to reset the equipment, the controller should then take action to cancel the RVSM condition of the aircraft (prescribed vertical separation of 1,000 feet) and provide a proper conventional vertical separation from other traffic (2,000 feet).

The abnormality occurred at 19:02 UTC, seven minutes after the moment at which prescribed actions should have been taken by the controller, among them the commandment of a frequency change.

Then, besides the data block information that the **“flight level authorized in the flight plan for the segment being flown”** was not the same flight level at which the aircraft was flying, there was also the information that the radar detection associated to the aircraft was only a primary-radar return. The altitude displayed was now being obtained by the available 3D radar, since the Transponder signal was no longer being received. Consequently, the altitude information was not as precise as the one provided by the Transponder.

It was necessary to contact the aircraft in order to confirm its altitude, request the crew to verify the functioning of the Transponder, as well as assess the condition of the aircraft to remain under RVSM rules.

However, no contact was made by that controller with N600XL, and as two hours had elapsed since he began working at the console, it was time for him to be relieved by another controller.

It may be supposed that the controller perceived the indications of the mode C loss, but, judging inadequately that the aircraft was at the planned flight level, he would have evaluated the resulting risks incorrectly.

This attitude would have influenced the lack of information or transmission of incorrect information on the occasion of service transfer to the relieving ATCO 2 of sectors 7, 8 and 9.

As for the pilots, within RVSM airspace, it is their obligation to monitor and constantly verify the functioning of the Transponder, which in this aircraft has 8 visual indications in all: 2 at the RMUs, 2 at the PFDs, another 2 at the MFD (these depending on the activation of the TCAS window of the MFD), and an amber light of the reply annunciator blinking in the “ATC window” boxes at the two RMUs.

If there is any interruption in its functioning, as was the case, the pilots should have alerted ATCO right away, with the message: NEGATIVE RVSM.

This, however, does not exempt the controllers from their own obligations previously described.

#### 4.8 THE CONTROL POSITION RELIEF

According to information provided by the controllers to the ASSEGCEA (Flight Safety Advisory of DECEA) just after the accident, the time of the relief had been 19:15 UTC.

According to the ACC BS Operational Model in force on the date of the accident, the item 5.1.4 – TRAFFIC/SERVICE TAKE-OVER, sub item 5.1.4.4 Controller Position, prescribed that, at that moment:

“Besides updating the relieve Controller on the current weather conditions, the Controller being replaced shall inform him of all existing aircraft in his area of responsibility, confirming the individual situation of each one, and pointing to the aircraft icon on the console screen”.

The above mentioned sub item also states that sixteen different situations shall become clear enough to the controller taking over the position, highlighting the following:

- **traffic without transponder, with inoperative transponder, or with erroneous information.**

The Operational Model in force on the day of the accident since was dated from 10 June 2004.

This document had the purpose of “complementing the norms and rules of the air traffic services, detailing the specific functions, activities and procedures to be carried out by the **Brasilia Area Control Center (ACC BS)**” (Operational Model, item 1.1 - Purpose)

From a technical perspective relative to the specific issue of transfer of position responsibility, we can conclude that the prescribed procedures would still be sufficient for guaranteeing safety, provided they were complied with accordingly.

In accordance with the Operational Model of Brasilia ACC already mentioned, the controller being relieved had to inform the relieving controller that the flight progress strip was indicating flight level 360, that no secondary radar (Transponder) signal was being received from the aircraft and, as a result, the altitude information was not reliable. Therefore, the N600XL could not remain separated by RVSM criteria, without a confirmation of its altitude. There was not an adequate transfer of service or a warning of these items of information.

There should be **two** controllers (the controller and his assistant) taking over the traffic directly on the screen. However, there is information that the assistant-controller was not present at the position relief, having arrived at a non-specified later time.

The analysis of this position relief still lacks an interview with the controllers, and has been based on their routine reports.

Neither of them recognized, in the data blocks and strips available, the abnormalities affecting that aircraft.

It was not possible to verify with precision how the position relief procedures were performed, since they are not recorded by electronic means, although, according to prescriptions, personal codes are entered through the keyboard.



The way the position relief was conducted, possibly not complying with the Operational Model, contributed to the neutralization of the system defenses.

The several pieces of equipment functioned within their characteristics of operation, but it is necessary to consider that:

- The level change was programmed to occur over BRS VOR, still within sector 5.
- The controller of sector 5 handed off the traffic to the controller of sector 7, still within his own sector, and did not make any reference nor gave any warning either to the controller or to the N600XL pilots that there was a level change programmed to be made soon, therefore establishing a clearance limit, in accordance to ICAO Doc 4444 (PANS-ATM) Procedures for Air Navigation Services – Air Traffic Management, item 11.4.2.5.2.2c.
- The controller of sector 7 received the traffic, which was still off the limits of his area of responsibility, and confirmed flight level 370 and provision of radar surveillance service to N600XL.

The software of the system would warn this controller 2 minutes before the aircraft passed BRS VOR that a level change was to be analyzed and coordinated.

The warning was given by means of the automatic change in the CFL field, which began to indicate a new flight level (FL 360), as flight level requested.

This automatic change is a defense of the system for the situation. However, the controller of sector 7 either did not perceive the information presented to him on his console during seven minutes.

With the discontinuance of the aircraft transponder operation (not observed by the pilots), the situation aggravated. The **NIV** field in the data block which had been showing accurate altitude information, suddenly **started presenting a 3D radar generated altitude measurement** which, as we have already seen, **cannot be (and is not)** utilized in Brazil for the provision of vertical separation between aircraft, especially within RVSM parameters.

The NIV field started showing inaccurate altitude information which, on account of not being originated from the transponder mode C, show variations ranging from 1,000 to 1,600 feet, as occurred in the data block.

The altitude information varied between FL360 and FL385, although the **T field** of the data block was indicating the **letter Z** to the controller, to warn him that the altitude indications were coming from a 3D radar. In addition, the circle around the “cross”, which appears in the correlated aircraft icons, when the Transponder is exchanging data with the SSR, disappeared, thus indicating a loss of the Transponder signal.

The fact is that the first controller of sector 7 assumed that the aircraft was flying at FL 360, and, subsequently, passed this wrong information to the relieving controller of sector 7 who took over the responsibility for the N600XL.

The mistaken assumption by the first controller of sector 7 can be attributed to human failure, associated with deficient oversight.

From the investigation of the Human Factor, the following was obtained:

The ATCO 2 of sectors 7, 8 and 9 of the ACC BS did not perform the procedures prescribed for transponder and radar contact loss within RVSM airspace, and for communications failure, besides displaying poor communication with the assistant controller.

The ATCO 2 perceived and identified the loss of mode C, and performed inefficient procedures to solve the problem. In relation to the difficulties establishing contact with the aircraft, the controller was not able to detect, identify and diagnose the situation correctly and, consequently, failed to adopt the prescribed procedures.

The hypotheses for the inadequate action taken by the ATCO 2 include the lack of knowledge of the prescribed procedures relative to the situations experienced, and the deficient judgment concerning the real altitude of the aircraft and to the level of risk involved.

The attitudes of passivity and complacency displayed by the ATCO 2 may have been generated by the wrong assumption that the N600XL was maintaining the flight level FL360. These attitudes influenced his behavior in that he did not request support from the regional supervisor, and did not tell the assistant controller to advise the ACC AZ about the conditions involving the N600XL aircraft.

In relation to the supervisors, the CIAA observed a lack of involvement with the events associated with the control of the N600XL.

It was observed that the decisions and actions at the ACC BS originated from individual initiatives, indicating a lack of communication, integration and cooperation between the members of the work team on duty (Deficient team resource management).

Among the responsibilities of the regional supervisors listed in the Operational Model of the ACC BS, there is the following one: "to supervise the execution by the controllers, under their supervision, of the air traffic control services provided within their respective control sectors, so as to correct errors, omissions, irregularities or inadequate employment of ATS procedures."

It was not possible to define the aspects that contributed to the lack of involvement of the supervisors with the events, as they refused to participate in interviews.

The following non-conformities were also present in the communication: lack of information and/or wrong information transmission by the ATCO of sectors 5 and 6, ATCO 1 and 2 and assistant controller of the sectors 7, 8 and 9, on the occasion of the execution of the procedures of coordination and handoff relative to the N600XL, between sectors, and between area control centers (ARTCCs), and during the controllers' relief; lack of communication between controllers and supervisors.

Deviations from the procedures concerning the prescribed phraseology were observed, in various situation of the air traffic control activity, and in the several units involved in the accident. These deviations contributed to the lowering of the situational awareness of the controllers responsible for the N600XL traffic.

The controller had had the following information available:

- The data block (with a correlated radar icon), the flight progress strip, and the last communication with the aircraft, whose crew had informed to be maintaining flight level 370.
- The data block changed the CFL field to 360, automatically.
- The flight progress strip had the indication 360 in the RFL field. The CFL field was also indicating 360, because this field is automatically repeated by the software.
- The data block confronted the FL 370 in the **NIV** field, with the CFL FL 360, by means of the equality signal of the T field, for seven minutes, during the time the aircraft mode C was being received.

When the mode C was lost, the **NIV** field started showing variable altitudes at values around 360, although the letter **Z** in the **T** field of the data block was clearly warning that the information was coming from a 3D radar, requiring immediate actions to be taken by the controller.

It is possible to consider that the controller, besides not having memorized the last level informed by the N600XL flight crew, did not interpret correctly the information available.

The automatic change of the CFL field in the data block changes the information on the current altitude which was authorized by another controller, into the information of a **proposal** of change to a new flight level authorized by the active flight plan.

Likewise, the initial automatic repetition in the flight progress strip of the flight level proposed (RFL) in the CFL field, requires the controller to be attentive to understand that the CFL field (where he **may and must** insert the flight level authorized) may be showing a flight level not yet analyzed, although already authorized by the active flight plan.

No clear guidance or mention was found in the Controllers' Manual relative to the fact that the CFL field of the data block may indicate either the status of the last clearance, or an alert requesting coordination to change to an authorized flight level. (Item 3.1.2, Controller and Assistant-Controller's Operations Manual).

However, this information is given to the new controllers during the instruction period (ATM-15 course), and they have always operated the system within this conception.

The same can be considered about the 3D radar altitude information. The system tells the controller, by means of the **letter Z**, that the altitude information is being obtained by the 3D radar and, therefore, must not be used for vertical separation under RVSM rules.

The altitude variations presented in the NIV field are expected and known to the controllers, and any controller operating his or her equipment attentively is able to control the traffic with safety, provided the required preventative actions are taken. In the scenario of the accident in question, the controllers involved received every piece of information from the equipment, but failed to take the required actions, on account of reasons they have refused to clarify.

Although there are not recordings of the position relief between these controllers, the system recorded, at 19:24 UTC, a change to flight level 360 made in the CFL field of the strip, left side, by the relief controller.

The manually made change caused all subsequent strips, including the one at the ACC AZ, for example, where the plan had a pre-active status, to also change to FL360, as if the aircraft had been authorized by ATC and really flying at FL360. This is a clear indication of the assumption by the ATCO 2 of sector 7 that the aircraft was maintaining flight level FL360.

If such change had not been made, then in the strips of the sectors where the flight plan was pre-active, the CFL field of the strip would be indicating 380, together with the RFL, which was the flight level planned for the segment from TERES to Manaus. Thus, with the aircraft at TERES position, the ATCO 2 of sector 7 would have had another opportunity to prevent the accident, perhaps by being more incisive in questioning the aircraft as to the need of climbing to flight level 380.

#### 4.9. UNSUCCESSFUL COMMUNICATIONS ON ACCOUNT OF PROCEDURE ERRORS

On the one hand, an aircraft whose pilots had a low situational awareness relative to the flight they were conducting, up to the point of not having perceived that the Transponder had stopped transmitting, as their attention was focused on the solution for the NOTAM of Manaus, while trying to make up for the time that should have been spent on the ground to solve this question, as well as familiarize with the aircraft and deal with the planning of the trip.

On the other hand, the Air Traffic Control Center, in which a control position relief occurred, and the controllers were not aware of the abnormality that was being informed by the detection equipment.

It is important to analyze the attempts to communicate made by both sides.

On the part of the N600XL, from 18:51 UTC to 19:48 UTC, 57 minutes elapsed without any attempts to contact the control units.

On the part of the ACC BS, after the mentioned last radio contact, various situations occurred that demanded contacts with the N600XL, but the first attempt was only made at 19:26 UTC. Therefore, 35 minutes passed without any attempts to contact the aircraft.

No attempts of communications were made on the HF frequencies either by the N600XL or by the ATC.

#### **4.9.1 At the ACC BS**

There are no recordings of communications or attempts to call, between 18:51 UTC and 19:26 UTC.

Seven calls were made by the ACC BS, all of them on VHF frequencies, while nineteen were made by N600XL, always on VHF frequencies.

The ACC BS transmitted simultaneously on six VHF frequencies selected on the control console number 08, as shown below:

**135.9/ 125.2/ 125.05/ 133.1/ 122.25 and 125.45 MHz.**

The N600XL aircraft used a radio navigation chart that indicated five frequencies for sector 07, as follows: **123.3/ 128.0/ 133.05/ 134.7 and 135.9 MHz.**

The change in the strip, made by the relief controller (ATCO 2), was made at 19:24 UTC. The change was in the CFL field, left side, to flight level 360.

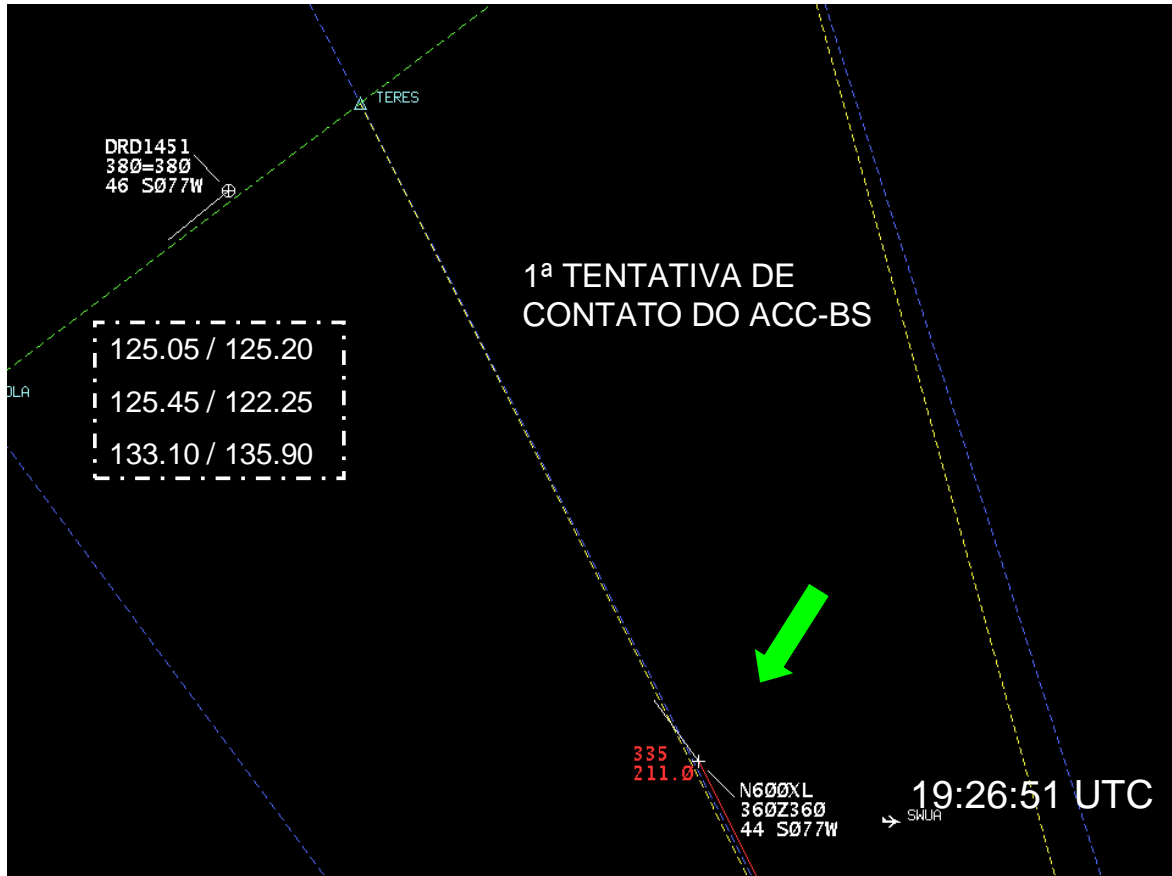
The information received from the ATCO 1 by the ATCO 2 of sector 7 were considered enough by the ATCO 2 to assume that the N600XL was at flight level 360, although the altitude information source was the 3D radar. Had the controller's interpretation been different, he would have not changed the CFL field in his strip.

Two minutes elapsed before the **first attempt to contact** was made by the ACC BS at 19:26:51 UTC. They got no reply.

From that moment on, a series of communication failures occurred, up to the moment of the collision.

Despite being transmitting on 125.05 MHz, the first call was only made when the aircraft was already at **211 NM away from BRS VOR.**

The aircraft icon still showed a correlation between the primary radar and the 3D radar returns.



**Figure 60**

The effective range of the frequency 125.05 MHz at FL 300 is 300 NM. Although the aircraft was within the frequency theoretical maximum range, the positioning of the aerials is for sector 09.

At the **second attempt, at 19:27:12 UTC**, for the **first time** a frequency change to **135.9 MHz** was commanded. Such a command should have been given, at least, 30 minutes earlier.

The aircraft was already at **218.5 NM from BRS VOR**, still with primary radar contact and correlation.

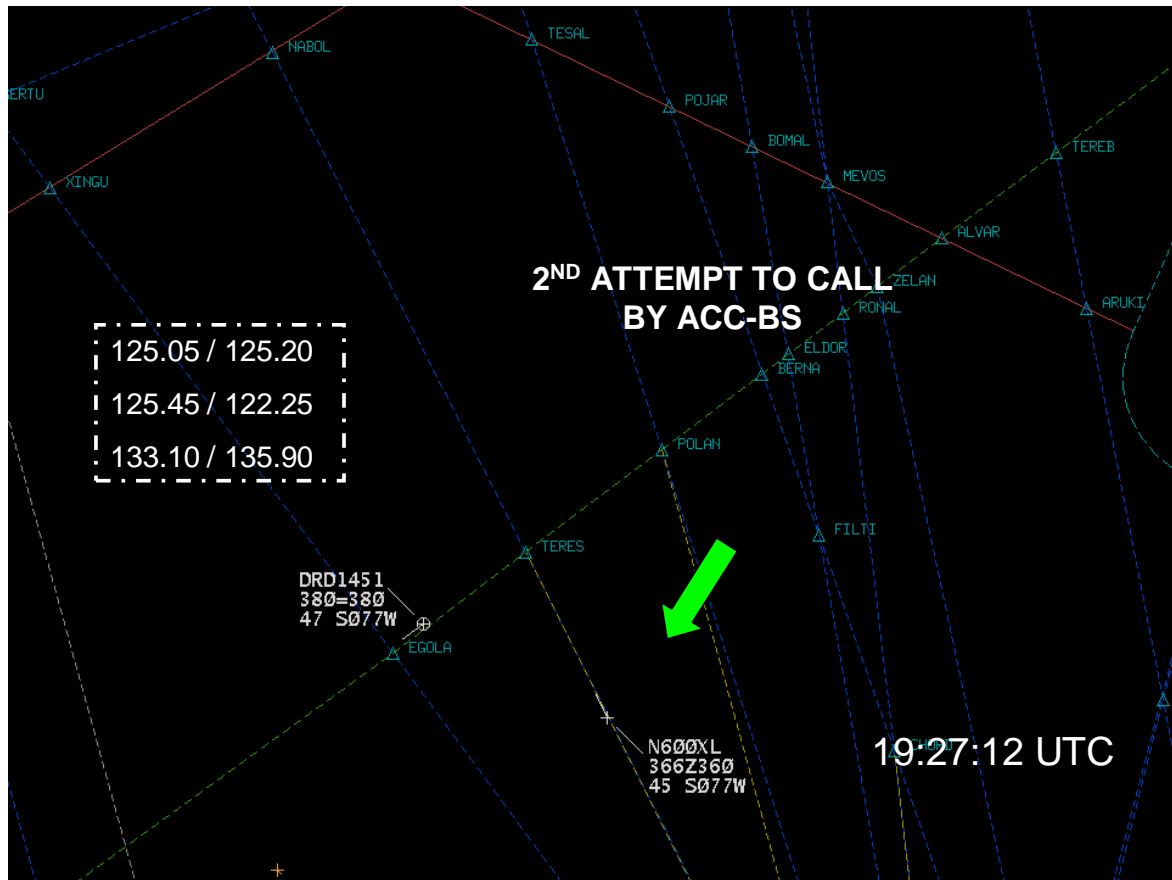


Figure 61

There was not any reply from N600XL to either call. The controllers did not take any alternative actions, such as resorting to an alternative, in an attempt to establish contact.

These actions could have been, for example, a request to another aircraft flying near the sector to relay a message, or even a transmission in the blind.

It was urgent to contact N600XL, in order to confirm its flight level and question about the transponder operation. The transcript of the two first calls is presented in **item 3.6** of this report.

The ACC lost primary radar contact with the aircraft for two minutes. A **third attempt of radio contact** was made, at **19:30:40 UTC**, when the aircraft was already at **248 NM** from BRS VOR.

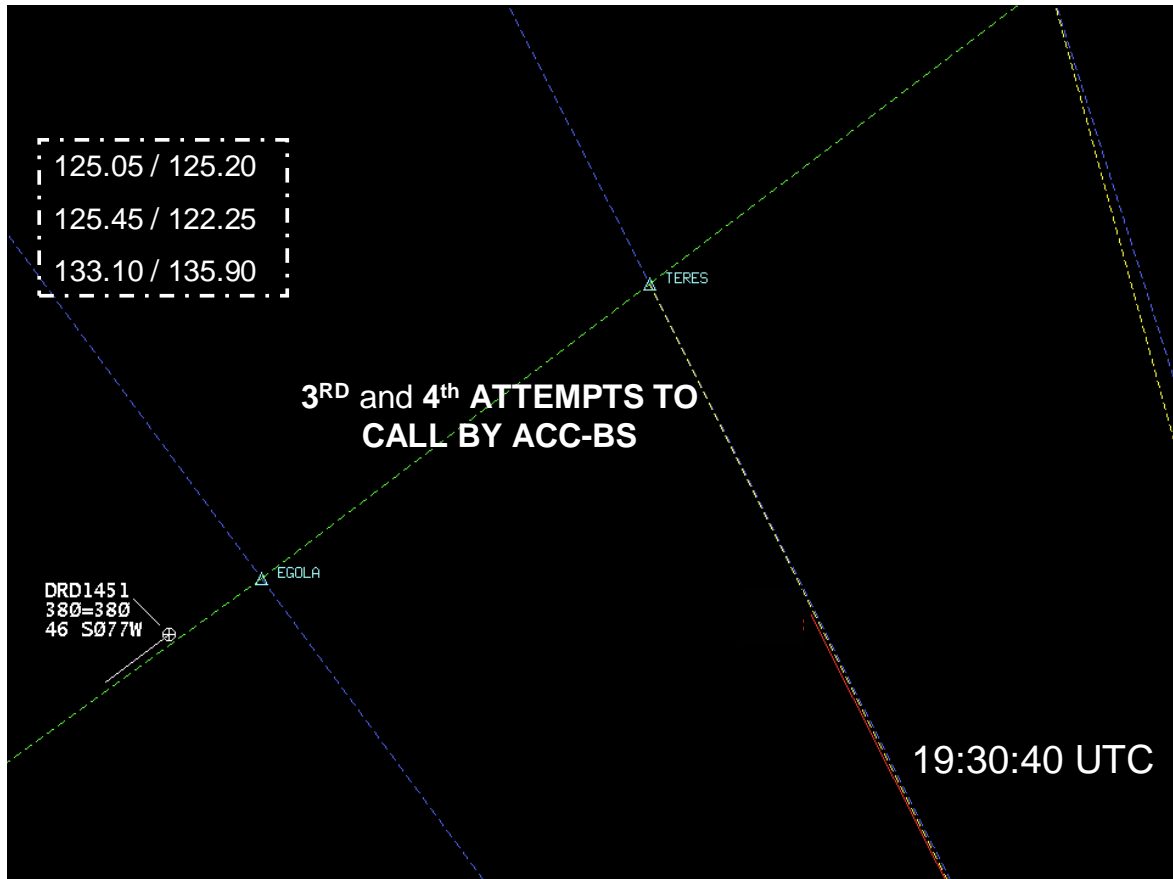


Figure 62

A few seconds later, a **fourth attempt** to call was made at **19:30:56 UTC**, with the aircraft at about **250 NM** and not replying to the calls.

At **19:32:48 UTC**, the aircraft reappeared as a primary radar contact, at **265 NM**, but now without its correlation symbol. Instead of the earlier data block, it had only speed and 3D radar altitude information. This type of altitude information can not be used for vertical spacing under RVSM. The controller then made the **fifth** unsuccessful **attempt** to contact.

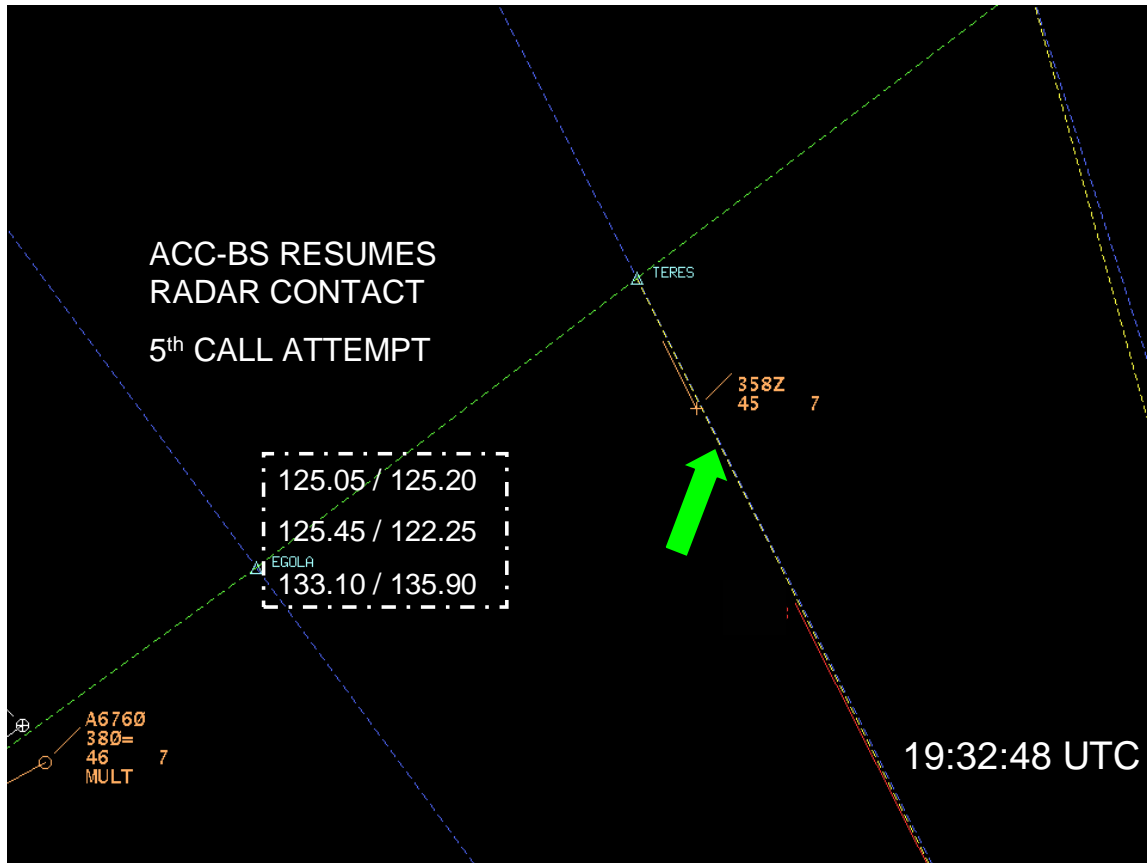


Figure 63



At **19:34:08 UTC**, the controller made the **sixth attempt**, and for the **second time** he added an instruction of frequency change to **135.9 MHz**, when the aircraft was already at **280 NM**.

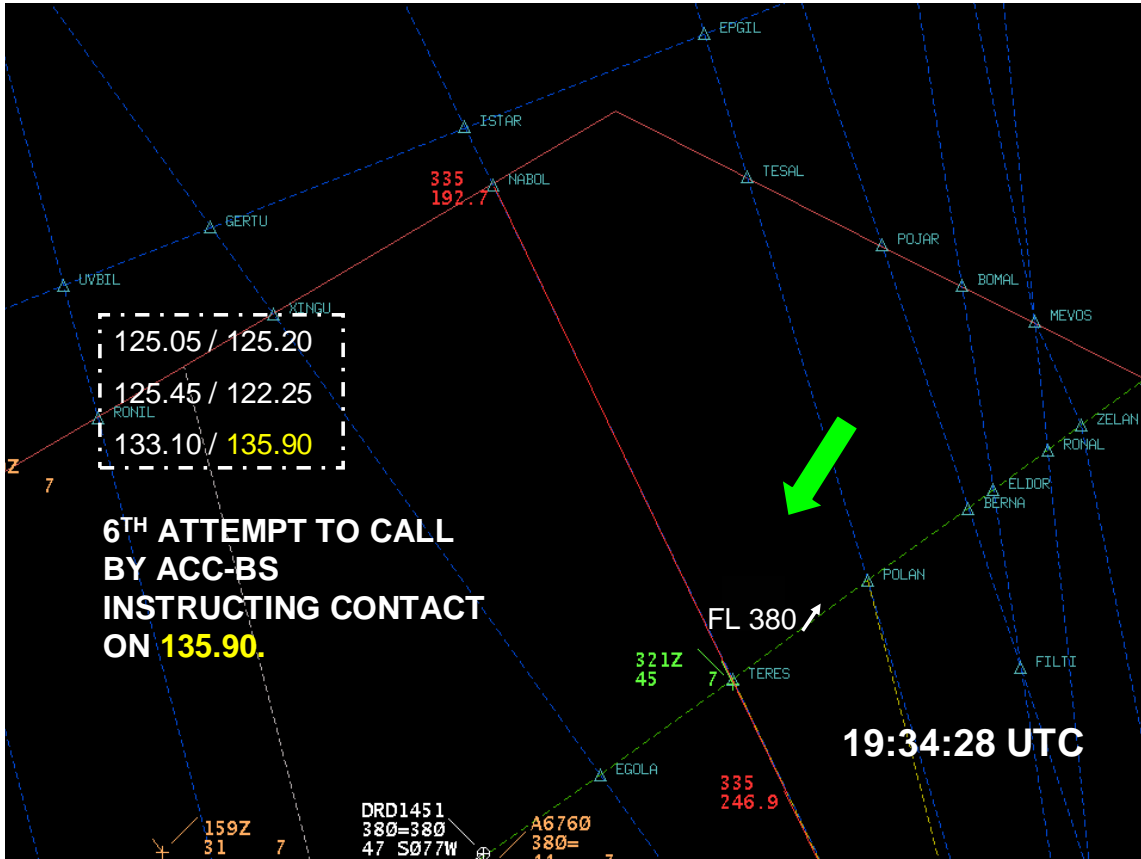


Figure 64

At 1938:23 UTC, the primary radar contact was lost, when the aircraft was at 311 NM. If the transponder had been transmitting, the secondary radar coverage would have been available to the controllers.

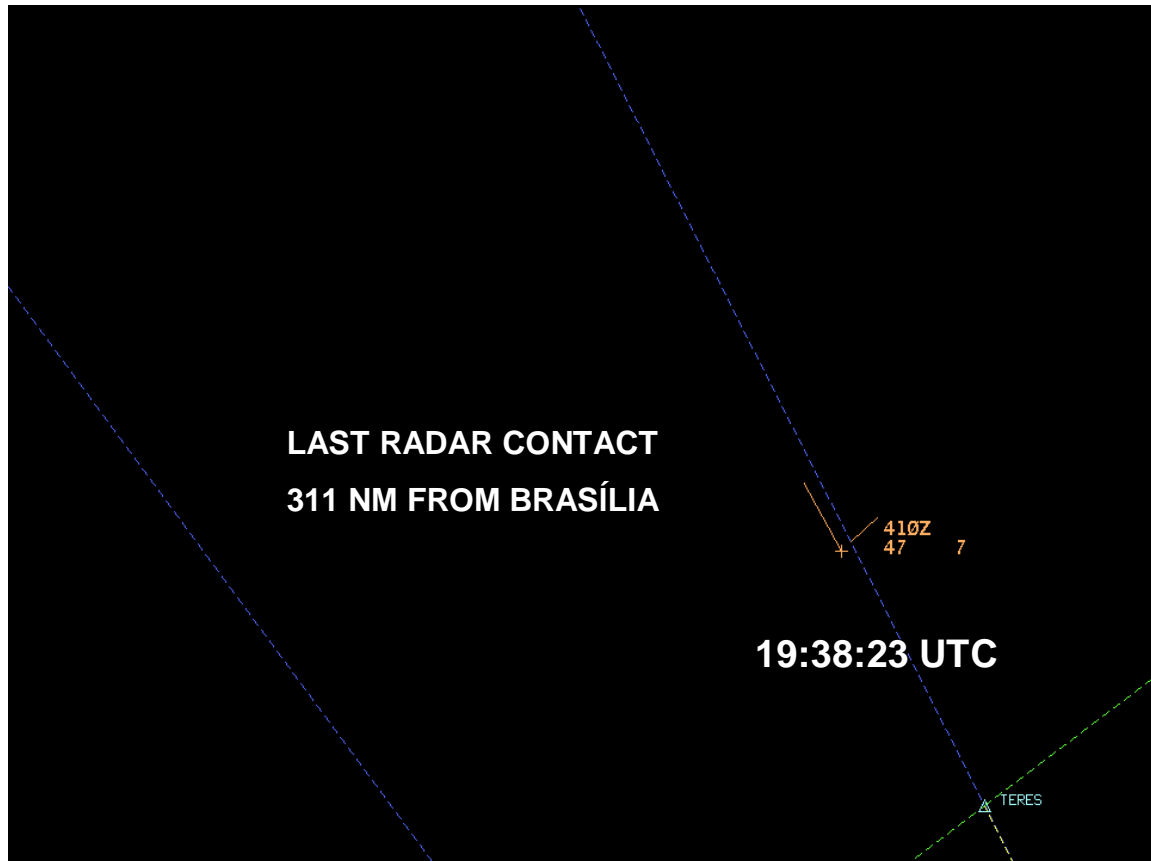


Figure 65

The controller would only make a new attempt, his **seventh and last**, at **19:53:39 UTC**, when, by means of a transmission in the blind, he instructed the aircraft to call the Amazonic ACC. The N600XL was at **422 NM** from Brasilia VOR.

The transcription of the last five calls made by the ACC BS to the N600XL is in **item 3.6** of this report.

So, it is observed that there were only two attempts containing an instruction for a frequency change to 135.9 MHz. In both attempts, an alternative frequency was not provided.

It is worth pointing out that those attempts to contact were made simultaneously on the six frequencies selected at the control console 08, as follows:

**135.9/ 125.2/ 125.05/ 133.1/ 122.25 and 125.45 MHz.**

#### **4.9.2 Onboard the N600XL**

The CVR showed several moments during the flight at which the crew had clear opportunities to discover that the transponder was at STANDBY (by means of the RMU indication, and also by means of the TCAS OFF presented in both PFDs). The transponder remained at STANDBY in the 57 minutes that preceded the collision, without any reaction on the part of the pilots.

In the period from 19:39 UTC to 19:55 UTC, a non-recommended action was taken that contributed to worsen the situation: the PIC left the cockpit and stayed away for 16 minutes.

Such a prolonged absence was totally inopportune, and the PIC never gave the SIC any indication that he would stay away for so long, on account of physiological reasons. In his interviews, he attributed his delay to an attempt to solve a problem in the lavatory. The CVR did not record any comments on the subject.

The majority of SOPs is very restrictive as to the absence of a crew member from the command cockpit.

The crewmember that stayed in the cockpit should have worn his oxygen mask, as prescribed in the RBHA 91/ 14 CFR Part 91, but that did not happen.

The presence of the captain in the cockpit would have increased the chances of success of the communication attempts, as he might have suggested, for example, the use of the HF, or a relay by means of a nearby aircraft.

As already mentioned, after the last radio contact, at 18:51:07 UTC, the N600XL crew only made a new attempt 57 minutes later.

From the data obtained in the CVR, it was verified during most of the flight after the vertical of Brasilia VOR, while the Legacy was flying northbound, that the other aircraft being heard by N600XL were on the frequency 125.05 MHz. However, those aircraft were in sectors 5 and 9, according to the table shown already shown.

The N600XL crew used a Jeppesen Navigation Chart, which indicated the following frequencies for the sector 7 of Brasilia ACC:

#### SECTOR 7

**123.3 128.0**

**133.05 134.7**

**135.9**

At 19:48 UTC, the SIC of N600XL started his attempts to contact the ACC BS, with a total of 12 attempts in 5 minutes.

According to the CVR data, the N600XL crew started a series of 12 (twelve) unsuccessful calls to Brasilia ACC, at the times listed below:

19:48:16 UTC	19:51:08 UTC
19:48:40 UTC	19:51:24 UTC
19:49:33 UTC	19:51:41 UTC
19:50:08 UTC	19:52:10 UTC
19:50:28 UTC	19:52:42 UTC
19:50:48 UTC	19:52:59 UTC

An error was found in the chart used by the pilots, which had influence on the communications. It contained a wrong extra frequency in relation to the Brazilian chart in force. The frequency 134.7 MHz was not listed in the standard Brazilian chart.

The frequencies of the H1/H2 Brazilian chart were the same, with the exception of 134.7 MHz. Instead of this frequency, the Brazilian chart contained the emergency frequency 121.5 MHz.

At 19:53:39 UTC, N600XL was able to receive the last radio call from the ACC BS, transmitted in the blind, with an instruction to call the Amazonic ACC. The crew did not manage to copy the frequencies.

An adequate *airmanship* would require a visual verification to be made in the RMU, in order to check whether the last frequency provided by ATC was being presented – another opportunity to discover that the Transponder was at STANDBY.

Almost one hour had elapsed since the last communication with ATC and, even so, up to the moment the Captain left the cockpit, not a mention was made of the fact that no contact was being made by the ATC with the aircraft.

The little concern with the lack of communication, mainly if one considers that it was a flight in a foreign country, denotes a low level of airmanship, professionalism and concern with the situational awareness on the part of the crew.

However, it is worth pointing out that the fact that they were under radar surveillance and could hear the radio transmissions between the other aircraft contributed to their unconcern.

During the brief time the SIC was trying to understand and repeat the frequency provided by the Air Traffic Control, he failed to get it right. Had the PIC not stayed away for so long, the chances of understanding the frequency would be better, considering the fact that two people in the cockpit would then be listening to the controller's message.

If the frequency provided by the controller had been understood, the two-way radio contact with Air Traffic Control would have been reestablished.

Again, we have to assume that, if the SIC was trying to establish radio contact, he would have to look directly at his RMU. If he did it, then he certainly could see the STANDBY

in the RMU, mainly due to the fact that the field that indicates the operation mode of the transponder in the RMU is located just below the field "COM".

### WINDOW INDICATING THE MODE OF OPERATION



Figure 66

At 19:53:57 UTC, the N600XL pilot replied to the ACC BS, asking for a repetition of the decimals of the first frequency that had been informed, because he had not copied them. The ACC did not receive the message.

After that moment, N600XL made seven more calls to Brasilia ACC:

19:54:16 UTC	19:55:43 UTC
19:54:40 UTC	19:56:41 UTC
19:55:00 UTC	19:56:53 UTC
19:55:16 UTC	

When the PIC returned to the cockpit, the SIC had already made his **seventeenth call** in the attempt to establish radio contact. The SIC informed the PIC that they had a communication problem, and that several attempts were made to contact the ACC BS, without success.

This means that the SIC had certainly selected several frequencies in the RMU but, unfortunately, he did not pay the necessary attention to notice the STANDBY indication, relative to the transponder.

It is possible to imagine that both pilots turned their eyes to their respective RMUs at that time, but they still did not notice the conspicuous STANDBY indication that was being presented to them.

That could perhaps be attributed to the "tunnel vision" effect resulting from the increasing levels of adrenaline in the pilots when they found lately that they were facing communication problems.

After two more calls (19:56:41 UTC and 19:56:53 UTC), at 19:56:54 UTC, the collision occurred.

Before analyzing the moment of the collision, let us deal with the points relative to the communications that could not be established, and, thus, removed some more defenses that could have prevented the accident.

The CVR in the N600XL recorded the voices and sounds within the cockpit. Through the CVR, we have the recordings of the calls made to Brasilia and Amazonic ACC's. However, there is not information about the frequencies on which those calls were made. The same is true for the transmissions received.

However, by means of a logic line of reasoning, if the last frequency commanded is considered as an initial reference, and following the sequence of the frequencies in the chart used by the pilots, it is possible to determine with accuracy some of the frequencies which were utilized, after crosschecking with the recordings of Brasilia ACC.

Frequencies analyzed (summary of the transcripts):

- 123.30 MHz – recorded in the recorder of CINDACTA I – correlation with N600XL.
- 128.00 MHz – not recorded in the recorder of CINDACTA I.
- 133.05 MHz – recorded in the recorder of CINDACTA I – correlation with N600XL.
- 135.90 MHz – recorded in the recorder of CINDACTA I – correlation with N600XL.
- 121.50 MHz – not recorded in the recorder of CINDACTA I.

The frequencies recorded at CINDACTA I were correctly correlated with the data obtained from the CVR of the Legacy aircraft.

It is a fact that in the Audio Center of CINDACTA I:

- Not all frequencies assigned to sector 7 were programmed in the air traffic controller's page of console 8.
- The emergency frequency 121.50 MHz was not programmed in console 8.

It is also a fact that, in the audio recorder of CINDACTA I, communications were recorded on the following frequencies.

- 123.30 MHz – only N600XL.
- 125.05 MHz – two-way.
- 133.05 MHz – only N600XL.
- 135.90 MHz – no recordings of contacts made by N600XL, only the ones made by the controller at 19:26:51UTC, 19:27:12 UTC, 19:30:40 UTC, 19:30:56 UTC, 19:32:48 UTC, 19:34:08 UTC and 19:53:39 UTC.

It is a fact that, in the CVR of N600XL, there are the following recordings:

- 125.05 MHz – all two-way contacts made with the ACC BS.
- 123.30 MHz - all calls made by the crew to the ACC BS.
- 133.05 MHz - all calls made by the crew to the ACC BS.
- 135.90 MHz – receiving of the last call made in the blind by Brasilia ACC, at 19:53:39 UTC, and reply of the crew to Brasilia ACC, at 19:53:57 UTC, which was neither received nor recorded by Brasilia ACC.

It is a fact, in relation to the communications with the ACC AZ, after the impact:

- 1) Chart used by the crew of N600XL – no error in relation to the frequencies.
- 2) Chart used by the controller – no error in relation to the frequencies.
- 3) 121.50 MHz – there was no recording of transmission or reception in the ATC.

No calls were made by the N600XL or by the controller of CINDACTA I on the HF frequencies available.

According to the data and facts collected, it is possible to determine a probable sequence of the calls made by the N600XL, on the following frequencies (MHz):

19:48:16 UTC	(125.05)	19:51:08 UTC	(128.0)
19:48:40	(125.05)	19:51:24	(128.0)
19:49:33	(125.05)	19:51:41	(133.05)
19:50:08	(123.3)	19:52:10	(134.7)
19:50:28	(123.3)	19:52:42	(134.7)
19:50:48	(128.0)	19:52:59	(134.7)

The first three calls were possibly made on the last active frequency instructed by the controller, 125.05 MHz. There were no recordings of those calls at the audio center of CINDACTA I.

Since there was no reply, two calls were possibly attempted on 123.3 MHz, which is the first frequency of the chart frequency box, from left to right, top to bottom. These calls were received and recorded by the Audio Center of CINDACTA I. The time of the recordings in both recorders is consistent (in accordance with the transcript no. 132 of 05 October 2006, in item 3.6 of this report).

Continuing in the sequence of the chart frequency box, the next frequency would be 128.0 MHz, on which three attempts were made that were not recorded at the audio center of CINDACTA I.

Continuing in the sequence of the box, from left to right, top to bottom, the next frequency would be 133.05 MHz. One call on this frequency was received and recorded by the audio center of CINDACTA I. The time of the recordings in the recorders is consistent (in accordance with the transcript no. 133 of 05 October 2006, in item 3.6 of this report).

The penult frequency was **134.7 MHz, which was incorrectly indicated in the Jeppesen chart, and did not appear in the Brazilian chart.** The last three calls attempted by N600XL, before receiving the last call from the ACC BS at **19:53:39 UTC**, were possibly attempted on this frequency.

Then, the last frequency in the box for sector 07 was 135.9 MHz. This one would be the right frequency, which the ACC BS tried to inform in two of the call attempts.

When it was selected by the pilots, they were able to receive the seventh transmission from the ACC BS, but the crew did not manage to copy the frequencies they would have to use to contact the Amazonic ACC.

That transmission, besides being recorded by the CVR of N600XL and by the recorders of the audio center of CINDACTA1, was also recorded by the CVR of PR-GTD, which had

just changed to the ACC BS on the frequency of 125.2 MHz. At 19:52:56 UTC, the Amazonic Center called Flight 1907 on 126.45 MHz and, after informing that radar service was terminated, instructed him to call Brasilia ACC at NABOL position on the frequency 125.2 MHz, alternating 135.9 MHz.

The frequency 125.2 MHz was one of the six frequencies that were being transmitted simultaneously by the ACC BS (**135.9/ 125.2/ 125.05/ 133.1/ 122.25 and 125.45 MHz**).

#### **4.10. MOMENTS BEFORE THE COLLISION**

##### **4.10.1 At Brasilia ACC (handoff of the N600XL to the ACC AZ)**

The collision occurred near the boundary between the Flight Information Regions (FIR) of Brasilia and Manaus.

The flight GLO1907 had already been coordinated and instructed to call the ACC BS at NABOL position. It was still under the responsibility of the ACC AZ.

It remained under full radar contact with the ACC AZ and there had not been any problems regarding communication.

The aircraft was handed off to Brasilia ACC at flight level 370, according to the flight plan activated by the ATC.

The coordination of the N600XL had already been made by the ACC BS and ACC AZ, and, by means of a transmission in the blind, the aircraft had been instructed to call the ACC AZ.

The Legacy aircraft had already left the Brasilia FIR, since it had passed NABOL position. The last two-way radio contact had been at 18:51 UTC, and the radar contact with the N600XL was lost at 19:38 UTC, while the other airplanes in the sector remained being normally detected.

The N600XL was handed off as if it were at flight level 360.

In relation to the images received by the ACC BS, the fact that, at the time of the accident, the radars of the ACC AZ did not send images of the area of the collision to Brasilia did not have any influence, since the secondary radars would not receive precise altitude information from the N600XL.

Even if the ACC BS controllers received the data block of the GLO 1907, by means of collaborative detection, with the information that the Boeing airplane was maintaining FL370, the controllers' situational awareness, assuming that the N600XL was at FL360 would not permit them to take any action to separate the two airplanes, as they believed the aircraft were at different levels (N600XL at FL360, and GLO1907 at FL370).

##### **4.10.2 At the ACC AZ**

The collision occurred within the airspace under the jurisdiction of the ACC AZ, which had radar contact with the flight 1907.



The ACC AZ also had a non-correlated primary radar contact of the N600XL, without precise altitude information. The ACC BS had informed them that the N600XL was maintaining flight level 360.

According to the transcripts, nobody visualized the collision.

There was no previous perception on the part of the air traffic control of the possibility of collision.

The ACC AZ maintained a primary radar contact with the N600XL during three minutes and eighteen seconds up to the collision.

There was not any perception or reaction on the part of the controller that was waiting for the call of the N600XL, since he had been informed that the aircraft was flying at flight level FL360.

The controller was not advised about the previous loss of transponder or about any communications failure of the aircraft.

The ATCO of the ACC AZ Manaus sub Center deviated from the standard procedure at the handoff of the PR-GTD and at receiving the control of N600XL, erroneously confirmed the radar detection of the N600XL, and did not perform the prescribed procedure for radar contact loss, considering that the aircraft was under the rules of RVSM.

The ATCO of the ACC-AZ did not interpret the control conditions of the N600XL as critical, and did not feel uncomfortable with the situation, thus showing a poor situational awareness.

#### **4.10.3. Onboard the N600XL**

Immediately after receiving the message transmitted in the blind by the ACC BS, at 19:53:54 UTC, telling him to call the ACC AZ, the N600XL pilot requested confirmation of the frequency instructed. However, the ACC AZ did not receive his transmission, as it was blocked by another aircraft (TOTAL 5589), which was communicating with the ACC BS on the same frequency.

The TOTAL 5589 maintained a continuous contact with the ACC BS, from 19:54:02 UTC to 19:54:34 UTC.

Then, at 19:55:17 UTC, Brasilia ACC started transmitting instructions to TAM 3471 which then read them back until 19:55:21 UTC

In this period, N600XL started a series of seven more calls:

<b>19:54:16 UTC</b>	<b>19:55:43 UTC</b>
<b>19:54:40 UTC</b>	<b>19:56:41 UTC</b>
<b>19:55:00 UTC</b>	<b>19:56:53 UTC</b>
<b>19:55:16 UTC</b>	

**NB:** The chronological sequence presented above, relative to the calls made by N600XL, was extracted from the aircraft CVR and corrected for a difference of three seconds of advance in relation to the time of the ATC recordings used in the transcriptions.

Thus, the pilots' immediate reply to the last transmission of Brasilia ACC at **19:53:39 UTC**, shown in the CVR transcript as having been at 19:53:54.4 UTC, asking for confirmation of the frequencies, occurred at **19:53:58 UTC**.

The call from TOTAL 5589 was recorded at 19:54:02 UTC; therefore, it had already entered the audio center four seconds prior to the beginning of the message conveyance by the pilot, who spent approximately six seconds to stop transmitting his message.

The use of the radio by TOTAL 5589 possibly blocked the two first calls of N600XL (19:54:16 UTC and 19:54:40 UTC).

The third call, at 19:55:00 UTC, would have a chance of being received, depending on the propagation speed.

The fourth call, made at 19:55:16 UTC, would be interrupted by the call from Brasilia Center to TAM 3471, recorded in the ACC BS at the same time, and that occupied the frequency until 19:55:21 UTC.

The fifth, sixth and seventh calls, respectively made at 19:55:43, 19:56:41 and 19:56:53 UTC, may not have been made on the frequency of 135.9 MHz. There was a squelch break noise in the CVR, prior to these last three calls, characteristic of a frequency change and, just after the fifth call, the CVR recorded the other pilot's coming back to the cockpit, after having been away from the cockpit since 19:39:00 UTC, for 16 minutes, to go to the toilet, as shown by the CVR recordings.

At this moment, the SIC, who had stayed alone in the cockpit attempting to make the calls since 19:48:16 UTC explained that they had a radio problem.

He said that the other controller had probably forgotten them, and that he started attempting to call on a series of frequencies. While he was trying, he suddenly heard the controller calling them and telling them to speak or call on another frequency, but he did not manage to copy the last two digits.

Subsequently, at 19:54:41 UTC and 19:56:53 UTC, the SIC made the last two calls before the collision occurred.

From this explanation, we can assume that at least the last two attempts were no longer made on 135.9 MHz, or on 123.32 MHz and 126.45 MHz, which were the ones provided for the contact with the Amazonic ACC.

The pilots had their attention focused on cockpit tasks. The sun was almost on the horizon, to the left of the aircraft heading.

#### **4.10.4. Onboard the PR-GTD**

In the cockpit of the Boeing, moments before the collision, there was absolute tranquility.

The ACC AZ had just instructed Flight 1907 to call Brasilia ACC at NABOL position on the frequencies 125.2 MHz (primary) and 135.9 MHz (alternative).

The pilots immediately selected the frequency on which they would call the ACC BS. The selected frequency, 125.2 MHz, allowed them to hear the last transmission in the blind from Brasilia ACC to N600XL.

The pilots were talking, and the collision took them by surprise. The airplane started an abrupt descending roll to the left.

#### 4.11. THE COLLISION

The two aircraft approached each other at a speed of about one thousand six hundred kilometers per hour. The Boeing was a little left of the Legacy and slightly above.

According to the data obtained from the CVR and DFDR of both aircraft, their TCAS systems did not emit any traffic alert or instruction for an evasive action to the respective crews, so that the collision could have been prevented.

There were not any indications on the part of the crews relative to a previous visual perception of the approach between the two aircraft.

No attempt of an evasive action or maneuver was made, according to the existing data of the flight recorders.

After the collision, the PR-GTD lost 6.96 m (direction winglet – fuselage) of its 17.89 m left wing, which rendered the aircraft immediately and irreversibly uncontrollable.

Immediately after the collision, PR-GTD started a fast descending spiral, similar to the maneuver known as **spin**, which by no means could be recovered or controlled by the crew.

During the vertiginous dive, the aircraft was submitted to extreme aerodynamic forces, around all the axes, with positive and negative accelerations, well above the maximum resistance limits of the operational envelope. As a result, there was an in-flight break-up of the aircraft in several pieces of different sizes, which hit the ground.

The extent of the left wing that was instantaneously cut from the aircraft took away with it the entire left aileron, and part of the coating of the extrados of the remaining portion of the wing.

The aerodynamic effect generated by the sudden loss of lift at the left wing made the aircraft lose control, even with the Captain acting on the flight controls up to the maximum amplitude of the surfaces, according to the DFDR and CVR data.

For this kind of anomaly, there is no training in the flight simulator, simply because it is a catastrophic failure, resulting from the high unbalance of the lift at one of the wings and from the loss of the aileron, which is a primary flight control surface.

It was not possible to determine at what altitude the aircraft structure collapsed as a result of the aerodynamic forces acting on the surfaces.

The CVR and DFDR continued to record data for about 53 seconds after the impact, but the duration of the fall was estimated to be one minute and three seconds. The altitude reading of the DFDR was interrupted at 7,887 feet, when the electric power supply was discontinued.

There was neither panic nor lack of control on the part of the pilots in the CVR. The SIC asked what had happened and the PIC said he did not know, but asked the SIC keep calm several times.

This insistence of the PIC about staying calm was possibly due to the fact that he imagined that, since the aircraft had entered an abnormal attitude, it would be necessary to work on the controls to bring it back to straight and level flight.

An abnormal attitude can occur at high altitudes, on account of CAT (Clear Air Turbulence), or due to other problems of flight control, situations for which the pilots receive simulator training, aiming at recovering the flight attitude.

Due to the swiftness of the situation, the pilots never learned they had sustained such a big damage on the left wing, but they remained calm to the extent possible, while trying to recover the aircraft, as far as the CVR could record.

The analysis of what happened in the cockpit of the PR-GTD, after the impact, does not bring any teachings justifying the issuing of recommendations that could prevent future accidents. But it brings the reveals the lack of perception of the crew in relation to circumstances of the collision, and of the situation in the cabin, while the aircraft was diving. It also shows the high level of professionalism of the pilots, in their last attempts to manage the emergency and control the aircraft.

After the collision, the N600XL airplane remained controllable, the auto-pilot was disengaged by the forces of the impact, and the PIC assumed manually the flight controls of the aircraft, which had sustained damages on the left wing.

A considerable part of the left winglet was torn away as a result of the collision. Other damages on the left wing were observed, after the aircraft made an emergency landing at SBCC.

Besides the damage to the winglet of the left wing, there were damages to the longeron of the left wing, to the tip of the left horizontal stabilizer, and to the tip of the left elevator.

#### **4.12. The cockpit of N600XL, after the collision.**

All the commandment of actions regarding the management of the emergency was taken over by the co-pilot (SIC), with the captain (PIC) just receiving instructions, and displaying a complete passivity in relation to the situation.

When we compare the recordings of the four mixed channels with the recording of channel 4, which is the microphone of the cockpit area, the SIC seems to have noticed it was an in-flight collision, as he immediately exclaimed:

“What the (h...) was that?”

He, then, started to direct the PIC:

“All right, just fly the airplane, dude.”

And, again, he alerted:

“Just fly the airplane”.

The SIC noticed that there had not been an explosive decompression, and tried to calm the PIC.

#### 4.13. Emergency management by the ATCO and by the Pilots

As already seen, the SIC took over the controls of the N600XL after the collision.

He told the PIC to declare emergency on the frequency 121.5 MHz.

Then, one of the passengers said that part of the winglet of the left wing was missing, and the SIC asked:

*“Where the (f...) did he come from?”*

At that moment, the crew started believing they had hit or had been hit by something.

They began a series of calls to the ACC BS on 121.5 MHz, the international emergency frequency (compulsory within RVSM airspace, according to ICAO Doc. 4444)

The **first** call was made at 19:57:47 UTC, and the **second** at 19:58:09 UTC.

The pilots began to define their probable diversion airfield.

The PIC seemed to not have recovered from the fright and kept cutting in, while showing not to know what to do.

The SIC noticed it, and again said:

*“Let me just fly the thing, dude, cause I just think...”*

The PIC asked again where “he” had come from.

The SIC asked whether they had hit something and whether the PIC had seen “that”. Again, he asked the PIC whether he had seen “something”.

The PIC answered incoherently:

*“I thought I saw...”* but did not end the phrase.

*“I looked up ...”* again, he did not complete the statement. He, then, made the **third** call to Brasilia ACC, on 121.5 MHz, getting no reply.

The pilots decided to proceed to SBCC, and discussed whether the runway would be appropriate for their landing.

They complained about the lack of contact with the air traffic control units that did not reply to the calls made on the emergency frequency.

The PIC, who was just complying with the instructions of the SIC, began to insert the new airfield into the FMS. Meanwhile, the SIC, who was commanding the actions, flew the aircraft and monitored the instruments.

#### 4.14. The Transponder restarts transmitting

As the SIC was lowering the aircraft, he asked, still astonished, where whatever-had-collided-with-them had come from. He decided to proceed directly to SBCC, which was the nearest aerodrome, according to the FMS.

The SIC supervised the insertion of the ICAO location indicator, SBCC into the FMS, by the PIC, who was just obeying him. The insertion of that information allowed the indication, in the Primary Flight Display (PFD), of the exact route to be flown.

Then, possibly on account of having looked more attentively at the information displayed on the screen, the SIC appears to have seen the "TCAS OFF" information in white color at the top left, indicative of the status of the TCAS, noticing too late that it was not operating.

The recording in the CVR is very clear and, at 19:59:13 UTC, the co-pilot delivers an exclamation of fright when he saw that the TCAS was OFF.

"Ahh!... dude, is the TCAS on?"

"Yes, the TCAS is off!"

There was an uncomfortable silence of ten seconds, interrupted by the SIC who, again reestablishing control of the situation, said:

"All right, just keep an eye for traffic. I'll do that, I'll do that, I'll do that . I got that"

In the CVR, this last utterance, which appeared to indicate that the SIC was about to reset the transponder, occurred at 19:59:29 UTC.

In the N600XL DFDR, there is the recording of the opening of the screen, on the right side, of the Multi-function Flight Display 2 (MFD TCAS) relative to the TCAS display, at precisely the same time, between 19:59:50 and 20:00:00 UTC.

At 19:59:50 UTC, according to the rerun, a secondary radar return of the N600XL appeared on the screens of CINDACTA 4, with images captured every ten seconds. The radar return presented a correlated icon, whose data block showed the aircraft crossing flight level FL325. The flight level FL360 was shown as if it had been authorized, on account of having been modified by the second controller of the ACC BS.

These recordings point toward the logical consequences of an action taken by the SIC to select the TA/RA mode of the transponder, and the selection resulted in the re-activation of the TCAS.

Still ratifying the perfect working condition of the Transponder: after its reactivation, the ACC AZ received the blue color emergency code 7700 EMERG on the radar screens at 20:03 UTC.

This action is also indicated in the CVR, at 20:02:08 UTC, when the crew mentioned that they would select the emergency code in the Transponder.

In the interviews given by the pilots to the NTSB investigators and to the investigators of the commission, they denied having reactivated the transmission mode of the Transponder.

They declared that they did not see anything which might be an indication that the TCAS was not operating, and that they never noticed the Transponder had stopped operating. They were sure that the equipment was operating all the time.

It is possible to imagine that, after verifying that the Transponder was not transmitting, the PIC, who was not piloting, tried to reset it and, during ten seconds, he had difficulties on account of not knowing how to handle it. When the SIC noticed that, he decided to do it himself.

For the comprehension of this accident, there are a few moments which are particularly important: the understanding of the clearance, the moment of the discontinuance of the Transponder transmissions, the attempts to make radio contact with ATC, and the moment at which the Transponder restarted transmitting signals.

The interviews which were held to clarify what happened at the moments mentioned above did not present any contradictions between the PIC and the SIC, except for the moment at which the transponder restarted transmitting.

For the commission, the sentence “ Ahh!...dude, is the TCAS on?...” was uttered by the SIC, when he noticed that the transponder was not transmitting.

And the answer “...Yes, the TCAS is off.” was given by the PIC.

This would be the moment at which the flight crew finally perceived that the transponder was not transmitting.

The SIC, then, with the ability and initiative he had displayed since the beginning of the emergency generated by the collision, although piloting an aircraft with a damaged wingtip, reset the transponder equipment from the STANDBY to the TA/RA mode.

This action is confirmed by the recordings of the aircraft DFDR, because at that very moment the transponder window rises in the pilots' screen, and also by the fact that five different radars of the Amazonic ACC resume receiving the transponder signals emitted by the Legacy aircraft, all perfectly synchronized, including the assigned code, which was exactly the same one being used prior to the discontinuance of the transmission almost an hour before.

In the interview given to the commission, the captain (PIC) declared that the exclamation “Ahh!” was made by him, and was motivated by the difficulty he had inserting the SBCC indicator, and that the question “...dude, is the TCAS on? was made by the SIC.

After that, he allegedly only watched the SIC insert the SBCC indicator in the FMS.

As for the SIC, he insisted that he never took his hands off the control column at that moment, and that the expression: “All right, just keep an eye for traffic. I'll do that, I'll do that, I'll do that .I got that”... referred just to landing the airplane.

In relation to the screen that was selected, he said he did not remember when he selected it. Such an event would lead us to the fact that the exact concomitance between the selection of the screen and the return of the secondary radar signal to the CINDACTA 4 radar screens was not a coincidence.

The very perception of the TCAS OFF message by the co-pilot may have happened at the moment he started scanning the screen in the conduction of the descent of the aircraft.

The sentence confirming that the TCAS was OFF is perfectly logical in the context of reading the white “TCAS OFF” message on the PFD, meaning that the Transponder had been set to STANDBY.

Otherwise, the most logical comment would be, for example:

“Is the transponder at Stand-by?” (This would be a confirmation of status verification in the RMU).

This answer was explained by the SIC to the commission of investigation, as being a normal routine verification that the equipment was in the mode desired, because a descent procedure requires special care with the other traffic, since they did not have radio contact with the control units.

The SIC insisted that he did not take his hands off the control column, did not insert anything in the FMS, and did not touch the RMU, which is where the Transponder selections are made. This is in contradiction with what the PIC said about having watched the SIC insert the SBCC indicator in the FMS.

Therefore, if the PIC watched the SIC insert or handle some piece of equipment, there is little probability that it was the insertion of the location indicator of the destination (SBCC).

It would be more likely to have been the modification of the Transponder mode, an action which would be simpler, faster and easier for the co-pilot to carry out, even piloting an aircraft that had damaged controls.

It is important to highlight that up to the end of the recording, there were no further comments relative to the transponder equipment or to its functioning during the flight, except for a brief comment ("*so much for TCAS*" or "*what's with TCAS*"), an expression denoting surprise in relation to something.

Although there was uncertainty whether an in-flight collision had occurred, there were no more comments about a possible surprise in relation to the inoperability of the TCAS.

#### **4.15 The landing at SBCC**

25 minutes elapsed, and, at least, ten calls were made on 121.5 MHz, but no control units replied to them.

As already seen, the cargo aircraft Polar 71 helped the N600XL to contact the ACC AZ. The N600XL contacted the ACC AZ and coordinated the landing.

The lack of interviews with the controllers directly involved in the accident hindered the clarification of important points relative to the moments that preceded the collision.

The authorities responsible for the judicial processes aiming at the verification of the criminal liabilities requested all the material gathered by this commission until then, when two months had elapsed after the accident.

For this reason, the attorneys representing the controllers instructed their clients not to give any declarations, even after it was exhaustively explained that the purpose was to prevent the occurrence of further accidents.

#### **4.16 SYNTHESIS OF THE ANALYSIS OF THE MOST RELEVANT POINTS**

##### **Operation of the N600XL Transponder and radio/navigation equipment.**

No problems were found in relation to the working condition or integration of the Transponder/TCAS systems during the tests conducted by the investigators responsible for the Material Factor, in the laboratories of the manufacturer.

Since no equipment failure was observed, according to the reports of the results of the exhaustive tests in the investigation of the Material Factor, the focus moved the Human Factor, in its Operational Aspect relative to the operation of these pieces of equipment.

The low situational awareness resulting from the insufficient level of standardization of procedures in the cockpit favored not only the occurrence of a series of operational non-conformities in the chain of events that led to the accident, but also prevented the pilots from



timely noticing that the aircraft transponder had stopped transmitting (and that, therefore, the TCAS was OFF).

There are several conspicuous indications of the TCAS/Transponder status in the aircraft instrument panel – eight visible indications in all, with two in the RMUs, two in the PFDs and another two in the MFDs (when the MFD was set to display TCAS), and the blinking amber transponder reply light in the “ATC window” boxes on both RMUs.

It is worth pointing out that it was the first real flight of the PIC and the SIC together in that type of aircraft.

For the SIC, it was the first flight in the executive aviation.

Again, it was the first flight for both pilots, receiving a complex aircraft in a foreign country and, on top of that, it was observed a lack of standard operational procedures (SOP) for the aircraft model in question, which should have been established by the operator to be complied with by the pilots, considering that their company frequently performed that kind of activity.

In the interview voluntarily given by the pilots, it got apparent that many details of the routine relative to this type of mission had not been clearly established. Therefore, on several occasions, they had to make decisions in accordance to their knowledge and personal experience, which, sometimes, were not adequate to the situation.

Among these decisions, were the following: preparation for the flight (in the midst of delivery ceremonies), flight plan request, procedures and clear definition of tasks and responsibilities between the pilot and the co-pilot, in the face of the receipt and verification of a new equipment with complex systems.

The oversight of the company relative to the amount of time planned for the mission appears to not have verified whether it was sufficient for an adequate preparation and adaptation of the pilots to the new airplane.

It would not be advisable to designate two pilots that had never flown together as a crew, for a mission with so many unprecedented situations, without being fully assured that they were adequately prepared.

The fact is that the discontinuance of the transponder transmission contributed to the accident, and the reason for that remains in the field of hypotheses, since the pilots affirmed that they did not do anything to change the Transponder operation mode, besides not having perceived any indication in the aircraft systems that the transponder was not transmitting.

All possible tests of the equipment were conducted in order to find evidence of the action that discontinued the transmission of the mode C of the Transponder, as well as identify some failure or defect in the equipment handled.

The following possible hypotheses were listed in the attempt to explain this fact:

- **Intentional switch-off of the Transponder by the crew;**
- **Transponder failure (continuous or intermittent)**
- **Inadvertent switch-off, through the handling of the Laptop;**
- **Inadvertent switch-off, through the use of the *footrest*; and**
- **Inadvertent switch-off, during familiarization/operation of the RMU.**

### **Intentional switch-off of the Transponder by the crew**

**Discarded:** The CVR did not show any indication that the N600XL crew had that intention. In the interviews, both pilots were definite regarding this aspect. Besides, the N600XL crew would not benefit from setting the transponder to STANDBY, as, for example, to fly at different RVSM flight levels, without clearance for that.

### **Transponder failure (continuous or intermittent)**

**Discarded,** on account of the extensive tests performed in the electronic components of the N600XL. All the pieces of equipment associated with the *transponder* (radios, TCAS and navigation) of the N600XL were removed from the aircraft, and taken to the manufacturer (Honeywell), where they were tested individually and in an integrated manner. No problems were detected in the equipment.

### **Inadvertent switch-off, through the handling of the Laptop**

The CVR indicated that, some minutes before the *Transponder* stopped transmitting, both pilots were working together with a laptop. There is the hypothesis that the corner of the laptop may have repeatedly hit the fourth button of the RMU.

**Discarded.** In the interview, the pilots explained that it was the SIC who was using the laptop, holding it on his lap, sitting on the right. They were definite when they said that did not hand the notebook between them at the moment of the interruption of the Transponder transmission. They affirmed that the laptop was not supported on the throttle pedestal or in a position that it could touch the RMU. **According to the report of the reconstitution flight of 29 September 2007, it was not possible for a laptop,** being used on the lap of the PIC or SIC, to touch the aircraft panel, due to the control column. In addition, the sighting of the panel was only hindered for the pilot using the laptop on his lap. For the laptop to touch the buttons of the RMU, it would be necessary that it had been placed between the pilots and with the screen opened, in a position at which its use would be impossible, on account of the throttle pedestal that would be under it, and the angle of the screen impeding it to be seen by the pilots. Thus, combining the results of the reconstitution flight with the report of the pilots and the data recorded, this hypothesis can be discarded.

### **Inadvertent switch-off, due to the use of the footrest;**

The possibility of inadvertently switching off the *Transponder* with the captain's right foot was raised by the FAA.

**Discarded:** In the interview, the crew affirmed that they did not place their feet on the *footrest*, especially during the time the Transponder stopped transmitting.

In addition, the investigation and studies made by the CIAA lead to the conclusion that the *Transponder* was not inadvertently switched off by the crew's use of the *footrest*, which was based on the following:

- Analysis of the data obtained by the CVR of the N600XL, related to the to the inadvertent handling of the *Transponder*: in the CVR the captain of the N600XL mentioned that he would not use the footrest (approximately 20 minutes after the *Transponder* ceased to transmit), saying " *I won't put my feet up here until one of these guys are not around*", for considering that this action would place a negative image to them.

- Identification of sounds recorded on the CVR of the N600XL, related with the movements of the crew inside the cockpit: the CVR has no sounds recorded that are compatible with a seat being moved back prior to the instant 19:02 UTC;
- The analysis of the probability of inadvertently touching the buttons of the RMU two times within 20 seconds, with the PIC's right foot and that would result in the *Transponder* going to STANDBY, for the EMB-145 and Legacy 600 fleet, was calculated as less than  $5,2 \times 10^{-15}$  per flight hour. Therefore, this kind of condition can be considered virtually impossible to occur during the fleet's life time.
- In accordance with the reconstitution flight performed on 29 September 2007, the *foot protector* as designed, does not allow the touching of any panel instruments by the PIC's right foot, being his seat moved to the back stop (in a way of getting some comfort to rest his legs while not in command). The reconstitution flight indicates that, in order for the PIC to reach with his foot any of the RMU1 buttons, he had to move, with the leg raised, his seat to the backstop position and displace his foot to the right, outside the *footrest*, resting it at the edge of the *foot protector*. Then, he needed to twist the foot in such a way that the tip of the shoe touched the RMU buttons, in an angle not natural to the human being and in an intentional attempt to reach such buttons. Because of the discomfort to reach any of the RMU1s buttons, this action was considered as highly improbable to happen inadvertently. The flight reconstitution indicated, therefore, for the buttons on the left side of the RMU to be touched by the right foot, it is necessary an intentional movement of the shoe forward, which was considered very uncomfortable due to the angle the foot must flex. With this in mind, the involuntary touching was considered an action of high level of difficulty.
- The commission (CIAA) requested the Legacy manufacturer to provide an ergonomic evaluation of the aircraft's cockpit, which was performed using a virtual human model representing the ergonomic measurements of the PIC, seated at the left seat of the N600XL. This evaluation indicated that, for the pilot to be able to reach with his right foot any button of the RMU1 (whatever button) with the seat in the DEP position or close to it, it would require placing his foot outside the *footrest* and resting it on the lateral edge of the *foot protector*, in other words, inappropriately using the place for resting the foot, and also "forcing" the foot forward in a movement unnatural that would presumably be intentional. The study also showed that the *foot protector* does not allow the pilot's foot to touch the instrument panel, when the foot is correctly placed in the area delimited for the *footrest*, providing the conclusion that the normal utilization of the *footrest* assures a non occurrence of any inadvertent foot touching of the instrument panel, as required by the applicable rules. This study is presented with more details in the item 3.16 "Ergonomic Aspects" of this report.

### **Inadvertent switch-off, during familiarization/operation of the RMU**

The interviews voluntarily given by the pilots were of great value to clarify some important points relative to the moment of the interruption of the Transponder transmissions.

The CVR indicated that, at the precise moment when the Transponder stopped transmitting, the SIC was calculating takeoff parameters with the laptop, with the attention of both pilots focused on trying to solve the issue of landing at and departing from Manaus due to runway length restrictions, a piece of information that they had obtained in flight, after

reading the NOTAM of Manaus. The CVR also shows that the pilots remained in silence for about two minutes.

They confirmed that, at the moment of the interruption of the transmission, it was the SIC who was handling the laptop, holding it on his lap, and sitting on the right seat.

The PIC, sitting on the left seat, was monitoring the instruments, and does not recall having used the footrest at that moment in particular.

He says that the only action taken by him was the verification of the fuel transfer at the overhead panel, therefore, away from the RMU.

The pilots were not able to inform precisely what the PIC, sitting on the left seat, was really doing. Their answers were always that they did not recall precisely what happened during that period.

They do not disagree as to the actions of the SIC, who was calculating the figures of the performance associated with the available power for the takeoff from Manaus, as confirmed by the CVR.

The CVR, however, did not indicate what the PIC was doing at the very moment that the transponder stopped transmitting.

Nonetheless, this was his first flight as captain after the training at the simulator, and after having participated in three short duration acceptance flights with Embraer pilots onboard. Therefore, it is possible to imagine that it was one of the first moments the captain had some "spare time" to get familiarized with the aircraft systems.

The CVR indicated that, some time before the moment of silence and of the interruption of the transponder transmission, the PIC was looking at the fuel page at the MFD or RMU, in the effort to help the SIC find whether they would be able to land at, and depart from, Manaus, with the restrictions informed by the NOTAM. At this moment, when returning to the page of communications of the RMU, he could, unintentionally, have changed the Transponder to STANDBY.

While the PIC was apparently trying to clarify the issue of the airplane fuel status, at the end of the period of silence (19:00:01.5 UTC until 19:01:44.3 UTC) his RMU was used in a way that changed the mode C of the *Transponder* from the status "TA/RA" to "STANDBY".

This condition must have been displayed on the instrument panels on both RMUs and in the message "TCAS OFF" which appeared in the PFD of both pilots.

The crew, with their attention focused on the calculations of the fuel, remained completely unaware of the situation until the moment just after the collision (when, their reaction was especially quick, correctly reestablishing the TA/RA mode).

The change to "STANDBY" occurred at the end of the period of silence, when the SIC suddenly informed the PIC, who was probably working with the RMU, that he had finally obtained in his notebook the information which would allow them to depart from SBEG on the following day.

The most likely explanation for the change of the *Transponder* to "STANDBY" is, therefore, that the PIC, while inattentively trying to return his RMU to the page of communications after consulting the fuel page, did not notice that he had pushed a button that would change the status of the Transponder to "STANDBY", and again he focused his

attention on the work he was doing with the SIC, in the effort to solve the problem brought by the NOTAM of Manaus.

When questioned about whether he would be verifying the fuel system, his answer was that he did not remember. He was definite to say that he did not remember having taken any action that could have interrupted the operation of the transponder.

The RMU is used primarily for adjusting the navigation and communication frequencies. It also functions as a backup for the EICAS; therefore, pages of the RMU can be accessed to check the fuel status, engine parameters, flap position, TCAS, etc., as shown in the Figures below.



Fig. 67 and 68 (Adjustment of communication and navigation frequencies)



Fig. 69 and 70 (as a back-up, pages with information of the fuel system and engine parameters.

Therefore, it is possible that, while handling the pages of the RMU, the captain unintentionally set the Transponder to STANDBY, by pressing the RMU button twice in less than 20 seconds, without being aware of his action.

The fact that the CVR demonstrates that the pilots appear to have noticed and then modified the status of the equipment after the collision, strengthens the hypothesis that the problem was just an unintentional change of the operation mode.

Besides, the fact that this was the only moment of the interview at which they showed contradiction relative to the facts presented. Besides, despite their denial to have dealt with the RMU at the moment of the Transponder loss, the events that resulted from the possible perception by the pilots, such as the recording in the DFDR of the activation of the TCAS screen on the MFD2 (graphs shown below), and the reappearance of the mode C in the radars of the control system, make the hypothesis of a simple coincidence appear rather inconsistent.





Fig. 71

The Figure 71 (above) shows the data from the DFDR of N600XL, with the opening of the TCAS screen on the MFD2 display (co-pilot side), precisely at 19:59:50 UTC.

In addition, the recording of the telephone contact between the Commander of CINDACTA 4 and the N600XL PIC, in which the PIC suddenly changes his answer to the chief of the control organization involved in the occurrence, who was on the occasion seeking information about the other airplane with which they could possibly have collided, and which was still missing. Initially, the PIC said that the TCAS was off and then changed his answer, saying that it was on. The transcription is in item 3.13.4.3.1 "Chronology of the Events" of this report.

The hypothesis above was considered the most likely to have occurred.

### Knowledge and preparedness required from the N600XL pilots for the conduction of flights in the airspace outside the USA

If we observe the website of the operator attentively, we will notice that the company is ruled by 14 CFR Part 91, less restrictive, and by 14 CFR Part 135, much more restrictive than the former.

The entire training of the PIC and SIC was done under the aegis of the 14 CFR Part 135, on account of what was established by the Flight Safety International (FSI), a company ruled by 14 CFR Part 142.

The Section 135.244 of the 14 CFR Part 135 establishes that, in order to conduct a flight similar to the one of the accident, the pilots would have to fly 25 hours on domestic flights as members of the same crew.

If we apply the whole Section 135.244 of the 14 CFR Part 135 to qualify the PIC and the SIC, we would observe that this Section is rather restrictive, requiring from the airline company a substantial investment of time and flight hours regarding its compliance, when compared to the requirements of 14 CFR Part 91, which does not have a section similar to the Section 135.244.

This section of the 14 CFR Part 135 contributes to the safety of the operation, as it obliges the PIC to seek a gradual operational improvement in the quest for proficiency.

If the PIC and the SIC had flown 25 (twenty-five) hours on domestic flights, as members of the same crew, they would have had better chances of flying between Brazil and the United States displaying a higher level of proficiency in the operation of the multiple systems of the airplane.

In this context, there is no doubt that the application of Section 135.244 of the 14 CFR Part 135 would make an excellent barrier to be used by the Directorship of Operations for the Safety of Flight, even though such a rule was not specifically applicable to the flight being examined.

This is based on the analysis of Doc. A001 – “Issuance and Applicability”, which deals with the Operative Specifications of the operator in question.

However, our analysis focused on letter (d) of the Doc. A001, as it represents the legal support for the operators to move to 14 CFR Part 91:

*d. The **certificate holder** is authorized **to conduct flights under 14 CFR Part 91 for crewmember training, maintenance tests, ferrying, re-positioning, and the carriage of company officials using the applicable authorizations in these operations specifications, without obtaining a Letter of Authorization, provided the flights are not conducted for compensation or hire and no charge of any kind is made for the conduct of the flights.***

In other words, upon completion of the training at FSI, both pilots were entitled to fly on domestic and international flights under the aegis of the 14 CFR Part 91, without having interacted as a crew before.

The outcome of the first flight of the N600XL crew shows that the entire process of Judgment and Decision Making (ADM) of the Directorship of Operations, with the consent of the Excelsior Directorship, could have been more adequate.

The 25 (twenty-five) hours not flown as PIC and SIC of the airplane made a difference, mainly if we analyze the CVR of the flight of 29 September 2006, in relation to the operation of the aircraft systems.

The training at a Simulator that had a different fuel system made the pilots start the real flight with an insufficient degree of knowledge concerning this system, with direct influence on the inadequate preparation for the flight.



The lack of confidence in their own preparedness relative to the fuel system, in addition to the restrictions of the Manaus runway informed by the NOTAM, made the pilots spend flight time with their attention focused on the study of the weight and balance performance of the aircraft, to the detriment of the attention that should have been dedicated to the monitoring and management of the flight.

The pilots configured the TCAS screens inadequately, on account of feeling the need to monitor a system that they had never operated without the assistance of the manufacturer before. Moreover, in legal terms they were considered proficient and apt to conduct the aircraft on an international long duration flight, in a country which was strange to both of them.

The Directorship of Operations considered that all the experience earned by the newly hired SIC would be sufficient to counterbalance the natural operational limitations of the pilot assigned to be the PIC, the captain of the flight of the 29 September 2006.

Besides, it is necessary to consider that the SIC had flown 317 hours on an EMB 145, a model that, although requiring the same pilot certification, has differences that could not, and should not, be studied aboard the Legacy, during the ferry flight conducted on 29 September 2006. Those differences should have been dealt with during the initial phase held at the company and, later, at the training done in the simulators of the FSI-Houston-Texas.

In the Operational Aspect, it is shown that the inadequate assessment made by the Operations Directorship of the time needed for the qualification of the pilots for the mission could have been identified by the FAA, through the ASI designated to responsible for audit and monitor the Excelaire company.

In the Operational Aspect, it was considered that the deficiencies displayed by the PIC and SIC should have been identified, first, by the operator, and later, by the FAA ASI designated to inspect Excelaire.

The PIC designated to the flight of the accident scenario failed to show confidence, knowledge and leadership.

This could be observed since the beginning of the preparations for departure, and during the en-route flight (when he left the cockpit for sixteen minutes, unconcerned with the navigation and the communications), even after they had been fifty-seven minutes without radio contact with the control units. This attitude overburdened the SIC, during a period in which the presence of the captain in the cockpit was indispensable.

The emergency culminated his deficient management of the tasks and inability to make decisions with swiftness and precision.

The initiative and leadership of the SIC during the management of the emergency resulting from the collision, favored the safe conduction of the aircraft up to the landing.

The lack of adequate SOP's established by the operator for this type of aircraft and flight also contributed to a deficient management of the flight by the pilots.

The pilots of the N600XL they were certified as ATP, had accumulated a great number of flight hours, were in good health, had already flown other types of equipment and were highly motivated.

On an individual basis, each pilot had met all the requirements established in the selective process by the operator. However, when they were gathered to compose a crew,

they lacked efficient oversight. At that point, the errors that occurred in the internal administration of the company were such, that a better managed training would be advisable, so that they could be well prepared to conduct the flight on another occasion, since they were not ready yet.

### **Aspects of current Air Traffic Control rules and procedures in Brazil and worldwide**

First, it is necessary to stress that the legal processes, opened in parallel with the SIPAER investigation, caused mistrust among the air traffic controllers who started refusing to be interviewed by the commission and clarify some important points relative to the accident.

A series of non-compliances, without a plausible reason, of procedures established through rules and operational models contributed to the accident, and took the line of investigation to the Human Factor in the Operational and Psychological aspects.

The sequence of events started with the controller that transmitted the first clearance. He transmitted the clearance in an abbreviated and incomplete way, in discordance with ICAO Doc.4444, Chapter IV, item 4.5.4 (Contents of Clearance) "Procedures for Air Navigation Service-Air Traffic Management (PANS-ATM)", the document that guides all the normalization in Brazil. He alleged having done that on account of having received the clearance from ACC BS in that way.

A second controller handed off the N600XL to the next sector well before the limit between the sectors, without a plausible reason. This airplane was to change the flight level, but nothing was said in this respect to the receiving controller of the next sector.

Also, the traffic was not advised of any clearance limit, in discordance with ICAO Doc. 4444, item 11.4.2.6.2.2b, letters **a** and **c**. The way the clearance was transmitted induced the pilots of the N600XL to understand that they were authorized to proceed up to Manaus at flight level FL370.

11.4.2.6.2.2 Instructions included in clearances relating to levels shall consist of:

- a) cruising level(s) or, for cruise climb, a range of levels, and, if necessary, the point to which the clearance is valid with regard to the level(s);

*Note.— See 11.4.2.6.2.1 d) and associated Note.*

- b) levels at which specified significant points are to be crossed, when necessary;
- c) the place or time for starting climb or descent, when necessary;

*Note.— If the clearance for the levels covers only part of the route, it is important for the air traffic control unit to specify a point to which the part of the clearance regarding levels applies whenever necessary to ensure compliance with 3.6.5.2.2 a) of Annex 2.*

The controller of the next sector, who received early transfer of the aircraft, made the last successful two-way radio contact with the aircraft, and identified it at flight level FL370. This controller was the same that did not take any action when the aircraft passed over BRS VOR and, at an incorrect flight level, considering the flight plan, joined airway UZ6, along which the collision would occur.

This same controller failed to instruct the aircraft to change to one of the adequate frequencies of the new sector, in addition to having failed to act when the transponder stopped transmitting the mode C, which was imperative for the maintenance of the flight under RVSM rules, in contradiction with his shared responsibility with the pilots, according to ICAO Doc. 4444, Chapter 5, item 5.2.2.

### 5.2.2 Degraded aircraft performance

Whenever, as a result of failure or degradation of navigation, communications, altimetry, flight control or other systems, aircraft performance is degraded below the level required for the airspace in which it is operating, the flight crew shall advise the ATC unit concerned without delay. Where the failure or degradation affects the separation minimum currently being employed, the controller shall take action to establish another appropriate type of separation or separation minimum.

It was this controller that transferred the control of the N600XL to the relief controller, with the information that it was flying at FL360, and not at flight level FL370. This mistake impeded the ACC AZ controllers to issue a new clearance to the PR-GTD in order to change level and avoid the collision, in opposition to three items of the ICAO DOC. 4444:

4.5.1.4 ATC units shall issue such ATC clearances as are necessary to prevent collisions and to expedite and maintain an orderly flow of air traffic.

4.5.1.5 ATC clearances must be issued early enough to ensure that they are transmitted to the aircraft in sufficient time for it to comply with them.

4.5.6.1.2 After the initial clearance has been issued to an aircraft at the point of departure, it will be the responsibility of the appropriate ATC unit to issue an amended clearance whenever necessary and to issue traffic information, if required.

Had just one contact been effective, from the total of 26 calls (19 by N660XL, and 7 by the ATC unit), communication would have occurred, and the controller would have learned about the real flight level being flown by the N600XL.

The succession of procedures that were disregarded by more than one controller takes us to an organizational analysis that was approached at the analysis of the Human Factor, Psychological Aspect, relative to the training and supervision of the SISCEAB organizations involved in the scenario of the accident.

There were sporadic reports of difficulties concerning the communication on some frequencies in that area, which were not confirmed.

However, we could only admit a failure of the communication equipment, **if**:

- The controllers had commanded the change of frequencies adequately, at the points prescribed by the Operational Model of ACC BS;
- The frequencies had been correctly selected at the consoles of the controllers responsible for the traffic of the airplanes involved in the collision;
- The prescribed connections of the frequencies with the audio center of the ACC BS had been correctly installed.
- All the frequencies of the charts were correct, selected at the consoles, and with the connections established.

We could, then, point toward the possibility of failures caused by defects and poor maintenance of the equipment of the Airspace Control System.

There was evidence of human failure in the communications, overriding the operational capacity of the frequencies and equipment.

Not only individual failures at the execution level were identified, but also failures at a supervision level.

From what has been analyzed, and to the extent that was possible to reconstitute which frequencies were used by the N600XL, and in what sequence they were used, the failures that were found in the communications were generally caused by error of procedures, such as the incorrect selection of frequencies at the console, failure to inform the correct frequency for the sector, or lack of connection of the frequency installed in the VHF site with the audio center of the ACC BS.

In an **overview of the communications**, it was possible to clearly verify the following aspects:

#### **With regard to the flight of the PR-GTD**

No problems related to communications were determined. There was a correct functioning of the communications equipment, both of the aircraft and of the air traffic control units. The operational procedures were adequately carried out by pilots and controllers who interacted during the whole operation.

#### **With regard to the flight of the N600XL**

Several problems were determined in relation to the non-compliance of the procedures prescribed for a correct management of the communications by the pilots and air traffic controllers who interacted during the operation.

There were operational failures, on the part of the pilots and air traffic controllers, in the handling of the communications equipment available.

At the very beginning of the flight, a series of messages were deficiently transmitted and incorrectly understood during the delivery of the IFR flight plan clearance, start of taxi, and transmission of takeoff clearance.

The IFR flight plan clearance was transmitted to the pilots in an incomplete manner. It did not mention the clearance limit for the first flight level, and the pilots understood that the flight level FL 370 was authorized for the whole route up to the destination.

From the takeoff, at 17:51 UTC, up to the last two-way radio contact between the N600XL crew and ACC BS, at 18:51:14 UTC, the flight occurred in accordance with the expected routine.

It is worth pointing out that the aircraft handoff from the controller responsible for the N600XL in sector 5, to the controller responsible for sector 7, was made well before the limits between the two sectors.

The programmed N600XL flight level change from FL370 to FL 360 would normally occur within sector 5. However, the controller of sector 7 was not advised and the aircraft did not receive any clearance limit.

The controllers did not provide N600XL with the prescribed frequency 135.9 MHz, so that the aircraft could communicate adequately when entering sector 07.

The air traffic controllers did not comply with the RVSM traffic separation standard procedures when they let N600XL to fly at a non-standard flight level, after the aircraft passed the vertical of BRS VOR, even having received information coming from the radar screens that the active flight plan requested a coordination of a new flight level authorized according to the active flight plan.

They did not perform the procedures prescribed to contact the aircraft when the transponder signal transmission was interrupted, a contact which was mandatory for the maintenance of the aircraft under RVSM vertical separation parameters. An action by the pilots would also be pertinent, relative to the discontinuance of the transponder transmission.

The air traffic controllers at console 8 did not select the appropriate frequencies prescribed in the chart for that sector. That was the reason why the calls made by N600XL on two of the frequencies listed in the chart for sector 07 (123.3 MHz and 133.05 MHz), despite being received and although recorded in the audio center of the ACC BS, never arrived at the control console.

The frequency 128.0 MHz, although selected on the console and installed in the communication site, still lacked a connection with the audio center of CINDACTA I, resulting that no recording of communication on that frequency was made.

Three out of the five frequencies listed in the pilots' chart were not available on account of procedure and resource management errors.

Thus, of the five frequencies for sector 7 listed in the pilots' Jeppesen chart, only 135.9 MHz was operational, since the fifth frequency, 134.7 MHz, was not correct as it was not prescribed in the Brazilian chart.

The pilots failed to exercise good flight management.

They did not monitor the functioning of the Transponder, and maintained a poor situational awareness, well below the recommended standards, for someone operating a new aircraft in a foreign country under ICAO rules. In addition, they let themselves remain 57 minutes without communication in flight, without any attempt to contact the ATC units.

When the pilots noticed that they were having difficulties contacting the control units, they did not either attempt any calls on HF frequencies or follow the international rule concerning the use of the code 7600 in case of communications failure (had they done this, they would probably have discovered that the transponder was not transmitting).

## **Air Traffic Control Surveillance System.**

### **Surveillance**

The Brazilian ATC surveillance system comprises primary and secondary radars, the latter being integrated and isolated, as well as application programs aimed at the integration and presentation of radar data.

### **Analysis of the surveillance:**

The STVD operated uneventfully at Brasilia ACC.

The flight plan treatment function was responsible for the actions relative to the N600XL flight. The approval of the flight plan, the elaboration of the strip and of the FPL messages are examples of actions of this section of the X-4000.

After departing from SBSJ, the N600XL, transponder code 4574, began to be detected by the radar network of CINDACTA I.

Up to the vertical of BRS VOR, there was not any alert or relevant event.

After the vertical of BRS VOR, the data block pertaining to N600XL started to show, as specified, the information 370=360, warning the controller that the aircraft was at flight level 370, while the level authorized for that segment was FL 360 (See Figure 70).

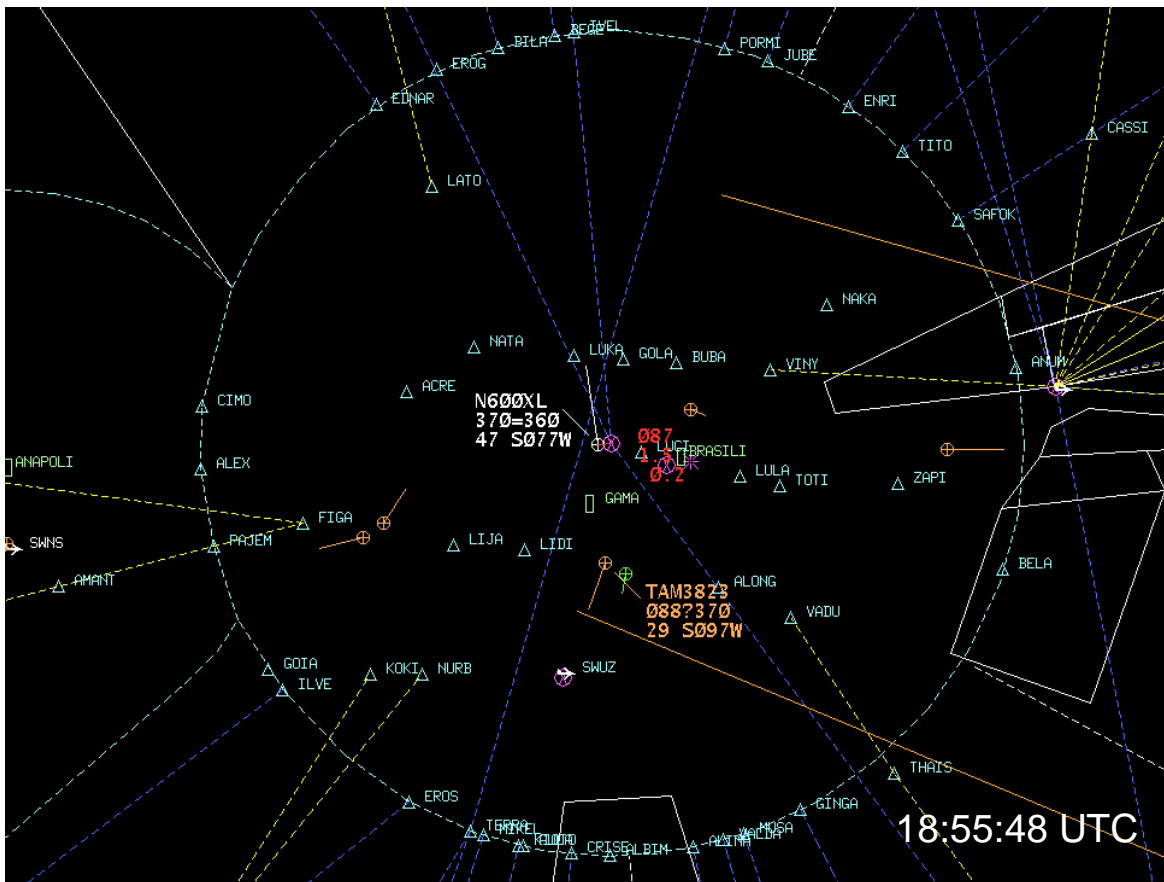
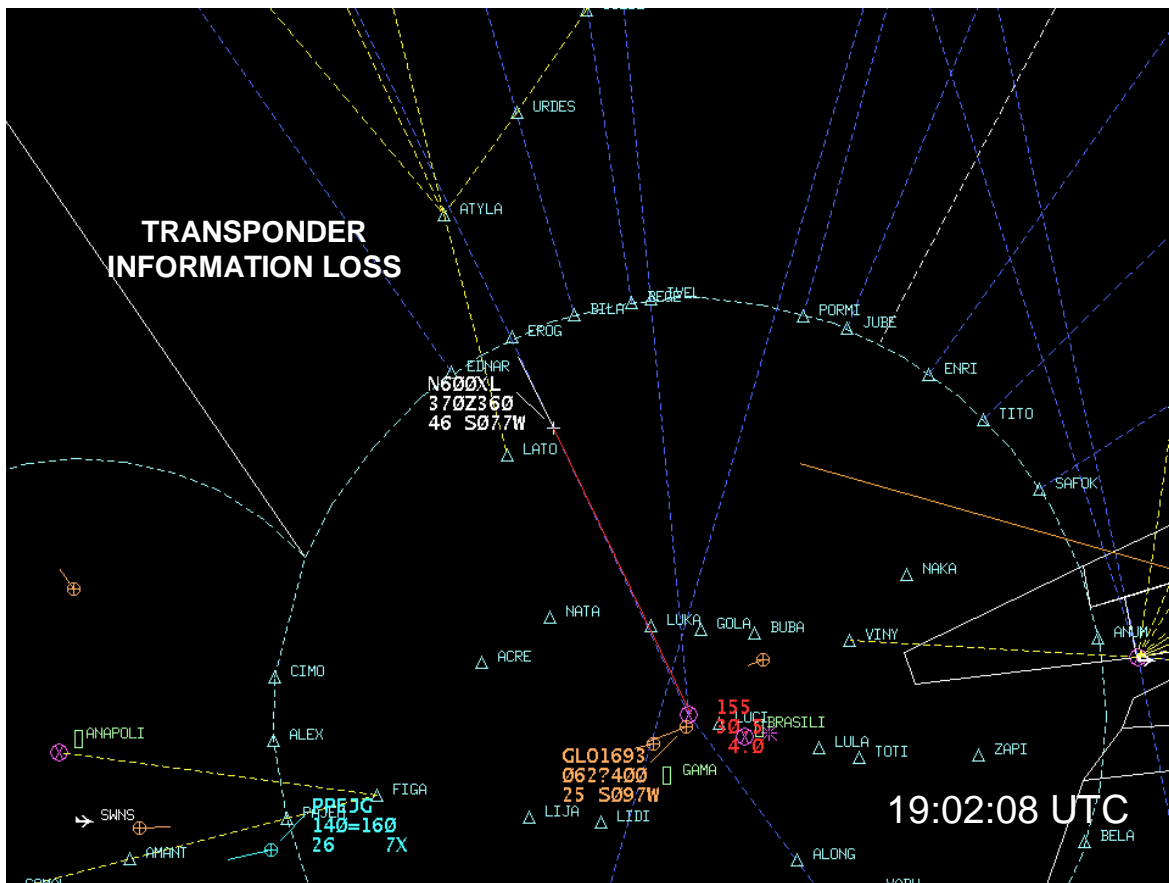


Figure 72 – RADAR presentation of the STVD at CINDACTA I

The system has the fields RFL (Flight Level Requested) and CFL (Flight Level Authorized). The RFL is initiated with the digits relative to the flight level requested by the aircraft operator in the flight plan which has been filed. The CFL is the flight level authorized by the air traffic controller for the segment to be flown. The CFL field is automatically filled in by the system at the aircraft icon initialization, or by means of a manual insertion made by the controller, which is replicated to all the subsequent segments.

Another important point is the presentation of the three-dimensional radar altitude information. It is identified with the letter Z after the measured level, and it is known to the controllers.

Figure 73 depicts the change in the presentation of the N600XL data block, with the addition of the letter Z after the aircraft measured altitude.



**Figure 73** – Presentation of the N600XL data block, after the transponder transmission discontinuance.

This characteristic of the system was not included in any standard procedure documents or controllers' training manuals.

When the SSR radar contact is lost, the software may remove the altitude information, since the 3D altitude indication is not prescribed to be used for traffic separation.

The radar coverage did not present technical failures that could have contributed to the accident. Without a transmitting transponder, there was no way to receive precise altitude information from the N600XL.

The information was available, and the alerts functioned as expected, but they were not identified by the controllers.

The difficulties continued after the collision, during the management of the emergency by the N600XL crew. The pilots were not able to make contact with the air traffic control units on the international emergency frequency 121.5 MHz, but this was not a contributor to the occurrence of the accident.

The pieces of equipment involved in the scenario of the occurrence did not present design failures, since they functioned within their specifications on the day of the accident, removing the possibility of a contribution of the Communication and Surveillance Systems and Equipment.

## 5. CONCLUSION

### 5.1. Facts

- a. The pilots of both airplanes held valid Medical Certificates;
- b. The pilots of both airplanes held valid Pilot Licenses and IFR Ratings;
- c. The pilots of both airplanes were qualified to conduct their respective flights;
- d. The maintenance services of the two airplanes were considered periodic and adequate;
- e. The airplanes were within the limits prescribed for weight and balance;
- f. The airplanes were considered latest-generation aircraft, equipped with VHF and HF transceivers, Automatic Flight Management Systems (FMS), Global Positioning Navigation System (GPS), Radar Signal Transmitter-Responder (Transponders), Airborne Collision Avoidance Systems (ACAS), VOR and NDB Receivers, and other equipment required by the legislation;
- g. The PR-GTD airplane, which was operating the flight GLO 1907, departed from Manaus, and was cleared to maintain flight level 370 up to Brasilia, according to the active flight plan;
- h. The ACC BS transmitted an incomplete clearance to SJ GND relative to the N600XL;
- i. The crew of the N600XL received from the SJ GND the incomplete clearance, and understood that the flight level FL370 was authorized all the way up to the destination. However, according to the active flight plan, the clearance limit for the flight level FL370 was the vertical of BRS VOR;
- j. While the N600XL was en route, the controller of sector 5 handed off the N600XL airplane to the ATCO 1 of sector 7, at about 52 nautical miles to the south of BRS VOR, although the limit between sectors 5 and 7 of Brasilia FIR is to the north-west of Brasilia.
- k. The controller of sector 5 did not advise either the controller of sector 7 or the pilots of the N600XL of the programmed flight level, according to the flight plan filed;
- l. When the N600XL passed over the vertical of BRS VOR, the ATCO 1 of sector 7 received from his equipment a visual information alerting that there was a flight level change programmed to occur over BRS VOR for the Legacy, and this information remained available for seven minutes;
- m. The ATCO 1 of sector 7 neither took any action for the coordination of the N600XL flight level change nor tried to contact the aircraft;
- n. Seven minutes after the aircraft had passed over BRS VOR, the N600XL Transponder stopped transmitting the Mode C aircraft altitude, and, consequently, de-activated the TCAS of the airplane, a fact that was not perceived by the pilots;
- o. The CVR of the N600XL indicated that the attention of the crew was focused on solving issues relative to the performance of the aircraft for the operation in Manaus, after they learned of a NOTAM limiting the length of the runway of that airport..



- p. The ATCO 1 of sector 7 did not notice the information alerts relative to the loss of the mode C and did not take the prescribed corrective actions:
- q. When transferring the responsibility for the aircraft to the relief controller (ATCO 2), the ATCO 1 of sector 7 told him that the aircraft was at flight level FL360;
- r. The ATCO 2 of sector 7 started trying to make contact with the N600XL 34 (thirty-four) minutes after the last two-way radio contact;
- s. The N600XL crew started trying to make contact with the ACC BS, 57 (fifty-seven) minutes after the last two-way radio contact;
- t. During approximately 32 (thirty-two) minutes, nineteen attempts to contact ACC BS were made by the N600XL, and seven attempts to contact the aircraft were made by the ACC BS, all of them unsuccessful, up to the moment of the collision;
- u. Three out of the five frequencies listed in the Jeppesen chart used by the N600XL pilots were not available, due to errors in the selection of the frequencies 123.3 MHz and 133.05 MHz at the consoles, and the fact that the frequency 128.00 MHz was not connected to the audio center of CINDACTA I, according to item 3.6 of this report;
- v. Of the five frequencies for sector 7 that were listed in Jeppesen chart used by the N600XL pilots, only the 135.9 MHz was capable of operating accordingly on the day of the accident, because the frequency 134.7 MHz was incorrect and was not listed in the Brazilian chart.
- w. The Assistant-Controller of sector 7 handed off the N600XL aircraft to the ACC AZ and said that it was at flight level FL360, but did not mention that it was without radar contact, without altitude information and without radio contact;
- x. The PR-GTD and the N600XL airplanes were maintaining the same flight level, along the same airway and were approaching each other in opposite directions.
- y. The PR-GTD was flying with its Transponder and TCAS systems in operation, transmitting the Mode C aircraft altitude, as required for RVSM airspace, during all the flight;
- z. Despite the fully visual conditions at the moment of the collision, there was not either visual perception of the approach or an evasive action attempt on the part of the crews;
- aa. The airplanes collided head-on, having touched each other's left wing, within controlled airspace under RVSM, next to the boundary between the Brasilia and Amazonic Flight Information Regions (FIR);
- bb. The airplanes collided, whereas their crews did not receive any warnings from the respective TCAS Systems, due to the fact that the Transponder of one of the airplanes, the N600XL, had stopped transmitting 54 minutes before the collision;
- cc. The loss of the transponder reply from N600XL made it impossible for the radars of the ACC AZ to warn the controllers of the imminent collision, due to the lack of altitude information;
- dd. The damages caused to the left wing of the PR-GTD by the collision rendered the airplane uncontrollable by its pilots.

- ee. The aircraft entered a left spiral dive, at an abnormal attitude known as “spin”.
- ff. The uncontrolled dive of the PR-GTD made the airplane exceed its flight structural limit, and caused the structural separation of the aircraft in flight (in-flight break-up) during the fall, not allowing any chances of survival of its 148 passengers and 6 crew;
- gg. The N600XL airplane sustained damages on the left wingtip, having lost part of the winglet. The left horizontal stabilizer was also damaged. The aircraft, despite the damage, remained controllable by the pilots, who managed to make an emergency landing at SBCC;
- hh. Tests of the N600XL TCAS and Transponder were performed and indicated normal functioning, without detection of any failure;
- ii. During the emergency descent, the N600XL CVR recorded a dialog in which the pilots refer to the functioning of the TCAS;
- jj. Concomitantly to the dialog mentioned, the DFDR recorded that the TCAS screen started being used. At the same time, the radars of the ACC AZ resumed reception of the Transponder mode C, with the same code previously allocated;
- kk. Then, the pilots changed to the international emergency code (7700), which was immediately received by the radars of the ACC AZ;
- ll. After the collision, during the descent for the landing at SBCC, the pilots of the N600XL had difficulty establishing radio contact with the air traffic control units;
- mm. The landing was successful, and all the passengers and crew members of the N600XL airplane were unhurt; and,
- nn. The recovery of the N600XL airplane was considered economically viable.

## **5.2.1 CONTRIBUTING FACTORS.**

### **5.2.1. Human Factor**

#### **5.2.1.1. Psychological aspect – a contributor**

##### **5.2.1.1.1. PR-GTD**

Neither active failures were identified in relation to the crew, nor latent failures in relation to the organizational system of the company.

##### **5.2.1.1.2. N600XL**

Relatively to the crew of the N600XL, the following active failures were identified: lack of an adequate planning of the flight, and insufficient knowledge of the flight plan prepared by the Embraer operator; non-execution of a briefing prior to departure; unintentional change of the transponder setting, failure in prioritizing attention; failure in perceiving that the transponder was not transmitting; delay in recognizing the problem of communication with the air traffic control unit; and non-compliance with the procedures prescribed for communications failure.

The low situational awareness of the pilots (airmanship) was a relevant factor for the occurrence of the accident. It began during the phase of preparation for the operation, which was considered by them as “routine”. The attitude of the pilots about the mission permeated their behavior during the other phases, with the addition of several factors that contributed to aggravate the lowering of the situational awareness:

- The non-elaboration of an adequate planning of the flight, a behavior that was influenced by the habitual procedure of the company, an aspect not favorable for the construction of a mental model to guide the conduction of the flight;
- The haste to depart and the pressure from the passengers, hindering adequate knowledge of the flight plan, and negatively influencing the sequence of actions during the pre-flight and departure phases;
- The crew dynamics, characterized by lack of division of tasks, lack of an adequate monitoring of the flight, and by informality. It was influenced by the lack of knowledge of the weight and balance calculations, and by the predominant little experience of the pilots in that aircraft model; and
- the lack of specific Standard Operational Procedures (SOP's) set by the company for that aircraft model to be complied with by the pilots.

Within this context, the inadvertent switch-off of the transponder occurred, possibly on account of the pilots' little experience in the aircraft and its avionics. The transponder switch-off was not perceived by the crew, due to the reduction of the situational awareness relative to the alert of the TCAS condition, which did not draw the attention of the pilots. The lack of situational awareness also contributed to the crew's not realizing that they had a communication problem with the ATC. Although they were maintaining the last flight level authorized by the ACC BS, they spent almost an hour flying at a non-standard flight level for the heading being flown, and did not ask for any confirmation from the ATC.

The performance deficiencies shown by the crew have a direct relationship with the organizational decisions and processes adopted by the operator: the inadequate designation of the pilots for the operation; the insufficient training for the conduction of the mission, and the routine procedures relative to the planning of the flight, in which there was not full participation of the crew.

#### **5.2.1.1.3 SISCEAB**

Considering the diversity and complexity of the non-conformities observed in the air traffic control domain, they will be presented in topics.

It is important to point out that the refusal of the Brasilia ACC controllers involved in the accident to participate in the interviews hindered the precise identification of the individual aspects that contributed to the occurrence of the non-conformities. Some of these aspects were kept in the field of hypotheses.

a) Transmission of an incomplete flight clearance by the assistant controller of the São Paulo Region of Brasilia ACC, and by the Ground controller of DTCEA-SJ.

There was a deviation from the procedure, together with an informal procedure pattern concerning the transmission of clearances, originated at Brasilia ACC, and disseminated at

DTCEA-SJ, as an outcome of daily practice, in replacement of the model prescribed by the legislation. The reception and transmission of incomplete clearances were erroneously adopted as normal, routine practices, rationally justifiable, within the DTCEA-SJ. The incomplete clearance transmitted to the N600XL crew favored the understanding by the pilots that they had to maintain FL 370 all the way to Manaus.

b) The ATCO of sectors 5 and 6 of Brasilia ACC did not provide the ATCO 1 of sectors 7, 8 and 9 with the necessary information, when coordinating and handing off the N600XL aircraft.

The incomplete information transmitted by the ATCO of sectors 5 and 6 is an indication that he had a low situational awareness concerning the N600XL in his sector. He, possibly, considered that his priority in relation to the mentioned aircraft would be an early transfer to the next sector, as his own sector was showing an increasing volume of traffic at that moment (09 aircraft), although it was below the limits prescribed for grouped sectors.

c) The ATCO 1 of sectors 7, 8 and 9 of ACC BS did not make a radio contact with N600XL to change the aircraft flight level and to switch the frequency from sector 9 to sector 7; did not perceive the N600XL loss of mode C; he assumed that the N600XL was at flight level FL360; did not perform the procedures prescribed for the loss of transponder in RVSM airspace, and for the control position relief, by both omitting information and transmitting incorrect information.

The non-transmission of important information to the ATCO 1 of sectors 7, 8 and 9, concerning the N600XL in sector 5, contributed to the diminishing of the situational awareness of that controller in relation to the aircraft and the need to change its level and frequency.

The failure of the ATCO 1 of sectors 7, 8 and 9 to act in relation to the change of frequency allowed the aircraft to get out of the coverage of the frequency 125.05 MHz, making it impossible to receive the transmissions. By not contacting the aircraft to change its level at the vertical of Brasilia, the ATCO 1 of sectors 7, 8 and 9 let the N600XL join the UZ6 airway at an incorrect level in relation to the active flight plan.

Although the system presented the prescribed indications for the loss of the N600XL transponder, they did not draw the attention of the controller to the need of changing the flight level. The lack of action after the loss of the N600XL Transponder mode C allowed the aircraft to maintain a flight level that was incorrect in relation to the active flight plan.

When he passed the information to the ATCO 2 of sectors 7, 8 and 9 that the aircraft was at flight level FL360, the ATCO inserted a false assumption, which became very difficult to be detected, on account of the lack of the Transponder altitude information and the impossibility of communication due to the failure to timely instruct the aircraft to change the frequency. Misjudging that the aircraft was at the flight level planned for the segment (FL360), the ATCO 1 possibly disregarded the risks resulting from the inaccurate 3D radar altitude information. The controller, also, failed to resort to the support of the regional supervisor.

His attitude of evaluating the resulting risks in an incorrect manner may have influenced on the lack of information/ transmission of incorrect information, when he was relieved by the ATCO 2 of sectors 7, 8 and 9.

d) The ATCO 2 of sectors 7, 8 and 9 of ACC BS did not perform the procedures prescribed for the loss of transponder and loss of radar contact within RVSM airspace, and for communications failure, and failed to communicate with the assistant controller.

By failing to perform the prescribed procedures for the loss of Transponder and radar contact, as well as for communications failure, the ATCO 2 of sectors 7, 8 and 9 allowed the N600XL to maintain the incorrect flight level (FL370) on the UZ6 airway.

The lack of communication with the Assistant-Controller allowed a deficient hand-off of the N600XL to the ACC AZ, with incomplete information, by not mentioning the difficulties of the ACC BS in relation to the radar contact and communications.

The attitudes and incorrect evaluation of the resulting risks by the controller may have been generated by the wrong assumption that the N600XL was at FL 360. Such attitudes may have influenced his behavior of not resorting to the support of the regional supervisor, and of not advising his assistant-controller to inform the ACC AZ about the conditions of the aircraft.

e) Lack of communication between controllers and supervisors: lack of information and/or transmission of incorrect information by the ATCO of sectors 5 and 6, the ATCO's 1 and 2, and Assistant-ATCO of sectors 7, 8 and 9, during the execution of the procedures for coordination and handoff of the N600XL between sectors and between Control Centers, and at the control position relief; lack of communication between controllers and supervisors.

Deviations from the procedures regarding the prescribed phraseology were observed, in various situations of the air traffic control activity and in the various control units involved in the accident. Such deviations contributed to the lowering of the situational awareness of the controllers responsible for controlling the N600XL flight.

The supervisors were not advised by the controllers about the problems experienced in the control of the N600XL, an aspect that generated the making of inadequate decisions, which occurred isolatedly and individually, reflecting a deficient coordination of the team resources.

f) Supervisors of the Brasilia ACC: lack of involvement in the events concerning the control of the N600XL.

The lack of involvement of the supervisors allowed the decisions to be made and the actions to be taken in relation to the N600XL in an individual manner, without due monitoring, advisory and guidance prescribed for the air traffic control.

Among the duties of the regional supervisors, listed in the Operational Model of the ACC BS, there is the following: "to supervise the provision by the controllers under his/her responsibility of the air traffic services in their respective sectors, and to correct errors, omissions, irregularities or inadequate employment of ATS procedures".

Thus, when the supervisors did not participate in the events, an opportunity was lost, with the participation of more people in the process, to detect the need of efficient actions for the reestablishment of the radar contact and radio contact with the N600XL, in addition to other procedures prescribed.

It was not possible to define the aspects that contributed to the non-involvement of the supervisors in the events, as there was a refusal to participate in interviews.

g) The ATCO of the Manaus Sub Center of the ACC AZ showed deviation from the standard procedure during the hand-off of the PR-GTD and the take-over of the N600XL; erroneously confirmed the existence of the N600XL traffic; and did not perform the procedure prescribed for the loss of radar contact.

The ATCO did not perceive the control condition of the N600XL as critical, and did not demonstrate discomfort with the situation, thus displaying a low situational awareness. This may have been influenced by the information received from the ACC BS that the aircraft was at flight level FL360, and by not being informed that the aircraft had been without radar contact and radio contact for some time. Again, this allowed the two airplanes to fly in opposite directions, along the same airway and at the same flight level.

The personnel shortage at CINDACTA IV hindered the maintenance of a continued training of the controllers, by means of refreshers, TRM trainings and English courses.

It was observed that the annual theoretical evaluation (TGE) was not being able to aid in the identification and diagnostic of the controllers' performance deficiencies, thus failing to assist in the process of determination of the training needs.

There were difficulties in re-creating the operational profile of the ATCO's involved, due to the shortage of records relative to the instruction and technical qualification.

Lastly, it is important to point out that the personnel shortage hindered the structuring of the operational work-shifts, as well as the instructional activities, as mentioned earlier.

The effects of the personnel shortage were reflected in the quality of the services as they contributed to the degradation of the controllers' performance and/or to the insufficient technical qualification.

#### **5.2.1.2. Physiological Aspect – not a contributor**

No factors of physiological origin were evidenced that may have contributed directly or indirectly to the occurrence of the accident.

#### **5.2.1.3. Operational Aspect.**

##### **a) Training – a contributor**

*(Participation of the received training process, due to a qualitative or quantitative deficiency, for not providing the trainee with full knowledge and other technical skills required for the performance of the activity).*

The FSI refused to receive the visit of the CIAA at the unit of Houston-Texas and brought considerable difficulties for the investigation of the instruction given to the pilots in the simulator.

The training provided to the N600XL pilots proved insufficient for the conduction of the repositioning flight from Brazil to the USA. The lack of interaction between the pilots was apparent in the difficulties with the division of tasks and in the coordination of the cockpit duties, with both of them devoting their attention to the calculations of the aircraft weight and balance during the flight. The lack of theoretical knowledge became evident when they showed difficulty operating the aircraft systems, mainly the fuel system, according to the CVR.

These gaps in the received training favored a deviation of the pilots' attention to other aspects during the flight, in detriment of the aircraft operation. Such distraction allowed the discontinuance of the transponder transmission to go unperceived, resulting in the incorrect maintenance of the FL370 on the UZ6 airway and lack of TCAS collision alert.

Upon completion of the training at the FSI, both pilots would be entitled to fly domestic and international flights, under the aegis of the 14 CFR Part 91, without previous interaction as a crew.

Since the prescriptions of the regulation mentioned were complied with, it was observed that they were not adequate to meet the minimum required levels for a safe operation of high performance jet aircraft in acceptance and repositioning flights.

b) Air traffic control – a contributor

*(Participation of the air traffic service provider, on account of inadequate service provision).*

The authorization to maintain flight level FL370 was given to the crew of the N600XL, as the result of a clearance transmitted in an incorrect manner. The vertical navigation conducted by the crew ended up being different from the one prescribed in the flight plan that was filed and activated, on account of the instruction incorrectly transmitted that led the N600XL crew to maintain flight level FL370.

The air traffic control units involved, although providing radar surveillance (radar monitoring) service, did not correct the flight level and did not perform the prescribed procedures for altitude verification when they stopped receiving essential information from the Transponder due to the loss of mode C. The controllers assumed that the traffic was at a different flight level, without even being in two-way radio contact with the N600XL for confirmation. They did not make a correct handoff of the traffic between sectors and between FIRs. They maintained RVSM separation when the necessary requirements no longer existed. As a final consequence, they did not provide the proper traffic separation as prescribed in the ICAO Doc. 4444, item 5.2 "Provisions for the Separation of Controlled Traffic", thus allowing the in-flight collision between the two airplanes.

Neither material nor design failures were found in the pieces of equipment of the air traffic infrastructure that might have contributed to the accident.

The various contributing non-conformities found by the investigation are presented in the item 5.2.1.1 of this report, as they are directly related to the Human Factor.

c) Cockpit coordination – a contributor

*(Error resulting from an inadequate utilization of the human resources for the operation of the aircraft, on account of an ineffective distribution and management of the tasks affecting each crew member, failure or confusion in the interpersonal communication or relationship, inobservance of operational rules).*

The attention of both pilots of the N600XL focused on solving the question relative to the performance of the aircraft for the operation in Manaus, as they had learned of a NOTAM limiting the length of the runway of that airport. This hindered the routine of monitoring the evolution of the flight, because both pilots got busy with the same subject, creating the environment in which the interruption of the Transponder transmission was not perceived.

There was not a good division of the flight management tasks, culminating with a prolonged absence of the PIC from the cockpit, thus overburdening the SIC when he tried to establish contact with the control units.

The utilization of the screens by both pilots to show the fuel system, consequently without visualization of the TCAS, contributed to the lack of perception of the inoperative TCAS.

d) Judgment – a contributor

*(Error committed by the pilot, resulting of an inadequate assessment of certain aspects of the operation, despite his being qualified for that operation)*

The pilots judged that they would be able to conduct the flight even with their little adjustment as a crew and with their little knowledge of the aircraft systems, mainly the fuel system and the calculations of the weight and balance. They believed they could hasten the departure, resulting that they had just a short time to verify the flight plan and other documents, such as the NOTAM informing about the reduction of the runway length available at Manaus airport.

On account of that, they judged that they both could concentrate on the calculations of the weight and balance in flight, something that allowed the non-functioning of the *Transponder* and TCAS to occur unperceived.

There was an incorrect evaluation of the situation relative to the attempts to contact the ATC, as more than 43 minutes had elapsed without communication with the ACC BS, and they were late to recognize the need to contact the control center.

The PIC left the cockpit and stayed away 16 minutes, not considering the consequences of overburdening the SIC.

e) Planning – a contributor

*(Pilot error, resulting of inadequate preparation for the flight, or part of the flight)*

The planning of the flight was inadequate. Before the departure, there was not a monitoring of the elaboration of the flight plan that was being prepared by the Embraer employee, not allowing the pilots to have a previous knowledge of the proposed route and flight levels, although, in accordance with the Excelsaire Manual of Operations, the PIC had to open and close the flight plan at the nearest FAA FSS or ATC office.

There are numerous situations recorded in the CVR showing the lack of an adequate concern of the crew with details of the pre-flight planning. An example was that only in flight did they learn of NOTAM of SBEG containing information about the reduction of the runway length available. This fact, added to the little familiarization of the pilots with the fuel system and with the aircraft weight and balance calculations, favored the deviation of their attention, during the flight, from the aspects relative to the operation of the aircraft, allowing the non-functioning of the *Transponder* and TCAS to go by unperceived.



f) Oversight – a contributor

*(participation of third parties, not belonging to the crew, on account of lack of adequate supervision of the planning or execution of the operation, at administrative, technical or operational levels)*

The oversight conducted by the operator for the flight proposed was inadequate. The composition of the crew, with two pilots that had never flown together before, to receive, in a foreign country, an airplane in which they had little experience, with air traffic rules different from those with which they were used to operate, favored the lack of a good adjustment between the pilots, along with the already mentioned difficulties of cockpit coordination.

Besides, there was not a specific SOP for the receipt of aircraft from the manufacturer, resulting that their decisions were made according to the individual experience of the pilots, Who had never received an aircraft in those conditions. The decisions made, as seen in the contributing factors “Judgment” and “Planning” influenced the sequence of events that led to the accident.

The monitoring of the instruction provided to the pilots was inadequate, because the operator did not perceive that the acquired knowledge was not sufficient for the conduction of the intended flight.

The performance of the N600XL crew had a direct relationship with the decisions and organizational processes adopted by the operator, on account of culture and attitudes of informality.

All of this was considered as a chain of errors, without violations on the part of the operator.

g) Little flight experience in the airplane – Undetermined

*(Pilot error, resulting from little experience in the aviation activity, in the aircraft, or, specifically, in the circumstances of the operation)*

The CVR indicated that, shortly before the moment of silence and the moment at which the Transponder discontinued the transmission, the PIC was looking at the fuel page of the MFD, and solved a doubt about fuel management with the SIC. It is possible that the PIC may have continued to look at other pages of the MFD and, possibly, to pages of the RMU.

The little experience of the PIC in this aircraft possibly made him look for information about the fuel consumed on the RMU fuel page, and, when leaving from this page and pushing the pertinent buttons, he unintentionally changed the setting of the Transponder from TA/RA to STANDBY, thus interrupting the altitude information of the mode C;

The insufficient adaptation of the crew with this type of aircraft and with the DISPLAYS of the respective avionics may have contributed to the unintentional selection of the STANDBY mode and to the subsequent lack of perception of the Transponder/TCAS status.

### 5.2.2. Material Factor

Not a contributor.

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On 08 / Dec / 2008.

  
Brig Ar JORGE KERSUL FILHO

Chefe do CENIPA

Brig Gen Jorge Kersul Filho  
Chief of the CENIPA

I HEREBY APPROVE THIS FINAL REPORT

  
Ten Brig Ar PAULO ROBERTO RÖHRIG DE BRITTO  
Chefe do EMAER

Air Force Gen Paulo Roberto Röhrig de Britto  
Chief of the General Staff of the Aeronautics

# **APPENDIX 1**

**(In accordance with ICAO Annex 13)**



## National Transportation Safety Board

Washington, D.C. 20594

Office of Aviation Safety

### **U.S. Summary Comments on the Draft Final Report of the Aircraft Accident Involving PR-GTD and N600XL, 29 September 2006**

#### **INTRODUCTION**

This letter relates to the 29 September 2006 midair collision involving PR-GTD, a Boeing 737 operated as Gol Airlines flight 1907, and N600XL, an Embraer Legacy operated by Excelaire, near the NABOL navigation fix over the state of Mato Grosso, Brazil. As the State of Design and Manufacture of the 737 airplane and the State of Registry and Operator of the Legacy airplane,<sup>1</sup> a U.S. Accredited Representative and advisors<sup>2</sup> participated in the Brazilian Centro de Investigação e Prevenção de Acidentes Aeronáuticos (CENIPA) investigation. On 30 July 2008, the U.S. Accredited Representative received CENIPA's draft final report. The U.S. investigative team's comments are submitted to CENIPA pursuant to section 6.3 of Annex 13 to the Convention on International Civil Aviation.

#### **SUMMARY**

The U.S. Accredited Representative and advisors responded to the accident notification and traveled to Brazil. Additional advisors supported the team from the United States and participated in recorder readout in Canada. Followup work, including avionics examination, air traffic control (ATC) familiarization, operator personnel and pilot interviews, obtainment of records relevant to the operator, and cockpit voice recorder transcription was performed in the United States with CENIPA participation. This investigation was considered extremely complex with factors that would not likely be readily evident, as two virtually brand-new aircraft, with modern equipment, operating under instrument flight rules, collided in flight. The CENIPA accident investigation commission organized the investigative efforts into two broad categories—Operational, which included Human Factors and Material Factors, which comprised areas relating to airworthiness. Extensive examination of the material factors relative to both aircraft and their equipment revealed no preaccident failures or significant malfunctions. The material factors part of the investigation team provided input to the operational factors part of the team regarding how avionics components respond to certain inputs. The operational factors part of the investigation covered various topics related to the flight crew's preparation, training, familiarity with the aircraft, relevant flight rules and practices, company aspects, and situational

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<sup>1</sup> Additionally, the United States is the State of Manufacture of Honeywell and Aviation Communications & Surveillance Systems avionics components, which were considered significant major components in accordance with section 5.18 of Annex 13.

<sup>2</sup> Advisors to the U.S. Accredited Representative included representatives from the National Transportation Safety Board; Federal Aviation Administration; Boeing Commercial Airplanes; Excelaire Services, Inc.; Honeywell Aerospace Systems; and Aviation Communications & Surveillance Systems, Inc.

awareness. Operational factors also examined ATC issues, including the procedures used by controllers, equipment use, communications, and awareness. Additionally, investigation into human factors, including physiology and culture, was conducted.

The U.S. team's assistance focused primarily on aspects of the investigation that are relevant to U.S.-manufactured avionics components, the policies and procedures of the Legacy operator, and the background and actions of the Legacy flight crew. Additionally, the U.S. team examined most of the factual data and information regarding ATC, as well as the preparations for the Legacy's delivery.

The enclosed comments, which are based on the factual information gathered throughout the investigation, include analysis, findings and proposed causal factors by the U.S. Accredited Representative and advisors. In summary, the team has no substantial disagreement with the facts gathered and discussed in this report and generally concurs that the safety issues involved in this accident are related to ATC, operational factors, and the loss of in-flight collision avoidance technology. However, the interpretations, conclusions, and understandings of the relationship between certain factual items and the demonstrated risk differ in a number of respects. For example, the report states that the investigation was based on the following four focal points: functioning of equipment on board N600XL, preparation of the flight crew, ATC rules and procedures, and functioning of Brazilian airspace system.

The U.S. team believes that these points all stem from the basic investigative question, namely, how the primary mission of ATC to separate aircraft within positive controlled airspace was unsuccessful. This investigation has identified many safety issues for ATC operations, but these issues need to be further highlighted. Even though the body of the report acknowledges safety deficiencies with ATC, these deficiencies are not sufficiently supported with analysis or reflected in the conclusions or cause of the accident. These deficiencies include a lack of timely ATC action after the loss of N600XL's transponder and two-way radio communication, and features of the ATC software that may have aggravated deficiencies in altitude clearance awareness for N600XL. The U.S. team's additional ATC findings, which are provided in accordance with International Civil Aviation Organization Document 9756, Part IV, are central to understanding this accident and supplement the findings and contributing factors already cited in the draft report.

The flight crew of N600XL, although not in violation of any regulations, was not aware of the loss of transponder and collision avoidance functionality, lack of ATC communication, and the flight's progress reference altitude convention. The team agrees that safety lessons in these areas can be determined to better prepare flight crews for international operations.

Finally, the U.S. team has worked closely with CENIPA as a result of this accident to improve collision avoidance technology. Along with CENIPA, the U.S. team drafted a Safety Board recommendation, A-07-35, which asked the Federal Aviation Administration to require an enhanced aural and visual warning requiring pilot acknowledgment in the event of an airborne loss of collision avoidance system functionality for any reason. ACAS systems are an integral component of current air space safety, and this accident highlights the need for upgraded cockpit warnings whenever ACAS functionality is compromised. The U.S. team also believes there are

safety issues uncovered in the course of this investigation concerning the guarding or relocating of important cockpit controls from inadvertent activation.

The U.S. team appreciates the opportunity to comment on this report and contribute to this important investigation and its effect on worldwide air safety.

## **FINDINGS**

1. The Sector 5 controller initiated the handoff of N600XL to Sector 7 at an unusually early point, prior to a navigational fix at which a level change should have been assigned.
2. ATC did not issue a level change instruction to N600XL at or prior to crossing Brasilia.
3. The controllers at Sector 5 and Sector 7 were unaware of the status of N600XL's altitude clearance, and did not take positive action to provide an amended clearance, confirmation, or appropriate coordination.
4. The automatic change of the datablock field from "cleared altitude" to "requested altitude" without any indication to, or action by, the ATCOs, led to the misunderstanding by the Sector 7 controller about what altitude clearance was issued to N600XL.
5. The collision avoidance technology aboard the aircraft did not function, likely due to inadvertent inactivation of the transponder on N600XL.
6. The flight crew of N600XL did not notice the inactive status of the transponder.
7. ATC did not take appropriate action in response to the loss of N600XL's transponder.
8. The automatic display of an altitude value ("3D") which is invalid for ATC use reinforced the incorrect assumptions that N600XL was descending.
9. ATC continued to apply RVSM separation standards despite a lack of mode C transponder altitude information.
10. Neither ATC nor the flight crew recognized the significance of the long time period without two-way communication to N600XL.
11. The flight crew of N600XL did not recognize the significance of the long time period spent at a non-standard cruise altitude for the flight direction.
12. ATC did not take adequate action to timely correct a known lost communication situation with N600XL.
13. Incorrect frequency utilization and ATC sector configuration within the CINDACTA contributed to the breakdown in communication with N600XL and the accident sequence of events.

14. The Sector 07 controller did not inform Amazonic ACC of the lost communication and non-transponder status of N600XL.
15. DECEA did not provide adequate training and supervision to develop effective skills for the ATCOs to appropriately handle this situation.
16. The evidence does not fully support the conclusion that the crew of N600XL's flight planning, or amount of time spent planning, contributed directly to the accident.

### **PROBABLE CAUSE**

The evidence collected during this investigation strongly supports the conclusion that this accident was caused by N600XL and GLO1907 following ATC clearances which directed them to operate in opposite directions on the same airway at the same altitude resulting in a midair collision.

The loss of effective air traffic control was not the result of a single error, but of a combination of numerous individual and institutional ATC factors, which reflected systemic shortcomings in emphasis on positive air traffic control concepts.

Contributing to this accident was the undetected loss of functionality of the airborne collision avoidance system technology as a result of the inadvertent inactivation of the transponder on board N600XL.

Further contributing to the accident was inadequate communication between ATC and the N600XL flight crew.

**APPENDIX 2**  
(In accordance with ICAO Annex 13)





## National Transportation Safety Board

Washington, D.C. 20594

Office of Aviation Safety

### U.S. Detailed Comments on Draft Final Report of Aircraft Accident Involving PR-GTD and N600XL, 29 September 2006

#### ANALYSIS

##### Air Traffic Control Discussion

ICAO document 4444<sup>1</sup> defines the purpose of ATC services as “preventing collisions ... between aircraft, and ... expediting and maintaining an orderly flow of air traffic.” Similar definitions appear in U.S. documents as well. As both of the involved aircraft in this collision were operating under required positive control, and under all applicable directions, ATC services must be examined in detail to determine the factors that initially placed the aircraft into conflict and why ATC services did not resolve the conflict before the collision. Only the ATC system had knowledge of both airplanes and their respective intentions. ATC service is a complex subject that does not lend itself to one overall conclusion. ATC services can be broken down in a similar manner to overall accident investigations in general, such that operational, physical, and human factors can all be applied. In fact, the draft report does examine many of the subjects relevant to the ATC services provided. However, to clearly define the causal factors of this accident, each of the ATC issues described in the report should be fully analyzed, lead to specific findings of risk, and support the probable cause.

The ATC computer automatic insertion of the “cleared altitude” field in the displayed datablock was one of the first chronological events that led to the collision. Sections 4.6 and 4.6.1 of the analysis discuss this feature; however, the only conclusion drawn is on page 219, which states that the controllers “have always operated the system in this manner.” The discussion in the report notes that the controllers did not react correctly to the information presented on the displays. However, a design in which two distinctly different pieces of information (that is, requested altitude and cleared altitude) appear identical on the display is clearly a latent error. In the accident scenario, because the altitude change to FL360 was planned to occur over BSB, well within sector 5 airspace, it is likely, that the sector 7 ATCO believed that the sector 5 controller (or a previous controller) had already issued the clearance to FL360. The clearance could have been issued well in advance of the airplane passing BSB by specifying where an altitude change takes place, such as “maintain FL370 until BSB, descend to FL360,” as indicated in ICAO 4444 11.4.2.5.2.2b. In fact, this clearance would have been not only acceptable but also desirable.

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<sup>1</sup> According to CENIPA, the Brazilian ATC document ICA100-12 is substantively the same as ICAO document 4444.

Such an understandable assumption by the sector 7 ATCO would be reinforced by the automatic “cleared altitude” field change and by the 3D radar values that appeared to show a descent. It is clear that the sector 7 ATCO believed that N600XL had been cleared to FL360, and that is how he briefed the controller who relieved him, thereby perpetuating the incorrect assumption.

The automatic change to the “cleared altitude” field did not accurately reflect the status of N600XL’s clearance. There is no distinction between a “requested altitude” value that is serving as a reminder to the controller and a “cleared altitude” value that actually reflects the status of the aircraft’s clearance, as noted in section 4.6. If the automatic change is intended to serve as a reminder, the controller that should have issued the clearance is sector 5 because the change took place in his airspace. Alternatively, he should have either changed the data to accurately reflect the clearance or advised the sector 7 controller of the actual clearance.

This scenario explains why the use of the automatic “cleared altitude” field change has the potential to mislead controllers, is a poor human factors design, and is a clear finding of risk. In fact, this event was one of the first that is **directly** tied to the accident scenario. This feature has the undesirable effect of making the ATC automation “lead” the actual clearance issued to the flight crew. A basic tenet of ATC is to have a double check of clearances. The automatic change takes away a method for the ATCO to reinforce the proper clearance in his mind. If the controller makes the entry, the action of keying in the numbers helps to confirm that he has issued the correct altitude and that the pilot has read back the clearance correctly. Therefore, the automatic change of the datablock field from “cleared altitude” to “requested altitude” without any indication to, or action by, the ATCOs led to the misunderstanding by the sector 7 controller about what altitude clearance was issued to N600XL. **[Conclusion]**

We recommend modifying the software to make it clear to controllers whether this field of the datablock is displaying a requested altitude or a cleared altitude. At the least, a “reminder” feature should be distinguishable from a display that reflects the actual clearance status of the aircraft. This feature has been discussed in worldwide ATC publications, and the report must address the issue completely. A detailed assessment of this feature should be conducted, and, if the feature is not changed, the assessment should completely demonstrate why retaining the feature is desirable. Such an assessment must specifically show training and procedures that fit with the feature and support correct issuance of clearances in accordance with ICAO document 4444. **[Recommendation]**

Further aspects of the ATC automation reinforced the mistaken assumption by the sector 7 controller. The report clearly acknowledges that the 3D altitude feature (“Z” altitude) included in the CINDACTA systems is not to be used for civilian ATC separation. However, that altitude value is automatically displayed upon loss of mode C information and in this case helped to reinforce the assumption that N600XL was actually descending. Although potentially valuable for emergency or air defense purposes, there is no reason to routinely display height-finder information to civil controllers for normal ATC purposes. As the report indicates, the 3D altitudes displayed in association with N600XL coincidentally supported the assumption that the airplane was descending to FL360, although the altitude later became very erratic, as would be expected as the airplane flew farther from the relevant radar site. The report includes recommendations that loss of mode C information should be made more evident to controllers.

However, in the body of the report, it is correctly noted that the “Z” symbol appeared in the datablock as well as the loss of the circular target marker and that both indicated that mode C information had been lost. There is no reason to believe the controllers did not understand the datablock information; however, they either were not aware of it or did not attach the appropriate level of significance to it. This training and awareness issue will be discussed in the next section, but the fact that the 3D altitude values reinforced an incorrect assumption leads us to conclude that the automatic display of an altitude value that is invalid for ATC use contributed to the accident scenario. **[Conclusion]**

When the 3D data is being displayed, it should be unmistakably distinguishable from mode C altitude reports received from aircraft. Therefore, we believe that the 3D altitude should only be displayed to ATCOs upon request through a keyboard entry or other means of selection. **[Recommendation]**

As outlined in the report, the sector 7 ATCO had many opportunities to realize that N600XL was not in two-way communication. No transmissions were made to the flight crew until the airplane had flown beyond the coverage of the assigned radio frequency. Discounting the loss of transponder, the controller had no other reason to communicate with the flight crew; however, when he began making radio calls to the crew, he had many opportunities to correct the loss of communication. The flight crew would not have any knowledge of radio transceiver locations and coverage, but ATC does. The sector 7 controller never attempted to try a relay through other flight crews, emergency frequency, or any other means to treat the flight under lost communication procedures. ATC clearly had knowledge that the crew was not in communication well in advance of the crew, yet ATC did not take sufficient action. This known information was not passed to the Amazonic ACC controller. Correcting the lost communication situation was another opportunity to interrupt the accident sequence of events. Therefore, although ATC was aware that N600XL was not in radio communication, the controllers and supervisors did not take adequate action to correct a lost communication situation. **[Conclusion]** As an additional aspect of ATC communications procedures, the use and management of the radio frequencies and transceiver assignments should be considered an associated finding. As the report fully describes, the errors made within the CINDACTA by not correctly utilizing frequencies and configuring ATC sectors contributed to the breakdown in communication with N600XL and the accident sequence of events. **[Conclusion]**

As noted in the report and related to the above findings, ATC continued to apply a projected vertical separation standard of 1,000 feet between N600XL and GLO1907, although there was no transponder return or two-way communications from N600XL. ICAO document 7030 requires radar service with operable mode C transponder and two-way radio communication to apply RVSM (Spell out). It is clear that the sector 7 controllers were well aware that neither condition applied to N600XL, yet they took no action to increase vertical separation with GLO1907 to the standard 2,000 feet. The GLO1907 flight data were available to the controllers, and they could have simply advised the Amazonic ACC to amend GLO1907’s clearance to an appropriate altitude (or to apply lateral separation.) Although full standard separation might not have existed, the collision risk would have been eliminated. ATC continued to apply RVSM separation standards despite a lack of required conditions. **[Conclusion]**

All the information about the flight plan and intent of N600XL was available to the sector 5 ATCO. The flight plan requested a level change to FL360 to be applied over Brasilia, which was well inside the sector 5 airspace. Basic ATC concepts place the responsibility for appropriate clearance or coordination at this point with the sector 5 controller, who should have either issued a clearance to FL360 (either as the airplane passed Brasilia or as a crossing restriction) or coordinated the status of the airplane with the sector 7 ATCO. Because the controller did neither and initiated the handoff of N600XL at an exceptionally early point, the latent failure was set, which led to the sector 7 false assumption. The sector 7 controller shares in this contributing factor because he did not verify the assigned or actual altitude of N600XL. The controllers at sectors 5 and 7 were unaware of the status of N600XL's altitude clearance and did not take positive action to provide a clearance, confirmation, or appropriate coordination.

### **[Conclusion]**

Further aspects related to ATC and Operational Factors that may not be direct findings of risk require some discussion to clarify the events leading up to the accident. This section provides discussion and clarification of these items, which appear throughout the report.

At numerous points in the report, there is discussion and analysis of the initial ATC clearance issued by São José ground control and the pilot's understanding of portions of the clearance. Specifically, the terms "clearance limit" and "cleared as filed" appear to be misunderstood. "Clearance limit" is defined in ICAO document 4444 as "the point to which an aircraft is granted an air traffic control clearance" and in the FAA Pilot/Controller Glossary (P/CG, part of FAA Order 7110.65 and the Aeronautical Information Manual) as "the fix, point, or location to which an aircraft is cleared when issued an air traffic clearance." However, numerous times this phrase is associated with the altitude portions of a clearance.<sup>2</sup> The report correctly notes that the initial clearance issued to N600XL before departure from São José dos Campos did not follow the correct format for an initial clearance. However, we believe that the ground controller's statement "clearance to Eduardo Gomes," could not realistically be interpreted as anything other than the "clearance limit" item of the clearance. Furthermore, numerous statements in the report imply that issuance of a clearance limit, whether for the intended destination or an intermediate navigational fix, correlates with the assigned altitude. Section 4.5.7.1 of ICAO document 4444 describes the relevant application of a clearance limit, which in no way affects the assigned altitude of the airplane. The report cites section 11.4.2.5.1 of ICAO document 4444, which reads as follows:

Clearances shall contain the following in the order listed:

- a) aircraft identification;
- b) clearance limit;
- c) route of flight;
- d) level(s) of flight for the entire route or part thereof and changes of levels if required;

*Note.— If the clearance for the levels covers only part of the route, it is important for the air traffic control unit to specify a point to*

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<sup>2</sup> These instances include, but are not limited to, pages 39, 40, 54, 97, 197, 198, 201, 217, 250, 252, and 256.

*which the part of the clearance regarding levels applies whenever necessary to ensure compliance with 3.6.5.2.2 a) of Annex 2.*

e) any necessary instructions or information on other matters such as SSR transponder operation, approach or departure maneuvers, communications and the time of expiry of the clearance.

This section is quite clear that the note referring to en route level changes applies to the “altitude” (levels) portion of the clearance. A common application of this procedure would be the issuance of a crossing restriction, as in the example in ICAO 4444 11.4.2.5.2.2b. Therefore, we submit that, although the initial departure clearance was incomplete and in a nonstandard format, the issuance of a clearance limit did not contribute to any misunderstanding. It is possible that, if the initial departure clearance had been stated as discussed above, it may have served as a reminder to the flight crew; however, any intervening altitude assignment by the en route controllers would be in force unless amended.

Similarly, the phraseology “cleared as filed” is not always cited correctly in the report. The report states in numerous places, “no mention was made whether the flight plan had been ‘cleared as filed’”. This would certainly be fundamental to alert the pilots about where further level changes would occur.” This is not supported by any reference or published guidance.

It is clear from these definitions that the altitude portion of the ATC instructions are not related to clearance limits, but rather to crossing restrictions or other instructions. Therefore, the sections referencing these concepts should be rewritten to more accurately reflect the intentions of relevant directives. Although the description of the intended clearance format that should have been issued by Sao Jose Tower is technically in compliance with standard procedures, the training and operational procedures must be reviewed for correlation with ICAO standards in order to minimize the potential for misunderstanding.

## **Flight Operations Discussion**

### **Flight Planning**

Beginning on page 92 and recurring throughout the report are numerous passages and citations of events that are associated with the flight crew of N600XL not being aware of the elements of the flight plan, an unusually short time elapsing between the obtainment of the printed flight plan and the departure, or the crew having an unusually short period of time to prepare for the flight. These items appear to be partly in support of paragraph (e) on page 264 of the report, which indicates, “Planning – a contributor.” We do not agree that the analysis is sufficient to support any deficiency in the conduct of the flight, which can be related to planning. The crew flew the route precisely as cleared and complied with all ATC instructions. The crew’s awareness of their current altitude and its relation to the hemispheric convention applicable to the course of flight north of Brasilia is entirely independent of the requested level in the flight plan. Therefore, we do not fully concur with contributor (e) and the citations in the report leading to it.

### **Altitude Awareness**

Page 100 discusses the sequence of events regarding the assigned altitude when passing Brasilia. The report notes that no mention of an altitude change was made by either the flight crew or ATC. This point is extremely important and must be emphasized. All existing ATC and flight procedures support the conclusion that the crew was operating in compliance with ATC instructions. As noted in the ATC analysis discussion, there was no reason for any pilot to believe that the assigned altitude was anything except FL370 and would remain so without further instructions, an emergency situation, or application of prescribed lost communication procedures. ATC did not issue an amended clearance; therefore, the crew had no reason to change altitudes and could not unilaterally do so.

Both accident aircraft were operating in controlled airspace. 14 CFR 91.179 specifies that “(a) *In controlled airspace. Each person operating an aircraft under IFR in level cruising flight in controlled airspace shall maintain the altitude or flight level assigned that aircraft by ATC*”. Hemispherical altitudes such as those shown on the index of an IFR chart or in the Aeronautical Information Manual, although used as conventions by ATC, are only a requirement when operating in uncontrolled airspace. The implication that a crew should somehow observe hemispherical altitudes while being positively controlled by an ATC facility is incorrect. Informal use of the term “wrong way” by pilots and controllers is merely a shorthand way of acknowledging that an assigned or requested altitude is not the one normally used for that direction of flight. Pilots and controllers display good judgment when they use such means to alert one another of nonstandard flight conditions, but the term “wrong way” does not imply a violation of regulations or faulty planning or operation. Conversely, when pilots and controllers allow an airplane to operate for long periods of time at a nonstandard altitude without verifying the assigned altitude in some way, it casts doubt on their judgment. Although a review of the draft report and supporting documentation by the FAA’s Flight Standards Division concluded that there was no evidence of regulatory violations by the crewmembers, they did have a long-term opportunity to note a nonstandard situation and request clarification or confirmation from ATC. For about 1 hour the significance of the long time period spent at a nonstandard cruise altitude for the flight direction by N600XL was not recognized. **[Conclusion]**

### **Transponder Operation**

We agree with the observation that the footrest guard is designed to prevent unintended interactions with the buttons of the RMU1 and other flight deck controls and agree with the evaluation provided in the report that, if properly used by the flightcrew, the footrests in the Legacy should prevent such inadvertent inputs. However, in flight deck observations conducted by the NTSB and FAA, it was observed that pilots might misuse the footrests since, in certain forward seat positions, there appeared to be a very comfortable resting position that involved resting the feet on top of the footrest guards rather than inside the designated footrest areas. This position allowed the resting pilot to remain within easy reach of the primary flight controls but, unfortunately, located the captain’s right foot in the area of the RMU1 so it could make unintended contact without the captain’s awareness. It can not be determined exactly how the accident crew commanded the transponder to standby, but the possibility of an unexpected use of the footrest guard, along with other possibilities discussed in the report, serve as important reminders of human ergonomic considerations at preventing inadvertent contacts in actual flying situations. We believe that an additional safety message from this accident could be to

encourage industry to develop upgraded guidelines and regulations of flight deck best design practices to further minimize unintended contacts.

### **Communications**

Title 14 CFR 91.183 (IFR communications), which is presumed to be identical to the Brazilian regulation, states the following:

*Unless otherwise authorized by ATC, the pilot in command of each aircraft operated under IFR in controlled airspace must ensure that a continuous watch is maintained on the appropriate frequency and must report the following as soon as possible (a) The time and altitude of passing each designated reporting point, or the reporting points specified by ATC, except that while the aircraft is under radar control, only the passing of those reporting points specifically requested by ATC need be reported; (b) Any unforecast weather conditions encountered; and (c) Any other information relating to the safety of flight.*

Both 14 CFR 91.185 and ICAO Annex 2 3.6.5 specify procedures to be followed in the event of lost communication but do not specify criteria for determining when this condition is met. Furthermore, the procedures for flight crews to follow in the event of lost communication differ substantially between the two documents. The Aeronautical Information Manual notes that the following:

*It is virtually impossible to provide regulations and procedures applicable to all possible situations associated with two-way radio communications failure. During two-way radio communications failure, when confronted by a situation not covered in the regulation, pilots are expected to exercise good judgment in whatever action they elect to take.*

The pilot-in-command of N600XL had a safety-of-flight duty to see that immediate communications capabilities with ATC were being maintained and to act promptly if they were not. Although the term “continuous watch” is not defined, its implication is that the crew’s communications with ATC were not intended to be a passive activity. Being under radar control exempted the pilot from making certain radio reports but did not exempt him from remaining aware and alert.

The challenge for the N600XL crew was that they continued to hear transmissions from ATC and other airplanes, which was misleading for them. There is no standard under radar control for how often a crew should verify that two-way communications remain established, but such verification should be often enough that the pilots have no doubt.

The report cites a failure by the crew and ATC to invoke lost communications procedures. These factual findings are also obvious conclusions; however, during the investigation, it became quite clear that the procedures for lost communication were not well known and that the applicability to actual in-flight situations was difficult. Without question, N600XL proceeded for an inordinately long time without two-way communication [**Conclusion**]. A review of U.S.

and ICAO regulations that apply to both ATC and flight crews, indicates that clarification and harmonization may be desirable. The U.S. team believes that it may be necessary for the appropriate regulatory authorities to conduct a review and will study the need for a safety recommendation.

### **Training for International Operations**

Pages 69 and 74 of the report state that the flight crewmembers were not experienced in the operation of the avionics in N600XL. Although the transponder outage was likely because of an inadvertent action, no evidence in the factual record indicates that a lack of familiarity with the avionics is related to the outage.

Further statements and conclusions about the training and experience of the flight crew are related to international operations. Page 74 states, “the level of proficiency of the PIC in the new aircraft model proved inadequate for an International Operation,” and page 198 states that the pilots’ experience was “not sufficient for an adequate adaptation of the pilots to the requirements of the flight.” However, there is no supporting evidence to indicate that any deficiencies in the operation, as specifically related to Brazilian or ICAO procedures, existed. The awareness issues mentioned, and the potential for distractions in the cockpit, are not unique to an international operation.

Nevertheless, during the course of this investigation, it became clear to the U.S. team that training for international operations may be insufficient for certain operations. Although all international training received by the flight crew met existing requirements, the U.S. team plans to study the possibility for a safety recommendation related to international training, especially as it relates to high performance business jet aircraft.

## **RECOMMENDATIONS**

### **Safety Recommendations Issued During the Investigation**

261/A/06, 263/A/06, 264/A/06, 101/A/07, 102/A/07

These recommendations should have references either in the recommendation text or in the body of report explaining or indicating the content of the procedures. Otherwise, there is no way to determine if the procedures are adequate.

266/A/06

There is no direct discussion of flight path offsets in the report or any discussion about the role that a lack of offset procedures played in the accident. Also, because the word “offset” is capitalized in the report, it would seem to need a definition somewhere.

70/A/07, 75/A/07



These recommendations should identify what aspects of crew resource management (CRM) training contributed to an identified safety deficiency. NTSB currently has an open recommendation regarding CRM training for on-demand Part 135 operators. The NTSB recommendation, A-03-52, asks the FAA to do the following:

*Require that 14 Code of Federal Regulations (CFR) Part 135 on-demand charter operators that conduct dual-pilot operations establish and implement a Federal Aviation Administration-approved crew resource management training program for their flight crews in accordance with 14 CFR Part 121, subparts N and O.*

This recommendation was issued as a result of the NTSB's investigation of the accident that killed a member of the U.S. Senate. We have also investigated several other on-demand Part 135 accidents in which issues of CRM were revealed during the investigation. These accidents were caused by crew errors, and it is possible that an effective CRM program might have interrupted the sequence of events that led to the accident. Part 121 and scheduled Part 135 operators are required to provide pilots with CRM training in which accidents are reviewed and skills and techniques for effective crew coordination, resource allocation, and error management are presented. CRM training augments technical training and enhances pilots' performance in the cockpit. The FAA has indicated that it agrees with this recommendation and that it would include it as part of comprehensive rewrite of Part 135 that is likely to take considerable time to complete. The NTSB believes that, because Part 121 programs already exist and have proven very effective, there is no need to delay the rewrite of Part 135. Although the accident flight was not conducted under Part 135, the circumstances of the accident may provide further support for the need to improve CRM training for Part 135 on-demand operators and thus further support the NTSB recommendation. With such background and justification, CENIPA could refer to NTSB Safety Recommendation A-03-52 in making an effective argument.

72/A/07

The intent of this recommendation is not clear. Does it refer to a "sterile cockpit" concept?

125/A/07

It is not clear what documentation should be updated and to what.

130/A/07 and 131/A/07

These recommendations for Gol Airlines would seem to be related to activities that occurred on PR-GTD, but there is no discussion in the report of any findings or crew actions that would have supported these recommendations.

**Suggested Additional Recommendations from U.S. Team:**

DECEA should do the following:

Ensure that ATC 3D data display is unmistakably distinguishable from mode C altitude values, preferably via a specific ATCO selection, such as keyboard entry.

Ensure that controllers have the ability to quickly distinguish whether a datablock is displaying a requested altitude or a cleared altitude, for example, by eliminating automatic fill or making the field distinguishable by color or blink.