AIRWORTHINESS GROUP CHAIRMAN'S FACTUAL REPORT OF INVESTIGATION

November 5, 2011

A. ACCIDENT ID: DCA11IA040

LOCATION: Louis Armstrong New Orleans International Airport (MSY), Louisiana

DATE/TIME: April 4, 2011, at about 0725 am (CDT/Local)

AIRCRAFT: Airbus Model A320-232, registration N409UA
Operating as United Airlines Flight 497

B. GROUP MEMBERS:

Group Chairman: Robert L. Swaim
National Transportation Safety Board (NTSB)
Washington, DC 20594

Member: Laurence Edwards
United Airlines (UAL)
Chicago, Illinois

Member: William Daschbach
United Airilines (UAL)
San Francisco, California

Member: Gerald Walker
Airbus
Chicago, Illinois

C. SUMMARY:

On April 4, 2011, at about 0725 central daylight time, an Airbus 320-232, registration # N409UA, serial number 462, operating as United Airlines flight 497, exited the left side of runway 19 at the Louis Armstrong New Orleans International Airport (MSY) after returning to the airport due to automated warnings of smoke in an equipment bay. The airplane's nose wheel exited the side of runway 19 upon completing the landing roll, and an emergency evacuation was conducted. The airplane, with 109 passengers and crew aboard, had departed MSY about 20 minutes prior. The passengers and crew exited the airplane via the emergency evacuation slides. There were no reported injuries, and the airplane sustained minor damage.

D. DETAILS OF THE INVESTIGATION:

The short flight had departed KMSY and was climbing when the crew reported that they had received automated warnings about the detection of smoke in the avionics system. The transponder, flight data recorder (FDR), and other electrical devices ceased to function. Following the flight, the ram air turbine (RAT), a device which may provide emergency electrical power, was found extended. The airplane turned back to land at the airport. The crew reported a loss of anti-skid control for the main wheel brakes and a loss of nose wheel steering.

On the runway, tire marks could be followed from the airplane toward where it touched down. The initial path was slightly skewed to the left from the runway center, until a sudden change in one of the skids. After that point, the direction of the airplane turned to the left and the nose of the airplane exited the runway north of the intersection with runway 28.

The nose landing gear was found submerged in soft soil and the assembly sustained minor damage. The airplane was recovered to the runway, the right tires were changed, and the airplane was then towed to a parking area for examination.

An Airworthiness Group was convened to examine the airplane at the New Orleans airport from April 4 through April 8, 2011. No evidence of fire or of overheated components were found. In addition to conducting an examination of the avionics smoke warning and about the loss of electrical power in flight, information was collected about the engines and thrust reversers, the brakes, and the internal communications.

The avionics smoke detector was functioned within normal limits for smoke when tested at the FAA Fire Research Laboratory. In a non-standard test, the ionic type of detector also generated a warning signal when exposed to high humidity.[1]

A meeting at the Airbus factory in Toulouse France was conducted on September 20-21, 2011 to discuss the airplane and event.

1 When the smoke detector is triggered from monitor mode, the component maintenance manual uses the term “warning” or “warning mode,” which are the terms generally used in this report. Airbus documents use the term “alarm.”

D.1 TABLE OF CONTENTS:

D.2 AIRPORT

The airplane came to rest with the nose landing gear submerged in soil and the main gear on pavement, east of the intersection of runways 10/28 and 1/19. Black rubber marks led to the main landing gear tires and light gray led to the nose tires. Apart from black rubber marks on the runway and displacement of the grass and soil, the airport was not physically damaged or altered by the landing. (See Figure 1)

Figure 1 Relative locations of points on runway 19. Red arrow denotes direction of landing.

To expedite opening the runway, a hand-held GPS device was used next to the runway to find the following approximate coordinates (degrees, minutes, seconds).[2]

1. N 29 59 54.5 W 090 14 49.2 Approximate touchdown
   201 feet between this location (Point #1) and the next (Point #2)

2. N 29 59 52.5 W 090 14 49.8 Initiation of braking marks
   596 feet between this location and the next

3. N 29 59 46.8 W 090 14 51.5 Failure of right outboard tire
   2075 feet between this location and the next

4. N 29 59 27.0 W 090 14 57.6 Indications of heavy braking begin along track of the left tire set (See Figure 2)

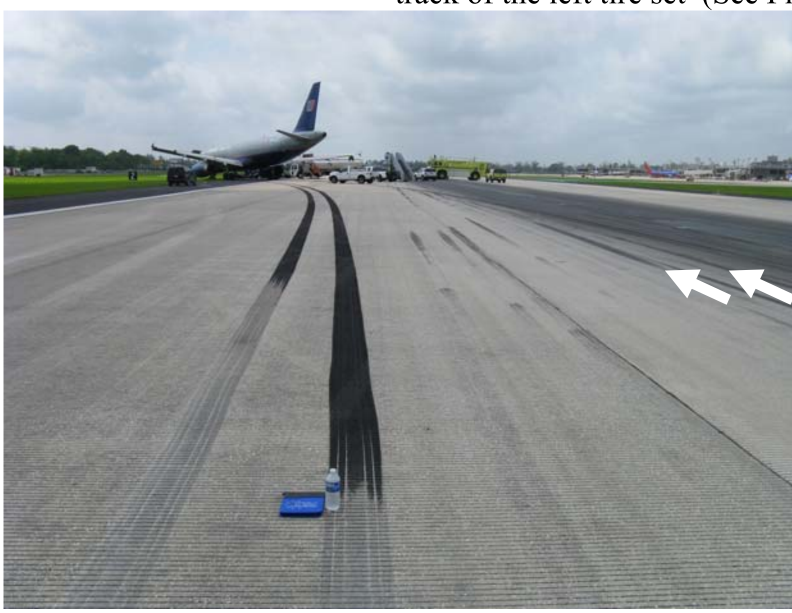


Figure 2. The water bottle is where the overhead photo in Figure 1 is labeled "Heavy Braking Begins – Left Turn." The white pickup truck is parked on the tire marks that lead to the right set of tires, also shown at the pair of white arrows.

   275 feet between this location and the next

5. N 29 59 24.3 W 090 14 58.1 Right inboard tire marking change Consistent with loss of pressure
   164 feet between this location and the next

6. N 29 59 22.7 W 090 14 57.8 Resting position of nose wheel.

TOTAL DISTANCE 3,311 feet

2 The distances between the coordinates were calculated with the Federal Communications Commision calculator that is available at http://transition.fcc.gov/fcc-bin/distance.

D.3 AIRPLANE

D.3.1 STRUCTURE

No physical damage was observed to the structures of the fuselage, wings, flight controls, flaps, or fairings and no physical evidence of fire was found. The nose landing gear had been buried before the nose of the airplane was recovered to the runway. (See Figures 3 and 4) During replacement of an electrical conduit and the nose wheels, no visible damage was found to the structure surrounding the nose landing gear.

Figure 3. Nose tire below ground level.

Figure 4. Close up of buried nose landing gear.

Once in a parking area, the group did not have the jacks and other equipment necessary to accomplish the visual inspection requirements specified by the Airplane Maintenance Manual overweight landing or for an off runway excursion. United Airlines subsequently performed these inspections and found no anomalies. United Airlines performed additional inspections in the area of the nose landing gear and found no structural damage.

D.3.2 COCKPIT

On the Captain's desk was an approach chart for the MSY airport. On the First Officer's desk was a laminated checklist that included A320 EMERGENCY steps. (See Figure 5) The laminated checklist pocket was empty on the First Officer's side of the pedestal and the Captain's laminated checklist was still in the stowage pocket. An airplane flight manual (AFM) was found on the floor behind the pedestal, to the right of center.

Figure 5. Cockpit, as found. The two vertically oriented Engine Centralized Aircraft Monitoring (ECAM) displays are in the center.

All cockpit oxygen masks were found stowed.

Both engine fire handles were found in the pulled state. When electrical power was restored, none of the fire bottles were found to have discharged.

On the electrical overhead panel, the following switch positions were observed after the airplane had been recovered to the examination area. In a conversation with a mechanic who had been involved with the move, he related that the switch positions that he needed to change were those required by checklist to tow the airplane from the runway. He then restored the switches to the positions that he originally found them in. (See Figures 6A and 6B)

Figure 6A. Cockpit overhead panel.

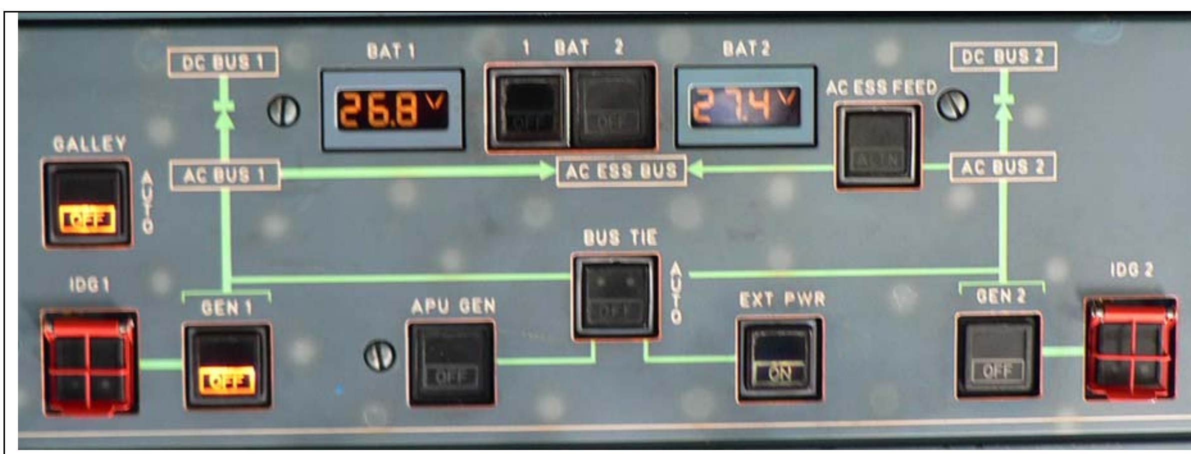


Figure 6B. Close up view of the electrical panel. The GEN 1 and GEN 2 puch button switches control the transformer rectifiers (TR1 and TR2).

Nomenclature note: The terms “in” and “out” describe the as-found states of push button switch mechanisms, with respect to being latched in the depressed position or found with the mechanism extended.

BATT 1 at 25.6, BATT 2 at 25.1 [volts]
BATTERY 1 and 2 switches were found out.
GALLEY switch was found in
AC ESS FEED switch was found in
GEN 1 switch was found in
APU GEN switch was found in
BUS TIE switch was found in
EXT PWR switch was found out
GEN 2 switch was found out

The switch marked ANN LT was in the DIM position.

The ELEC EMER PWR panel was found with:
RCDR GND CTL was found out
GEN 1 LINE switch out. When powered, the legend showed OFF.
After lifting the cover of the EMER ELEC PWR switch labeled MAN ON, the switch was found out (See Figure 7)

Figure 7. The edge of the MAN ON switch is visibly against the red cover, not in the depressed state. This is the EMER ELEC PWR control panel and the adjacent RAT & EMER GEN visible is not a switch, it is a fault light.

The GEN2 OFF light passed the bulb test, but did not appear to illuminate the OFF legend when the button was pressed. It was later noted that the switchlight was of the LCD type illumination and it was significantly less conspicuous than the bright amber bulb illumination in the other panel lighting.

The thrust reverser piggyback levers were in the stowed positions, the flap handle was down, and the speedbrake lever was in the extended position.

Interrogation of the flight management guidance computer (FMGC) memory revealed four items that had been recorded at about the time of the incident, consistent with transients in the electrical supply.[3] The A320 Technical Training Manual shows that the FMGC has the capability of disengaging the autothrottle. Disconnection of the autothrottle is also described as potentially triggered by human actions, lack of generator power (failure/switching/etc), computer failures, electronic engine control feedbacks, and other human and automated inputs.

The panel over the cockpit door was missing two screws and the panel interfered with closing the cockpit door. The screws were not found on the cockpit floor and the metal around the remaining screws showed signed of fretting. (See Figure 7)

Figure 7. Panel over the cockpit door was missing screws, allowing the panel to descend

[3] The items were maintenance level and the pilots would not have been aware. For example: NO FDIU DATA. Detail about each of the recorded items may be found in Attachment 1.

and interfere with closure of the door.

D.3.1 COCKPIT DOCUMENTS FOUND

The Standard Airworthiness Certificate showed:

Registration:	N409UA
Manufacturer and model:	Airbus Industrie A320 Model 232
Aircraft serial number:	462
Category:	Transport
Date of Issuance:	March 21, 1994

An aircraft printout that is titled "Maintenance Post Flight Report" (PFR) showed the following items for the previous day (April 4):

> The PFR for each previous flight recorded faults for Fire Detection Unit #1. The message is Class 3, meaning that it is a maintenance level message and not displayed to flight crews. The message for the accident flight was recorded at time 12h09 UTC.
>
> For time 12h10 UTC, the PFR showed an [Engine Centralized Aircraft Monitoring] ECAM message AUTO FLT A/THR OFF in flight phase 6. The message did not show how or why the autothrottle was deactivated.

Attachment 1 contains photographs of the numerous other documents found in the cockpit.

D.3.3 ELECTRIC SYSTEM

D.3.3.1 DESCRIPTION

The function of the A320 primary flight controls requires electricity.[4] To supply the electrical system, the A320 has two engine-driven AC generators, an AC generator mounted on the auxiliary power unit (APU[5]), and a fourth emergency constant speed magnet generator (CSMG) that may be hydraulically driven after deployment of a ram air turbine.

Transformer rectifier devices (TR1, TR2, and ESS TR) are installed for conversion of alternating current into direct current. The TRs have internal monitoring that may open (trip) the device upon internal detection of an overheat or low output current.

---

4 The pitch trim is a cable-driven mechanical system.
5 The APU may be started when beneath 25,000 feet altitude and may operate to the maximum altitude of the airplane.

The airplane is equipped with a pair of batteries that may power essential components for flight when no alternating current is available. (See Figures 8A and 8B)

Airbus provided extensive descriptions about the electrical system in presentations about the A320 systems, including configurations that may occur during specific switching and/or failure conditions. The presentations are included in Attachment 4.

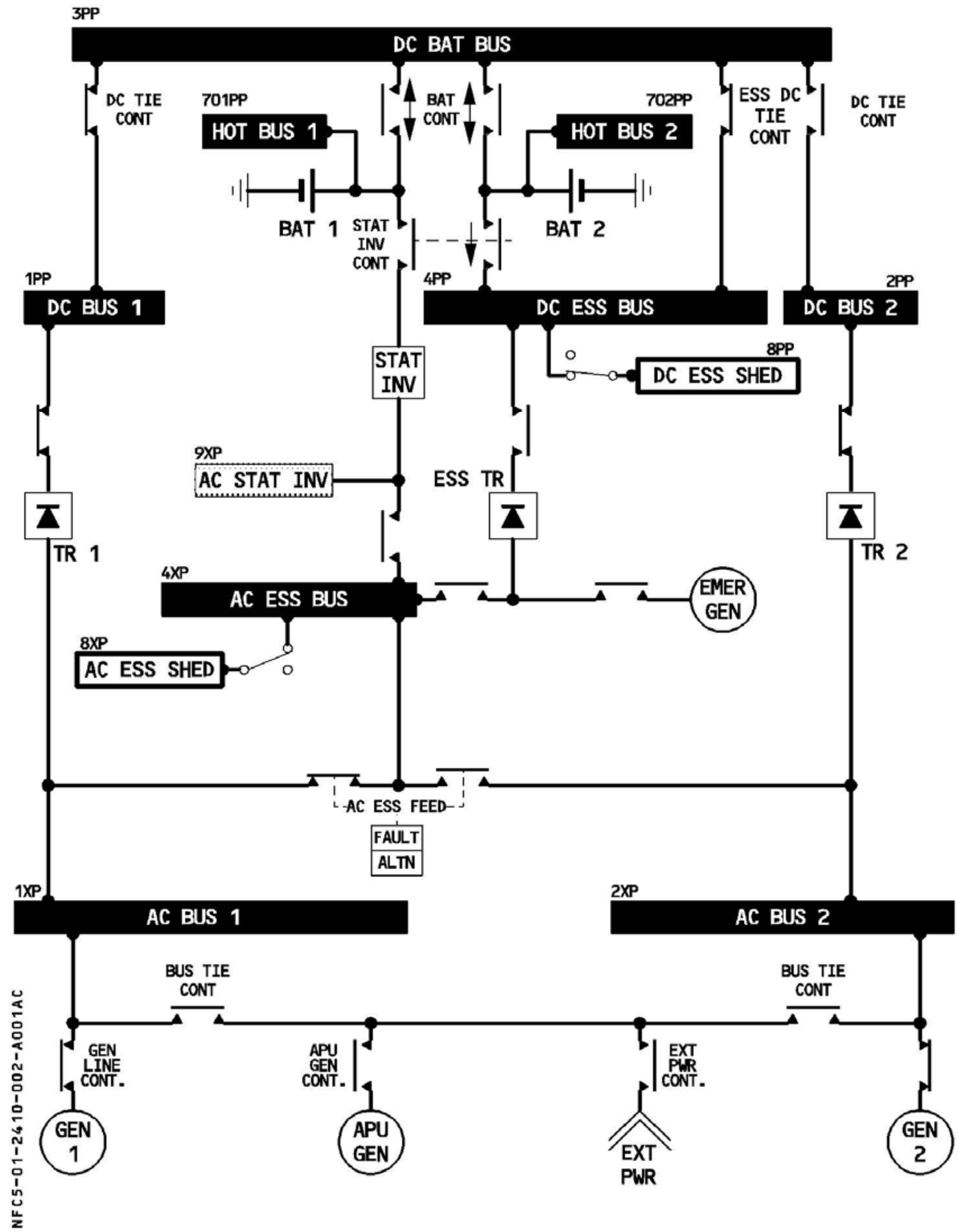


Fig 8A. Simplified electrical system architecture, as shown in the Flight Crew Operating Manual.

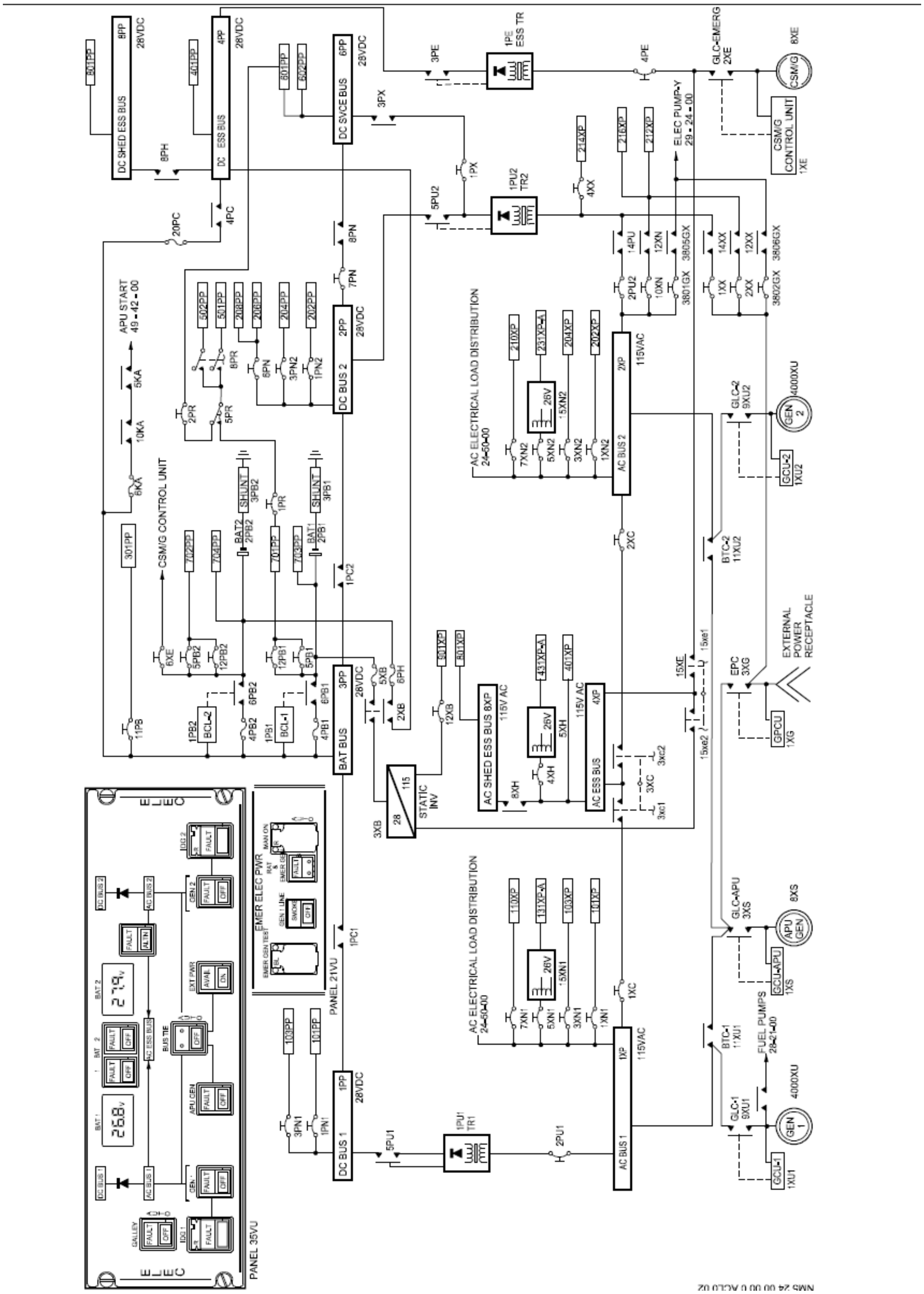


Figure 8B. General electrical schematic shown in Aircraft Maintenance Manual lists individual busses.

D.3.3.2 CERTIFICATION

As described in Attachment 2, the airplane was type certificated in France to Joint Aviation Regulation (JAR) Part 25, Change 11. The Federal Aviation Administration issued Type Certificate A28NM for the A320 in the United States. The FAA issued a list of Special Conditions for certification, effective on December 15, 1988, and published as No. 25-ANM-23: Airbus Industrie Model A320 Series Airplane.

The following is how the Special Conditions described the unique relationship between the electrical system and the flight controls:

> The model A320 utilizes fly-by-wire (FBW) flight controls for the elevators, ailerons, spoilers, tailplane trim, slats and flaps, speed brakes, trim in yaw, and engine control. The aerodynamic surfaces are positioned relative to the pilot's command by electronic signals sent via airplane wiring from the flight control computers to hydraulic actuators. Conventional mechanical control is provided for the rudder and tailplane trim hydraulic actuators. Should a short-term interrupt occur in the electronic flight controls, flight could be maintained for a period of time through the use of mechanical control of rudder and airplane trim.
>
> Normal electrical power is supplied by a constant frequency generator on each engine. An auxiliary power unit (APU) driven electrical generator is also available. A continuous source of electrical power is required by the A320 fly-by-wire flight controls. In the event of the loss of normal electrical power, a ram air turbine (RAT) is automatically deployed. The RAT provides hydraulic power which is used by a constant frequency generator to supply electrical power. Until the RAT powered generator comes on line (approximately 7 seconds), the flight control system is powered from the airplane's batteries. RAT deployment may also be selected manually by pushing switches either on the electrical or the hydraulic overhead panel. Hydraulic power to the flight control system is simultaneously provided by three independent hydraulic systems. Functions are shared among these systems in order to ensure airplane control in the event of loss of one or two systems. Two of the systems are pressurized by variable displacement pumps driven by the engine accessory gearbox, and the third system is powered by an electrically driven pump or by the RAT hydraulic pump in case of loss of normal electrical power.
>
> …After 30 minutes of operation in lMC, the airplane must be demonstrated to be capable of continuous safe flight and landing in VMC conditions. …

In describing the need for a Special Condition about the A320, the FAA wrote that the Special Condition was in lieu of compliance with § 25.1351(d) of the FAR, "*Operation* *without normal electrical power*." The FAA continued, by stating that electrical power is required for use of the A320 flight controls and that the applicable regulations did

> …not contain adequate or appropriate safety standards because of a novel or unusual design feature, special conditions are prescribed under the provisions of § 21.16 of the FAR in order to establish a level of safety equivalent to that established in the regulations.

Electrical systems in transport aircraft typically must meet Federal Aviation Regulation 14 CFR Part 25.1351. At the time of A320 certification, the regulation effective September 1, 1977, per Amdt. 25-41, stated:

> (a) *Electrical system capacity.* The required generating capacity, and number and kinds of power sources must--
> (1) Be determined by an electrical load analysis; and
> (2) Meet the requirements of Sec. 25.1309.
> (b) *Generating system.* The generating system includes electrical power sources, main power busses, transmission cables, and associated control, regulation, and protective devices. It must be designed so that--
> (1) Power sources function properly when independent and when connected in combination;
> (2) No failure or malfunction of any power source can create a hazard or impair the ability of remaining sources to supply essential loads;
> (3) The system voltage and frequency (as applicable) at the terminals of all essential load equipment can be maintained within the limits for which the equipment is designed, during any probable operating condition; and
> (4) System transients due to switching, fault clearing, or other causes do not make essential loads inoperative, and do not cause a smoke or fire hazard.
> (5) There are means accessible, in flight, to appropriate crewmembers for the individual and collective disconnection of the electrical power sources from the system.
> (6) There are means to indicate to appropriate crewmembers the generating system quantities essential for the safe operation of the system, such as the voltage and current supplied by each generator.
> **[**(c) *External power.* If provisions are made for connecting external power to the airplane, and that external power can be electrically connected to equipment other than that used for engine starting, means must be provided to ensure that no external power supply having a reverse polarity, or a reverse phase sequence, can supply power to the airplane's electrical system.
> (d) *Operation without normal electrical power.* It must be shown by analysis, tests, or both, that the airplane can be operated safely in VFR conditions, for a period of not less than five minutes, with the normal electrical power (electrical power sources excluding the battery) inoperative, with critical type fuel (from the standpoint of flameout and restart capability), and with the airplane initially at the maximum certificated altitude. Parts of the electrical system may remain on if--

(1) A single malfunction, including a wire bundle or junction box fire, cannot result in loss of the part turned off and the part turned on;
(2) The parts turned on are electrically and mechanically isolated from the parts turned off; and
(3) The electrical wire assembly insulation, and other materials of the parts used on are self-extinguishing when used in accordance with Sec. 25.1359(d).**]**

D.3.3.3 ELECTRIC AND ELECTRONIC FINDINGS

Following takeoff, the crew reported that the ECAM presented an AVIONICS SMOKE message and checklist.

Airbus schematics show that the warning also triggers a discrete SMOKE light in the GEN 1 LINE push button, located to the left of the electrical control panel in the cockpit ceiling. Two other push buttons for avionics compartment ventilation illuminate with legends that state FAULT.

Recorded information and pilot statements indicate that after they began to respond to the smoke warning, electrically powered items in the airplane ceased to function. These items included the air traffic radar transponder, the flight data recorder, one thrust reverser, the antiskid braking, and the public address system. The RAT is normally retracted unless the airplane is in an emergency electrical or hydraulic configuration, and following the flight the RAT was found extended. The investigation examined potential human and automated causes of interruption to the supply of electrical power.

The circuit breakers were checked in the cockpit, forward galley, and in the electrical equipment compartments. Following the inspections and discussions with the mechanics, it was determined that the only open circuit breakers were those that the mechanics opened after the flight, to preserve flight recordings.

Electricity from the engine driven generators passes through transformer rectifiers (TR1 and TR2) to power direct current devices and the TRs can not reset automatically after tripping/opening for an electrical fault or internal overheat. The left (TR1) and right (TR2) transformer rectifier units were found closed (not tripped) and functioned normally when the engines were started for the first time after landing.

A test was conducted with the engines running and the bus tie switch open. Pushbutton latching switches are located in the overhead panel and are pressed to control the configuration of the electrical system. In this test, sequentially pressing each switch to open the related generator resulted in blanking the electronic displays for the associated pilot's side of the cockpit.

When power from a main engine-driven generator is not available, the bus tie switch can be pressed/closed to access power from the generator that is mounted on the opposite engine. During the ground testing with the engines running, the electrical panel control switches were inadvertently not pressed in the planned sequence. Instead of first closing the bus tie switch when the control switch was open for generator #2, the generator #1 switch was also inadvertently opened. All six of the glass cockpit displays went blank.

During discussions about what happens when the engine driven generators go off line, Airbus engineering personnel related that the transition to battery power intentionally has a slight delay, estimated to be about a second. This allows the system to respond to an actual loss of generator power and not to transient fluctuations.

The generator switches were pressed to restore AC electrical power from the engines. Instead of restoration of AC power to the system, both TR1 and TR2 remained off line and could not be reset by switching actions in the overhead panel. Powering of the left DC Battery Bus could only be accomplished by resetting power on the airplane. To reset TR1 and TR2 required manual actuation of switches that were physically located in the electronics compartment, which is only accessible from the outside of the airplane. Note: TR1 was part number Y005-2, serial number 1717.

Other than for loss of current or internal overheating, each of the TRs are designed to automatically reset to match the commanded cockpit control switch positions. On the next test, TR2 was opened by pressing the generator control switch in the cockpit. The TR did open but then could not be reset by switching actions in the overhead panel. Subsequent evaluation revealed this was sensed as a fault for loss of current, so was a normal system operation when the bus tie is isolated and the applicable AC bus is depowered.

Loss or low TR input voltage will cause a trip condition that may only be reset while on the ground with the physical switches in the electronics compartment, or with the CFDS. Reset was accomplished through a series of selections on a cockpit display (CFDS), which is a maintenance function that is only enabled on the ground. Note: TR2 was part number Y005-3, serial number 5184.

United Airlines personnel removed the transformer rectifiers in New Orleans at the end of testing, along with a third "Essential Power" TR (p/n Y005-2, s/n 1698). Subsequent examination revealed no visual damage. During bench tests, two units were found to be out of adjustment limits and adjusted to within limits. (Ref: RC 40-24-31-01-JD, Dated 11/04/94) No faults were found during retesting, including at maximum permissible temperatures.

An aircraft electrical schematic showed that the indicating and recording systems were powered by the 28 VDC Bus 2 and by 115 VAC Bus 2. The schematic indicates that the 115 VAC Bus 2 is not powered when TR2 is switched to off and the cross tie is open. (Ref: ASM-31-36-00 SCH 01 P 101 Fig 1 INDICATING/RECORDING)

A United Airlines process of fleet modification had not yet reached this airplane to implement a service bulletin that modifies the circuit to the ESS electrical switch. (Ref: 24-11-00 and airworthiness directive AD 2010-10-08) The switch provides pilots with a single switch to shed non-essential loads or to manually cross power the ESS bus on airplanes without the modification. United is currently in the process of modifying the remainder of the A320 fleet to comply with the AD and service bulletin.

D.3.3.3.1 EMERGENCY ELECTRIC POWER SYSTEM

The Special Conditions state the following about the A320 and electrical power:

> (a) *Operation Without Normal Electrical Power.* In lieu of compliance with § 25.1351(d) of the FAR, it must be demonstrated by test or combination of test and analysis that the airplane can continue safe flight and landing with inoperative normal engine generated electrical power (electrical power sources excluding the battery and any other standby electrical sources), The airplane operation should be considered at the critical phase of flight and include the ability to restart the engines.
>
> *Discussion:* This special condition requires that the emergency electrical power system be designed to supply: (1) Electrical power required for immediate safety, which must continue to operate without the need for crew action following the loss of the normal electrical power system: (2) electrical power required to continued safe flight and landing: and (3) electrical power required to restart the engines. For compliance purposes, a test demonstration of the loss of normal engine generated power is to be established such that:
>
> 1. The failure condition should be assumed to occur during night instrument meteorological conditions (IMC) at the most critical phase of flight relative to the electrical power system design and distribution of equipment loads on the system.
>
> 2. After the unrestorable loss of the source of normal electrical power, it must be possible to restart the engines and continue operations in IMC until visual meteorological conditions (VMC) can be reached. (A reasonable assumption can be made that turbojet transport airplanes are able to enter into VMC conditions 30 minutes after experiencing the failure.)
>
> 3. After 30 minutes of operation in IMC, the airplane must be demonstrated to be capable of continuous safe flight and landing in VMC conditions. The length of time in VMC conditions must be computed based on the maximum flight duration capability for which the airplane is being certified. Consideration for speed reductions resulting from the associated failure must be made.

The Aircraft Maintenance Manual (AMM, Section 24-24-00) provides the following descriptions:

> The AC emergency generation enables part of the distribution network to be recovered in case of:
> - loss of the two main generation sources and,
> - unavailability of the auxiliary generation.
>
> The emergency generation system is mainly composed of:
> A hydraulic motor drives the emergency generator.
> A servo valve speed regulator controls the speed: it transforms the oil flow of the Blue hydraulic system into constant speed for the generator.

When emergency conditions are met, this Blue system is supplied by a Ram Air Turbine (RAT).

The Emergency Electrical (EMER ELEC) configuration involves both the direct current (DC) and alternating current (AC) systems.[6] The EMER ELEC configuration may be initiated when no AC power is supplied by the two engines or the APU through the two TR units. Without those AC sources in flight, DC power is provided by a set of airplane batteries. The FAA Special Conditions state that "Batteries are time-limited emergency power sources."

The loss of engine and APU power in flight results in deployment of the RAT; a propeller-driven hydraulic pump.[7] The RAT hydraulically powers an AC constant speed magnet generator (CSMG) to restore portions of the AC power system after about 7 seconds.

The investigation documented how the RAT and the batteries would power various electrical busses and found that:

When operating with the RAT extended into the airstream, the following busses are powered:	When operating with the batteries as the only source of electrical power, the following busses are powered. Battery 1 powers the AC busses and battery 2 powers the DC busses, until less than 100 knots, when the batteries are connected together.
AC ESS-4XP (de-powered at less than 50 kts)	AC ESS-4XP (de-powered at less than 50 kts)
AC SHED ESS – 8XP	
	AC STAT INV – 901XP
DC ESS – 4PP	DC ESS – 4PP
DC SHED ESS – 8PP	
HOT BUS 1 – 701PP Powered by battery only	HOT BUS 1 (DC) – 701PP
HOT BUS 1 – 702PP Powered by battery only	HOT BUS 1 (DC) – 702PP

An Airbus presentation (See Attachment 4 for detail) lists specific electrical items that are active or inactive when power is provided by the RAT or the batteries. The electrical schematics indicate that the sequence of which generator was first to be lost would not

6 Various places in aircraft documentation describe the configuration either EMER ELEC or ELEC EMERG.
7 Automated RAT deployment requires loss of power through both TR units, the airplane to be off of the ground, and more than 100 knots airspeed.

change the list. On battery power, only one thrust reverser would operate in 4 of the approximately 150 United A320 airplanes, as discussed in a later section.

Airbus personnel noted that if electrical power is not sensed on AC busses 1 and 2 for about one second (sensed at the TR units and delayed to filter out transients) then the RAT will automatically deploy. Power to create a display on the ECAM may be interrupted for a period of seconds, as the system power source passes from the engine-driven generators, to the batteries, to the RAT CSMG. (See Figure 9)

Figure 9. Ram Air Turbine, as found extended beneath the airplane after flight.

D.3.3.3.2 RAM AIR TURBINE (RAT) AND CSMG GENERATOR

The CSMG is driven by hydraulic pressure that is generated when the ram air turbine (RAT) is extended into the airstream, turning a wind-driven hydraulic pump (blue system). Extension of the nose landing gear disables the CSMG generator.

The incident airplane was equipped with a RAT that had been supplied by Dowty Aerospace. Airbus personnel related that turbulence from the nose landing gear could disrupt airflow to this version of the RAT at less than 140 knots airspeed. Newer A320 airplanes incorporate a RAT that is made by Hamilton Sundstrand that is usable at airspeeds of greater than 100 knots. The mounting structure and fairings for the two versions of RAT are substantially different and the RATs are not interchangeable.

The ram air turbine (RAT) was found extended and the AMM (24-24-00) shows that the blue hydraulic system drives a 5KVA constant speed magnetic generator (CSMG). The AMM provides the following descriptions about extension:

- the automatic electrical logic: this energizes solenoid No. 1 when there is loss of voltage at busbars 1XP and 2XP and speed V > 100 kts,

- the manual electrical logic: this energizes solenoid No. 2 directly, via OVRD ELEC pushbutton switch,

- the manual hydraulic logic: this energizes solenoid No. 1 directly, via OVRD HYD pushbutton switch.

The RAT and CSM/G are:

- automatically controlled by AC BUS 1 and AC BUS 2 loss and V > 100 kts,
- or manually by means of the ELEC EMER PWR/MAN ON guarded pushbutton switch on the ELEC EMER PWR section of the overhead panel 21VU.

- the RAT is automatically extended,

- the emergency generator is automatically coupled to the AC ESS and the DC ESS busbars,

- the red FAULT legend comes on on RAT & EMER GEN annunciator until the emergency generator is available.

In all cases, the pilot has to press ELEC EMER PWR/MAN ON pushbutton switch in order to confirm the automatic logic. Red FAULT legend disappears if coupling is obtained.

Lowering the nose landing gear disconnects power from the CSMG. It is possible to re-establish power in flight with a procedure in the Flight Crew Operating Manual procedure (3.02.04, page 19), titled ELEC ESS BUSSES ON BATT. The procedure calls for pulling the Landing gear Control Interface Unit circuit breaker (LGCIU 1, C09) to create a landing gear up logic condition, then pressing the MAN ON button for ELEC EMER PWR. If the crew elects to perform a go-around and extends a flight, or lowers the landing gear for other reasons (example: landing gear compartment overheat), this procedure is not cited by the ECAM. The ELEC EMER CONFIG checklist specific for avionics smoke does call for reconnecting both engine driven generators prior to landing gear extension.

D.3.3.3.2 BATTERIES

Without the engines or APU supply of electrical power through the transformer rectifiers, and without power from the RAT, the two main aircraft batteries would be the sole source of power for the flight controls and other requirements. The batteries would not be recharged in this configuration.

The two main batteries for the airplane are each a 28VDC nickel cadmium unit that is rated at 23amp-hours and mounted beneath the cockpit in an avionics compartment. Equipment in the airplane is required to operate with as little as 18 volts and the contactors are designed to remain closed until there is less than about 10-15 volts. The maintenance program includes a heavy current draw test that demonstrates the ability of the 20 cell set to provide sufficient capacity to the level of 20-21 volts.

In-flight, the batteries are the only source of electrical power when the generators, including the RAT-driven CSMG, are not available. This includes flight with the nose landing gear extended and in during the approximately 8 seconds required from initiating extension of the RAT until the CSMG is on-line.

Airbus personnel stated that the batteries are guaranteed to be able to provide at least 30 minutes of power to the systems required for landing. This period of time is discussed in the Special Conditions. Airbus personnel further related that the 30 minutes is established with batteries that are at 80% capacity to represent actual conditions in service, and that the battery maintenance program is designed to assure that the 30 minutes remains valid.

The essential systems that utilize battery power consume about one KVA per AC and DC set of busses. Therefore, the 46 amp-hours (23 AH times two batteries) could theoretically provide up to 46 minutes of essential systems. (36.8 minutes with the 80% de-rating)

D.3.4 SMOKE DETECTION AND VENTILATION OF COCKPIT AND AVIONIC COMPARTMENTS

No specific regulations directly cite smoke detection requirements for avionics compartments that the crew may not reach, but which have air communication with the cockpit. The two types of smoke detectors certified for A320 avionics compartment installations are manufactured to Technical Standard Order (TSO) C1b (subsequently C1d), which is titled "Cargo Compartment Fire Detection Systems." The TSO was established to meet 14 CFR Part 25.858, titled "Cargo or baggage compartment smoke or fire detection systems."

The avionics smoke detector was in a duct leading overboard, leading to examination about how the crew could perceive the existence of smoke when the detector activates a warning. When in the warning mode, the Electronic Centralized Aircraft Monitor (ECAM) contains an Avionics Smoke checklist that starts with the words "If perceptible smoke." A subsequent line in the checklist describes how to proceed if the smoke is "confirmed." The checklist does not provide definitions about how these words are to be determined or whether the smoke detector itself can be the confirmation.

The ECAM checklist did not have a procedure to clear ECAM messages and watch for a refreshed message, temporarily resetting the smoke detector, or other potential methods of "confirming" an ECAM Avionics Smoke message. No other references were found that described how the crew should perceive or confirm the presence of smoke.

Airbus personnel related that the primary method of smoke detection is visual and smell on the part of the flight crew and that the avionics smoke detector is secondary. Flight test results from November 18, 1987 showed that smoke intentionally created at four locations in the avionics compartment was detected by the pilots. Airbus personnel related that pilots have reported smells from smoking avionics.

Although the smoke detector was reported not to be the primary method of smoke detection, the smoke detector going into warning mode results in:

1. An audible warning chime.

   The chime sounds once when the detector goes into warning, whether the cockpit is attended or not. For example, if the detector went into warning prior to flight, the crew would not hear a second chime after starting the engines.

2. Illumination of discrete amber captions in pushbuttons.

   The pushbuttons remain illuminated for as long as the detector is in warning mode.

3. Display of an ECAM checklist and the message LAND ASAP in amber.

   If the detector clears within five minutes, the ECAM message disappears. If longer than five minutes, the ECAM is latched for the remainder of the flight.

   If the ECAM control panel button labeled CLEAR is pressed and the detector is still in warning mode, the ECAM checklist will be cleared from display. If cleared beyond five minutes, the message will be recorded and may be recalled later. The recorded message may be recalled by pressing the RECALL (RCL) button.

   The crew following the checklist will change the configuration of the avionics compartment ventilation.

   Airbus documents showed that the ventilation system had configurations for normal and abnormal operations. As summarized in the Flight Crew Operating Manual:

> The avionics ventilation system is fully automatic. It cools the electrical and electronic components in the avionics compartment and on the flight deck, including the instrument and circuit breaker panels. It uses two electric fans to force the circulation of cooling air.
>
> Whatever the configuration of the avionics ventilation system is, a part of the avionics ventilation is sucked from the cockpit through the different cockpit panels.

At New Orleans, the avionics inlet and outlet valve positions matched the SMOKE configuration. The two skin valves marked AVIONICS EQPT VENT AIR INLET VALVE were each found closed. The two skin valves marked AVIONICS EQPT VENT AIR OUTLET VALVE were each found in the open positions, prior to recovery of the airplane.

Notes:

1. The schematics label these valves as SKIN AIR EXTRACT VALVE
2. The positions were determined visually, without time to measure before recovery to open the runway. The positions could have been partial and not completely open.

The positions of the four valves matched the Flight Crew Operating Manual (FCOM) and maintenance schematics that showed the configuration labeled NORMAL OPERATION, INTERMEDIATE CONFIGURATION or the configuration labeled SMOKE. The inlet valves are shown only open when the system is in the normal ground operating mode and not in either of these configurations. With the inlet valves shut, the extract valves are shown in the partial two positions only when the system is either in the SMOKE mode (with inlet valves shut), or in the NORMAL OPERATION, INTERMEDIATE CONFIGURATION.

The logic conditions were not met for the NORMAL OPERATION, INTERMEDIATE CONFIGURATION at the time that power was removed from the airplane. The logic for the configuration would require the airplane to be in flight, or on the ground with the throttles at takeoff settings.

The FCOM summarized the SMOKE configuration as follows: (Figure 10 provides a schematic view)

> When the smoke detector detects smoke in the avionics ventilation air the BLOWER and the EXTRACT FAULT lights come on.

When both the BLOWER and EXTRACT pushbuttons are set to the OVRD position, the air conditioning system supplies cooling air, which is then exhausted overboard. The blower fan stops.

Controller Failure

The system goes to the same configuration as above, except that the skin exchange isolation valve stays open. [a valve within the avionics compartment]

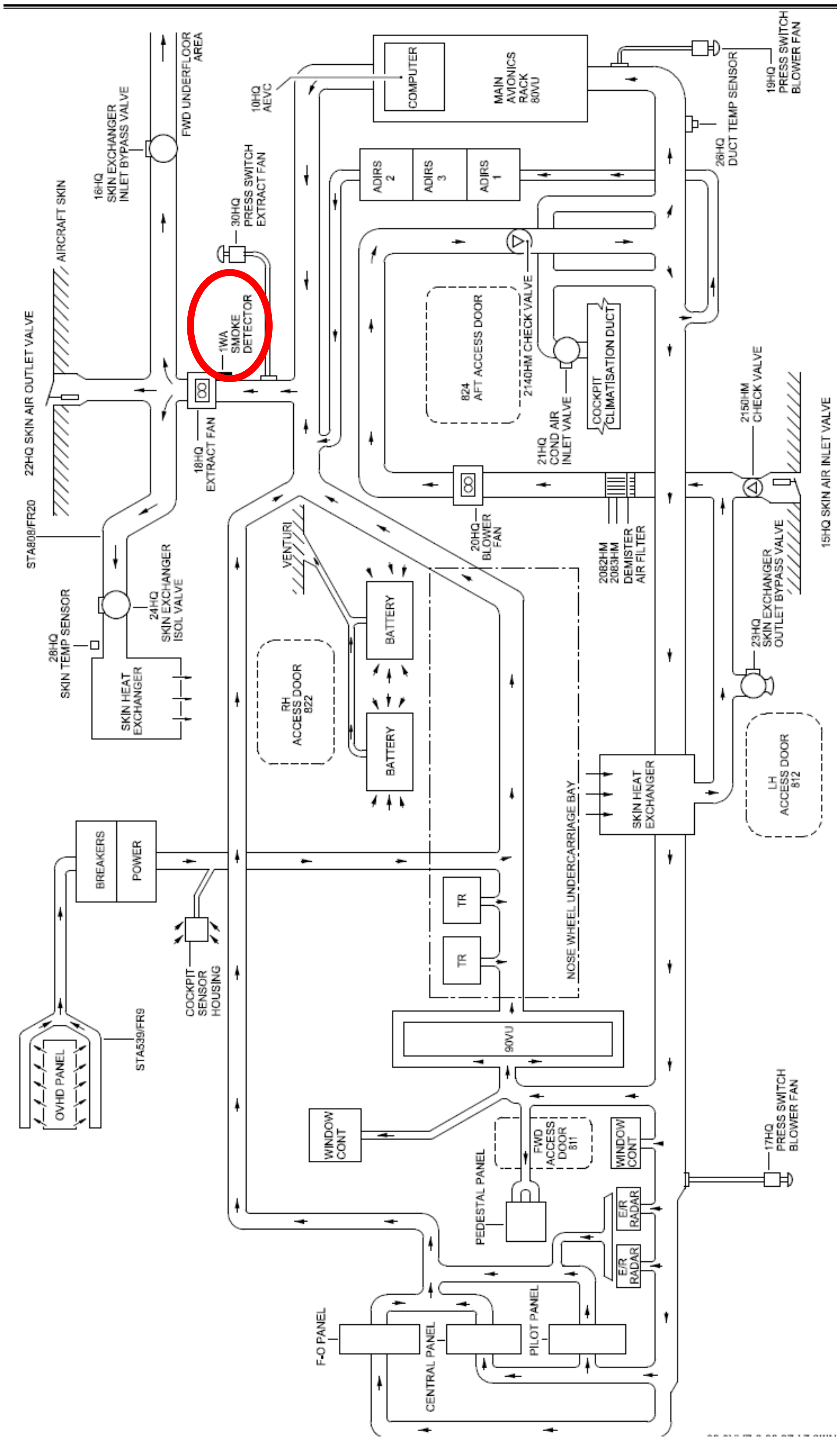


Figure 10. Avionics ventilation and components, as shown on AMM 21-26-00, with the avionics smoke detector circled

No ventilation components were found to have failed in the airplane. The three circuit breakers (D5 & D6 overhead, Z17 & AE2 aft) for avionics ventilation were found engaged. When the airplane was powered, both avionics ventilation fans operated.

The avionics blower fan (part number EVT3454F, serial 3480) functioned without discrepancy in the airplane. It was removed and the United Airlines component shop found no faults during detailed examination.

The avionics cooling air extraction fan (part number EVT3454HC, serial 4818) functioned in the airplane with a light bearing noise that was only detectable by stethoscope. The fan would occasionally squeal at the start of operation, as well. The fan was removed and the United Airlines component shop found worn bearings. No signs, smell, or evidence of heat or smoke were found.

No confirmed smells of smoke were detected in the airplane, aside from a light trace of stale smoke immediately at a galley oven. (The galley ovens use totally separate ventilation.) On the second day after the incident and after engaging the blower fan, the trace of a scent similar to that of a heated component was detected momentarily in the avionics compartment. The compartment was located beneath the cockpit and it was not clear what the smell was or where the smell was from.

Within the avionics ventilation ducts was a grey residue, typical of avionics ventilation systems in other airplanes. The residue did not have greasy properties, ash, or an acrid smoke smell.

D.3.4.1 AVIONICS SMOKE PERCEPTION IN COCKPIT

The investigation examined the ability of smoke from the avionics compartment to reach the cockpit and the pilots not being able to access the compartment.

The design of the normal A320 flow of air is from the cockpit through the avionics compartment, located beneath the cockpit floor, and then overboard. The aircraft maintenance manual showed that the supply of ventilation system fresh air into the cockpit compartment is through a dedicated supply duct. Air from the cockpit then passes into the avionics compartment through gaps between cockpit panels, floor vents, and other inconspicuous passages.

Records were found that certification flight tests showed that at least part of the smoke artificially generated in the avionics compartment flowed into the cockpit and could be detected by the pilots. This happened in four out of four tests involving the avionics smoke warning system.

After the New Orleans airplane examination, certification requirements were researched and found to require a path that moves away from the crew any potentially contaminated air or air containing gasses and vapors. This is described in Federal Aviation Regulation 14 CFR Part 25.831 Ventilation[8], which states:

> (a) Under normal operating conditions and in the event of any probable failure conditions of any system which would adversely affect the ventilating air, the ventilation system must be designed to provide a sufficient amount of uncontaminated air to enable the crewmembers to perform their duties without undue discomfort or fatigue and to provide reasonable passenger comfort. For normal operating conditions, the ventilation system must be designed to provide each occupant with an airflow containing at least 0.55 pounds of fresh air per minute.
> (b) Crew and passenger compartment air must be free from harmful or hazardous concentrations of gases or vapors. In meeting this requirement, the following apply:
> (1) Carbon monoxide concentrations in excess of 1 part in 20,000 parts of air are considered hazardous. For test purposes, any acceptable carbon monoxide detection method may be used.
> (2) Carbon dioxide concentration during flight must be shown not to exceed 0.5 percent by volume (sea level equivalent) in compartments normally occupied by passengers or crewmembers.
> (c) There must be provisions made to ensure that the conditions prescribed in paragraph (b) of this section are met after reasonably probable failures or malfunctioning of the ventilating, heating, pressurization, or other systems and equipment.
> (d) If accumulation of hazardous quantities of smoke in the cockpit area is reasonably probable, smoke evacuation must be readily accomplished, starting with full pressurization and without depressurizing beyond safe limits.

Airbus was unable to provide test measurements or other documentation from certification tests that had been used to show how the acceptable levels of carbon monoxide and dioxide levels were determined, per 14 CFR Parts 25.831(b)(1) and 25.831(b)(2).

The cockpit display screens may lose colors and revert to a partial “gray mode” when there is less than normal avionics ventilation flow. Airbus personnel related that the “graying out” is part of the system design for protection against increased avionics temperatures. To prevent further temperature rise, the components used to generate colors are automatically switched off.

D.3.4.2 AVIONICS SMOKE DETECTOR UNIT

The Cerberus Model CG7GO ionic smoke detector installed in the A320 avionics cooling exhaust duct has been installed in the following locations:

---

8 Prior to Part 25.831, Part 25.561 also described airflow and contained the same carbon monoxide requirement since 1964.

- A300 and A310 series avionics, lavatories, and some main deck cargo compartments.

- A320 family avionics to airplane serial (msn) 1540 on the A319, MSN 1522 on the A320, and MSN 1553 on the A321. Following those line numbers and on all A318 airplanes, the ionic type of detector was no longer installed. Later airplanes had/have optical smoke detectors.

  Airbus personnel noted that the A320 series airplanes cool the avionics compartment with outside air when the airplane is on the ground and that the A300/A310 use internal air that has been conditioned by the engines, APU, or other source.

- No ionic smoke detectors have been installed by Airbus on the A330, A340, or A380 models.

The avionics smoke detector was installed in a duct at the outlet of the avionics compartment cooling system, near the overboard valve. The Component Maintenance Manual showed that the basic portion of this ionic type of smoke detector is used for cargo compartment protection. The part markings showed identification as United Airlines MR26150-28 (Chg Status 1), manufactured by Siemens/Cerberus as part number CG7GO, serial 1652. (See Figure 11)

Figure 11. Smoke detector undergoing testing at the FAA Fire Laboratory.

The smoke detector had been manufactured on August 1, 1992 and was marked TSO-C1b. It had been sent to Triumph Instruments of Burbank, California, following removal from United Airlines airplane 4661 on June 24, 2009 (ref: p/o 59887907386). Triumph Work Order S3721 stated that the unit had previously been at Triumph Instruments in Burbank (TIB) on October 29, 2008, on Work Order R5208.

The 2009 work order showed that the cause of Work Order S3721 was failure of a sensitivity test, that the complaint had been confirmed when the unit also failed a functional test at Triumph, and that the correction was to clean the [sensor] cell. The work was completed August 26, 2009 and the part had been returned to United Airlines.

The part met warning requirements after removal for functional tests at the FAA Fire Research Laboratory in the Hughes Technical Center at Atlantic City, New Jersey. The tests were conducted inside a NBS smoke chamber using a relatively low smoke output thermoplastic sample material exposed to the radiant heater. A mixing fan was installed inside the chamber to ensure a homogeneous smoke cloud within the chamber. A vacuum pump was attached to one side of the detector to draw the smoke filled air into the detector. The detector was installed inside the chamber, adjacent to the vertical smoke meter light beam. The path length of the light beam was 36 inches. The tests were conducted with the initial light transmission at 100% (clear air). The radiant burner was then powered on, exposing the sample material to heat. As smoke began to be emitted from the sample, the mixing fan distributed the smoke throughout the test chamber. The light transmission per foot was recorded at the time the unit went into warning. The tests were repeated 5 times with the following results:

Test #	% light transmission/foot at warning
1	91.96
2	92.98
3	91.5
4	93.05
5	91.91
Avg.	92.28

References:

(1) Code of Federal Regulations 14 CFR 25.857 is titled"Cargo Compartment Classification"

(2) Code of Federal Regulations 14 CFR 25.858 is titled "Cargo or baggage compartment smoke or fire detection systems."

(3) TSO-C1d became effective August 19, 2004, is titled "Cargo compartment fire detection systems," and like TSO-C1b, calls for an activation standard set by Society of Automotive Engineers (SAE) Document AS8036.

(4) The SAE 8036 document that it references states that the detector must alarm (warning mode) at light transmission levels between 60 and 96

> percent light transmission per foot. A standardized smoke box is used by manufacturers to determine the alarm point of the detectors.

No standard exists for smoke detector warning capabilities at various humidity levels. Because the United Airlines airplane had generated multiple false warnings in humid environments, a humid environment was generated by placing a pot of water on a hot plate in the test chamber. The detector went into warning mode in the humid environment.

The Cerberus SA Component Maintenance Manual states the following about how often the detector needs to be cleaned (ref: 26-11-15, Page 401, SEP 30/99):

> Cleaning procedures must be effected when the sensitivity test (on aircraft or in workshop) are not correct (these tests are systematically performed every 6000 operating hours).

D.3.4.3 IONIC VERSUS OPTICAL AND OTHER TYPES OF SMOKE DETECTION

The two types of smoke detectors certified for A320 avionics compartment installations each have a built in test (BITE) function that monitors for failures in the electronic portion of the assembly. The BITE is unable to detect when the detector cell is dirty.

The two types of smoke detectors could not be tested from the cockpit. Each is manufactured to Technical Standard Order (TSO) C1b (subsequently C1d), which is titled "Cargo Compartment Fire Detection Systems." The TSO was established to meet 14 CFR Part 25.858, titled "Cargo or baggage compartment smoke or fire detection systems."

The Cerberus Component Maintenance Manual contained the following description about the principle of operation for the CG7GO smoke detector:

> The cell comprises:
> - a measuring chamber,
> - a high impedance resistor.
>
> An electrical field is created between electrodes … by means of the DC power supply voltage.
>
> The air between the electrodes is ionized by means of a radio-active source. The ions (negatively or positively charged gas molecules) generated by this radio-activity are propelled by the electrical field to the reversely charged electrode. This results in an electrical current whose value is dependent on the velocity and number of the ions present. When fire aerosols (combustion products) enter the

> space between the two electrodes, part of the ions are deposited on these particles. These are heavy, up to 1000 times heavier than the particles which travel between the two electrodes when no aerosol is present. The heavy ions obtained in this way move more slowly as a result of mass inertia, and reduce the conveyance of charges ; the resulting current decreases and the electrical resistance of the circuit increases. Consequently, the voltage across the terminals of the measuring chamber becomes higher than the voltage across the high impedance resistor.
>
> The electronic circuit measures the unbalance prevailing between the voltage across the measuring chamber terminals and the voltage across the high impedance resistor, by means of threshold circuits. When the preset threshold is reached, the circuit generates a warning signal.

To reduce false alarms, Airbus worked with Siemens to develop a replacement optical smoke detector, part number CGDU2000-00. In an optical detector, smoke particles pass through a light beam and at predetermined level of light dispersion, the detector generates a warning. The optical detectors have significantly superior (lower) rates of false alarms when tested in humid environments, but are still sensitive to dust and some aerosols. This was the type of detector installed in later airplanes.

Airbus continued to examine how to improve false alarm rates. For example, at the 12th Annual Conference on Automatic Fire Detection, March 25-28, 2001, at the National Institute of Standards and Technology, Airbus personnel presented that:

> Technology under consideration to reach adequate detection properties includes :
> - Gas sensing with semiconducting metal oxide sensors in thick- or thin-film technology or/and electrochemical cells
> - Optical smoke sensing with light attenuation or back-scattering devices
> - Near infra-red (NIR, wavelengths < 1.2µm) and visible light sensing with CCD
> (Charge Coupled Device) and/or CMOS (Complementary Metal Oxide Semiconductor) technology
> - Infra-red sensing with thermopiles (for wavelengths > 1.2µm)

Airbus has implemented changes to reduce the rate of false smoke detector alarms. The company developed an alternative smoke detector that was based in an optical sensor, rather than the ionic type of sensor that was the basis of the Cerberus CG7GO detector, and developed a test for the potential of a smoke detector to create false alarms.

Airbus also has developed for subsequent airplane models a type of optical sensor that has two cells. One functions as a reference for the second, which is exposed to the air stream being monitored. The benefit to this type of detector is that the reference cell nulls out the cells becoming dirty. This type of detector is only used in cargo compartments and an A320 installation has not been developed.

In addition to improving the smoke detectors for Airbus airplanes, presentations from annual fire protection meetings (including the 2001 meeting cited above) show that the company has both developed test procedures and promoted that a maximum allowable rate for false alarms should be established. To date, these have not been adopted.

D.3.4.4 TFU AND SERVICE BULLETIN

Airbus issues a Technical Follow Up message, known as TFU 26.15.15.001 in July 1999, applicable to all A319, A320, and A321 airplanes. A revision was issued December 2002 to change the section titled "MAINTENANCE ADVICE." The TFU was not addressed to flight crews, it was issued to "LINE MAINTENANCE" in the category of "ECONOMIC."

The TFU stated:

> DESCRIPTION:
> SOME OPERATORS HAVE REPORTED MANY CASES OF SPURIOUS AVIONICS SMOKE WARNINGS, LEADING TO "AVIONICS SMOKE" OR "LAND ASAP" ECAM MESSAGES. THESE WARNINGS HAVE MAINLY BEEN REPORTED ON GROUND, HOWEVER THERE HAVE BEEN A FEW CASES GENERATED IN FLIGHT, SHORTLY AFTER TAKE-OFF AND GEAR RETRACTION.
>
> **CONSEQUENCES:**
> N/A
>
> **INVESTIGATION STATUS :**
> THE AIRCRAFT FLIGHT PHASE CONFIGURATION WHERE AVIONICS SMOKE WARNINGS HAVE BEEN GENERATED FALL INTO TWO MAIN CATEGORIES; ON GROUND AND TAKE-OFF.
>
> - ON GROUND - WITH THE AIRCRAFT ON GROUND THE AVIONICS VENTILATION IS SET TO 'OPEN LOOP', WHEREBY OUTSIDE AIR IS USED TO PROVIDE VENTILATION FOR THE AVIONICS COMPARTMENT. IN ENVIRONMENTS WHERE HIGH HUMIDITY AND/OR CONTAMINATION

EXISTS (JET EFFLUX/BLOWN DUST ETC). IT IS POSSIBLE FOR THE SENSITIVITY OF THE AVIONICS SMOKE DETECTOR TO BE AFFECTED CREATING AN ALARM CONDITION.

* TAKE-OFF - THE AVIONICS SMOKE WARNINGS ARE INHIBITED FROM 80KTS TO 1500 FEET. DURING THIS TIME IF THE AVIONICS DETECTOR GOES INTO ALARM THEN A 'LAND ASAP' (IN AMBER) IS GENERATED ON ECAM. THE ONLY WAY TO IDENTIFY THE CAUSE OF THE AMBER WARNING IS BY DEPRESSING THE RECALL BUTTON ON THE ECAM CONTROL PANEL. INVESTIGATIONS HAVE DETERMINED THAT SOME OF THESE 'LAND ASAP' WARNINGS HAVE BEEN GENERATED DUE TO A PREVIOUSLY LATCHED, BUT INHIBITED AVIONICS SMOKE WARNING THAT HAD BEEN GENERATED WHILST THE AIRCRAFT WAS ON GROUND.

INVESTIGATIONS HAVE SHOWN THAT THE IONIZATION TYPE SMOKE DETECTORS SENSITIVITY IS SUBJECT TO THE AMBIENT TEMPERATURE, PRESSURE AND AIR CONTAMINATION WITH MOISTURE, DUST OR POLLUTION. THE HIGHEST SENSITIVITY TRANSLATED INTO A VOLTAGE SHIFT BEING ON THE GROUND AND DURING TAKE-OFF.

INTERIM SOLUTION:
N/A

MAINTENANCE ADVICE:
IN CASE OF AN 'AVIONICS SMOKE' WARNING TRIGGERED AND LATCHED ON GROUND, FWC1 AND FWC 2 SHOULD BE RESETED ONE AT A TIME BY MEANS OF THEIR C/B (3WW C/B 49VU FOR FWC1 AND 2WW C/B 121VU FOR FWC2). THIS WILL CLEAR THE LATCHED CONDITION OF THE WARNING IF THE AVIONICS SMOKE CONDITIONS HAVE DISAPPEARED. THEN AN UNDUE 'LAND ASAP' ALARM WILL BE AVOIDED.

OPS ADVICE:
N/A

REPERCUSSION ON A/C DISPATCH:
N/A

PERMANENT OR FINAL SOLUTION:
A NEW GENERATION OF SMOKE DETECTOR PN CGDU2000-00 USING AN OPTICAL TECHNOLOGY HAS BEEN DEVELOPED IN ORDER TO REPLACE THE 'OLD' GENERATION OF IONIZATION TYPE SMOKE DETECTOR. THIS NEW GENERATION TYPE OF SMOKE DETECTOR HAS A DIFFERENT TRIGGERING PRINCIPLE AND IS THEREFORE NOT AFFECTED BY THE TEMPERATURE AND PRESSURE CONDITIONS.

> IN SERVICE EVALUATION (6 MONTH PERIOD) OF AVIONICS OPTICAL SMOKE DETECTOR PN CGDU2000-00 HAS BEEN PROPOSED TO TWO OPERATORS. DEDICATED SB A320-26-1052 HAS BEEN RELEASED MID JULY 2000. THE IN SERVICE EVALUATION HAS BEEN COMPLETED SUCCESSFULLY. SB A320-26-1052 REVISION HAS BEEN RELEASED THE 30TH OF AUGUST TO INCORPORATE ALL AIRLINES IN THE EFFECTIVITY.

The TFU status was classified as "CLOSED/SOLUTION AVAILABLE"and Service Bulletin 26-1052 was the documentation used to replace the p/n CG7GO ionic smoke detector with an optical unit, part number CGDU2000-00. The service bulletin was issued July 11, 2000 and revised August 30, 2001, also stating that the ionic unit could be used in place of the optical one, with the condition that "The sensitivity test (AMM task 26-15-00-720-001) is not applicable for the optical smoke detector." The TFU showed that the SB would be incorporated into new airplanes (issue 30-Aug-2001) at A319 serial 1541, A320 serial 1523, and A321 serial 1554.

Airbus issued a second TFU, number 21.26.00.019, titled AEVC Over current Protection Failures. The TFU called for an upgrade to the Avionics Equipment Ventilation Computer (AEVC) to Standard 6, Amendment A version, per VSB 87292325-21-006 to correct issues with internal circuitry which caused AVIONICS SMOKE ECAM warnings. In these cases, a manufacturing coating would heat on certain electronic parts and generate actual smoke that the detector would sense.

At the time of event, approximately 96% of the United Airlines fleet has been upgraded with optical detectors on an attrition basis.[9] After the incident, the change became a scheduled event, with completion targeted for October 31, 2011. As of October 28, the final five airplanes may be changed in mid-November.

D.3.4.5 A320 SMOKE DETECTION CONTROL UNIT (SDCU)

Depending on the CIDS standard installed ("Basic" or "Enhanced"), the A320 family fleet can be equipped either with a Smoke Detection Control Unit (SDCU) or a CIDS integrated smoke board (CIDS-SDF). The evolution of the smoke detection system is described in Airbus Service Information Letter SIL 26-034, issued May 25, 2007, and revised on November 7, 2008. The incident airplane was equipped with the earlier SDCU.

The SDCU receives signals from each of the smoke detectors in the airplane, processes the inputs, and outputs appropriate warnings for the crew, maintenance, and flight data recordings.

The circuit breaker (aft panel, T18) for the SDCU was found engaged and not tripped. The SDCU from the airplane was not removed and functioned normally following the incident.

---

9 United Airlines Change Order Authorization 407991, ref VSB 87292325-21-006 and CCOA 0-5310.

D.3.4.6 SMOKE RELATED CHECKLISTS PHYSICALLY FOUND

The following portion of this section describes three items. An Airbus-provided screenshot of the ECAM checklist as a reference, since the avionics smoke checklist was not visible in the group examination of the airplane. Two physical checklists were found in the cockpit, one being the laminated checklist that was found at the First Officer's station in N409UA, and the other was the A319/A320 Flight Manual that was found on the cockpit floor, at the rear of the pedestal.

On the left is the ECAM avionics smoke checklist from a screenshot that was provided by Airbus to compare with the checklist on the right. On the right are the items from the laminated checklist found in the airplane:

ECAM Screenshot Items:		N409UA text of the SMOKE-FIRE-FUMES Laminated Checklist Items
A[10]	AVIONICS SMOKE	
W	IF PERCEPTIBLE SMOKE :	
C	-OXY MASK/GOGGLE. . . . . ON	Oxygen masks and regulators. . . . . On, 100%
C	-CABIN FANS .. . . OFF	Crew and flight attendant communications . . Establish
C	-BLOWER . . . .OVRD	Cabin fans switch . . . . Off
C	-EXTRACT . . . .OVRD	Blower switch . . . . Override
W	.IF SMOKE AFTER 5MNOOS: [Confirmed 5MN00S]	Extract switch . . . . .Override
C	EMER ELEC GEN1 LIN OFF	Galley/galley and cabin switch . . . . Off
C	-EMER ELEC PWR . . .MAN ON	Cabin signs . . . . . On
W	. WHEN EMER GEN AVAIL :	Descent . . . . Initiate
C	-APU GEN . . . . OFF	Warning: Do not delay descent or diversion to find the smoke source
C	-GEN 2 . . . . .OFF	Refer to Reference Action FM page 15.50.3
C	MIN RAT SPEED . . . . . .140 KT	
C	FUEL GRVTY FEED	
C	- PROC: GRVTY FUEL FEEDING	

[10] First column denotes color, with A for amber, C for cyan, and W for white.

	Note: The above column shows only the AVIONICS SMOKE procedure, which would be followed by the specific ELEC EMER CONFIG procedure as soon as the last generator is switched off. That procedure is in both an attached Airbus presentation and in the Operations Group Chairman's Factual Report.	

With respect to the last step in the laminated procedure, the A319/A320 Flight Manual was found on the cockpit floor, at the rear of the pedestal. The top of page 15.50.3 Emergency Procedures, Fire, dated 4 March 2011, contained the same steps as above, except that the warning stated: "Warning: Do not delay landing to complete the remainder of this procedure." At the bottom of the page and copied here in entirety was the text specifically about avionics smoke:

If electrical or avionics smoke is suspected:
Accomplish AVIONICS SMOKE ECAM or Flight Manual procedure.
. . . . END OF ELECTRICAL OR AVIONICS SMOKE . . . .

No text refered to the following page, 15.50.4. On that page, the first two checklists were titled EMERGENCY DESCENT and then SMOKE REMOVAL. Under the title DENSE SMOKE, the third checklist was:

EMERGENCY ELECTRICAL CONFIGURATION
(If required)
Emergency electrical generator 1 line switch . . . . Off
Emergency electrical power switch . . . . Off
When emergency generator available:
APU generator switch . . . . Off
Generator 2 switch . . . . Off
Just before landing gear extension:
Generator 2 switch . . . . On
Emergency electrical generator 1 line switch . . . . On
- - - - - CHECKLIST COMPLETE - - - - -

For the first of three post-incident starts of the engines, a modified version of the avionics smoke checklist was accomplished. One line of the checklist called for sequentially shutting off electrical loads. Another line called for a 5 minute wait to see if perceptible indications of smoke would clear. The complete checklist was not followed during the ground test.

The checklists do not refer to resetting of the FWC1 and 2 circuit breakers to clear the latched condition for false warnings, as described by the July 1999 TFU 26.15.15.001, which was issued to line maintenance personnel.

D.3.4.7 LOGIC PATH - AVIONICS SMOKE MESSAGE GENERATION, DISTRIBUTION, AND LATCHING

The data from the digital flight data recorder (DFDR) indicated that the avionics smoke message bit had latched prior to takeoff. The ECAM message LAND ASAP is inhibited when the airplane is on the ground (weight on wheels).

The signal path from the avionics smoke detector splits to go to the avionics electronics ventilation computer (AEVC) and to the flight warning computers (FWC 1 and 2).

1. A hard-wired discrete connection passes the signal from the AEVC to illuminate the overhead GEN 1 LINE FAULT light and to record the avionics smoke detection in the DFDR. The only method available to maintenance personnel to control or reset the smoke detector is through cycling the AEVC circuit breaker. This method is not published in the FCOM, it is in the Troubleshooting Manual (TSM), which only available to maintenance personnel.

2. The second path from the smoke detector is to the FWCs, where the signal is combined with other inputs, such as whether the airplane is on the ground. The output of the FWC computers becomes visible as ECAM messages and audible in the cockpit chime.

   The FWCs are the source of the timer for perceptible smoke, process inputs for prioritization of the ECAM messages, and apply inhibition rules. The message AVIONICS SMOKE WARNING is generated in amber with a checklist for the crew to accomplish, and the amber message LAND ASAP. The TFU 26.15.15.001 pertaining to spurious avionic smoke messages calls for clearing of avionic smoke messages by pulling and resetting the FWC circuit breakers.

In flight warning computer prioritization of ECAM messages, the ELEC EMER checklists would have priority over those for AVIONICS SMOKE. Therefore, if the steps displayed for AVIONICS SMOKE were displayed on the ECAM when the conditions for ELEC EMER were reached, the ELEC EMER checklist would become the ECAM display and when complete, the AVIONICS SMOKE list would follow. Messages about aircraft condition, such as an unusual setting of power levers for a particular mode of flight, would rank below the AVIONICS SMOKE messages.

Note: Acronyms used for electronic devices involved in the signal path (See Figure 12):

AEVC	avionics electronics ventilation computer
CFDIU	centralized fault display interface unit
DFDR	digital flight data recorder
FWC	flight warning computer
MCDU	Multipurpose Control Display Unit
SDAC	system data acquisition concentrator

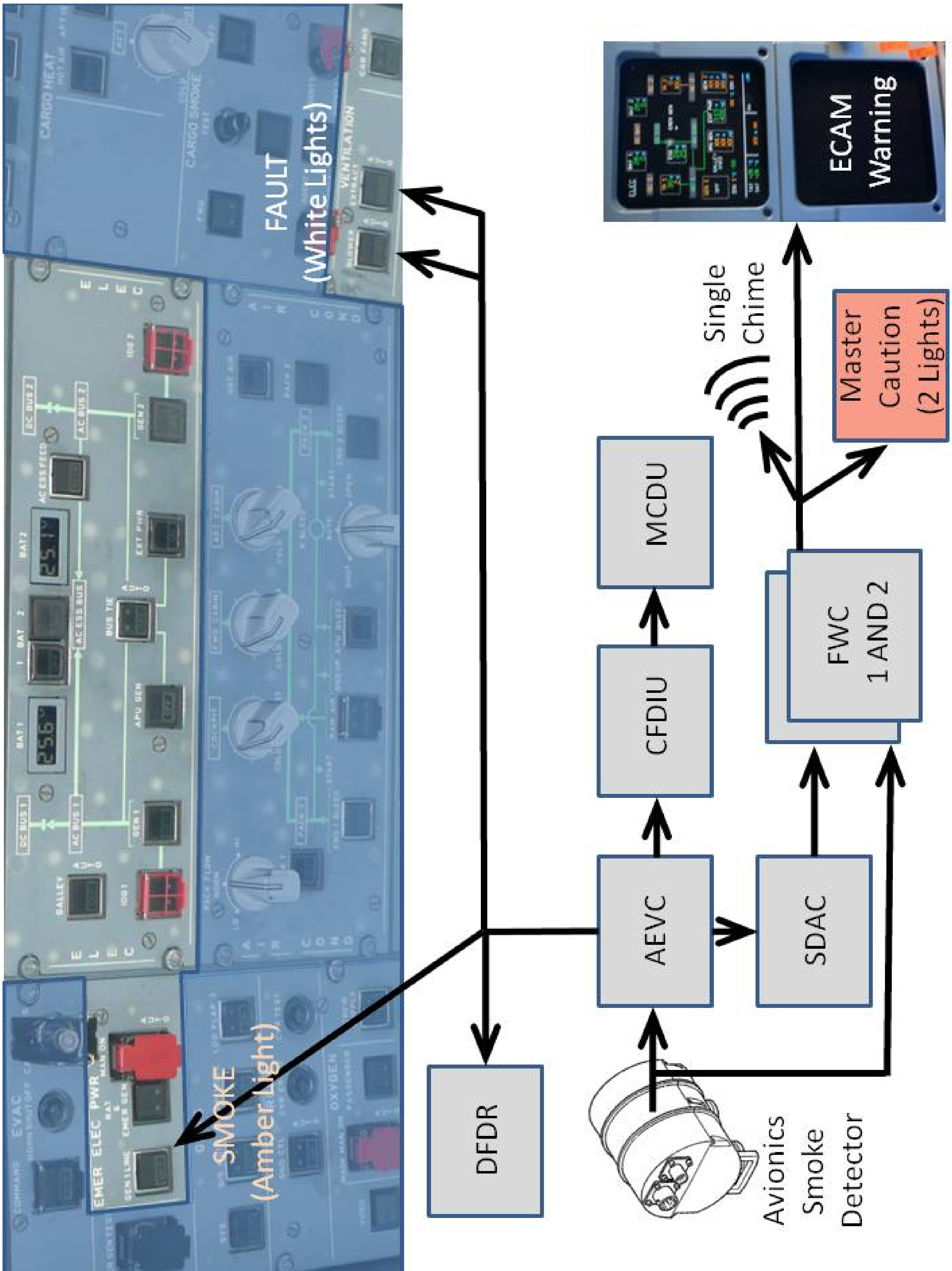


Figure 12. Avionics smoke signal path.

D.3.4.8 A320 FLEET SMOKE DETECTION, SPURIOUS WARNINGS

In the original delivery of the airplane, seven ionic type smoke detectors were installed, with the other six in the ceilings of the two cargo compartments.[11] Technical personnel from UAL and Airbus related that the cargo systems required triggering of two units to provide a warning to the cockpit and did not have the history of spurious warnings that had been experienced by the avionics detection systems. For the avionics smoke alarm, only a single trigger is required for actuation. Although spurious cargo system alarms have occurred, the ECAM checklist and FLT Manual have instructions to validate the signal.

Described previously in this report, Airbus TFU 26.15.15.001 from July 1999 (revised December 2000) was titled Spurious Avionics False Smoke Warnings. The TFU described false alerts and informed customers that an optical based detection unit had been developed and was available.

At the time of the incident, United Airlines had been replacing the ionic smoke detectors on an attrition basis. Until the incident, the optical and ionic detectors were given a common UAL number (MR) as authorized in the Airbus IPC, ICD, and SIL 26-034 documents. Prior to the investigation UAL had also planned a change that would replace the avionics ionic smoke detectors with optical type detectors. United personnel reported that this would be applicable to 117 of 152 UAL A320 aircraft and take about 12 months to accomplish.

Pending the replacement of ionic smoke detection devices, UAL is internally discussing how to educate flight crews about the potential for spurious smoke alarms from ionic detectors, about the need to precisely follow checklist steps, and include the need to include the 5 minute delay that the avionics smoke checklist calls for.

D.3.4.9 SMOKE ALERT FREQUENCY DATA

D.3.4.9.1 UNITED AIRLINES

Following the incident, the United Airlines Flight Operations Quality Assurance (FOQA) program conducted a 5 year avionics smoke warning study for the period from January 2006 through incident date, March 2011. The study was conducted to look at the nature of other avionics smoke warnings to compare against the incident flight. This study has been completed and United Airlines reported that a summary of the data found:

> 22 flights where the Avionics smoke warning was on at the beginning of recording and remained on the entire flight.

11 Differences exist in sub assembly dash numbers to account for minor variations, such as how the detectors are installed.

6 of the 22 returned to the field or diverted to another airport.

26 flights where the Avionics smoke warning was on at the beginning of recording and went out while airborne, switching between “ON” and “OFF” during the course of a flight.

2 of the 26 returned to the field or diverted to another airport.

D.3.4.9.2 FALSE SMOKE ALARMS, SAFETY RECOMMENDATION A-00-091

The Safety Board issued Safety Recommendation A-00-91 on JuIy 14, 2000, as a result of its concern for the evacuation of commercial airplanes in the event of an emergency. Several accidents investigated by the Board in the preceding decade involved emergency evacuations, which prompted the Board to conduct a study into the evacuation of commercial airplanes. The safety recommendation was a result of Safety Study NTSB/SS-00-01and stated that the FAA should:

> A-00-91
> Document the extent of false indications of cargo smoke detecotors on all airplanes and improve the reliability of the detectors.

In a letter of July 23, 2009, the Federal Aviation Administration's (FAA) concluded that most false alarms on cargo smoke detectors have been caused by dust and dirt particles that accumulate in the cargo compartments and interfere with the proper operation of the smoke detectors. The FAA stated that a revision had been initiated for Teclmical Standard Order (TSO) C1d, Cargo Compartment Fire Detection Instruments. The revision would include further testing on smoke detector units in dust, dirt, and high humidity environments. The FAA had requested detailed information from the smoke detector manufacturers to develop definitive pass-fail criteria for the TSO. However, the manufacturers refused to share this data, which they considered to be proprietary. As a result, the FAA was not able to complete our revision to TSO-CId.

In a letter of July 8, 2011, the FAA related that:

> On March 31, 2011, we sent a task request (enclosed) to the Society of Automotive Engineers (SAE) to task a committee to develop an improved test standard for Aerospace Standard (AS) 8036, Cargo Compartment Fire Detection Instruments. We are requesting a revision of AS 8036 to address the effects of dust, dirt, and moisture on false alarms in addition to current minimum performance standards. Based on our experience, we anticipate that industry will need at least two years to come to a consensus on a revised test standard. If SAE is unable to provide a revised test standard, the FAA will consider our own revision to the TSO.

> I will keep the Board informed of the FAA"s progress on this safety recommendation and provide an update by July 2012.

In a letter of October 19, 2011, the Safety Board acknowledged the FAA efforts and kept Safety Recommendation A-00-091 classified as "Open—Acceptable Response."

D.3.4.9.3 ADDITIONAL FALSE SMOKE ALARM INFORMATION

Safety Recommendation A-00-091, the United Airlines data, and fact that the smoke detectors were made to comply with cargo compartment TSO-C1b led to a renewed examination about how widespread smoke alerts were in general. The examination found that the problem existed in nearly all makes of transport airplanes, from all manufacturers, and that the trend was getting worse.

Not limited to avionics smoke, the FAA stated the following in a January 6, 2011, Information For Operators (INFO 11002)

> **Background:** Reports to air traffic, submission of Service Difficulty Reports (SDR), and several focused surveys reveal that approximately 900 smoke or fumes in the cockpit or cabin events occur annually in transport category airplanes. Many of these incidents prompted the flightcrew to declare an emergency and either divert, turn back or request priority handling to their destination.

In 2004, the FAA Fire Safety Branch compiled Service Difficulty Reports occurred during the period of 1974-2003. The reports were individually read and while avionics smoke reports were not included, the cargo and avionics systems use similar detector units. The false alarms were then plotted against unscheduled landings, as shown in Figure 13:

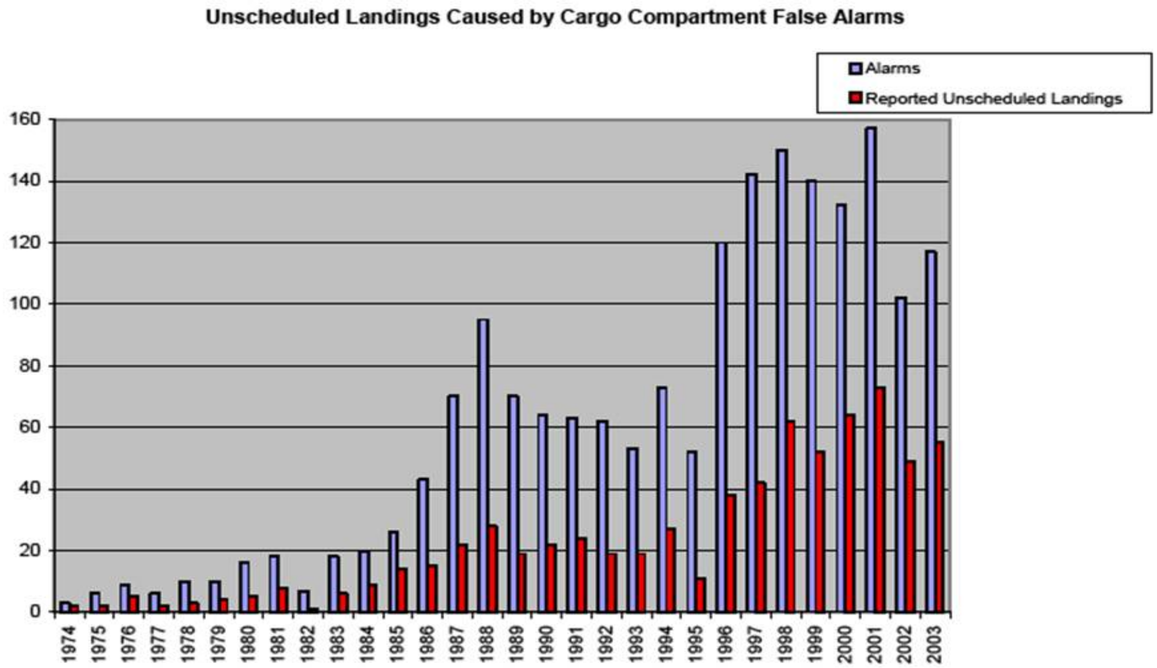


Figure 13. Smoke detector false alerts and unscheduled landings.

The data revealed 1,866 alarms 1974-2003, with an increasing trend (more alarms per year on average). These alarms had been recorded in airplane models from the manufacturers of all major transport and business aircraft, including Airbus, Boeing, Bombardier (also Canadair), Dassault, DeHavilland, Douglas, Embraer, Lockheed, Saab, and Shorts. The types of airplanes ranged from early Boeing 727s to new Airbus 340s. The phases of flight for the 1,866 records were:

241	during taxi
129	during takeoff
394	during climb
795	during cruise
149	during descent
38	during landing

As found during the Safety Study of 2000, the review No Federal Aviation Regulations were found specifically citing separate requirements for the use of smoke detectors in the venting of avionics and the smoke detector had been manufactured to the requirements for cargo or baggage compartments. Code of Federal Regulations 14 CFR 25.858 "Cargo or baggage compartment smoke or fire detection systems" states:

> If certification with cargo or baggage compartment smoke or fire detection provisions is requested, the following must be met for each cargo or baggage compartment with those provisions:
>
> (a) The detection system must provide a visual indication to the flight crew within one minute after start of fire.

(b) The system must be capable of detecting a fire as a temperature significantly below that at which the structural integrity of the airplane is substantially decreased.
(c) There must be a means to allow the crew to check in flight, the functioning of each fire detector circuit.
(d) The effectiveness of the detection system must be shown for all approved operating configurations and conditions

Current integration tests for smoke detectors are defined in the FAA Advisory Circular 25-9A. The integration tests mentioned herein can be performed with appropriate smoke generators, being selected out of the following list, depending on the actual installation point of the sensor:

- paper towel burn box
- Rosco Theatrical smoke generator
- Helium-injected Rosco Theatrical smoke generator
- A pipe or cigar
- A Woodsman Bee Smoker
- Any other acceptable smoke generator

There are no standards set for maximum permissible levels of false alerts, beyond performance requirements that require a smoke device not to create alarm as a result of specified changes in altitude. The investigation found that false alerts had been the subject of repeated industry and government meetings since Safety Recommendaiton A-00-091 was issued and that Airbus had promoted a committee to establish both test requirements and minimum standards.

Actions have been taken to better understand and minimize false smoke alarms. Creation of multi-sensor detectors has been used effectively to make alarm devices that are more accurate. The multi-sensor detectors are now in the Airbus A380 and Boeing 787 airplanes. Under contract from the FAA, Rutgers University has made progress in computational fluid dynamics and algorithms for development of smoke alarms.

The SAE committee responsible for the 8036 document has discussed establishment of false alarm standards for airborne particles. The discussions have not formalized into objectives for action. A FAA Fire Laboratory presentation to the International Aircraft Systems Fire Protection Working Group at Grenoble, France, on June 21-22, 2004, showed that potential requirements under consideration included Arizona dust and calibrated amounts of humidity. On May 11-12, 2011, the annual International Fire Protection Working Group Meeting took place. Airbus personnel gave a presentation about company progress in developing and promoting both a False Alarm Rejection Ratio and standardized test standards.

D.3.5 ENGINES, PHYSICAL AND OPERATION

The only anomalies found to the engines were the amounts of light tactile roughness and grass stains at the leading edges of the first stage fan blades. Trace amounts of dirt were found in the outer fan cowl. Nothing foreign was seen in the inlet or exhaust of either engine's core path. The visible turbine and exhaust areas were free of discolorations, metal spatter, or other anomalies. The fan cowls had no visible damage, opened normally, and no engine anomalies were found during visual inspections with the fan cowls open. The engines were started and ran normally three times as part of the investigation.

D.3.5.1 THRUST REVERSERS

No visual damage was found to the thrust reversers prior to the first start of the engines after the incident.

With the normal electrical configuration, the electrical control of each engine comes from the electrical busses on the associated side of the airplane. When on battery power in earlier A320 airplanes such as N409UA, the crew retains electrical control of the left thrust reverser and the reverser will operate normally. In this configuration, the electrical control of the right thrust reverser is disabled and the right thrust reverser will not open.

The ELEC EMER CONFIG checklist specific for avionics smoke does call for reconnecting both engine driven generators prior to landing gear extension to restore the normal electrical configuration. Reconnecting an engine-driven generator could provide the power required for both thrust reversers to operate normally.

In the ELEC EMER configuration, only the left thrust reverser would operate in 4 of the approximately 150 United A320 airplanes. United is in the process of changing the remaining airplanes so to prevent the potential for asymmetric thrust.

Airbus issued Service Bulletin Number A320-78-1023, dated August 12, 2003, revised January 7, 2005, titled EXHAUST – THRUST REVERSER – INTRODUCE A HYDRAULIC SHUT-OFF-VALVE ON THE IAE T/R SYSTEM.

The SB addressed installation of a hydraulic shutoff valve to prevent the potential for an in-flight thrust reverser deployment. In addition to installation of the hydraulic shutoff valve, the instructions connected the shutoff valve to associated wiring, connected throttle control unit switches, and activated the associated logic of the spoiler elevator computer (SEC) and engine interface unit. Because not all of these circuits would be available when the airplane was on battery power, this modification eliminated the potential for deployment of a single thrust reverser (asymmetric thrust) upon landing in the ELEC EMER configuration.[12]

Asymmetric thrust between two engine thrust reversers is not a specific topic for any one certification regulation. The sections that address thrust and control include the following:

Sec. 25.901 Installation.

---

12 Specifically, power would not be available from AC busses 1 (103XP/B) and 2 (204XP/B).

(c) For each powerplant and auxiliary power unit installation, it must be established that no single failure or malfunction or probable combination of failures will jeopardize the safe operation of the airplane except that the failure of structural elements need not be considered if the probability of such failure is extremely remote.

Sec. 25.903 Engines.

(b) Engine isolation. The powerplants must be arranged and isolated from each other to allow operation, in at least one configuration, so that the failure or malfunction of any engine, or of any system that can affect the engine, will not--

(2) Require immediate action by any crewmember for continued safe operation.

Sec. 25.933 Reversing systems.

(a) For turbojet reversing systems--

(3) Each system must have means to prevent the engine from producing more than idle thrust when the reversing system malfunctions, except that it may produce any greater forward thrust that is shown to allow directional control to be maintained, with aerodynamic means alone, under the most critical reversing condition expected in operation.

Sec. 25.1143 Engine controls. [This section is further addressed in the A320 Special Conditions.]

(c) Each power and thrust control must provide a positive and immediately responsive means of controlling its engine.

D.3.6 LANDING GEAR

On the runway and leading to the nose landing gear tires were light gray paths on the pavement. Following recovery, the treads of the nose landing gear tires were found worn.

Minor damage was found to an electrical conduit in the area of the nose landing gear. During replacement of the conduit and nose wheels, no visible damage was found to the axles, or to the retractable portions of the landing gear. The nose landing gear bracketry and electric “weight on wheels” switch assembly was found broken.

The right main landing gear tires were found deflated. The tread of the outboard tire had two flat spots, one of which surrounded an opening to the interior of the tire. The inboard tire (#3) was found deflated, the beads of the tire were not mounted on the wheel halves, and heavy abrasion was found to one tread shoulder. The group did not have the means to determine whether the inboard wheel fuse plugs were intact.

Tire serial numbers 0084S044 and 0230S083 were removed prior to moving the airplane from the runway and believed to be removed from positions 1 and 2 of the left main landing gear. The fuse plugs were found intact in these wheel assemblies and neither had visual signs of tread defect or abnormality. The wheels exhibited no sign of damage or unusual discrepancy.

The four brakes were identified as PCN 110-9448, MR 32016 and had evidence of wear. The #1 brake (outboard left, serial number 4035) carbon heat sink had some evidence of overheat that was within overhaul limits. The #2 brake (inboard left, serial number 1339) tie bolts had heat discoloration and the thrust plate had wear that exceeded usable limits.

Tire serial numbers 0298S016 and 0014S064 were believed to have been removed from positions 3 and 4 on the right main landing gear.

The number 3 position was marked in red ink on the outboard wheel half for the assembly with tire serial 0298S016. The fuse plugs were not intact for this wheel assembly. (The thermal plug material no longer blocked passage of air.) The assembly had paint burns (scorches) and marks from the exposure to excessive heat. Obvious tire tread damage was visible. The heat shields had visible heat damage.

The #3 (inboard right) brake assembly received the greatest heat damage of the four brakes. The torque tube failed a hardness test, tie bolts were rejected for further use due to discoloration, the thrust plate was rejected for further use due to wear, and the stators were rejected for further use due to thermal oxidation.

The assembly with tire serial 0014S064 had the number “4” written on the outboard wheel half in red ink. The tire tread had skid/flat types of damage in two places at about opposite sides of the periphery. Centered on one of the flat spots, the tread had a large opening that passed to the inside of the tire. The thermal fuse plugs were found intact. There were no signs of excessive heat types of damage found on the heat shield panels.

The #4 (outboard right) brake assembly carbon heat sink showed evidence of overheat, within the overhaul damage limits.

During replacement of the main wheels and tires, no visible damage was found to the axles, retractable portions of the landing gear, to the visible brake assemblies, the brake wear limits had not been reached, or to the structure surrounding the main landing gear.

D.3.6.1 BRAKING AND ANTI-SKID

The anti-skid system is controlled by the braking and steering control unit (BSCU). The **BSCU** is a fully digital dual-channel computer controlling the following functions:

- normal braking system control
- anti-skid control (normal and alternate)
- auto brake function with LO, MED, MAX
- nosewheel steering command processing
- monitoring of all these functions

The brake pressure indication is powered by a 3A circuit breaker (overhead C10, black)

The braking antiskid system utilizes electronic control which would not be available in the EMER ELEC configuration.

When the airplane electrical system is in the EMER ELEC configuration, the anti-skid system is not available. The pilots must regulate how hard the brake pedals are pressed to keep less than a specified level. This minimizes the potential for stopping tire rotation and a potential tire failure. To regulate how hard the pedals are pressed, a hydraulic pressure gage that is mounted near the left knee of the first officer. (See Figure 14)

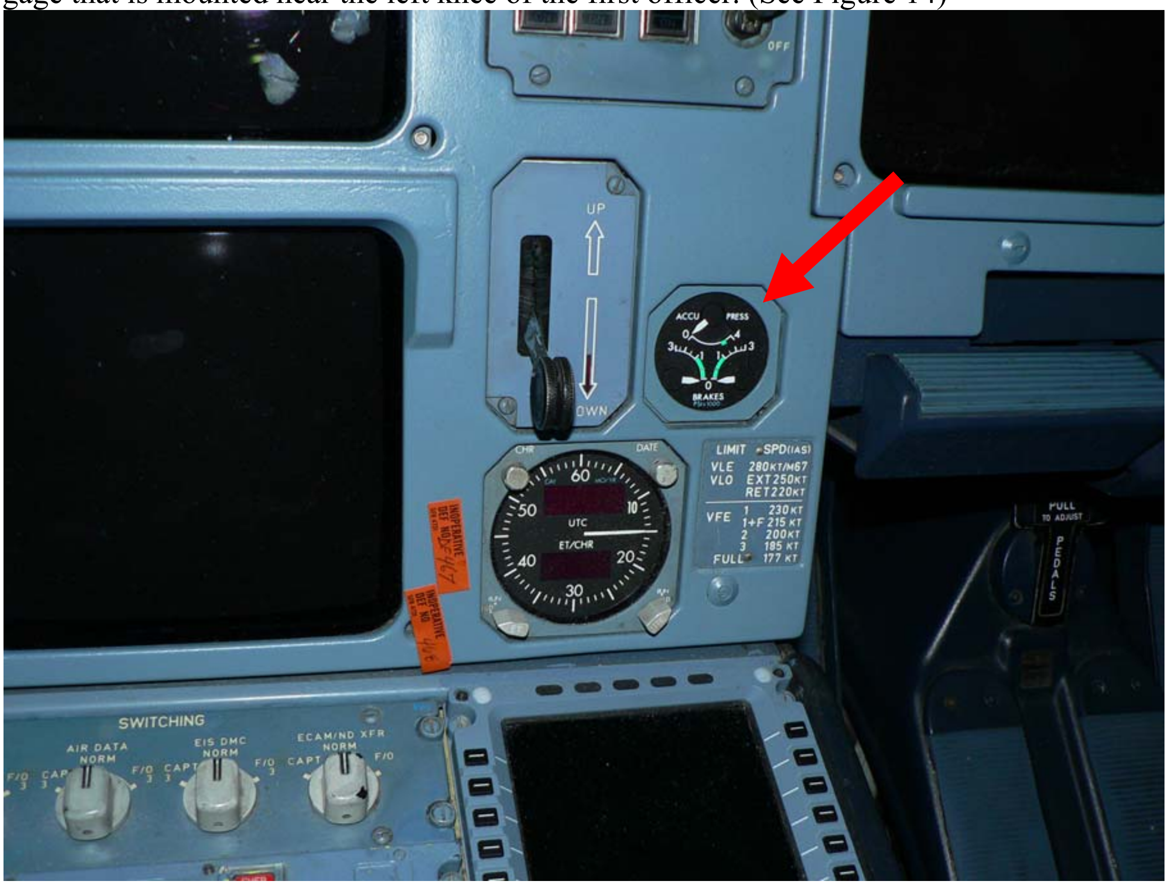


Figure 14. The red arrow points to a gage with three needles that is used to determine brake pressure when landing without the antiskid system.

D.3.7 MISCELLANEOUS:

D.3.7.1AVIONIC EXAMINATIONS

Avionics components were removed from the airplane for component level examination with the following results.

Unit	Part Number	Serial Number	Shop Test Results
AEVC	87292325V06	VL2062001943	No fault found
Centralized Fault Display Interface Unit (CFDIU), also known as the maintenance computer. Made by SFENA/SEXTANT	B401ACM0507	1257	No fault found
FWC	350E017271616	1831	The nonvolatile memory was downloaded. The shop was unable to test the unit due to a faulty CPU2 serial link. The unit failed "MARS" monitor CPU2 test, which is a serial link (communication) between FWC & ATEC (tester). This is only used for testing purposes and does not affect functionality of the FWC when installed on an aircraft.
FWC	350E017271616	1270	No fault found
DMC 1	9615325060	1889	No fault found
DMC 2	9615325060	3900	No fault found
DMC 3	9615325060	1556	No fault found

D.3.7.2 CABIN COMMUNICATIONS AND EMERGENCY EVACUATION SYSTEM

The mechanics stated that when power was first applied to the airplane, they had to turn off the evacuation alarm. When the evacuation alarm was turned back on in a test, the volume was such that investigators could speak over it. Volume is dependent upon a person's distance from the evacuation alarm speakers, which are located at the forward and aft flight attendant stations.

Schematically, the public address (PA) and evacuation alarm systems are both powered by the CIDS (Cabin Intercommunication Data System). The CIDS is powered by the DC Service Buss and DC Essential Buss. The PA system is powered by DC Essential bus 401PP and remains powered when the airplane is in the ELEC EMER condition or when powered by the battery bus.

Airbus personnel noted that automated switching that follows the loss of engine power may result in interruption of PA function and that the function may be restored by hanging up the handset(s) in use and picking them back up. This was not found in training or operating handbooks.

ATTACHMENT 1, PHOTOGRAPHED COCKPIT DOCUMENTS:

```
FLT INFO Ø315-Ø4   TZ L
)FW  Ø8Ø3   :ØØ   41Ø2
)EN  Ø858   :11E

)EN  1126   :ØØ   4278<
)NT  1243   :ØØ

FLIGHT NOT AFFECTED BY
FLOW CONTROL.

IAØ497-Ø4 MSY-SFO 11:58 Ø4/Ø4/11 .N4Ø9UA
----------------------------------------
```

```
RWY DATA-19
UA497 MSYSFO
*F3 BLEEDS ON    *
TOG 154.1P ZFW 12Ø.ØP
REDUCED THRUST OPTIONS
TW   EPR   ATGW   ATEMP
Ø    N/A   N/A    N/A
5    N/A   N/A    N/A
1Ø   N/A   N/A    N/A
MAX EPR: 1.39
R156.2  P17Ø.4  S169.7
T76(24) ALTM 2984I
WIND 1713M
    13KT HW 2KT XW
THR RED 81Ø (8ØØ AFE)
ACC ALT 81Ø (8ØØ AFE)

UAØ497-Ø4 MSY-SFO 11:25 Ø4/Ø4/11 .N4Ø
--------------------------------------
```

```
/C ID     DATE    GMT    FLTN      CITY PAIR
          Ø5APR   2216   497       KMSY KSFO
```

```
   FDU 1
 LAST LEG REPORT
-12-ØØ
IECK FDU ENG1 SUPPLY
```

```
MSY ATIS INFO G 1124Z
SPECIAL. 18Ø14G2ØKT 8SM
FEWØ15 BKNØ25 24/21
A2984 (TWO NINER EIGHT
FOUR). ARRIVALS EXPECT
LOC RWY 19 APCH. DEPG
RWY 19. NOTAMS... RWY 24
CLSD BETWEEN RWY 19 AND
TWY SIERRA. RWY 24 CLSD
BETWEEN TWY GOLF AND RWY
28. TWY G CLSD BTWN TWY
A AND TWY G3 TWY A CLSD
BTWN TWY G AND RWY 1Ø,
TWY G3 CLOSED.. AIRORT
ROTATING BECON OTS. BIRD
ACTIVITY VICINITY ARPT.
...ADVS YOU HAVE INFO G.

UAØ497-Ø4 MSY-SFO 11:57 Ø4/Ø4/11 .N4Ø9U
---------------------------------------
```

```
RLS VERIFICATION
RLS Ø2
MRD IAD Ø1-Ø138Z

UAØ497-Ø4 MSY-SFO 11:23 Ø4/Ø4/11 .N4Ø9L
---------------------------------------
```

497 C5 H 106

DPTR CLRNC
FLT 497-Ø4 MSY - SFO
UAL497 KMSY
A32Ø/Q P12Ø7 RQ36Ø
XPDR 7426

FILED ROUTE****
KMSY LCH J2
IAH./.KSFO
****

REVISED SEGMENT
NONE
****

REMARKS********
NONE
MAINT 4,ØØØ EXP REQ
ALT 1Ø MIN AFT T/O
DEPARTURE FREQUENCY
WILL BE 125.5
****

UAØ497-Ø4 MSY-SFO 11:46 Ø4/Ø4/11 .N4Ø9UA

.HDQWDUA Ø41158/CAN
AGM
AN N4Ø9UA/GL MSY
- FINAL WEIGHT MANIFEST
UA497 MSYSFO
ZFW 12Ø19Ø
ZFWCG 29.8
TOG 15429Ø
TOW CHG+ 1736
MAC 26.8
PSGRS 12/Ø88 -1ØØ-
(12/126) LAP 1
CREW Ø2/Ø3
OMC-NONE
CJA-NONE *SOB 1Ø6*

UAØ497-Ø4 MSY-SFO 11:58 Ø4/Ø4/11 .N4Ø9UA

SFO 48°F

SFO ATIS INFO Z 1Ø56Z.
ØØØØØKT 1ØSM CLR Ø9/Ø3
A3Ø14 (THREE ZERO ONE
FOUR). QUIET BRIDGE VA
IN USE. LNDG RWYS 28L,
28R. DEPG RWYS 1ØL, 1ØR.
NOTAMS... ILS RWY 28L
OTS, RY 28L ALS OTS.
READBACK OF ALL RWY
HOLDING INSTRUCTIONS IS
REQUIRED. ALL ACFT ARE
RQRD TO INCL ACFT CLSGN
IN ALL RDBKS AND ACKMTS.
...ADVS YOU HAVE INFO Z.

UAØ497-Ø4 MSY-SFO 11:22 Ø4/Ø4/11 .N4

MSYDD CHI12
.CHIVAUA 04041018 042453/RIC
UAL497-04 MSY SFO PART 1 OF 1 PARTS

497-04APR11 MSY 1207Z/0707C SFO 1636Z/0936P 04:29
00:15 LATE

~~AMEND *** RLS 02 *** IFR 4709/N409UA CHI12 700-3312~~

********************* DISPATCHER COMMENTS **********************
NO GPS-NO AUTOLAND ANC-NO GCM-PL3020*
ATUG-R:T77 R19 F3I AC A2985
ACF95=:00
SFO-NO SIG WX. ENRT LINE OF WX FRM MI. EVENTUALLY XTENDING
TO TX. PLZ SEE ALL CNVCTVE SIMETS. 1 CAT ALRT BOZ TO LAS.
RLS 2 NEW RTE PLZ CHECK WX CLRNCE

*** ACCOMPLISH FIRST FLIGHT OF THE DAY COCKPIT CHECKS ***

****

UAL497 A320/M 0455 MSY P1207 360 RT: 03J FMCS NO +9.2
KMSY DCT LCH J2 IAH J86 ELP J50 TFD J169 BLH J65 PMD DCT AVE
DCT BSR BSR2 KSFO/0429 (MTN WAVE AVOIDANCE RTE)

BURNOUT	04:29	25.6	
ALTERNATE(S)	00:00	0	
FAR RSV	00:45	3.5	
ACF	00:15	1.2	
HOLD	00:00	0	
EXTRA	00:25	1.8	ENRT
CLEARED	05:54	~~32.1~~ 34.1	

TAXI OUT 00:10 0.3
FAT 01:27 6.5

FAR121.191A2 ENRTE ALTN ELP PHX TUS ONT LAX SFO
(CAPTAIN CONTACT DISPATCH IF TOGW ABOVE 1581)

1766NM 1526/1581 1270/1422 1205 CLB 10-028 MSY 321

RCA	150	36	783	-05	53	455	24044-040	415	26	48	273
ECA	82	36	783	05	53	455	-042	413	12	11	262
RCA	23	38	779	03	53	451	-048	403	03	04	258
IAH	10	38	779	03	53	451	24052-048	403	02	02	256
DCT	236	38	781	03	45	452	25072-065	387	35	34	222
FST	165	38	782	02	40	451	26067-066	385	26	23	199
ELP	178	38	783	02	38	451	28057-057	394	27	25	174
ALIBY	77	38	783	00	38	450	29056-054	396	12	11	163
SSO	79	38	783	-01	39	449	30054-052	397	12	11	152
TFD	139	38	783	-02	41	448	29036-036	412	20	18	134
KOFFA	80	38	783	-02	42	448	30029-029	419	12	10	124
BLH	71	38	783	-02	43	448	30022-020	428	10	08	116

PMD	176	38	783	-02	43	440	01019-003	445	24	21	95
AVE	112	38	783	-01	44	448	02028-007	441	15	13	82
POD	34	38	783	-01	45	448	01030-008	440	05	05	77
SFO	154						23007 000		28	12	65

36	1527	04:28	257	M78
34	1530	04:29	260	M76
32	1536	04:29	266	M76

FL	LCH	IAH	JCT	FST
380	24047-040+03	24052-048+03	25072-065+03	26067-065+02
360	24044-039+05	24047-043+05	25067-062+04	27066-065+04
340	24041-036+03	24042-039+03	26062-058+01	27066-065+02
320	25040-036+05	25042-040+05	26061-057+03	27064-063+03
300	25039-036+06	25042-041+06	25061-056+05	26063-061+04
280	25037-035+06	25040-039+06	25061-056+05	27061-060+04
260	25035-033+06	25038-037+06	25060-054+05	27059-059+05
240	25033-031+07	25036-035+07	25060-053+06	27057-056+06
220	26031-030+08	26033-033+08	25057-050+07	27054-054+07
200	26029-029+09	27031-031+09	25054-046+08	27051-051+08
180	27028-027+10	28030-029+10	24051-042+10	27048-047+09

FL	ELP	MLIBY	SSO	TFD
380	28057-057+02	29056-054+00	30054-052-01	29036-036-02
360	29060-060+05	29057-055+03	30053-051+02	30033-032+02
340	29062-062+03	29058-056+02	30051-049+01	31030-027+01
320	29060-060+03	30054-050+03	31048-043+02	31028-025+03
300	29058-058+03	30051-046+03	32046-036+02	31027-024+04
280	29057-057+04	30050-044+04	33045-035+03	31025-022+06
260	29056-056+05	31048-042+05	33045-035+05	31023-021+08
240	30055-054+06	31047-040+06	33044-033+07	31021-020+10
220	30055-054+07	31047-039+07	33044-034+08	31020-018+10
200	30054-053+08	31048-039+08	33045-035+09	31019-017+10
180	30054-052+09	31048-039+10	32045-036+11	31018-016+11

FL	KOFFA	BLH	PMD	AVE
380	30029-029-02	30022-020-02	01019-003-02	02028-006-01
360	31027-027+02	30019-017+02	01016-004+02	02022-007+03
340	31024-023+01	31016-013+02	36013-005+02	01017-007+03
320	31024-023+03	31016-013+04	34010-007+04	35011-008+05
300	31023-022+04	31016-013+05	30010-009+05	30010-010+06
280	31021-020+06	31014-012+06	29008-008+06	28009-009+07
260	31019-018+08	30012-011+08	27007-007+08	26009-006+08
240	30017-017+10	29010-010+10	25007-005+10	24011-005+10
220	30016-016+10	30010-009+10	00000+000+10	23009-003+10
200	31016-016+10	30009-008+10	00000+000+10	23008-002+10
180	31015-014+11	30009-008+11	00000+000+11	22006+000+11

FL	BSR
380	01030-008-01
360	01023-006+03
340	01017-004+03
320	35011-006+05
300	30008-008+06
280	28008-008+07
260	26009-008+08
240	25011-008+10
220	25010-007+10
200	24008-005+10
180	23007-003+10

****

```
FL    BSR
380   01030-008-01
360   01023-006+03
340   01017-004+03
320   35011-006+05
300   30008-008+06
280   28008-008+07
260   26009-008+08
240   25011-008+10
220   25010-007+10
200   24008-005+10
180   23007-003+10

*************************************************************
*** ENROUTE DRIFTDOWN ***
METHOD II - ENROUTE ALTERNATES
FR ELP
TO SSO              - ELP
TO TFD              - PHX TUS
TO BLH              - TUS PHX NYL
TO PMD              - NYL ONT SAN
TO AVE              - PMD LAX
TO SFO              - SFO PMD
.........................................................................
METHOD I     ---------WEIGHTS---------- -FCST- -MEL REDUCTION-
       TEMP  T-10 T+00 T+10 T+20   T+NA        APPLIED
NORMAL BLD NOT AVAILABLE
ANTI-ICE   NOT AVAILABLE
*************************************************************

POSBD:
GEN     555-11 29MAR11 PLANNED WEIGHT MANIFEST   R:544-11
        551-11 28MAR11 FOM REVISED 01 APR 11
        654-10 21OCT10 VOR/NDB RAW DATA
320     549-11 16MAR11 A320 REVERSER FAULT ECAM
        543-11 04MAR11 FM REVISED 4 MARCH 2011    R:542-11
        666-10 23NOV10 A319/320 ELECTRICAL MALF

CMIDD   RICK JONES
UAL497-04 END OF PART 1

:04041018 106607 0535
```

A/C ID	DATE	GMT	FLTN	CITY PAIR
	05APR	2212	497	KMSY KSFO

PREV LEGS REP →
LEG DATE GMT PH ATA
<00 04APR 1624 01 313334
NO FDIU DATA
<00 04APR 1624 01 341234
NO ADR 1 DATA
<00 04APR 1624 01 315334
NO FWC 1 DATA
<00 04APR 1209 05 261200
CHECK FDU ENG1 SUPPLY
<01 04APR 0229 06 345133
DME-1 INTERROGATOR

PREV LEGS REP →
LEG DATE GMT PH ATA
<01 04APR 0203 05 261200
CHECK FDU ENG1 SUPPLY
<02 03APR 0041 07 345133
DME-1 INTERROGATOR
<02 03APR 2057 05 261200
CHECK FDU ENG1 SUPPLY
<03 03APR 1943 06 216152
P2 RAM AIR OUT ACTUATOR
<03 03APR 1932 05 261200
CHECK FDU ENG1 SUPPLY

PREV LEGS REP →
LEG DATE GMT PH ATA
<04 03APR 1348 05 261200
CHECK FDU ENG1 SUPPLY
<05 03APR 1144 06 228334
AFS:FMGC2
<05 03APR 1004 06 261200
CHECK FDU ENG1 SUPPLY
<06 03APR 0215 05 261200
CHECK FDU ENG1 SUPPLY
<07 02APR 2106 05 261200
CHECK FDU ENG1 SUPPLY

PREV LEGS REP →
LEG DATE GMT PH ATA
<07 02APR 2101 02 275134
SFCC2
<07 02APR 2052 02 732234
DMC3: NO EEC2B DATA
<08 02APR 1615 05 261200
CHECK FDU ENG1 SUPPLY
<08 02APR 1610 02 732234
FWC1 :NO DATA FROM
EEC2B

```
A/C ID     DATE    GMT    FLTN       CITY PAIR
           Ø5APR   2112   497        KMSY KSFO

+--------------------+
|    MAINTENANCE     |
| POST FLIGHT REPORT |
+--------------------+

A/C ID   DATE    GMT        FLTN      CITY PAIR
.N409UA  04APR   1204/1625  497       KMSY KSFO

ECAM WARNING MESSAGES
---------------------
GMT  PH ATA
1210 06 22-00 AUTO FLT A/THR OFF

FAILURE MESSAGES
----------------
                                             SOURCE    IDENT.
GMT  PH ATA
1209 05 26-12-00 CHECK FDU ENG1 SUPPLY        FDU 1
1624 01 31-53-34 NO FWC 1 DATA                CFDS
1624 01 34-12-34 NO ADR 1 DATA                CFDS      ATC 2
                                                        BSCU 2

1624 01 31-33-34 NO FDIU DATA                 CFDS

A/C ID     DATE    GMT    FLTN       CITY PAIR
           Ø5APR   2113   497        KMSY KSFO

LAST LEG REPORT  04APR

<GMT1209 PH05 ATA261200
CHECK FDU ENG1 SUPPLY
<GMT1624 PH01 ATA315334
NO FWC 1 DATA
<GMT1624 PH01 ATA341234
NO ADR 1 DATA
<GMT1624 PH01 ATA313334
NO FDIU DATA

A/C ID     DATE    GMT    FLTN       CITY PAIR
           Ø5APR   2113   497        KMSY KSFO

+--------------------+
|    MAINTENANCE     |
| POST FLIGHT REPORT |
+--------------------+

A/C ID   DATE    GMT        FLTN      CITY PAIR
.N409UA  04APR   1204/1625  497       KMSY KSFO

ECAM WARNING MESSAGES
---------------------
GMT  PH ATA
1210 06 22-00 AUTO FLT A/THR OFF

FAILURE MESSAGES
----------------
GMT  PH ATA                                  SOURCE    IDENT.
```

Purser

While doing the
nouncement (about
e conclusion) the
PA was abruptly cut
off. Also confirmed by other
F/A's
O. tried to CAll Purser
chimes + Call which
Purser did not recieve

ft F/A emergency lights
over doors and all
cabin lights (floor
track + overheads)
illuminated. Lights over
doors went away.
A/C ~~trembling~~ unstable
tremmering
ft F/A tried 3 times
unsuccessful to call Purser

and the cockpit.

Purser was at cockpit door twice
& neither time smelled or saw smoke.

WEIGHT AND BALANCE RECORD

FLIGHT 497

DATE 4-4-11

LOAD PLANNER [redacted]

SECURED BY [redacted]

A COPY OF THIS PAGE SHOULD BE PLACED IN A SEPARATE ENVELOPE TO SECURE WEIGHT AND BALANCE RECORDS.

```
DSTG    497-04APR MSY2/ .../     A./       .....       4051    MAX: *NEED.
PIT LIMIT: .14960 *BAG  78:2400          REAR: .....0 TCG: *NEED.
STAGED WT: ..2400  PAX 12/  / 88  ITEMS: .3 SBY: .0 MIN: *NEED.

          *** CLOSED    - NO FUEL  ***          PHONE: 3715

ITM  AREA  PIT          CNTNR       DST CONTENTS WGT
001  CITY. ...          CITY....... SFO BR....... ....24 (04-1302Z)
        RMKS: 8-PRI........................S63......  SLS: ...

002  CITY. ...          GATE....... SFO B........ .....2 (04-1302Z)
        RMKS: ............................S92......  SLS: ...

003  XFERB ...          TB......... SFO TB....... ....52 (04-1302Z)
        RMKS: 52-CNX,2-HVY,...............S24......  SLS: ...

PART 1 OF 1


:04041320 106605 0091



DDLR  S497-04APR MSY2/ U 4051 DPTR LOADING

ON  A0   M0    X0    F0    Q0    P0   S0   B78  -2400

-MANFWD-  2          3

SFO  B........... BR...........

-MANRER-  4          5          6     THRU   0 TTL   1620

SFO  TB.......... E........... E.......... SFO    0 SFO  1620.

+GATE DLVRY:    Y/Y-N   WCHR:  ../F    ../R    STLR:  02/F    ../R

+AIRCRAFT LOADED BY     073237  - MY FILE NUMBER (FN) CERTIFIES
 THIS AIRCRAFT WAS LOADED IN ACCORDANCE WITH ALL REQUIRED
 PROCEDURES INCLUDING DAMAGE CHECK, PIT CLEARANCE, PIT NETS,
 FLOOR LOCKS,DOORS SECURE, WALK AROUND AND DSTG LOADING LIMITS.

+RMKS:  ...................................................


**************************************************************
                    MAGNETIZED SHIPMENTS
                  **EFFECTIVE IMMEDIATELY**

 SHIPPER'S DECLARATION FOR DANGEROUS GOODS AND ELECTRONIC
 PILOT NOTIFICATION FORM (EPNF) ARE NO LONGER REQUIRED FOR
 MAGNETIZED MATERIALS.

 MAGNETIZED MATERIAL HANDLING LABEL MUST STILL BE ATTACHED
 TO THE SHIPMENT AND SLS CODE "MAG" MUST STILL BE USED

                                      773 TO PID 106605
```

UNITED AIRLINES FUEL SERVICE FORM

DFSF S497-04APR MSY-SFO (4709) 2C 409UA C5 JET A DENS 6.75

EA ..... ED 0707 ISSUE 2 - 0621 04APR *R*
*** REISSUE A/C AFFAM FUEL CHG ***

FINAL REQUESTED FUEL LOAD

TANK	FUEL DISTRIBUTION (LBS) PRE	DSRD	ACTUAL	STICK DESIRED UNITS(D4)	LOC	STICK ACTUAL UNITS	LOC
LEFT MAIN	3950	13850	13850	MAX	5	.....	...
				MAX	4	.....	...
CENTER	Ø	6700	6700	38	CTR	.....	...
RIGHT MAIN	4450	13850	13850	MAX	4	.....	...
				MAX	5	.....	...

TOTAL 8400 TOTAL 34400 DRIPSTICKS CHECKED BY ....

CLEARED FUEL 34100 TRUCK .... GALS ......

TAXI 300

TTL REQUESTED 34400 TRUCK 18189 GALS 3860

TTL FROM TRUCKS 3860

CALC GALS TO BE ADDED 3852

BLOCK FUEL 34400 ~~OR~~ ~~REMOVED~~ ......

PRESERVICE 8400 LIMITS DIFFERENCE +8

TO BE ADDED 26000 IN ✓ OUT ... TOLERANCE + 50/- 50

PROPERLY FUELED. DISCREPANCIES REPORTED. FUEL CAPS INSTALLED.

LIGHTS TESTED AND DOOR CLOSED BY: [redacted] FN. [redacted]

DEFERRED FUEL ITEMS / 4709 (PLACARD TEXT)
NO ITEMS

REMARKS:

CAUTION: PRIOR TO FUELING, ENSURE THE AIRCRAFT HAS SUFFICIENT
CLEARANCE FROM GROUND SUPPORT EQUIPMENT THAT MAY
DAMAGE THE AIRCRAFT AS IT SETTLES.

CHECK ONE: AIRCRAFT FUELED USING MANUAL ...✓ OR AUTOMATIC MODE ....

** WATCH YOUR WEIGHT ** DO NOT EXCEED DESIRED POUNDS

;04041249 106605 0081

QK MSYOOUA
.MSYRMUA 041250 MWGA U192508
UA 497 04APR MSY PAX BY NAME 13 F 91 Y
1.ANTARAN E SFO YK** A8 22A A C ET B O
2.ASEJO A SFO YK** A8 22F A C ET B O
3.BALANQUI\B SFO YK** A8 25F A C ET B O S
4.BEYGUI R SFO YE** 18D A C ET M S
5.BURNS H SFO YF** B2 10A S C07JUN04 EL B D
6.CASABUEN\R SFO YK** A8 25E A C ET B O S
7.CAVIN P SFO YW** C2 17C A C ET B S
8.CHATTO E SFO YK** A8 23A A C ET B O
9.CLOUSTON S SFO YS** 06F A C ET BF O S
10.COLLETT K SFO YT** D2 08E A C ET B O S
11.COLOMBO A SFO FA** 03C A CVGML DOCA ET F S
12.COX H SFO FA** 02B A CDOCA ET S
13.CROSBY W SFO YL ET O
14.CRUISE R SFO YM** 07F A C ET BM O S D
15.CUFF T SFOFNF** 01A A C ET BM* S
16.BUSH P SFO YK**AG2 06B A C ET B O S
17.DIAZ R SFO YK** A8 24F A C ET B O
18.DONATTO K SFO YV** 08C A C ET BM S
19.DROSSMAN L SFO YW** 19F A C ET M S
20.EASTON J SFOFNF** 03B A C ET M* S
21.FANG W SFO FF 020 O
22.FERNANDE\O SFOYXY** E2 07E A C ET S
23.FIELDS D SFO YS** F2 13D A C ET B S
24.FINCH C SFOYXY** G2 13A A C ET M- O S
25.FINCH M SFO YW** 13C A C ET BM O S
26.FOSTER M SFO YW** H2 18B A C ET B O S
27.FOX J SFO YW** I2 20C A C ET M S
28.FREYMAN S SFO YE** 11C A C ET M S D
29.FROST E SFO YV** 15D A C ET BF S
30.GABAIXHI\S SFO YW** J2 15B A CINFT CHLD INF ET B S
31.GABAIXHI\J SFO YW** J2 15A A C ET B S
32.GALLAHER D SFO FA** K2 01D A C ET BF O S
33.GALLAHER S SFO FA** K2 02A A C ET BF O S
34.GILMORE J SFO YG ET O
35.GOULD P SFO YW** I2 20D A C ET F S
36.GOUT A SFO YT** L2 12E A C ET M S
37.GRISHAM G SFO YW C ET M O
38.GROTH A SFO YS** F2 13E A C ET BM S
39.FORMAN J SFO YT** 17A A C ET M S
40.FRANCI K SFO YK**AG2 06A A C ET BM O S
41.HALL A SFO YT** L2 12F A C ET M S
42.HANSON K SFO YT** D2 08F A C ET B O S
43.HILL R SFOYXY** 20F A C ET BM- O S
44.HUI H SFO YL** 16A A C ET B O S
45.KLUG F SFO YW** H2 18A A C ET B O S
46.KRISHNAN G SFOYXY** 09D A C ET M- S
47.KRONENBE\S SFO YS** M2 14D A C ET BM S
48.KRONENBE\C SFO YS** M2 14F A C ET M S
49.KURTZ T SFOFNF** 02C A C ET M* S
50.LENTZ M SFOYXY** N4 16C A C ET M- O S
51.LIEU H SFO YE** 10D A C ET M S D
52.LONG E SFO YV** O2 08A A C ET M S D
53.LOWENBRA\N SFO YV** 12D A
CONTINUED
;04041250 106605 0082

QK MSYOOUA
.MSYRMUA 041250 MWGA U192508
UA 497 04APR MSY PAX BY N
CONTINUED

C			ET F	S							
54.LU	S	SFO	YV**	12C	A	C	ET			S	
55.LYDON	K	SFOYXY**		15C	A	C	ET	M-		S	
56.LIU	B	SFO	YT**	23D	A	C	ET	B	O	S	
57.MACGILLI\A		SFO	YL**AA2	12B	A	C	ET	M	O	S	
58.MAHNKE	L	SFO	YT**	19C	A	C	ET	B	O	S	
59.MARANO	D	SFO	YT**AB2	20B	A	C	ET	B	O	S	
60.MARONI	P	SFO	YT**AB2	20A	A	C	ET	B	O	S	
61.MATHIS	J	SFO	YL**AC2	21A	A	C	ET	B	O	S	
62.MATHIS	N	SFO	YL**AC2	21C	A	C	ET	B	O	S	
63.MAYFIELD	R	SFO	YL**AA2	12A	A	C	ET		O	S	
64.MCCORMIC\R		SFO	YW**AD2	07C	A	C	ET	B		S	
65.MCELROY	A	SFOYXY**AE2		15F	A	C	ET	M-		S	
66.MIMURA	K	SFO	YL**	19E	A	C	ET	BM	O	S	
67.MIRATRIX	L	SFO	YY**	21F	A	C	ET	M-		S	
68.OROSZ	D	SFOYXY**	G2	13B	A	C	ET	B	O	S	
69.PARKER	S	SFO	YW**	09A	A	C	ET	BM	O	S	D
70.PAVLIDIS	J	SFOFNF**		03A	A	C	ET	M*		S	
71.PETERS	G	SFO	YS**	07A	A	CPCFA	ET	M	O	S	D
72.PITTS	P	SFO	YV** O2	08B	A	C	ET	F		S	D
73.POUND	G	SFO	YV**	11F	A	C	ET	F		S	D
74.POWELL	T	SFO	YL**	21D	A	C	ET	BF	O	S	
75.PURVIS	E	SFOYXY**	E2	07D	A	C	ET	BM-		S	
76.PUTZER	N	SFO	FF** B2	03D	S	C07JUN04	EL				
77.NATH	D	SFO	YEX	OFF		C	ET	M	O	S	D
78.RAMSTAD	A	SFO	YT**	14A	A	C	ET		O	S	
79.REDITO	J	SFO	YK**	23F	A	C	ET	B	O		
80.ROBINSON	V	SFOYXY**AE2		15E	A	C	ET			S	
81.ROGERS	M	SFO	YV**	09C	A	C	ET	BM		S	D
82.SANDIFER	S	SFOYXY**		06D	A	C	ET	BM-	O	S	
83.SAWHNEY	T	SFO	YL**	19D	A	C	ET	B	O	S	
84.SCHEU	M	SFO	YV**	11D	A	C	ET	M		S	D
85.SCHEYD	D	SFO	YS**	18C	A	C	ET	BF	O	S	D
86.SCHNEIDE\B		SFOFNF**		01C	A	C	ET	BM*		S	
87.SCHROEDE\J		SFO	YV**	08D	A	C	ET	BM		S	D
88.SHANNON	M	SFO	YV**	17D	A	C	ET	B		S	
89.SILVERS	R	SFO	YY**	17F	A	C	ET	BM-		S	
90.SRIHARI	M	SFO	YL**	09E	A	C	ET	M-		S	
91.STORLAZZ\S		SFO	YW**AD2	07B	A	CCHLD	ET	B		S	
92.STULL	C	SFOFXF**		02D	A	C	ET	M-		S	
93.SUERO	R	SFO	YK** A8	25A	A	C	ET	B	O		
94.SUZUKI	T	SFO	FA**	01B	A	C	ET	M	O	S	
95.THOMPSON	M	SFO	YW** C2	17B	A	C	ET	B		S	
96.TOMAS	M	SFO	YK** A8	19A	A	C	ET	B	O		
97.TROUPIN	B	SFO	YV**	11A	A	C	ET	M		S	D
98.URASHIMA	M	SFO	YW**	06C	A	C	ET	BF		S	
99.WESTWICK	C	SFOYXY**	N4	16F	A	CCHLD	ET		O	S	
100.WESTWICK	D	SFOYXY**	N4	16E	A	CCHLD	ET		O	S	
101.WESTWICK	F	SFOYXY**	N4	16D	A	C	ET		O	S	
102.WINANS	D	SFO	YV**	18F	A	C	ET	B	O		
103.WOODS	J	SFO	YV**	22D	A	C	ET	B		S	
104.YANG	J	SFO	YM**	26F	A	C	ET		O		

END NAMES
;04041250 106605 0083

SMOKE/FIRE/FUMES

- Oxygen masks and regulators .... On, 100%
- Crew and flight attendant communications .... Establish
- Cabin fans switch .... Off
- Blower switch .... Override
- Extract switch .... Override
- Galley/galley and cabin switch .... Off
- Cabin signs .... On
- Descent .... Initiate

WARNING: *Do not delay landing to complete the remainder of this procedure.*

CONTINUED FROM QRC

Diversion may be needed.
If dense smoke at any time, accomplish reverse side.

REFERENCE ACTION:

<u>If cabin or galley equipment smoke/fire is suspected:</u>

- Emergency exit light switch .... On

<u>If commercial switch installed:</u>

- Commercial switch .... Off

<u>If commercial switch is not installed:</u>

- Bus tie switch .... Off
- Generator 2 switch .... Off

Just before landing gear extension:

- Generator 2 switch .... On
- Bus tie switch .... Auto

---------- ***END OF CABIN OR GALLEY EQUIPMENT SMOKE*** ----------

<u>If air conditioning smoke is suspected:</u>

- APU bleed switch .... Off
- Blower switch .... Auto
- Extract switch .... Auto
- Cargo heat aft isolation valve switch .... Off
- Pack 1 switch .... Off

If smoke does not decrease:

- Pack 1 switch .... On
- Pack 2 switch .... Off

If smoke persists:

- Pack 2 switch .... On
- Blower switch .... Override
- Extract switch .... Override

---------- ***END OF AIR CONDITIONING SMOKE*** ----------

<u>If electrical or avionics smoke is suspected:</u>

Accomplish <u>AVIONICS SMOKE</u> ECAM or Flight Manual procedure.

---------- ***END OF ELECTRICAL OR AVIONICS SMOKE*** ----------

<u>If lavatory smoke/fire is suspected:</u>

Accomplish Lavatory Smoke/Fire Flight Manual procedure.

---------- ***END OF LAVATORY SMOKE/FIRE*** ----------

DENSE SMOKE

WARNING: *Accomplish this side after fire has been extinguished or smoke is so dense that it is an emergency in and of itself.*

EMERGENCY DESCENT
- FCU altitude (safe altitude/10,000 feet) . . . . Set
- FCU expedite switch . . . . Push
- Target speed . . . . Confirm, .80M/340KIAS
- Thrust . . . . Confirm, idle
- Speed brakes . . . . Extend
- ATC . . . . Advise

SMOKE REMOVAL
- Pack flow selector . . . . High
- Landing elevation selector . . . . Safe altitude/10,000 feet

When at safe altitude/10,000 feet:
- APU master switch (if in emergency electrical config) . . . . . . On
- Pack switches 1 + 2 . . . . Off
- Cabin pressure mode selector . . . . Manual
- Manual vertical speed control switch . . . . Full up

When differential pressure is less than 1 PSI:
- Ram air switch . . . . On
- APU master switch . . . . Off

If cockpit smoke requires a cockpit window to be opened:
- Maximum speed . . . . 200 KIAS
- Headsets . . . . On
- Cockpit window . . . . Open

EMERGENCY ELECTRICAL CONFIGURATION (If Required)
- Emergency electrical generator 1 line switch . . . . Off
- Emergency electrical power switch . . . . Manual on

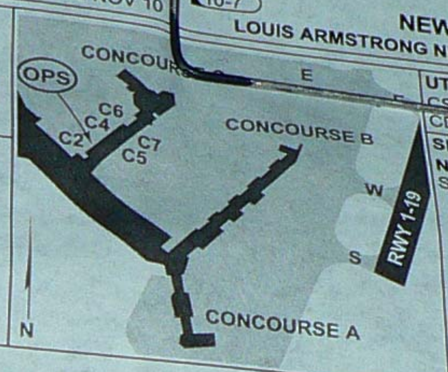
When emergency generator available:
- APU generator switch . . . . Off
- Generator 2 switch . . . . Off

Just before landing gear extension:
- Generator 2 switch . . . . On
- Emergency electrical generator 1 line switch . . . . On

---------------- CHECKLIST COMPLETE ----------------

POSITION
Elevation
4 feet
Gate Coords/FMCS
N29 - 59.1
W090 - 15.4/ALL

PUSHBACK
Advise Ground prior to pushback



UTC
CST + 6 = UTC
CDT + 5 = UTC

SPECIAL ITEMS
Noise Abatement
See below

FREQUENCIES
Operations . . . . 131.07 RDI capability
ARINC (Airborne only) . . . 131.17 (no coverage below 20,000 feet)

ARRIVAL/DEPARTURE

1. **Takeoff and Landing** Simultaneous takeoff and landing operations are conducted to intersecting runways in dry VMC conditions. With airplanes departing simultaneously on runway 10/19, both airplanes must acknowledge traffic information. Advise ATC if the full runway length is required.
2. **Taxiway E** Use caution on taxiway, due to a large bump west of taxiway A.
3. **Jetblast** Beware of possible jetblast during simultaneous intersecting runway operations.
4. **Gate C6** ACARS reception problems may be experienced due to antenna location and dead spots.

ARRIVAL

1. **Runway 19 Visual Approach** On a visual approach to runway 19, turn final before crossing the shoreline.
2. **Runway 10** Runway 10 approach is over a swamp. Poor visual cues at night.

DEPARTURE

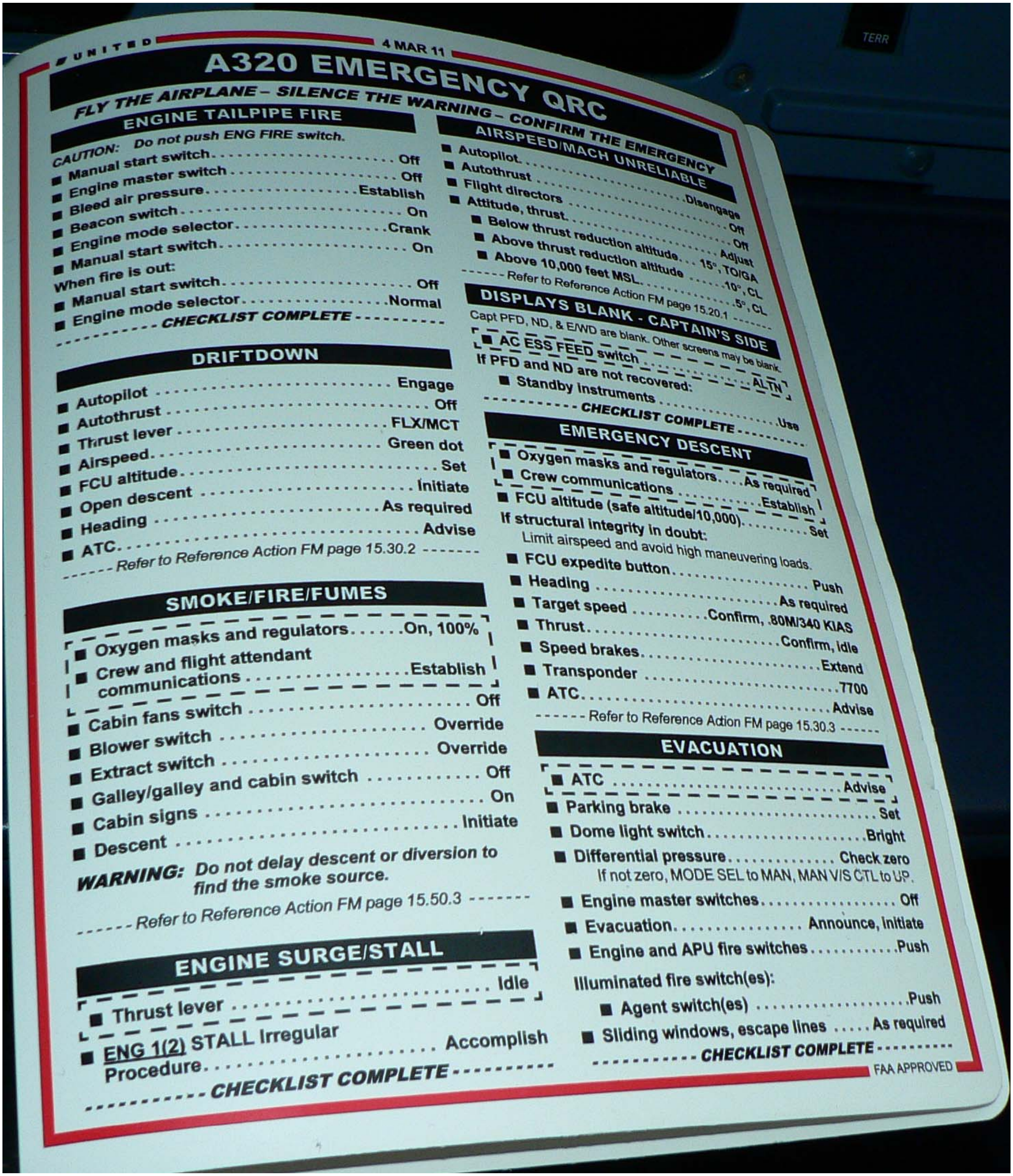
1. **VOR Caution** VOR test may not work at gates C2, C4, and C6.
2. **Noise Abatement** Runways 19 and 28 are preferred for takeoff. Advise Ground if runway 1 or 10 is required.

MISCELLANEOUS

1. **Flight Operations Location** Ramp level below gate C4.

DIVERSION AIRPORTS

Station	Name	Bearing	Distance	Runway	Length	Approach
NBG/KNBG	New Orleans NAS	124°	15	4/22	8000'	ILS/NDB
BTR/KBTR	Baton Rouge	302°	55	4/22	7000'	ILS
GPT/KGPT	Gulf Port	065°	66	13/31	9002'	ILS



UNITED — 4 MAR 11

A320 EMERGENCY QRC

FLY THE AIRPLANE – SILENCE THE WARNING – CONFIRM THE EMERGENCY

ENGINE TAILPIPE FIRE

CAUTION: *Do not push ENG FIRE switch.*

- ■ Manual start switch .... Off
- ■ Engine master switch .... Off
- ■ Bleed air pressure .... Establish
- ■ Beacon switch .... On
- ■ Engine mode selector .... Crank
- ■ Manual start switch .... On

When fire is out:

- ■ Manual start switch .... Off
- ■ Engine mode selector .... Normal

---------- ***CHECKLIST COMPLETE*** ----------

DRIFTDOWN

- ■ Autopilot .... Engage
- ■ Autothrust .... Off
- ■ Thrust lever .... FLX/MCT
- ■ Airspeed .... Green dot
- ■ FCU altitude .... Set
- ■ Open descent .... Initiate
- ■ Heading .... As required
- ■ ATC .... Advise

------ *Refer to Reference Action FM page 15.30.2* ------

SMOKE/FIRE/FUMES

- ■ Oxygen masks and regulators .... On, 100%
- ■ Crew and flight attendant communications .... Establish
- ■ Cabin fans switch .... Off
- ■ Blower switch .... Override
- ■ Extract switch .... Override
- ■ Galley/galley and cabin switch .... Off
- ■ Cabin signs .... On
- ■ Descent .... Initiate

WARNING: ***Do not delay descent or diversion to find the smoke source.***

------ *Refer to Reference Action FM page 15.50.3* ------

ENGINE SURGE/STALL

- ■ Thrust lever .... Idle
- ■ ENG 1(2) STALL Irregular Procedure .... Accomplish

---------- ***CHECKLIST COMPLETE*** ----------

AIRSPEED/MACH UNRELIABLE

- ■ Autopilot .... Disengage
- ■ Autothrust .... Off
- ■ Flight directors .... Off
- ■ Attitude, thrust .... Adjust
  - ■ Below thrust reduction altitude .... 15°, TO/GA
  - ■ Above thrust reduction altitude .... 10°, CL
  - ■ Above 10,000 feet MSL .... 5°, CL

------ Refer to Reference Action FM page 15.20.1 ------

DISPLAYS BLANK - CAPTAIN'S SIDE

Capt PFD, ND, & E/WD are blank. Other screens may be blank.

- ■ AC ESS FEED switch .... ALTN

If PFD and ND are not recovered:

- ■ Standby instruments .... Use

---------- ***CHECKLIST COMPLETE*** ----------

EMERGENCY DESCENT

- ■ Oxygen masks and regulators .... As required
- ■ Crew communications .... Establish
- ■ FCU altitude (safe altitude/10,000) .... Set

If structural integrity in doubt:

Limit airspeed and avoid high maneuvering loads.

- ■ FCU expedite button .... Push
- ■ Heading .... As required
- ■ Target speed .... Confirm, .80M/340 KIAS
- ■ Thrust .... Confirm, idle
- ■ Speed brakes .... Extend
- ■ Transponder 7700
- ■ ATC .... Advise

------ Refer to Reference Action FM page 15.30.3 ------

EVACUATION

- ■ ATC .... Advise
- ■ Parking brake .... Set
- ■ Dome light switch .... Bright
- ■ Differential pressure .... Check zero

  If not zero, MODE SEL to MAN, MAN V/S CTL to UP.
- ■ Engine master switches .... Off
- ■ Evacuation .... Announce, initiate
- ■ Engine and APU fire switches .... Push

Illuminated fire switch(es):

- ■ Agent switch(es) .... Push
- ■ Sliding windows, escape lines .... As required

---------- ***CHECKLIST COMPLETE*** ----------

FAA APPROVED

UNITED

A320 NORMAL CHECKLISTS

4 MAR 11

BEFORE START CHECKLIST

CHALLENGE [F] — **RESPONSE**

- Departure briefing . . . . Complete [C]
- FMGCs, radios . . . . Programmed, set, verified [C, F]
- ADIRS . . . . Nav, aligned [C]
- Fuel panel . . . . ____ Pumps on, crossfeed closed [C]
- Fuel qty, distribution . . . . ___lbs, cleared with ___lbs [C], Verified [C, F]
- Cabin signs . . . . On [C]
- Oxygen check . . . . Complete [C, F]
- Engine master switches . . . . Off [C]
- Parking brake . . . . Set, pressure normal [C]
- Altimeters . . . . _____ In/hPa, set [C, F]
- Airspeed . . . . Gross wt ___, flaps __, (V_1) __, (V_R) __, (V_2) __, set [C, F]

--- ***FINAL ITEM*** ---

- NW STRG DISC message . . . . Displayed/not required [C]

--- ***CHECKLIST COMPLETE*** ---

BEFORE PUSHBACK CHECKLIST

CHALLENGE [F] — **RESPONSE**

- Sliding windows . . . . Closed, locked [C, F]
- Doors, slides . . . . Closed, armed [C]
- Cabin preparation . . . . Complete [C]

--- ***CHECKLIST COMPLETE*** ---

BEFORE TAKEOFF CHECKLIST

CHALLENGE [F] — **RESPONSE**

- Control check . . . . Complete [C, F]
- Engine anti-ice . . . . On/off [C]
- Autobrakes . . . . Max [C]
- Flaps . . . . _____ Planned, _____ indicated, detent [C]
- Engine mode selector . . . . Normal/ignition start [C]

--- ***MANIFEST CHANGES*** ---

- TOW change ____, speeds . . . . Checked [F], Set [C, F]
- Trim . . . . _____ %, Zero, set [F]
- FMGCs . . . . Runway ____, (dep) ____, (trans) ____, set [F], Set [C]
- EGPWS, radar displays . . . . Terrain/weather [C, F]
- PWS . . . . Auto [F]
- Thrust . . . . _____ Flex / TO/GA EPR, set [C]
- FCU . . . . . . Managed speed, heading _____/nav, altitude _____, set [C]
- Takeoff configuration . . . . Normal [F]
- ECAM status check . . . . Complete [F]

--- ***FINAL ITEMS*** ---

- Cabin notification . . . . Complete [F]
- Transponder . . . . Traffic [F]
- Takeoff memo . . . . Green [F]

--- ***CHECKLIST COMPLETE*** ---

AFTER TAKEOFF CHECKLIST

(To be checked ALOUD by the pilot monitoring)

- Landing gear . . . . Up
- Flaps . . . . Up
- ECAM memo . . . . Checked

--- ***CHECKLIST COMPLETE*** ---

APPROACH DESCENT CHECKLIST

(To be checked ALOUD by the pilot monitoring)

- Approach briefing . . . . Complete
- FMGCs, radios . . . . Programmed, set for approach
- EGPWS, radar displays . . . . Terrain/weather
- ECAM status check . . . . Complete
- Autobrakes . . . . Lo/med/off

--- ***TRANSITION LEVEL*** ---

- Altimeters . . . . _____ In/hPa, set

--- ***CHECKLIST COMPLETE*** ---

FINAL DESCENT CHECKLIST

(To be checked ALOUD by the pilot monitoring)

- Cabin notification . . . . Complete
- Landing gear . . . . Down, 3 green lights
- Spoilers . . . . Armed
- Flaps . . . . _____ Planned, _____ indicated

--- ***CHECKLIST COMPLETE*** ---

PARKING CHECKLIST

CHALLENGE [F] — **RESPONSE [C]**

- Parking brake . . . . Set, pressure normal/off
- Slides . . . . Disarmed
- Engine master switches . . . . Off, fuel flow zero
- Engine mode selector . . . . Normal
- Radar . . . . Off
- PWS . . . . Off
- Spoilers . . . . Disarmed
- Transponder . . . . Standby
- Emergency exit lights . . . . Off
- Anti-ice . . . . Off
- Fuel pumps . . . . Off
- ADIRS . . . . Off

--- ***CHECKLIST COMPLETE*** ---

REFER TO THE NORMALS CHAPTER TO SECURE THE AIRPLANE

UNITED

A320 LANDING DISTANCE NORMAL CONFIGURATION

4 MAR 11

This chart is for normal landings (i.e., no failures affecting approach configuration/speed or stopping capability). For landing distance with failures, see Flight Manual Landing Performance chapter, Approach/Landing Corrections for Failures.

Note: *For detailed correlations between braking action reports, Mu, and runway contamination types, see FOM.*

Condition(s):

- Both engines operating
- Zero wind
- Max reverse thrust
- Standard temperature
- $V_{APP\ MAN}$
- V_{LS} at threshold
- Touchdown within first 1000'
- Ground spoilers

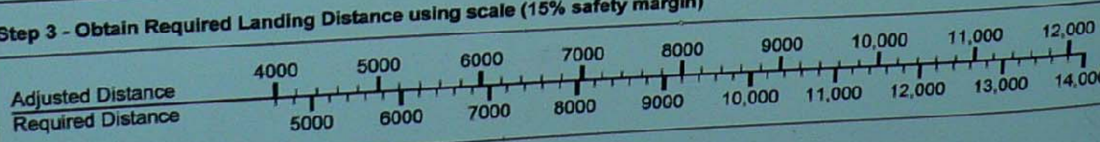
Step 1 - Obtain Actual Landing Distance

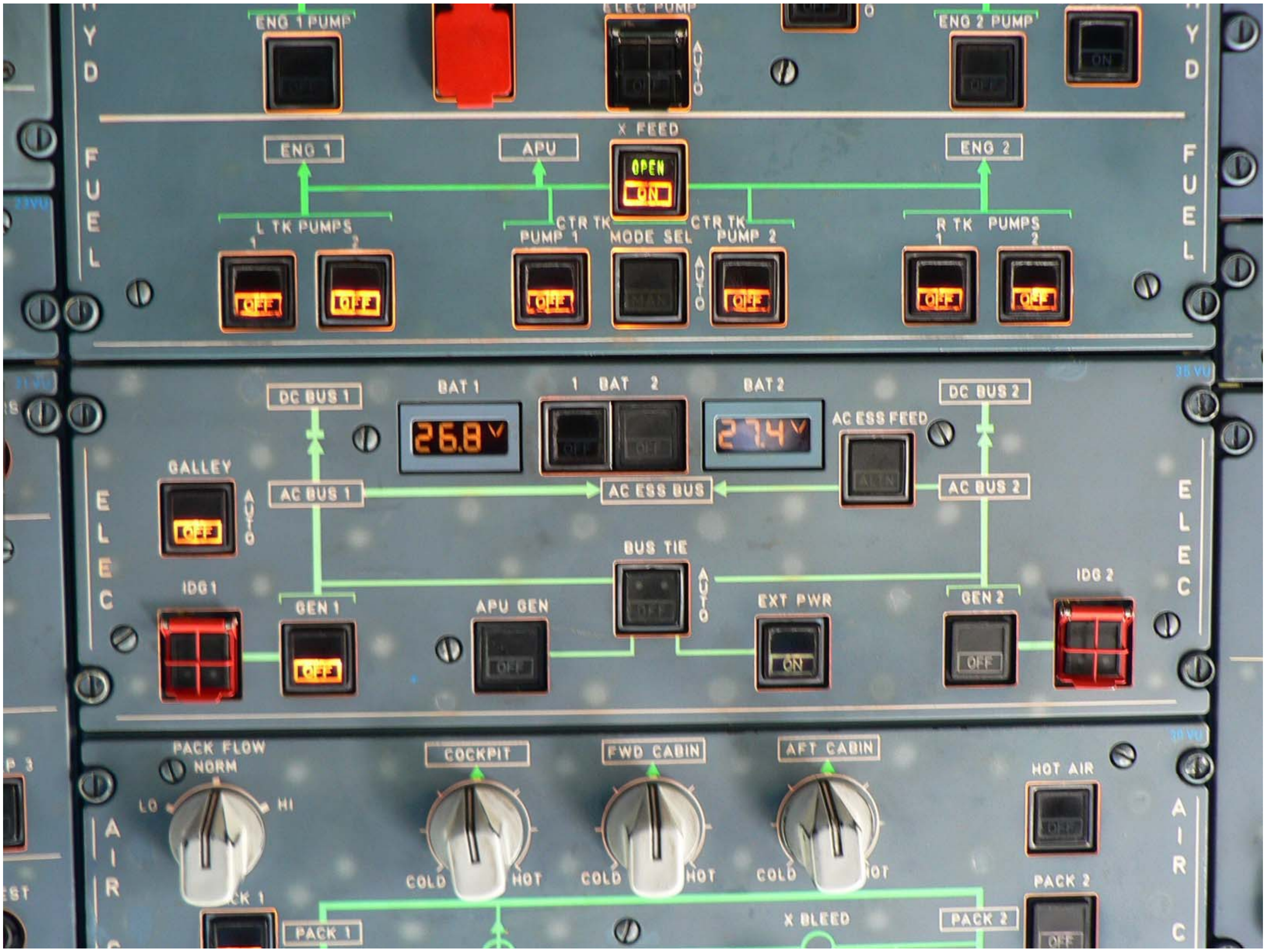
Flaps	Braking Action	Autobrake Setting	Gross Weight (1000 pounds) ≤ 110.0	120.0	130.0	140.0	150.0	160.0	170.0	Add for Reverser(s) Inoperative
			Actual Landing Distance (feet)							
Full	Dry	Lo	4800	5200	5500	5900	6200	6500	6900	0
		Med	3300	3500	3700	3900	4200	4400	4600	0
		Off (Max Manual)	2300	2400	2500	2700	2900	3200	3500	140
	Good (Wet)	Lo	4800	5200	5500	5900	6200	6500	6900	60
		Med	3300	3600	3800	4100	4300	4600	4800	0
		Off (Max Manual)	2800	3000	3200	3400	3700	3900	4100	420
	Medium (Snow)	Lo	4800	5200	5500	5900	6200	6500	6900	60
		Med	3700	3900	4200	4400	4700	4900	5100	490
		Off (Max Manual)	3600	3800	4000	4300	4500	4700	4900	530
	Poor (Ice)	Lo	5700	6100	6500	6900	7300	7700	8100	1940
		Med	5400	5800	6300	6700	7100	7400	7800	2100
		Off (Max Manual)	5400	5800	6200	6600	7000	7400	7800	2090
3	Dry	Lo	5200	5500	5900	6200	6600	7000	7300	0
		Med	3500	3700	3900	4200	4400	4600	4800	0
		Off (Max Manual)	2400	2500	2600	2900	3200	3500	3800	150
	Good (Wet)	Lo	5200	5500	5900	6200	6600	7000	7300	60
		Med	3600	3800	4100	4400	4700	5000	5300	40
		Off (Max Manual)	3000	3200	3500	3700	4000	4300	4500	510
	Medium (Snow)	Lo	5200	5500	5900	6200	6600	7000	7300	60
		Med	3900	4100	4400	4700	4900	5200	5400	630
		Off (Max Manual)	3800	4000	4300	4500	4800	5000	5300	620
	Poor (Ice)	Lo	6100	6600	7100	7500	8000	8400	8800	2630
		Med	6000	6400	6900	7300	7800	8200	8600	2700
		Off (Max Manual)	5900	6400	6800	7300	7700	8200	8600	2690

Step 2 - Obtain Adjusted Landing Distance

Adjustment(s)	Gross Weight ≤ 140,000 pounds – Braking Action: Dry	Good (Wet)	Medium (Snow)	Poor (Ice)	Gross Weight > 140,000 pounds – Braking Action: Dry	Good (Wet)	Medium (Snow)	Poor (Ice)
For each 1000 feet above SL	150	190	200	420	180	230	240	490
For each knot of tailwind	80	90	90	180	90	110	100	220
For each knot above V_{LS}	70	80	80	120	90	90	100	140
For autoland (Med autobrakes)	600	600	600	600	600	600	600	600

Step 3 - Obtain Required Landing Distance using scale (15% safety margin)




HYD
ENG 1 PUMP
ELEC PUMP
ENG 2 PUMPS
FUEL
ENG 1
APU
X FEED
OPEN
ON
ENG 2
L TK PUMPS
CTR TK PUMP 1
MODE SEL
CTR TK PUMP 2
R TK PUMPS
OFF
MAN
AUTO
ELEC
DC BUS 1
BAT 1
26.8 V
1 BAT 2
BAT 2
27.4 V
DC BUS 2
AC ESS FEED
GALLEY
AC BUS 1
AC ESS BUS
AC BUS 2
BUS TIE
IDG 1
GEN 1
APU GEN
EXT PWR
GEN 2
IDG 2
ON
AIR
PACK FLOW
NORM
LO
HI
COCKPIT
FWD CABIN
AFT CABIN
COLD
HOT
HOT AIR
PACK 1
X BLEED
PACK 2


ADR 1
ADR 3
ADR 2
FUEL
FLT CTL
ELAC 1
SEC 1
FAC 1
OFF
COMMAND
EVAC
HORN SHUT OFF
EMER GEN TEST
EMER ELEC PWR
GEN 1 LINE
RAT & EMER GEN
MAN ON
AUTO
ELEC
GALLEY
IDG 1
GPWS
SYS
FAULT
G/S MODE
FLAP MODE
LDG FLAP 3

ATTACHMENT 2, A320 CERTIFICATION SPECIAL CONDITIONS

SELECTED TEXT FROM SPECIAL CONDITION:

Non-pertinent text has been deleted about aerodynamic conditions, handling properties, etc.

Type Certificate A28NM

Special Conditions No. 25-ANM-23]: Airbus Industrie Model A320 Series Airplane

EFFECTIVE DATE: December 15, 1988.

Background

On February 7, 1984, Airbus Industrie, 1 Rond Point Maurice Bellonte, 31707 Blagnac Cedex, France, applied for type certification of their Model A320 by the Direction Generale de l'Aviation Civile (DGAC) under the provisions of Joint Airworthiness Requirements-25 (JAR-25) and by the FAA under the provisions of § 21.29 of the FAR and an existing bilateral airworthiness agreement with the government of France.

The bilateral agreement was reached in 1973 to facilitate French acceptance of aeronautical products exported from this country and reciprocal U.S. acceptance of such products imported from France. The bilateral agreement provides, in part, for U.S. acceptance of certification by the DGAC that the Model A320 complies with the applicable U.S. laws, regulations and requirements, or with the applicable French laws, regulations and requirements, plus any additional requirements the U.S. finds necessary to ensure that the Model A320 meets a level of safety equivalent to that provided by the applicable U.S. laws, regulations and requirements. The DGAC has elected to certify that the Model A320 complies with the French laws, regulations and requirements, plus any necessary special requirements.

The DGAC has advised that the French laws, regulations and requirements applicable to the Model A320 (i.e. the French type certification basis) consist of JAR-25 with changes 1 through 11 thereto and including the French National Variants, Joint Airworthiness Requirements-All Weather Operation (JAR-AWO), and Special Conditions and interpretations applied specifically to the Model A320. JAR-25 is a document developed jointly and accepted by the airworthiness authorities of various European countries, including France, for type certification of large airplanes. JAR-25 is based on Part 25 of the FAR, however there are certain specified differences in the requirements of the two documents. In addition, JAR-25 also contains requirements, known as National Variants, that are peculiar to individual accepting countries. "Orange Papers" are interim amendments which are eventually consolidated as a change to JAR-25. Special conditions are also applied where JAR-25 does not contain adequate or appropriate safety standards due to novel or unusual design features. In order to preclude confusion, these special conditions will be referred to herein as the "French Special Conditions." JAR-AWO contains additional requirements applicable to all weather operations.

[Deleted text]

Based on the February 7,1984, date of application for type certificate, the applicable U.S. laws, regulations and requirements, as established under the provisions of §§ 21.17 and 21.29 of the FAR, are Part 25 of the FAR with Amendments 25-1 through 25-56 thereto and the special conditions contained herein. When the applicable regulations do not contain adequate or appropriate safety standards because of a novel or unusual design feature, special conditions are prescribed under the provisions of § 21.16 of the FAR in order to establish a level of safety equivalent to that established in the regulations.

A comparison has been made of the French type certification basis and the above noted U.S. laws, regulations and requirements, including the respective French and U.S. special conditions. Based on this comparison, the FAA has prescribed the additional requirements that are necessary to ensure that the Model A320 meets a level of safety equivalent to that provided by the U.S. laws, regulations and requirements.

[deleted text]
The French type certification basis, together with the additional requirements discussed above, Part 36 of the FAR SFAR 27, and the Noise Control Act of 1972, will comprise the U.S. type certification basis for the Model A320.

A320 Design Features

General

The Model A320 airplane presented for U.S. type certification is a short to medium-range, twin-turbofan, transport category airplane with a seating capacity of 120 to 179 passengers, a maximum takeoff weight of 162,037 pounds, and a maximum operating altitude of 39,000 feet.

[deleted text]

The model A320 utilizes fly-by-wire (FBW) flight controls for the elevators, ailerons, spoilers, tailplane trim, slats and flaps, speed brakes, trim in yaw, and engine control. The aerodynamic surfaces are positioned relative to the pilot's command by electronic signals sent via airplane wiring from the flight control computers to hydraulic actuators. Conventional mechanical control is provided for the rudder and tailplane trim hydraulic actuators. Should a short-term interrupt occur in the electronic flight controls, flight could be maintained for a period of time through the use of mechanical control of rudder and airplane trim.

Normal electrical power is supplied by a constant frequency generator on each engine. An auxiliary power unit (APU) driven electrical generator is also available. A continuous source of electrical power is required by the A320 fly-by-wire flight controls. In the event of the loss of normal electrical power, a ram air turbine (RAT) is automatically deployed.

The RAT provides hydraulic power which is used by a constant frequency generator to supply electrical power. Until the RAT powered generator comes on line (approximately 7 seconds), the flight control system is powered from the airplane's batteries. RAT deployment may also be selected manually by pushing switches either on the electrical or the hydraulic overhead panel. Hydraulic power to the flight control system is simultaneously provided by three independent hydraulic systems. Functions are shared among these systems in order to ensure airplane control in the event of loss of one or two systems. Two of the systems are pressurized by variable displacement pumps driven by the engine accessory gearbox, and the third system is powered by an electrically driven pump or by the RAT hydraulic pump in case of loss of normal electrical power.

The airplane has two basic engine configurations: the SNECMA-General Electric CFM56-5 engines, and the International Aero Engines; (IAE) V2500 engines. Both engine types have a takeoff rating of 25,000 pounds of thrust (sea level, static). The engine control system consists of a dual channel Full Authority Digital Engine Control (FADEC) mounted on the fan case of each engine. Each FADEC interfaces with various airplane computer systems. The FADEC provides gas generator control engine limit protection, power management, thrust reverser control, and engine parameter inputs for the flight deck displays. In addition to control of the engines from the flight deck through changes in power lever position, an autothrust mode is provided which commands thrust changes directly to the FADEC without a corresponding range in power lever position. In this mode of operation, the position of the power lever sets the upper limit for thrust, except when alpha floor is reached. At alpha floor, the engines are commanded to full thrust, regardless of lever position, as part of the high angle-of-attack (AOA) protection. The autothrust mode can be disengaged by pushing a button on the power lever or by moving the thrust lever to TOGA or IDLE. The engine FADEC and associated airplane related systems form the complete propulsion control systems.

Pitch and roll control inputs are made through flight deck side stick controllers mounted on the lateral consoles of the pilot and copilot positions, in place of central control columns. The flight instruments are displayed on six cathode ray tube (CRT) displays. Two CRTs are mounted directly in front of both the pilot and copilot and display primary flight instruments and navigational information. The other two CRTs are located in the center of the instrument panel and display engine parameters, warnings, and system diagnostics.

The proposed type design of the A320 contains novel or unusual design features not envisioned by the applicable Part 25 airworthiness standards and therefore special conditions are considered necessary.

Discussion of Comments

Notice of Proposed Special Conditions No. SC-87-5-NM for the Airbus Industrie Model A320 series airplanes was published in the Federal Register on October 19, 1987 (52 FR 38772).

Some of the comments received were of an editorial or clarifying nature and have been incorporated where appropriate. A discussion of the remainder of the comments follows, corresponding to the specific special condition as proposed in Notice No. SC-87-5-NM.

1. *Electronic Flight Controls*

Paragraph 1(a). One Commenter expresses concern about the electrical power availability for the flight test instrumentation while the test is being conducted without the availability of normal electrical power sources. The FAA acknowledges these concerns. The test configuration must be tailored to the airplane and the electrical power demands for the flight instrumentation.

One commenter states that the compliance section should provide guidance on the test duration. The FAA agrees. The duration of the test demonstration after the loss of normal engine generated electrical power may be negotiated with the FAA on a case-by-case basis for test durations greater than 4 hours.

Another commenter proposes a clearer definition of normal and standby power. The FAA does not believe that the special condition wording should be changed but provides the following discussion for clarification for this commenter. Normal engine generated electrical power includes power supplied by the engine driven generators. Standby electrical power includes other means to generate electrical power on demand using, for example, Auxiliary Power Unit (APU) generators, Ram Air Turbine (RAT) driven generators, Hydraulic Motor Generators (HMG), etc. Batteries are time-limited emergency power sources.

One commander suggests the FAA retain §§ 25.1351(d) (1), (2), and (3) in conjunction with this special condition. The FAA disagrees because of the reference made to a time period of not less than five minutes. This is no longer relevant with modern aircraft designs.

One commoner suggests a clarification of the parenthetical sentence under the discussion. The FAA agrees and proposes "A reasonable assumption can be made that transport airplanes will not have to remain in IMC for more than 30 minutes after experiencing the lose of normal electrical power,"

Another commenter suggests that after 30 minutes in IMC, the airplane should be capable of continuous flight in VMC for a time sufficient to reach an alternate airport. The FAA disagrees because it is not feasible to so estimate what that time might be, in view of airline service on a world-wide basis and the variety of factors that affect routes and schedules. The FAA maintains that electrical power availability must parallel flight endurance.

One commenter requests further clarification about flight following loss of normal electrical power. The FAA requires, that after 30 minutes of operation in IMC, the airplane should be demonstrated to be capable of continuous safe flight and landing in VMC. The length of time in VMC conditions must be computed based on the maximum flight duration capability for which the airplane is being certified. Consideration for speed reductions from the associated failure must be made and supported by performance calculations and a failure analysis.

Paragraph 1(b(1)(i). One commenter suggests the removal of the words "when the failure or malfunctions occur within the operational flight envelope." The FAA agrees that this requirement could be too severe in cases of extreme failure combinations and flight envelope conditions. The words "operational flight envelope" have therefore been removed from the special condition. However, to ensure that the intent of the special condition is maintained, the manufacturer must present a document for FAA approval which contains: failure cases based on a failure analysis of the systems that affect the flight control systems, details of the analysis which was conducted to support the flying qualities, a listing of flight configurations with simulated faults, an overall description of the test facilities, and methodology used to validate the aerodynamic models used in the simulation.

Paragraph 1(b)(1)(i)(B). One commenter requests clarification of the wording of this paragraph. The FAA has revised the special condition to require that the airplane must be able to withstand the transient loads induced by the failure multiplied by a safety factor. It is further noted that acceptable airplane loads are defined under Special Condition 2(c). The factor of safely varies from 1.0 to 1.5 depending on the probability of failure of the system.

[deleted text]

Paragraph 1(d). One commenter suggests that the requirement for powered control integrity of hydraulic powered systems be deleted because such designs are covered by existing regulations. The FAA disagrees. The A320 has a reduced number of power control actuators (PCAs) when compared to previously certified airplanes with hydraulic flight controls (i.e., 3 PCA's on other recently certified large transports vs. 2 on the A320). Equivalent redundancy is achieved on the A320 by using computers and associated sensors which enhance the ability to detect faults. The electronic control system is now an integral part of the electro-hydraulic actuation system which requires a stronger technical emphasis when finding compliance.

Another commenter requests paragraph 1(d) be revised to add the statement that, in addition to compliance with the requirements of § 25.671 of the FAR, the airplane control system must be designed to allow for continued safe flight and landing after any failure condition to the flight critical powered system which is not shown to be extremely improbable. The FAA concurs with this change, and the special condition is revised accordingly.

[deleted text]

One commenter expresses concern for the consequences of an electrical fire in the electronic bay, in view of the greatly increased reliance on electrical power in this airplane. The FAA notes this commenter's concerns; however, the existing regulations, together with these special conditions, are sufficient to address these concerns, including interruption of electrical, hydraulic, and pneumatic power supplies to the essential flight systems. This situation is addressed in the airplane by physical separation of the computers in the electronic bay and separation of the wire bundles. There is also a smoke detection system and specific procedures to be followed in case of smoke from the electronic bay.

[deleted text]

Final Special Conditions Information
The Special Conditions

Accordingly, the following special conditions are issued as part of the type certification basis for the Airbus lndustrie Model A320 series airplane.

PARTS 21 AND 25 - (AMENDED]

The authority citation for these special conditions is as follows:

Authority: 49 U.S.C. 1344, 1348(c), 1352, 1354(a), 1355, 1421 through 1431, 1502, 1651(b)(2), 42 U.S.C.1857f-10, 4321 et. seq.; E.O.11514; 49 U.S.C.106(g) (Revised Pub. L. 97-449, January 12, 1983).

1. *Electronic Flight Controls.*

(a) *Operation Without Normal Electrical Power.* In lieu of compliance with § 25.1351(d) of the FAR, it must be demonstrated by test or combination of test and analysis that the airplane can continue safe flight and landing with inoperative normal engine generated electrical power (electrical power sources excluding the battery and any other standby electrical sources), The airplane operation should be considered at the critical phase of flight and include the ability to restart the engines.

Discussion: This special condition requires that the emergency electrical power system be designed to supply: (1) Electrical power required for immediate safety, which must continue to operate without the need for crew action following the loss of the normal electrical power system: (2) electrical power required to continued safe flight and landing: and (3) electrical power required to restart the engines. For compliance purposes, a test demonstration of the loss of normal engine generated power is to be established such that:

1. The failure condition should be assumed to occur during night instrument meteorological conditions (IMC) at the most critical phase of flight relative to the electrical power system design and distribution of equipment loads on the system.

2. After the unrestorable loss of the source of normal electrical power, it must be possible to restart the engines and continue operations in IMC until visual meteorological conditions (VMC) can be reached. (A reasonable assumption can be made that turbojet transport airplanes are able to enter into VMC conditions 30 minutes after experiencing the failure.)

3. After 30 minutes of operation in lMC, the airplane must be demonstrated to be capable of continuous safe flight and landing in VMC conditions. The length of time in VMC conditions must be computed based on the maximum flight duration capability for which the airplane is being certified. Consideration for speed reductions resulting from the associated failure must be made.

[deleted text]

3. *Engine Controls and Monitoring.*

(a) *Full Authority Digital Engine Control System (FADEC).* In addition to compliance with the requirements of §§ 25.901(c) and 25.903(b) of the FAR, the components of the propulsion control system for each engine, both airframe and engine furnished, that effect thrust in either the forward or reverse direction and are required for continued safe operation, must have the level of integrity and reliability of a hydromechanical system (HMC) meeting current airworthiness standards.

Discussion: An acceptable method to demonstrate compliance with this special condition is to show that the engine control system, when installed in the A320, has a level of design integrity equivalent to propulsion controls presently in commercial airline service. The inherent level of design integrity for present day propulsion controls is demonstrated by an in-service loss of thrust control approximately once per 100,000 hours of operation. A similar level of integrity must be demonstrated for a FADEC control system considering all dispatchable states. This level of reliability for the loss of thrust control on one engine will result in an overall airplane propulsion control system reliability that is consistent with the guidance associated with § 25.1309(b)(1), assuming an independence of the failure conditions that contribute to the loss of thrust control. Proper compliance with §§ 25.901(c) and 25.903(b) should not result in any control system functions for one engine that are critical to continued safe flight and landing, that are totally dependent on FADEC system reliability to meet the objectives of § 25.1309(b)(1). Sources of information which are necessary in order to establish a meaningful determination of reliability include assessing service experience of like controls in similar environments, testing (e.g., bench, flight, etc.) and analysis. Service experience of a complex system such as the FADEC could involve similar units in a similar installation, military experience of like installations, or possibly identical installations on other aircraft. In each of these cases, the type and degree of exposure would depend upon various factors such as service history of previous systems produced by the manufacturers involved, or the number and type of failures observed during the service evaluation. The minimum dispatch configuration will have to be taken into account.

ATTACHMENT 3, SAMPLES OF SMOKE DETECTION FALSE ALARM PRESENTATIONS AND DATA

AUBE '01

12TH INTERNATIONAL
CONFERENCE ON AUTOMATIC FIRE DETECTION

March 25 - 28, 2001
National Institute Of Standards and Technology
Gaithersburg, Maryland U.S.A.

PROCEEDINGS

Editors: Kellie Beall, William Grosshandler and Heinz Luck

NIST CENTENNIAL 1901-2001

EUSAS

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

Philippe MANGON
CERBERUS S.A, BUC, France

FIRE DETECTION FOR AIRCRAFT CARGO COMPARTMENTS , REDUCTION OF FALSE ALARMS

Abstract

In order to better understand the reasons for the current high false fire alarm ratio in Aeronautic Applications, an analysis of actual fire and false alarm events has been conducted using different database.

This research (funded by the European Commission within the 5th Framework Programme FireDetEx) included the following analysis :

1. **Analysis of false alarm cases**

   A review of false fire alarm cases extracted from different data bases will be presented, For some typical cases, it will be analysed whether the alarm was triggered by a system malfunction, particular environmental conditions or by the detection of aerosol particles.

2. **Analysis of fire alarm cases**

   Real fire alarm cases will also be considered, it will be determined what was the probable fire source, which phenomena has likely caused the ignition and what should have been the best fire sensor under these conditions.

3. **Definition of fire and non-fire scenario**

   The fire detection system can only be improved on the basis of clear performance objectives, fire and non-fire scenario will be presented against which the performance of new fire detection concept can be measured and evaluated.

Introduction

Among the various aircraft zones for which a fire protection is required, the cargo compartments are specific in this sense that their characteristics are very variable in terms of dimensions and topologies as well as environmental conditions and fire threats.

Fire sources and their combustion mechanisms and products are diversified, therefore there is no single physical parameter that would allow the detection of this wide fire spectrum with an evenly distributed sensitivity.

Under these conditions, in the currently used systems, the smoke detectors have to be adjusted so as to early detect the fire type for which their sensitivity is basically the worst (and to meet the certification requirements [1]); making them also more sensitive to environmental conditions.

Basically, a combination of several criteria to trigger a fire alarm would bring a significant benefit in terms of discrimination capabilities, provided of course that the fire and non-fire situations are well known.

Therefore in order to improve significantly the fire detection reliability, it is necessary to better understand, under this environment, the physical parameters that distinguish the start of a fire from those that are due to non-dangerous phenomenon.

Analysis principle

Fire and false alarm events in operation were extracted from different data base [2] [3] and compiled as shown below:

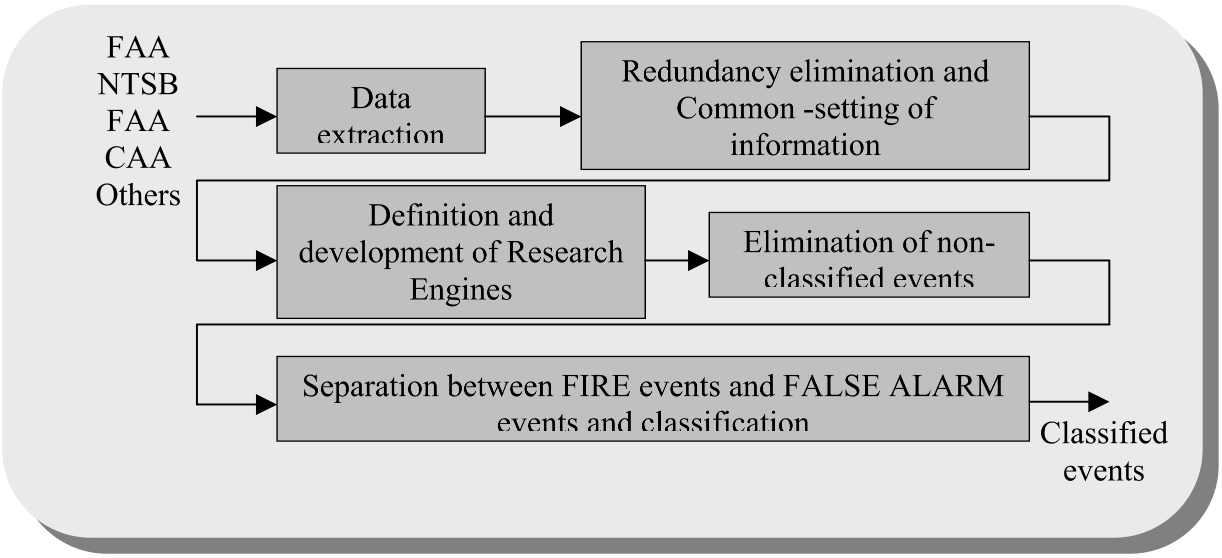


Figure 1 : Fire and false alarm events analysis

The following classification logic was applied :

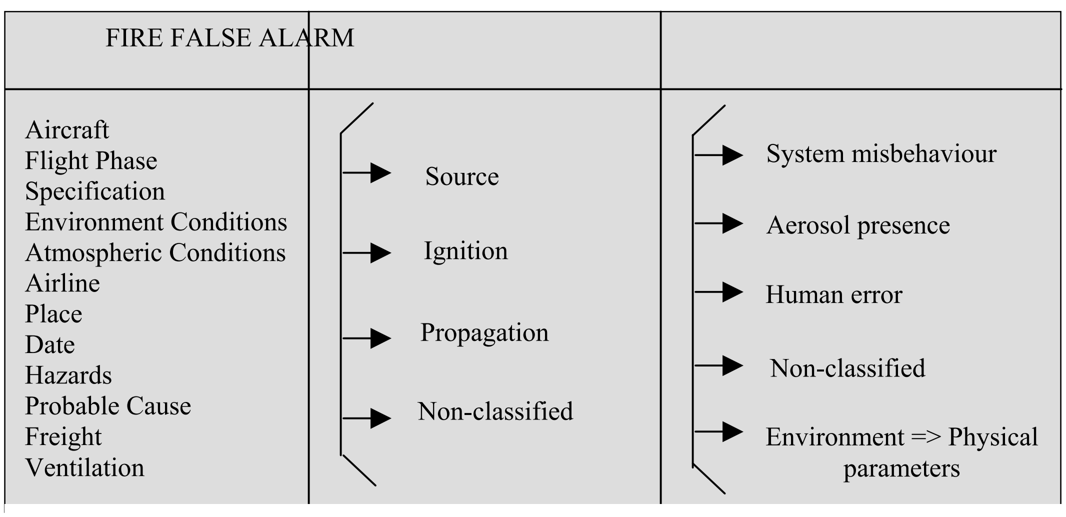


Figure 2 : Events classification logic

It is to be noted that at the time of the event, most of the here-above information was not recorded (and practically impossible to retrieve after).

General outcomes

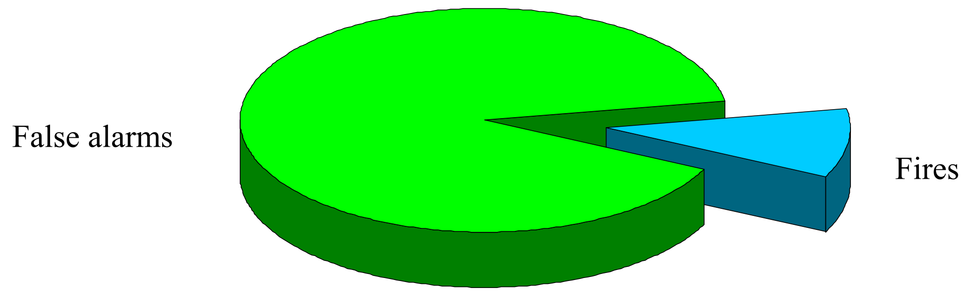


Figure 3 : Ratio fire/false alarm

In this graphic, regional aircraft are very few represented, the overall ratio (90% of false fire warnings) would be higher if this aircraft category was totally included [4].

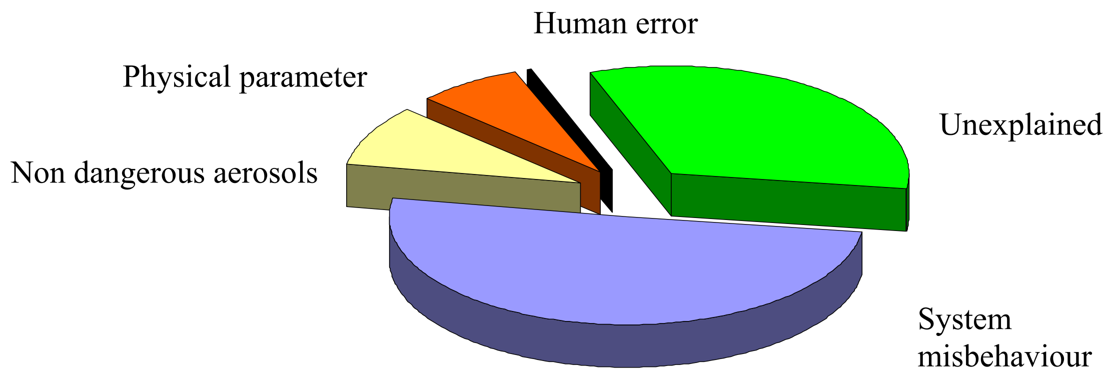


Figure 4 : False alarm analysis

In most of the cases, the conditions in the cargo compartment at the time of the alarm were not exactly known by the pilots or the crew, therefore false alarm events were often considered unexplainable or attributed to a system malfunction whereas a better knowledge of these conditions would have led to a different classification.

However, system misbehaviours under degraded situations (wiring failures, power supply failures, management of redundancies in case of internal failures, ..) take probably a significant part in the overall ratio and have to be considered as an improvement axis.

Analysis of typical false alarm cases

Event 1: Description

Date : 21/11/1985

Source : CAA (extract)

Aircraft Make : BOEING B-747

Carrier : NOT REPORTED

Phase Flight : CRUISE

Narrative : Lower aft cargo hold fire warning. A/c diverted emergency evacuation. False fire warning. Following a lower aft cargo hold fire warning a/c diverted to lajes where an emergency evacuation was effected. Some difficulty due to excessive force needed to open fully doors 2 & 4 l & 2 & 5 r. Several passengers sustained minor injuries. The cause of the fire warning was attributed to condensation emanating from a considerable quantity of 'warm' fruit. The two detectors were slightly oversensitive but this is considered a very minor contributory factor. A mod has been initiated to fit a dual loop smoke detector system.

Probable environmental conditions at the time of event 1

Physical parameter	Temp	Humid/ Condens	Radiat	Combust Aerosols	Other Aerosols	Comb gases	Other gases
Probable level	Low	High	Low	Low	Medium	Low	High

Event 2: Description

Date : 23/10/1998

Source : AIRBUS (extract)

Aircraft Make : AIRBUS A-340

Carrier : SABENA

Phase Flight : TAKE OFF

Narrative : At 4000 ft with configuration 1 forward cargo smoke red alarm came on. According to ec procedures the fwd cargo cooling was switched off. The switch was pre in max. One minute later the alarm went out. Visual check performed and confirmed neither smoke nor fire in the fwd compartment. Flight was continued. During cruise at flight level 290 lavatory sm warning came on. Toilet g1 triggered this alarm a lot of times. Visual confirmed nobody inside the toilet and no smoke evidence. Action: maintenance inspected fwd cargo and lavatory and did not find any indi of fire or smoke. Investigation related to oil smell in cabin revealed 3 oil quantity lower than on other engines. Suspected oil suction to air system. Deactivated engine 3 bleed system switch SDCU and smoke detector test were satisfactory. The next flights were also performed with engine 3 bleed off and oil consumption was monitored and found within limits. On ground in bru when switching APU bleed on smoke appeared in cabin cockpit. Smoke disappeared after switching off pack 2. Smoke did not with pack 2 on afterwards. Problems suspected to come from APU pneumatic duct. Maintenance found oil leak on filter bowl. O'ring replaced and leak check performed. Engine 3 bleed system was reactivated.

Probable environmental conditions at the time of event 2

Physical parameter	Temp	Humid/ Condens	Radiat	Combust Aerosols	Other Aerosols	Comb gases	Other gases
Probable level	Low	Low	Low	Medium or High	Low	Low or medium	Low

Analysis of fire alarm cases

Event 3: Description

Date : 20/03/1991

Source : FAA INCIDENT DATA SYSTEM

Aircraft Make : LKHEED L-188-C

Carrier : REEVE ALEUTIAN AIRWAYS INC

Phase Flight : FCD/PREC LDG FROM CRUISE

Narrative : Dense fumes in cargo compartment. Diverted and landed. Smoke from box marked fish that contained batteries.

Probable environmental conditions at the time of event 3

Physical parameter	Temp	Humid/ Condens	Radiat	Combust Aerosols	Other Aerosols	Comb gases	Other gases
Probable level	Low	Low	Low or Medium	Medium	Medium or High	Medium	Medium or High

Event 4: Description

Date : 05/09/1996

Source : NTSB AVIATION ACCIDENT/INCIDENT DATABASE

Aircraft Make : DOUG DC10-10F

Carrier : NOT REPORTED

Phase Flight : CRUISE

Narrative : The airplane was at fl 330 when the flight crew determined that there was smoke in the cabin cargo compartment. An emergency was declared and the flight diverted to newburgh/stewart international airport and landed. The airplane was destroyed by fire after landing. The fire had burned for about 4 hours after smoke was first detected. Investigation revealed that the deepest and most severe heat and fire damage occurred in and around container 6r which contained a dna synthesiser containing flammable liquids. More of 6r's structure was consumed than of any other container and it was the only container that exhibited severe floor damage. Further 6r was the only container to exhibit heat damage on its bottom surface and the area below container 6r showed the most extensive evidence of scorching of the composite flooring material. However there was insufficient reliable evidence to reach a conclusion as to where the fire originated. The presence of flammable chemicals in the dna synthesiser was wholly unintended and unknown to the prepared of the package and shipper. The captain did not adequately manage his crew resources when he failed to call for checklists or to monitor and facilitate the accomplishment of required checklist items. The department of transportation hazardous materials regulations do not adequately address the need for hazardous materials information on file at a carrier to be quickly retrievable in a format useful to emergency responders.

Probable environmental conditions at the time of event 4

Physical parameter	Temp	Humid/ Condens	Radiat	Combust Aerosols	Other Aerosols	Comb gases	Other gases
Probable level	High	Low	Medium or High	High	Low or Medium	High	Low

Definition of fire and non-fire scenario

Some fire and non fire scenario are presented here-below as possible development tests for fire detection systems.

<table>
<tr><th colspan="2">Fire cases</th></tr>
<tr><td>

Open cellulosic fire (wood) : EN 54 - TF1 [5]
Smouldering pyrolysis fire (wood) : : EN 54 - TF2
Glowing smouldering fire (cotton) : : EN 54 - TF3
Open plastics fire (polyurethane) : : EN 54 - TF4
Liquid fire (n-heptane) : : EN 54 - TF5
Liquid fire (methylated spirits) : : EN 54 - TF6
Paper (UL268) :
-Paper towels (open)
-Scheduled newspapers (open)
-Normal newspapers (open)
-Normal newspapers (smouldering)

</td><td>

Cardboard boxes :
-Open cardboard fire
-Smouldering cardboard fire
Textile :
-60 % Wool / 40 % Acrylic (open)
-60 % Wool / 40 % Acrylic (smouldering)
-100 % cotton (open)
-100 % cotton (smouldering)
-100 % polyester (open)
-100 % polyester (smouldering)
-100 % wool (open)
-100 % wool (smouldering)
Jet A fuel fire
Diesel fire
Oil fire
Cable fire

</td></tr>
<tr><th colspan="2">Non fire cases :</th></tr>
<tr><td>

Moisture
Condensation
Fog
Sand and Dust

</td><td>

Fruit / Animals / Vegetables
Oil
Exhaust gas

</td></tr>
</table>

Tableau 1 : Fire and non - fire scenario

Summary

The exploitation of actual fire alarm events is tricky because most of the time, the parameters recorded at the time of the event do not allow to determine the condition for which the alarms were triggered and can even lead to wrong conclusions.

However this analysis has allowed us to clarify some typical fire and non–fire situations and to outline performance tests accordingly.

Fire sources are extremely diversified and, in particular the materials involved are most of the time unexpected or even normally forbidden as cargo loads. As well their combustion products or effects are variable with, according to the event, predominance of different physical parameters.

False alarm sources are also diversified, in some cases the corresponding single physical parameters are very close to those that characterise the start of a fire.

Under these conditions, the adjunction of several detection criterion can increase considerably the discriminatory capabilities of the fire detection systems.

The dynamic of the various signals has to be taken into account in the fire alarm decision as an additional discriminatory factor, for this a minimum analysis duration is necessary which is very often not compatible with the current certification criteria (considering in particular the propagation time of the combustion products).

Performance development or qualification tests must be on one hand feasible under well controlled metrological conditions and on the other hand representative of a large range of realistic fire and non – fire situations.

References

[1] Schmoetzer, K . Aircraft Fire Detection: Requirements, Qualification and Certification Aspects, see this book of conference.

[2] FAA In service events Data Base.

[3] NTSB In service events Data Base.

[4] Blake, D. FAA Technical Center, Fire Safety Section, Report No DOT/FAA/AR-TN0029, June 2000.

[5] EN 54-9 Components of automatic fire detection systems Part 9 Methods of test of sensitivity to fire“.

AUBE '01

12TH INTERNATIONAL CONFERENCE ON AUTOMATIC FIRE DETECTION

March 25 - 28, 2001
National Institute Of Standards and Technology
Gaithersburg, Maryland U.S.A.

PROCEEDINGS

Editors: Kellie Beall, William Grosshandler and Heinz Luck

NIST CENTENNIAL 1901-2001

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

A. Freiling
European Aeronautic Space and Defense Company EADS Airbus GmbH, Bremen, Germany

New Approaches to Aircraft Fire Protection

Abstract
Currently, new fire detection technologies are under evaluation for aircraft application. The goal is to reduce the false alarm rate drastically and to improve safety and reliability figures. Gas sensor technologies, visualization devices and other multisensor/multicriteria are under discussion. In this paper, an overview of currently fire protected areas in Airbus aircraft is given. The potential to introduce specific fire protection by the means of new technologies in dedicated aircraft areas is discussed. If new fire detection technologies are used, there is the need to have modified integration tests. A comparison of a commonly used aircraft integration test to a real fire scenario is given by the example of a gas sensor based fire detector.

Introduction

A fire protection system in an aircraft includes passive and active fire protection means [1]. Passive fire protection is realized by using fire proof or inflammable materials in all areas of the aircraft including lining, cables, interior etc. In this paper, the active fire protection system will be regarded which consists of scattering light smoke detectors managed by a central control unit and a halon extinguishing system. Several aircraft areas are equipped with fire detection instruments. These are the cargo compartments, the electronic compartments and the lavatories. The most important and critical area is the cargo compartment, which is inaccessible during flight.

For ground based applications, which includes building fire protection, new kinds of fire detectors like multisensor/multicriteria- or gas sensor based fire detectors have currently been developed or are under discussion [2, 3, 4, 5]. The main goal of using these kinds of sensors is to reduce the false alarm rate. Also the aircraft fire false alarm rate and the correlated consequences have to be reduced drastically [6, 7]. There are several restrictions and additional requirements that come along with the airborne application [8]. For new fire detection technology to be used in aircraft, there is the necessitiy to revise the integration / validation test.

At EADS Airbus, new fire detection technologies are examined for aircraft application to improve the alarm reliability and to provide additional means for monitoring fire or smoke in dedicated aircraft areas.

Fire protected aircraft areas – state-of-the-art

Lavatories

The fire protection of aircraft lavatories is realized by a scattering light smoke detector near the air extraction and an automatic fire extinguisher in the receptacle. In case of a fire alarm, the lavatory door can be opened and a crew member can extinguish the fire with a handheld fire extinguisher. Figure 1 shows a drawing of a lavatory and installation points of smoke detectors.

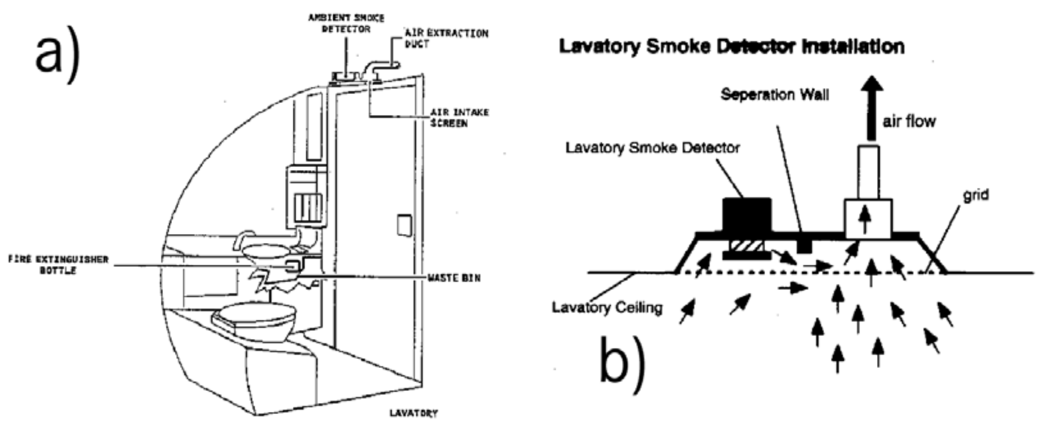


Fig. 1: a) Sketch of an aircraft lavatory

b) Installation of a lavatory smoke detector in Airbus

Avionics Compartment

In the avionics compartment, nearly all the electronics necessary to fly the aircraft is located. Commonly, the compartment is positioned under the cockpit, in the front part of the aircraft. In most aircraft, the avionics compartment is not accessible during flight. Only in larger Airbus aircraft, there is a small access hatch. The compartment is ventilated, with the extracted air passing through a common air extraction duct which is monitored for the presence of smoke.

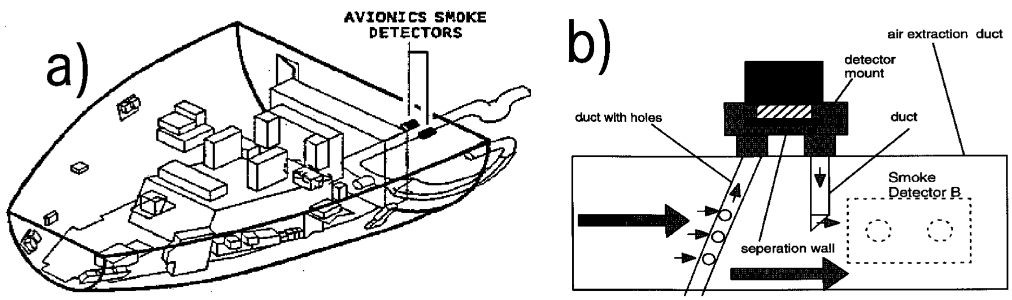


Fig. 2: a) Sketch of an aircraft avionics compartment
b) Installation of a duct type smoke detector in Airbus

Cargo Compartments

More critical areas in the aircraft in which smoke detectors are installed, are the cargo compartments. In transport aircraft, these compartments are normally located under the actual passenger cabin, the forward (FWD) compartment in front and the aft compartment behind the wing box. During flight, the cargo compartments are inaccessible. That means that in case of a fire warning, the pilot has got no possibility to verify if it is a real or a false alarm. The action the pilot has to take after a fire warning is to activate the extinguishing system and to land as soon as possible, eventually on an unsuitable airport [9].

A further reason for a high risk within the cargo compartment is that the freight cannot be controlled by the aircraft manufacturer. Although there are restrictions on what is allowed to be transported, there is still the possibility that dangerous ignition sources get into the aircraft.

Concerning fire extinguishing, there fire extinguishing bottles installed in transport aircraft. As extinguishing agent, halon is used. Although halon is generally banned by the Montreal Protocol, there is a time limited exceptional regulation and it can still be used for aircraft application. This regulation expires in 2003. Until then, alternatives have to be found.

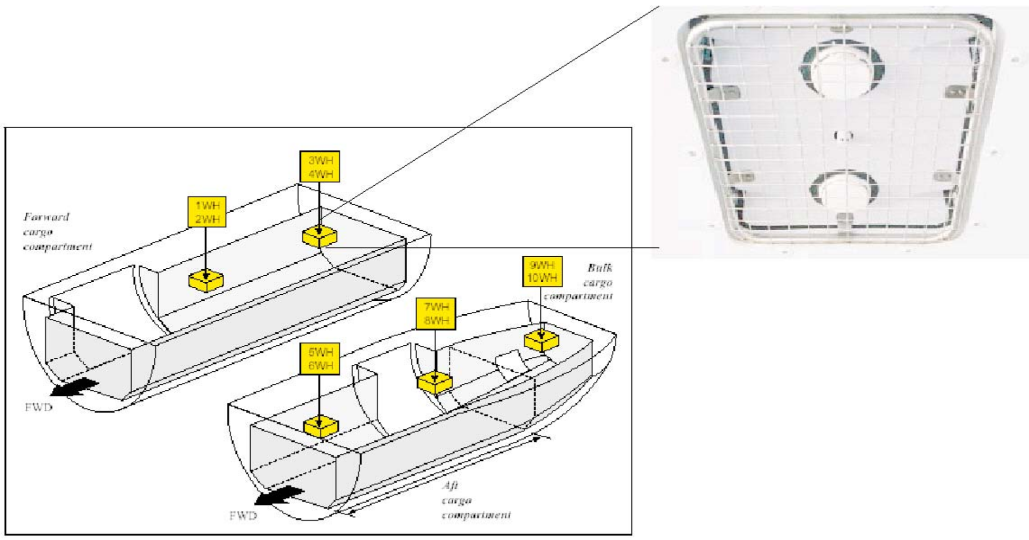


Fig. 3: Airbus Cargo Compartment Smoke Detector Positions and installation

<u>Lower Deck Facilities</u>

With the development and construction of larger aircraft, there comes the wish to use additional space gained in the lower deck. In order to accommodate more passengers in the main deck area, certain facilities will be located in the lower deck area of the aircraft. These are galleys, toilets, crew rest areas (with beds for the passengers/crew to sleep), etc. Along with the installation of such facilities, there comes the necessity to install fire detection.

State-of-the-art aircraft fire detection technology

The signal processing of the scattering light type smoke detectors currently applied in the Airbus aircraft series uses specifically developed smoke discrimination algorithms. Using specific light frequencies, modulations and correlation in the time domain with a database allows to differentiate between typical smoke patterns.

The overall aircraft smoke detection system consists of the smoke detectors at several locations (see section 2) and the so-called Smoke Detection Control Unit (SDCU) which controls and reads out the detectors. A block diagram of the system architecture is given in Fig. 4. For redundancy reasons, the smoke detectors in the cargo compartment and in the avionics compartment are installed in pairs. Each pair of detectors is supplied with power by a dual redundant power supply (see Fig. 4). One detector in the pair is installed on the Smoke Detection Control Unit (SDCU) loop A, the other on loop B.

The SDCU tests each loop to check whether it is functioning before it acts on a smoke alarm from a single smoke detector.

When a smoke alarm is generated by the SDCU the ventilation and heating systems (if installed) will be closed automatically.

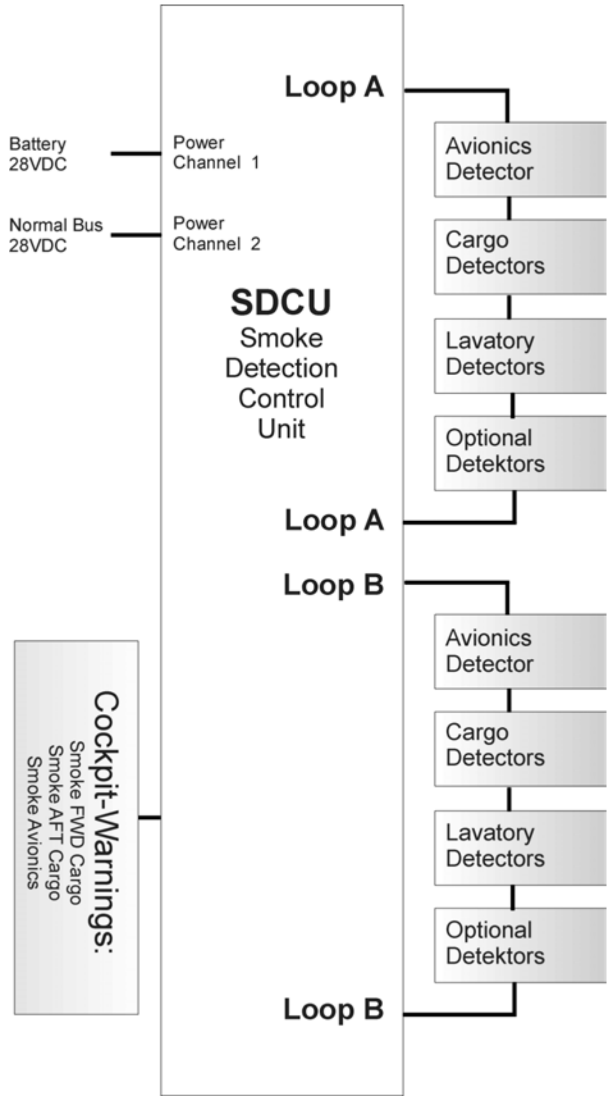


Fig. 4. Smoke Detection Loop Schematic for A340

Approaches to new kinds of fire detection

Currently under investigation are advanced fire detection technologies with the aim to identify the proper fire signatures (gas, smoke, heat etc.) as they may develop in a crucial, inaccessible area of the aircraft and develop the algorithms which allow to link these fire parameters to non-fire events that may be present in the aircraft. Technology under consideration to reach adequate detection properties includes [10]:

- Gas sensing with semiconducting metal oxide sensors in thick- or thin-film technology or/and electrochemical cells
- Optical smoke sensing with light attenuation or back-scattering devices
- Near infra-red (NIR, wavelengths $< 1.2\mu m$) and visible light sensing with CCD

(Charge Coupled Device) and/or CMOS (Complementary Metal Oxide Semiconductor) technology

- Infra-red sensing with thermopiles (for wavelengths > 1.2µm)

It is possible to subdivide several aircraft areas to dedicated fire sectors with dedicated fire protection systems. One example for that can be a special fire protection of avionics compartments where the materials that can burn are relatively well defined. So, may be the possibility to develop a system based on gas sensors that detects smouldering cable fires or overheated equipment. A certain spatial resolution in fire detection would give the pilot a decision means of what measures to take if an area of the electronics compartment becomes overheated. If the heat source is an uncritical item, then this equipment can easily be switched off.

In the Cargo compartment, where the kind of material that might burn is unpredictable, the approach is different. Here, there is the necessity to know the non-fire case in order to reduce false warnings. So far, it has never happened in Airbus aircraft that a fire was undetected when a smoke detection system was installed. The problems are false alarms caused by cargo. To improve the false alarm rate, knowledge about environmental conditions in false alarm cases is necessary. Therefore, database studies have been conducted in order to get as much information as possible about these conditions. The results are presented elsewhere [11].

Approaches to new fire extinguishing methods and dedicated fire detection

Water mist as halon replacement in combination with nitrogen inerting is regarded as a promising alternative to the today's extinguishing system. The use of a water mist system however implies several physico-chemical aspects which could have been neglected with gaseous systems but now have to be checked and solved. Agent freezing, short circuit prevention, weight, maintenance or smoke generation are points which have to be considered.

For weight and efficiency reasons, the water mist suppression system must be associated to a smart detection/activation system which is able to accurately detect and locate the fire and activate the suppression in adequate on/off sequences. There are several requirements for the detection system that are derived from a water mist based extinguishing system.

In order to carry only a minimum amount of water in the aircraft due to weight reasons, the extinguishing process has to be optimised. An extinguishing shall only be performed where the fire is located. This implies that the fire detection system must be able to provide a certain spatial resolution. At the moment, there is no need for such a zonal detection system because the halon extinguishing system is based on a total flood philosophy.

Furthermore, the detection system has to be waterproof because it has to monitor the fire criticality status for the total remaining flight. The extinguishing efficiency of water, even in combination with an inert gas is not comparable to the properties of halon and there is a remaining risk that the fire will light up again. So, a fire monitoring function is necessary.

The research concerning these items is being funded by the European Commission within the 5th Framework Programme FireDetEx

Aircraft integration of new fire detection technologies

After qualifying fire/smoke detectors for aircraft application, they have to be implemented/integrated into the aircraft environment. Current integration tests for smoke detectors are defined in the FAA Advisory Circular 25-9A [12]. The integration tests mentioned herein can be performed with appropriate smoke generators, being selected out of the following list, depending on the actual installation point of the sensor:

- paper towel burn box
- Rosco Theatrical smoke generator
- Helium-injected Rosco Theatrical smoke generator
- A pipe or cigar
- A Woodsman Bee Smoker
- Any other acceptable smoke generator

The smoke emerging from one of those sources must be detected within one minute after the start of the fire [13]. This time includes all the necessary signal processing and transduction to display an alarm message in the cockpit.

Consequences for new technologies

The existing authority requirements concerning integration of smoke detectors restrict the development of new approaches. An example are multicriteria/multisensor devices. Such a system needs a certain time to process a certain internal signal evaluation out of the various parameters that are recorded to come to an alarm decision. This alarm decision will be of a higher reliability, but might take a little more time.

Furthermore, the event "start of a fire" is not clearly defined. The amount of smoke produced for example by a smoke generator might be equal to the smoke emitted in a rather advanced state of a real fire. Although other parameters that represent a real fire are not reflected by an artificial smoke generator. This includes heat release in terms of radiation and convection as well as gas development.

Current developments show that gas sensing technologies have a potential to be new or additional fire detectors. At the moment, there is no integration test that is could be used for certification of such a system. A real fire test as described in AC 25-9A cannot be conducted during flight. But only a real fire has the gas constitution that is detected by gas sensors.

Fig. 5 shows a test that has been conducted to compare the response of gas sensors to a currently used smoke generator in Airbus (AX1000) and a real fire of Kleenex tissue towels. The test was carried out in a standard-layout lavatory. As sensing device a GSME smouldering fire detector as it is used for lignite power plants was examined [14]. This device comprises 3 semiconducting metal oxide gas sensors with optimized selectivity for H_2, CO and NO_x. The GSME detector and its signal processing algorithm had not been modified for this test. First, the smoke generator was switched on, producing an amount of smoke labeled equal to 5 kleenex tissue paper towels. It can be seen that the gas sensor device responds very poorly with all its 3 sensors and shows a slightly decreasing signal. The aircraft optical smoke detector which was also installed, reacted after 35 seconds.

The GSME was positioned near the basin, which means it was not installed where the current detector is installed. By burning 3 Kleenex, the detector showed a significant signal and the internal processing algorithm predicted a certain "fire probability" which can be used for defining an alarm threshold. Not being on its proper position yet and burning 5 Kleenex resulted in a higher signal but a similar fire probability.

Afterwards, the sensor was installed into the position of the current detector and again, 5 Kleenex were burned. This time, the signal shape looked different due to changed airflow conditions the sensor was exposed to and the fire probability had a higher value.

The final two peaks are two cycles of cigarette smoke, the first just normally smoking and the second smoking and blowing at the detector. Cigarette smoke shows a different signal shape than Kleenex towels and it can be seen that cigarette smoke does not result in any value for the fire probability.

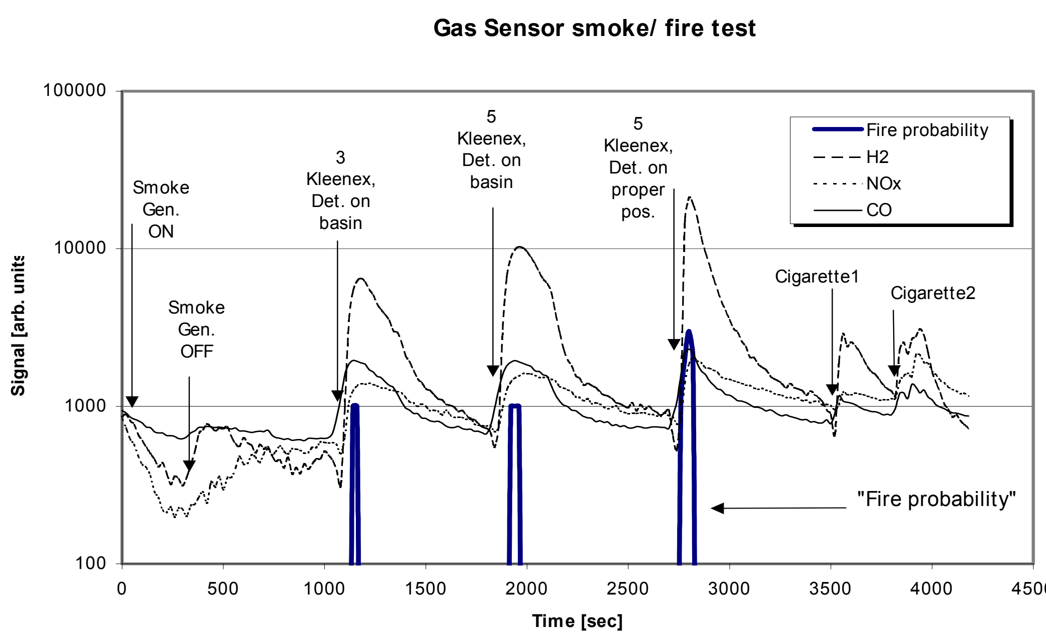


Fig. 5: Comparison of a smoke detector test with a real fire for a gas sensor based fire detection system

This example shows that the common smoke generator integration test is not suitable for this kind of fire detector because these types of gas sensors will never respond to this specific kind of smoke.

Only if the gas constitution of a characteristic fire is known, a gas generator might be constructed for assuring a correct integration. But in this case, all the other fire parameters will not be regarded. In this context it becomes clear, that new detection technologies need dedicated specific-to-type aircraft integration flight tests after they have proven their fire detection properties in ground tests.

Summary

New fire detection technologies bear the potential to improve the safety of aircraft by making a fire warning more reliable and by reducing the false alarm rate. The risk of unnecessary passenger evacuations and undue emergency landings can be minimized that way. Approaches are the use of gas sensors or other multisensor/multicriteria devices as well as visualisation tools like specific cameras with associated image processing. However, the way to an aircraft integration coincides with the fulfillment of stringent environmental and many other aircraft specific requirements.

The technology that is used for fire detection instruments strongly influences the kind of testing that is necessary to validate a proper integration. For this reason the user of new fire detection instruments, in this case the aircraft manufacturing industry, has to know exactly what technology is used inside a fire detector in order to perform the right verification for demonstration of compliance with the certification requirements.

Literature

[1] Freiling, A. Brandschutz in Airbus-Flugzeugen, S&S Report, April 2000

[2] Gottuk, D.T., Peatross, M.J., Roby, R.J., and Beyler, C.L., "Advanced Fire Detection Using Multi-signature Alarm Algorithms," International Conference on Automatic Fire Detection "AUBE '99", 11th, March 16-18, 1999, Gerhard Mercator University, Duisburg, Germany, Luck, H., Editor, pp. 237-246, 1999.

[3] Petig, H et al. History of Development Steps in Gas Sensor Fire Detection in RWE Powerplants for Lignite and Waste Combustion, International Conference on Automatic Fire Detection "AUBE '99", 11th, March 16-18, 1999, Gerhard Mercator University, Duisburg, Germany, Luck, H., Editor, pp. 284-294, 1999.

[4] Müller, H.C. Rule based Detection Algorithms, Proceedings of the VdS Conference "Gas Sensors for Fire Detection", Nov. 15th and 16th 2000, Cologne, Germany, Chairing: Michael Schnell, VdS Schadenverhütung

[5] Siebel, R. Strategies for the development of detection algorithms, Proceedings of the VdS Conference "Gas Sensors for Fire Detection", Nov. 15th and 16th 2000, Cologne, Germany, Chairing: Michael Schnell, VdS Schadenverhütung

[6] Blake, D. Aircraft Cargo Compartment Fire Detection, International Halon Replacement Working Group Meeting, May 2000, Atlantic Hotel, Bremen, Germany, hosted by EADS Airbus GmbH

[7] Grosshandler, W.L. (Editor), Nuisance Alarms in Aircraft Cargo Areas and Critical Telecommunication Systems: Proceedings of the Third NIST Fire Detector Workshop, December 4-5, 1997, NISTIR 6146, National Institute of Standards and Technology, Gaithersburg, MD, March 1998

[8] Freiling, A. Requirements for Fire Detection in Civil Aviation, Proceedings of the VdS Conference "Gas Sensors for Fire Detection", Nov. 15th and 16th 2000, Cologne, Germany, Chairing: Michael Schnell, VdS Schadenverhütung

[9] Schmötzer, K, Aircraft Fire Detection Requirements, see see this book of conference

[10] Freiling, A, Improving Safety for Aircraft, Proceedings of the Deutscher Luft- und

Raumfahrtkongress 2000, ref. DGLR-JT2000-156, Sept. 16-20 2000, Leipzig, Germany, Deutsche Gesellschaft für Luft- und Raumfahrt

[11] Mangon, P. Fire Detection for aircraft cargo compartments, reduction of false alarms, see this book of conference

[12] Federal Aviation Administration, Advisory Circular 25-9A, Smoke Detection, Penetration and Evacuation Tests and related Flight Manual Emergency Procedures, 1/6/94, Federal Aviation Administration, Washington DC, USA

[13] Joint Aviation Requirements, JAR-25, Large Aeroplanes, Change 14, 27May 1994, JAA, Hoofddorp, The Netherlands

[14] Kohl, D, Kelleter, J. Gassensor-Melder für Schwelbrände, in: Sicherstellung der Schutzfunktion von Gassensoren, A. Freiling, R. Fromm, Edts. pp. 154-165, Beuth-Verlag, Berlin, ISBN 3-410-79234-1, Dec. 1997

ATTACHMENT 4, AIRBUS PRESENTATIONS

From meetings of September 20-21, 2011

United Airlines A320 Emergency Landing

New Orleans – 4th April 2011

AIRBUS

AGENDA

- AVIONICS SMOKE procedure
- AIRBUS Analysis
- Answers to NTSB questions

AIRBUS

A320
ATA 24
Electrical system

CONTENT

1 - SYSTEM SEGREGATION

Design principle

Network architecture

Power center location

Installation precautions

2 - CREW INTERFACE

3 - COMPONENTS OF THE SYSTEM

4 - LOCATION OF THE ATA 24 COMPONENTS

5 – ELECTRICAL POWER SUPPLY:

6 – CERTIFICATION

APPENDIX

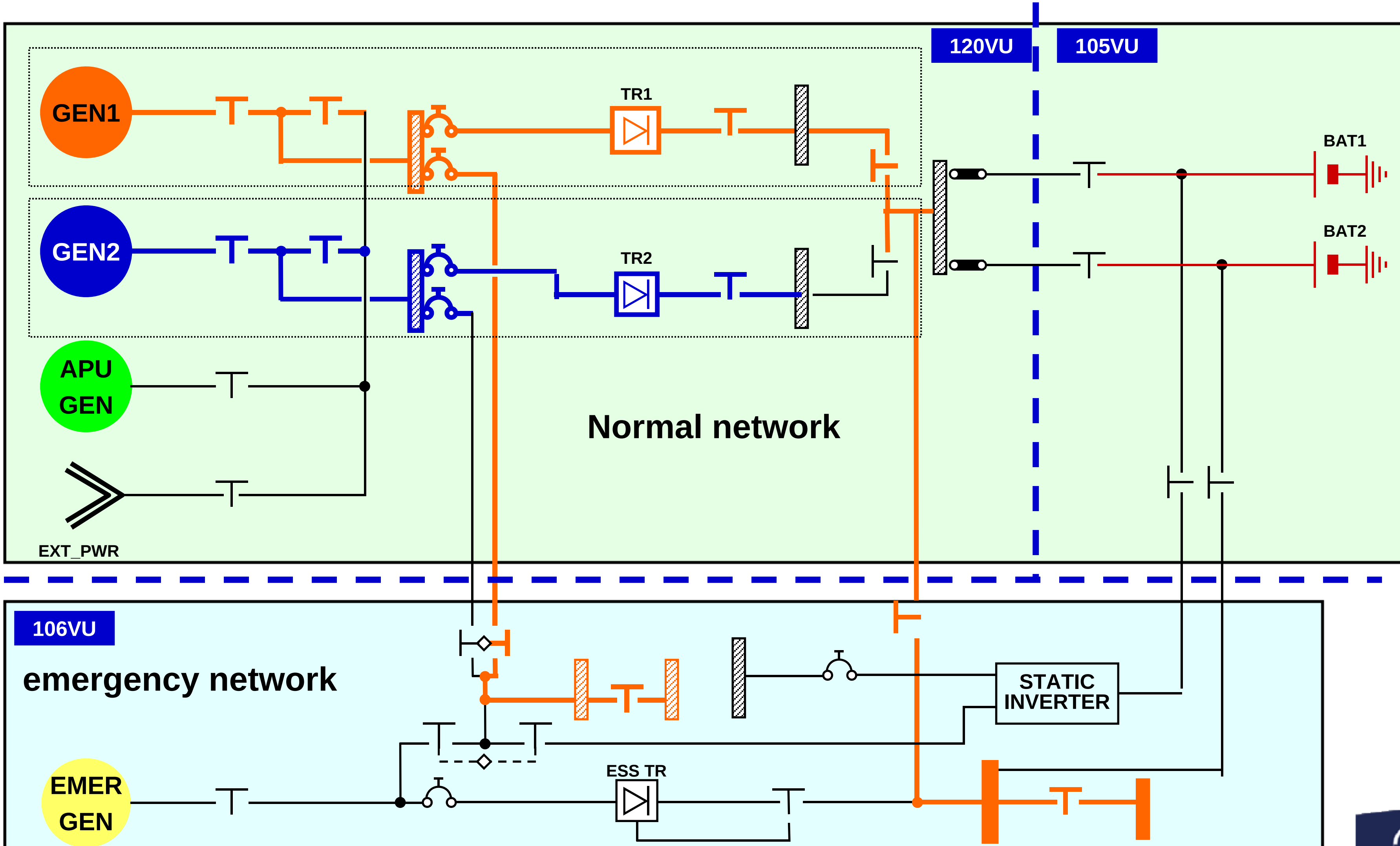
1 - SYSTEM SEGREGATION: Design principle

- The electrical system is a **critical system**, its architecture is designed to comply with an appropriate safety objective :

loss of whole electrical system **probability is less than 10^{-9}**

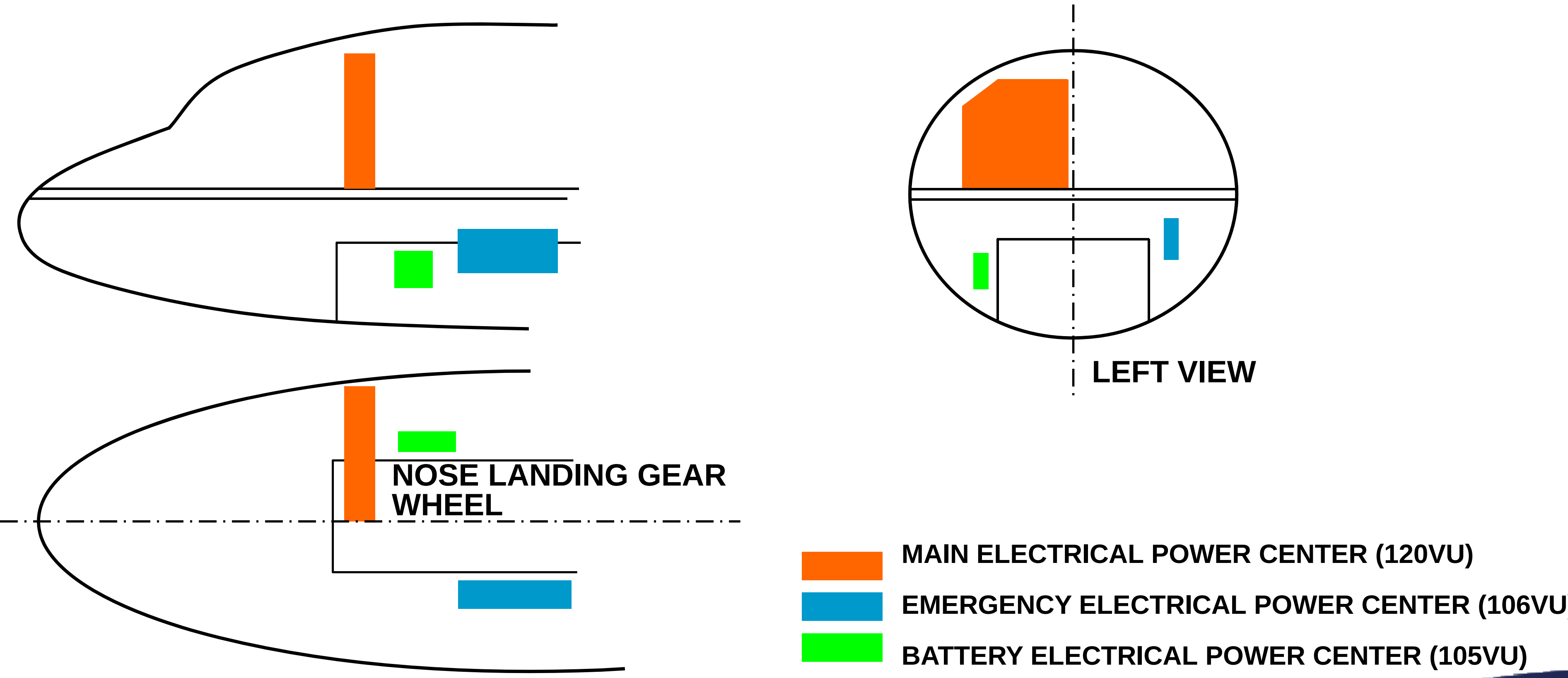
- To withstand such a requirement, network architecture consists of :
  - **A normal network : 2 independent channels** (Chl1 and Chl2), each of them consists of an AC network and a DC network
  - **An emergency network : a single channel** that consists of an AC network and a DC network

1 - SYSTEM SEGREGATION: network architecture

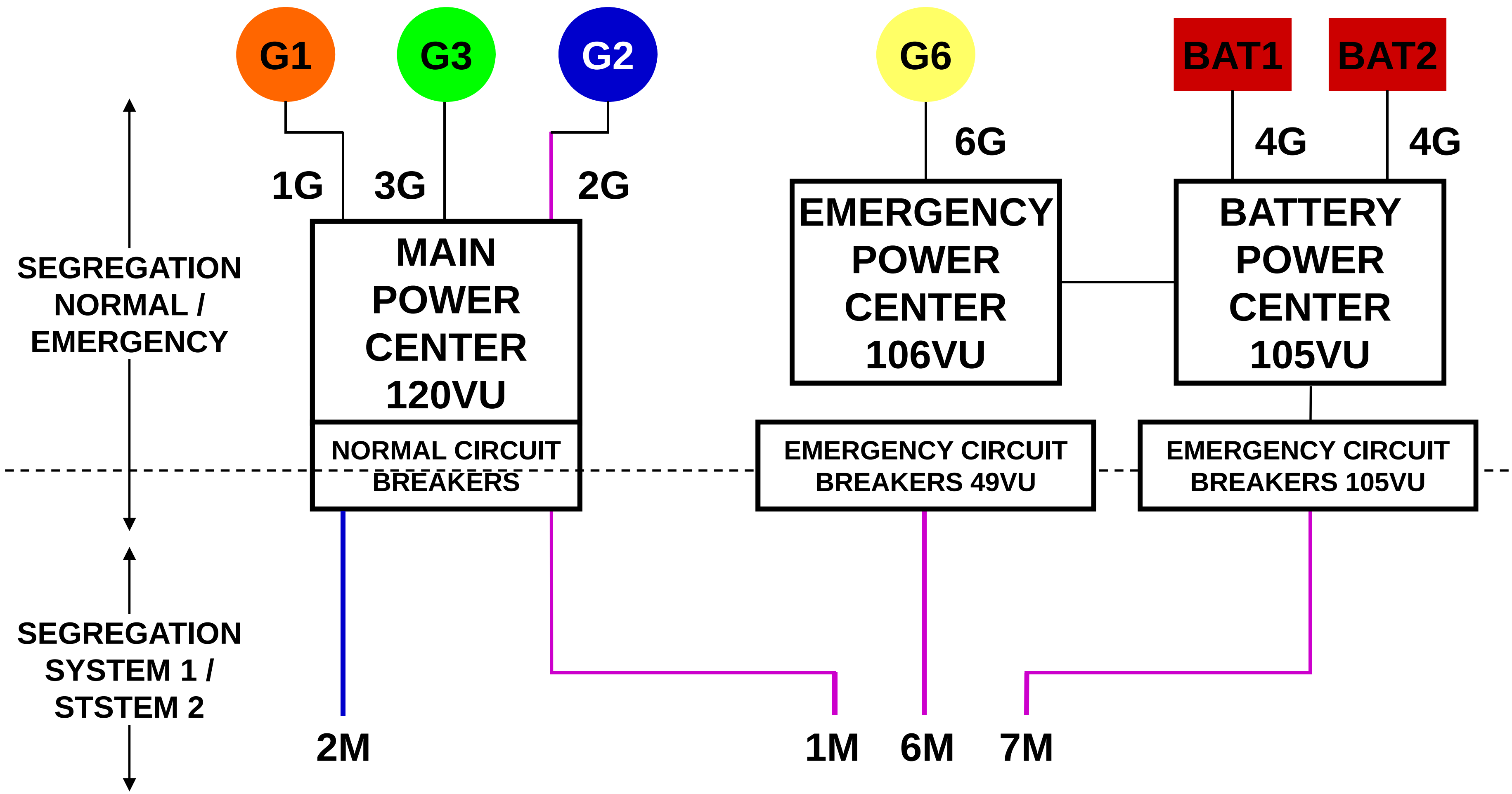


1 - SYSTEM SEGREGATION: power center location

The normal and the emergency components are physically segregated in different power centers

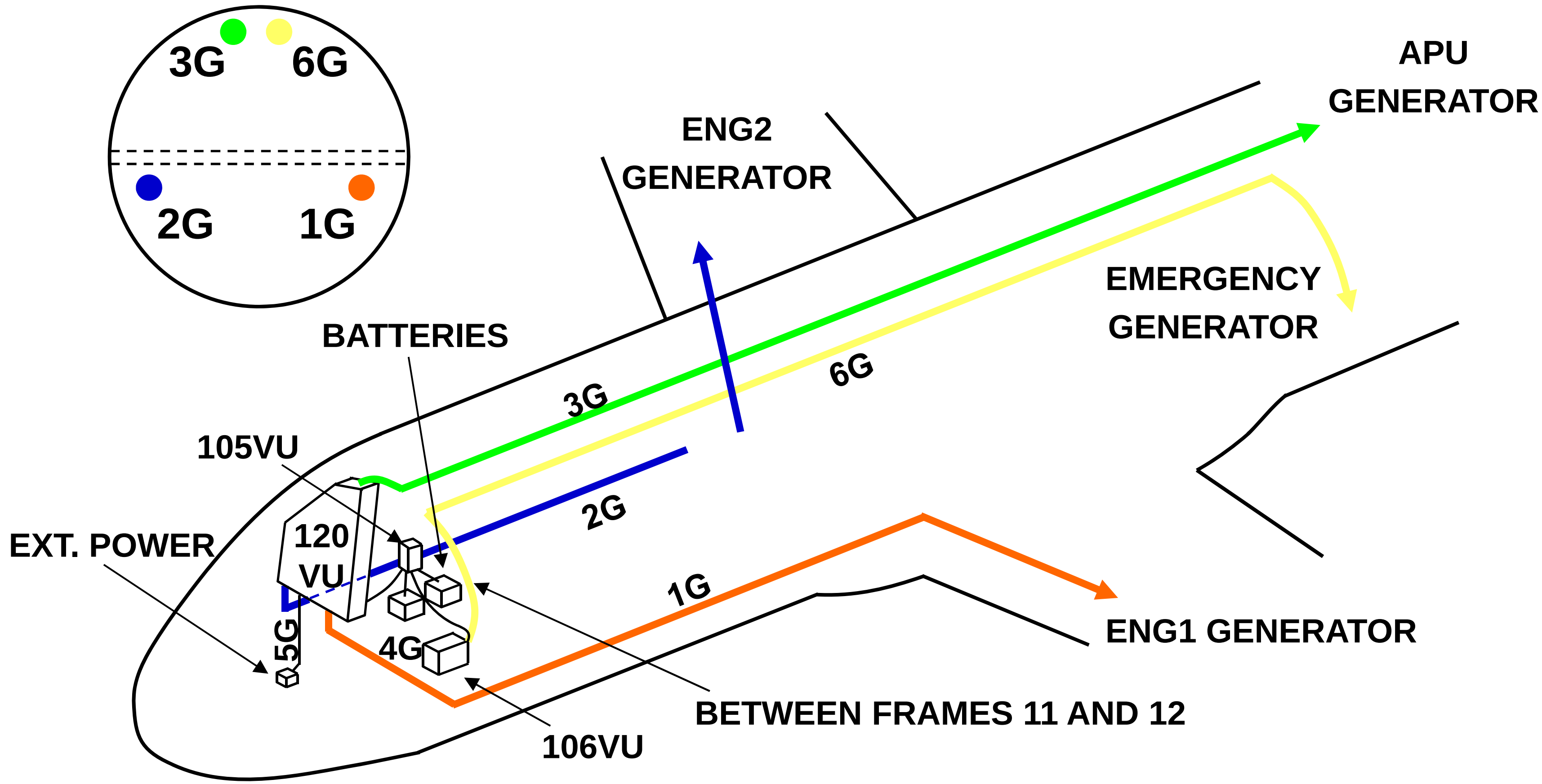


1 - SYSTEM SEGREGATION: installation precautions



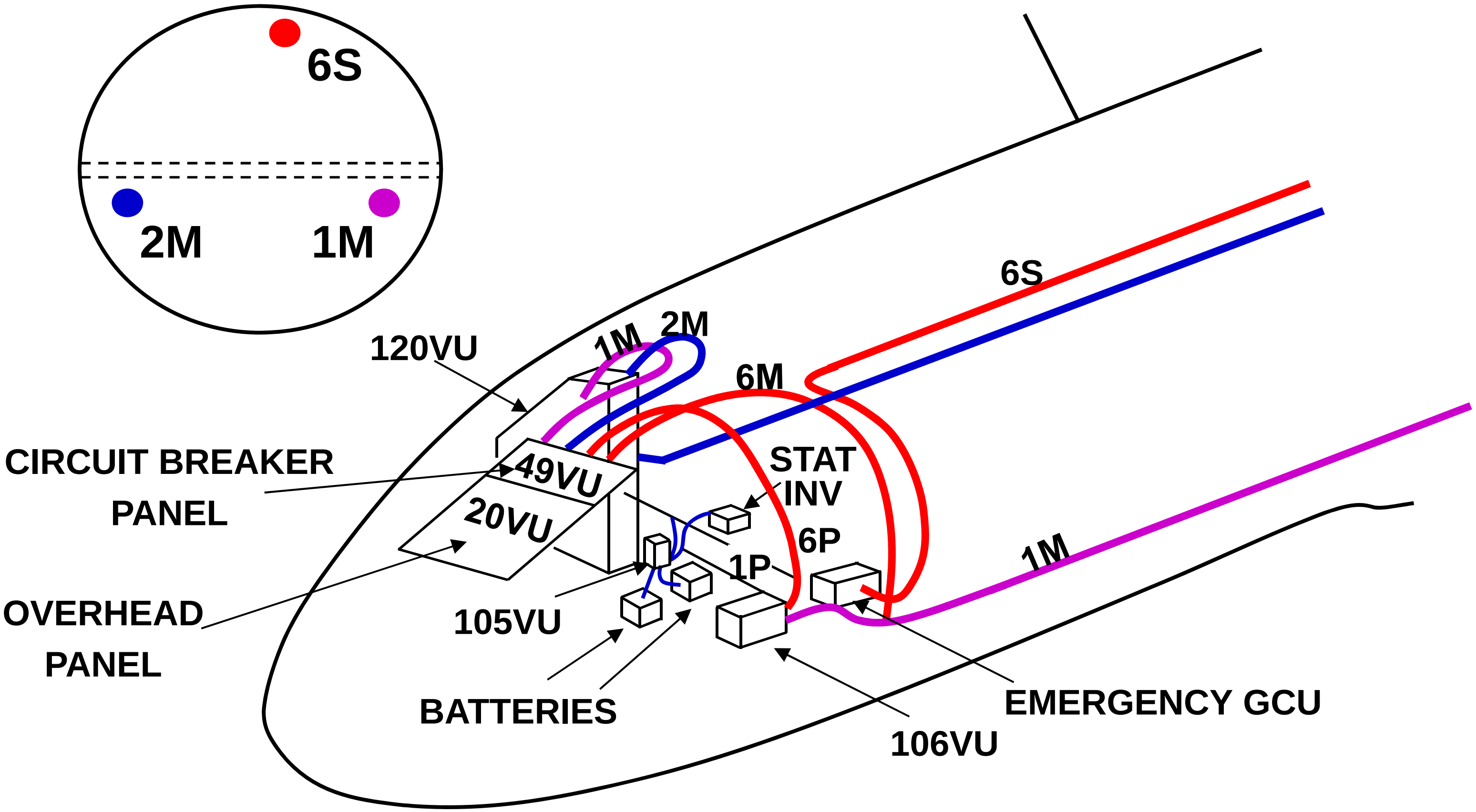
ELECTRICAL SEGREGATION

1 - SYSTEM SEGREGATION: installation precautions



"G" ROUTE SEGREGATION

1 - SYSTEM SEGREGATION: installation precautions



MAIN & EMERGENCY ROUTES SEGREGATION

1 - SYSTEM SEGREGATION

2 - CREW INTERFACE

Overhead panel

maintenance interface and display

3 - COMPONENTS OF THE SYSTEM

4 - LOCATION OF THE ATA 24 COMPONENTS

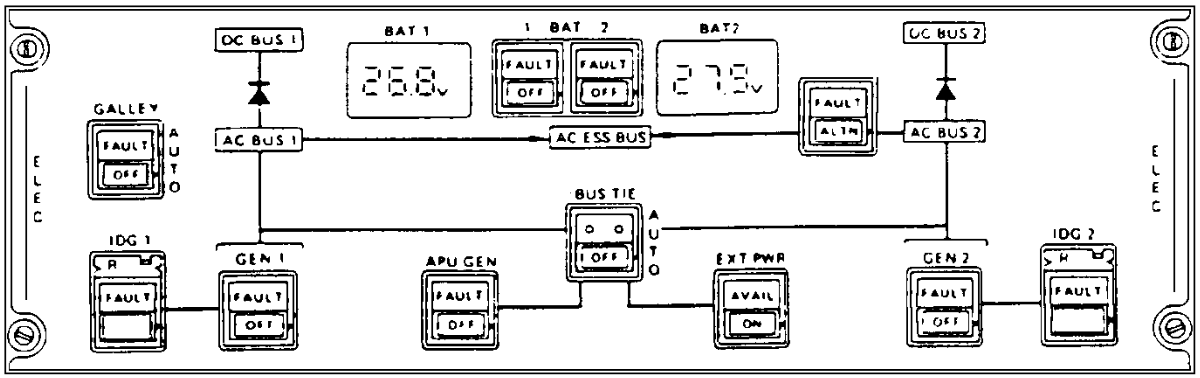
5 – ELECTRICAL POWER SUPPLY:

6 – CERTIFICATION

APPENDIX

2 – CREW INTERFACE: overhead panel

The electrical power sources can be manually controlled though the electrical overhead panels (two panels, one for the normal network and one for the emergency network)

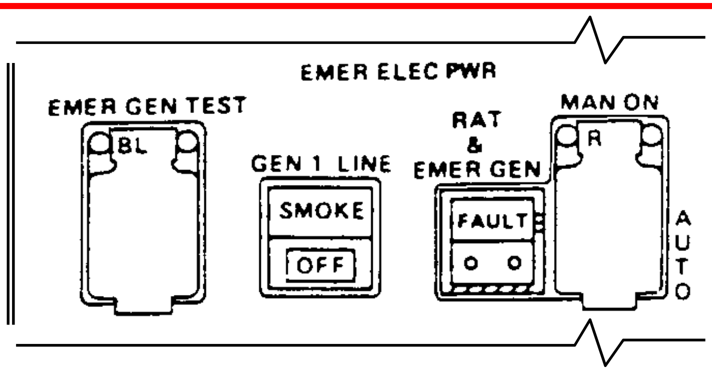


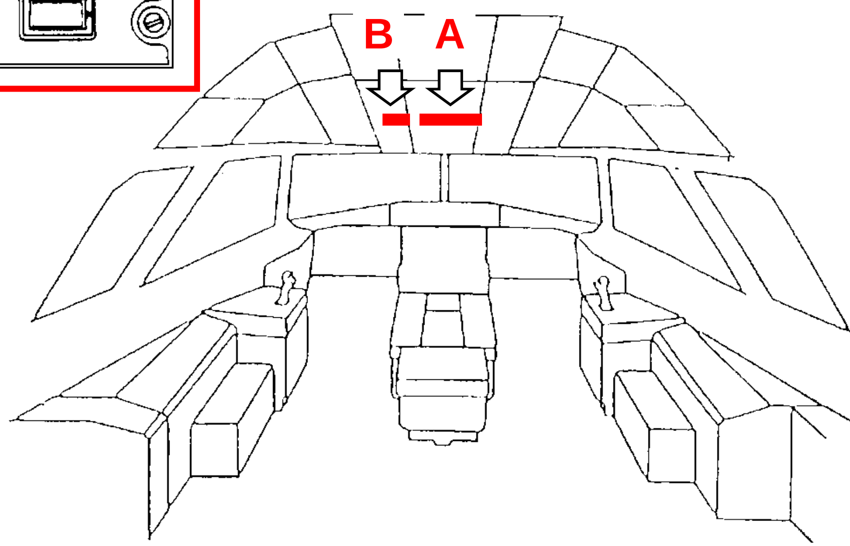
PANEL 35VU

A

PANEL 21VU

B

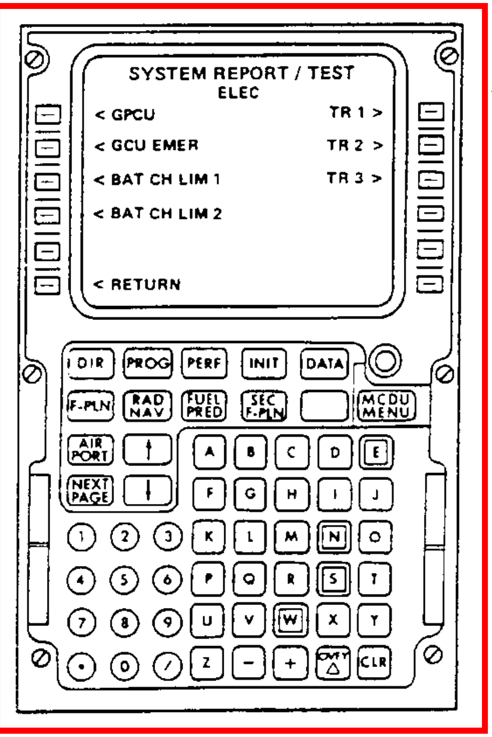




AIRBUS

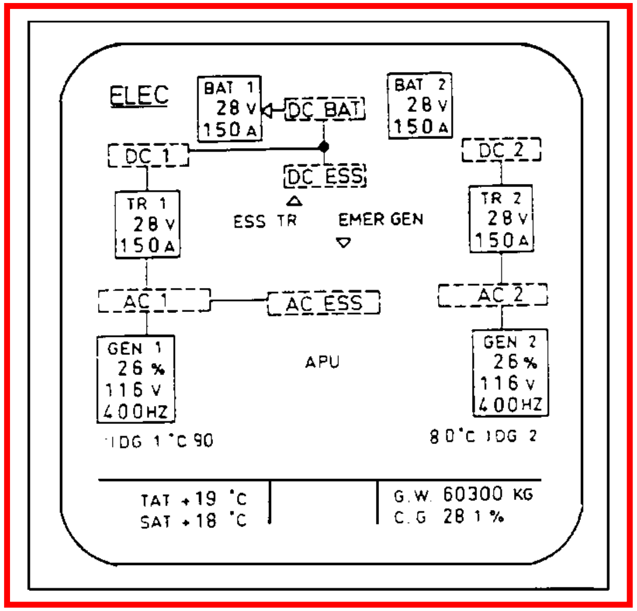
2 – CREW INTERFACE: Maintenance interface and display

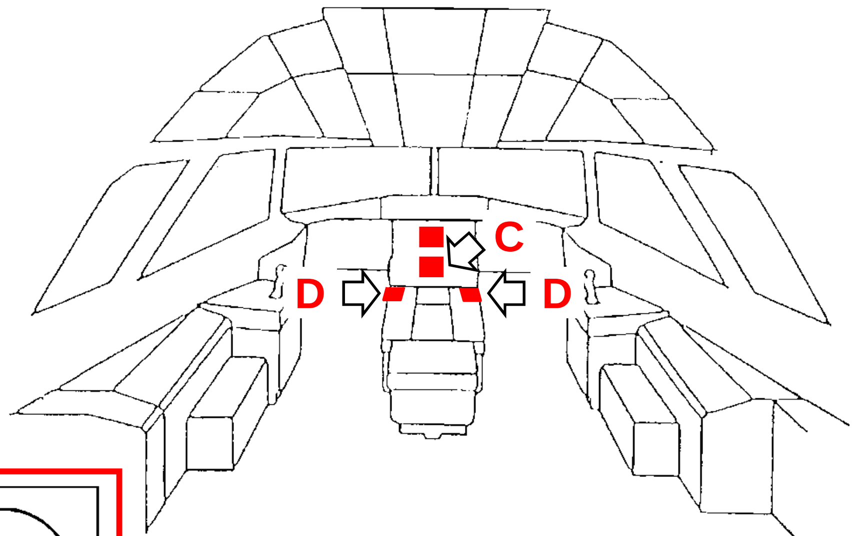
Maintenance interface and system page



D

MCDU maintenance interface





C

DU-ECAM, LOWER ATA 24 system page

AIRBUS

1 - SYSTEM SEGREGATION

2 - CREW INTERFACE

3 - COMPONENTS OF THE SYSTEM

4 - LOCATION OF THE ATA 24 COMPONENTS

5 – ELECTRICAL POWER SUPPLY:

6 – CERTIFICATION

APPENDIX

3 – COMPONENTS OF THE SYSTEM

The main components of the electrical systems are:

- AC network: 115V AC, 400Hz
    - 2 mains generators (IDG, rating: 90 KVA) each driven by 1 engine
    - 1 Auxiliary generator (APU GEN, rating: 90 KVA) driven by APU
    - 1 External power receptacle (rating: 90 KVA)
    - 1 Emergency generator (CSM/G, rating: 5 KVA) driven by a Ram Air Turbine
    - 1 Static inverter (rating: 1 KVA)
- DC network: 28V DC
    - 2 main Transformer Rectifiers (TRU, rating: 200 A) associated to normal network
    - 1 Essential Transformer Rectifier (TRU, rating: 200 A) associated to emergency network
    - 2 batteries (capacity 23 Ah)

All of these components are associated to control/regulation units as GCU for IDG - GPCU for external power- Emer GCU for emergency generator- Batt. Charge Limiter for batteries

3 – COMPONENTS OF THE SYSTEM

IDG : Integrated Drive generator

driven by the engine (variable speed, 4500- 9000 rpm), delivers the electrical power to the consumers.

rating : 90 KVA , three phase, 115 VAC , 400Hz

APU GEN : Auxiliary Power Unit GENerator

driven by the APU (constant speed), delivers the electrical power to the consumers.

rating : 90 KVA , three phase, 115 VAC , 400Hz

GCU : Generator Control Unit

Controls, regulates and protects the IDG and the APU GEN

function : speed regulation, voltage and frequency regulation , protections (Over/under-voltage, Over/Under-current, Over/under-frequency, short-circuits, Low oil pressure, Over-temperature, etc…) , BITE

3 – COMPONENTS OF THE SYSTEM

CSM/G : Constant Speed Motor Generator

driven by the Ram Air Turbine (variable speed), delivers the electrical power to the emergency network.
The CSM/G has two parts, one hydraulic motor driven by the RAT and a generator driven by the hydraulic motor.

rating : 5 KVA , three phase, 115 VAC , 400Hz

Emer GCU : EMERgency Generator Control Unit

Controls and regulates the hydraulic motor and the generator

function : speed regulation, voltage and frequency regulation , protection , BITE

STAT INV : STATic INVerter

delivers AC voltage 115V 400Hz from the DC voltage 28V

rating : 1 KVA , one phase, 115 VAC , 400Hz

control : analogic, regulates the output voltage, protections

3 – COMPONENTS OF THE SYSTEM

TR : Transformer Rectifier

delivers DC voltage 28 V from the AC voltage 115V 400Hz

rating : 28V, 200A continuous, 300A 5 min, 500A 30 sec, 1000A 1 sec

control : analogic, regulates the output voltage, protections

ventilation : Main TR1 and 2 by extraction from aircraft ventilation network, Emergency TR by natural convection (used at 100 A or less)

Batteries 1 and 2

cadmium nickel delivers 28 V DC voltage

characteristics : 20 nickel cadmium accumulators, 23 Ah, high instantaneous power, stainless steel case, two ventilation ducts, Explosion proof

BCL : Battery Charge Limiter

computer, ensures the battery control and the charge of the battery, one BCL by battery.

functions : ensures battery charge, assists the APU start, prevents battery thermal runaway, protects the network and battery against short circuit, supply the DC network on emergency on ground, BITE

1 - SYSTEM SEGREGATION

2 - CREW INTERFACE

3 - COMPONENTS OF THE SYSTEM

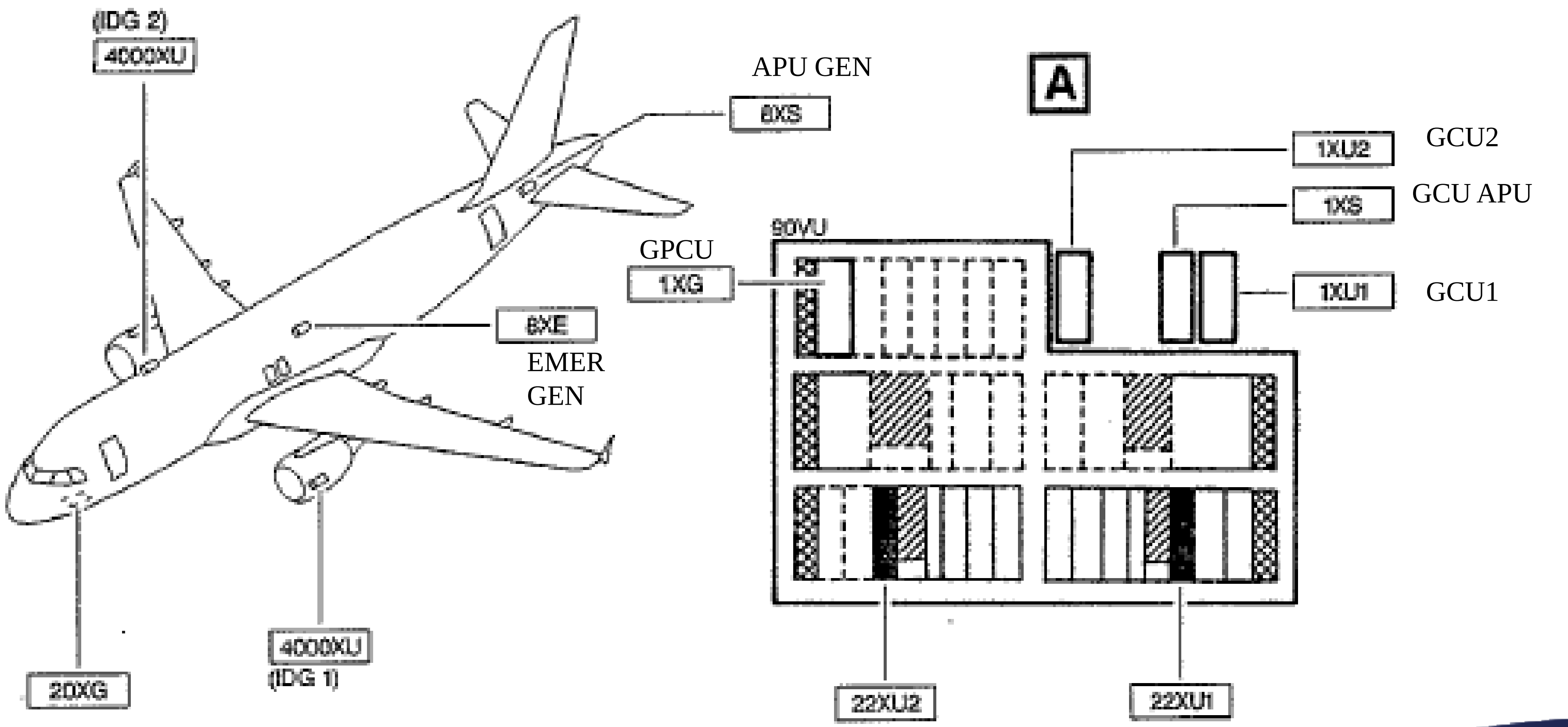
4 - LOCATION OF THE ATA 24 COMPONENTS

5 – ELECTRICAL POWER SUPPLY

6 – CERTIFICATION

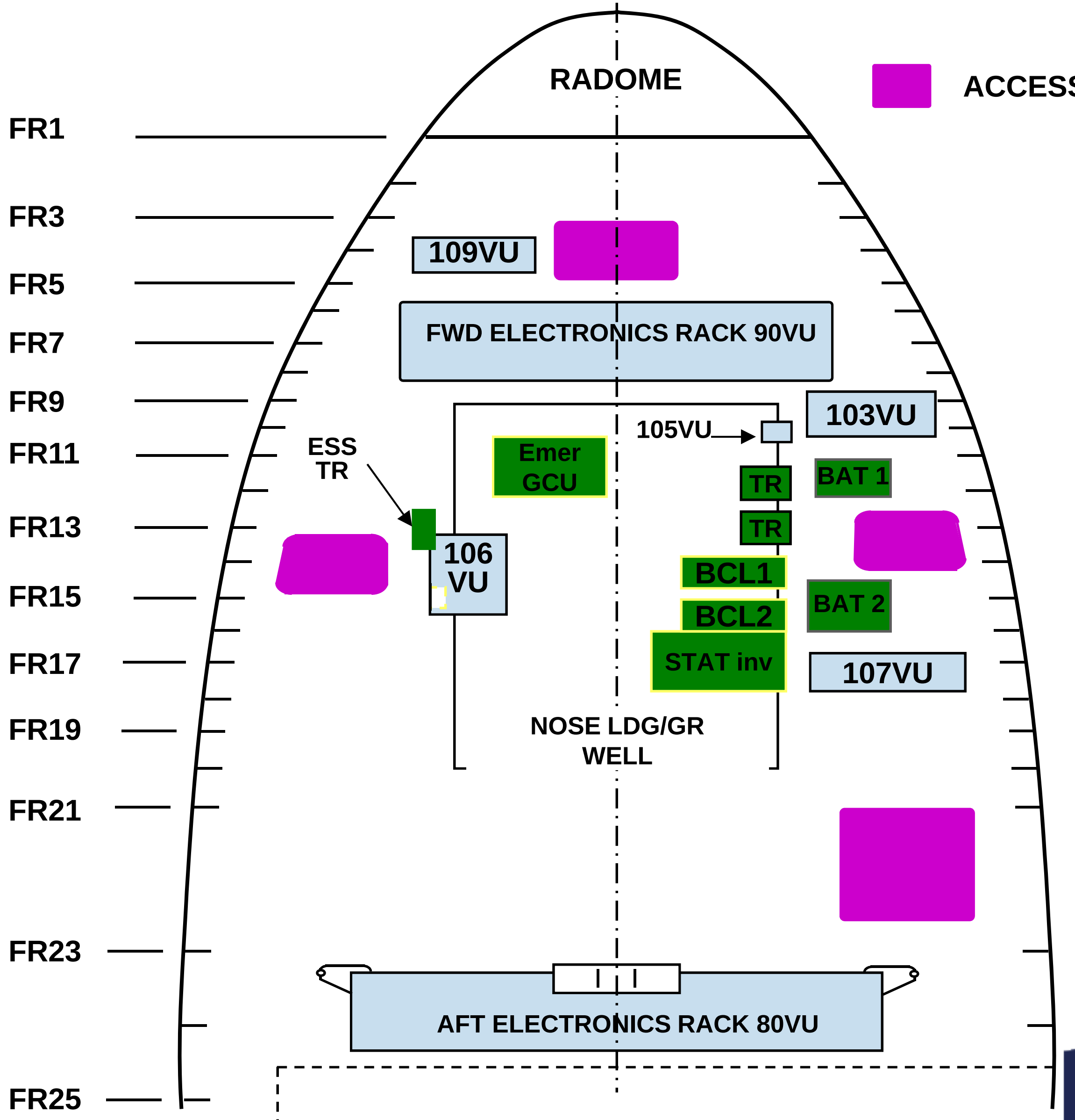
APPENDIX

4 – LOCATION OF THE ATA 24 COMPONENTS



AIRBUS

4 – LOCATION OF THE ATA 24 COMPONENTS



1 - SYSTEM SEGREGATION

2 - CREW INTERFACE

3 - COMPONENTS OF THE SYSTEM

4 - LOCATION OF THE ATA 24 COMPONENTS

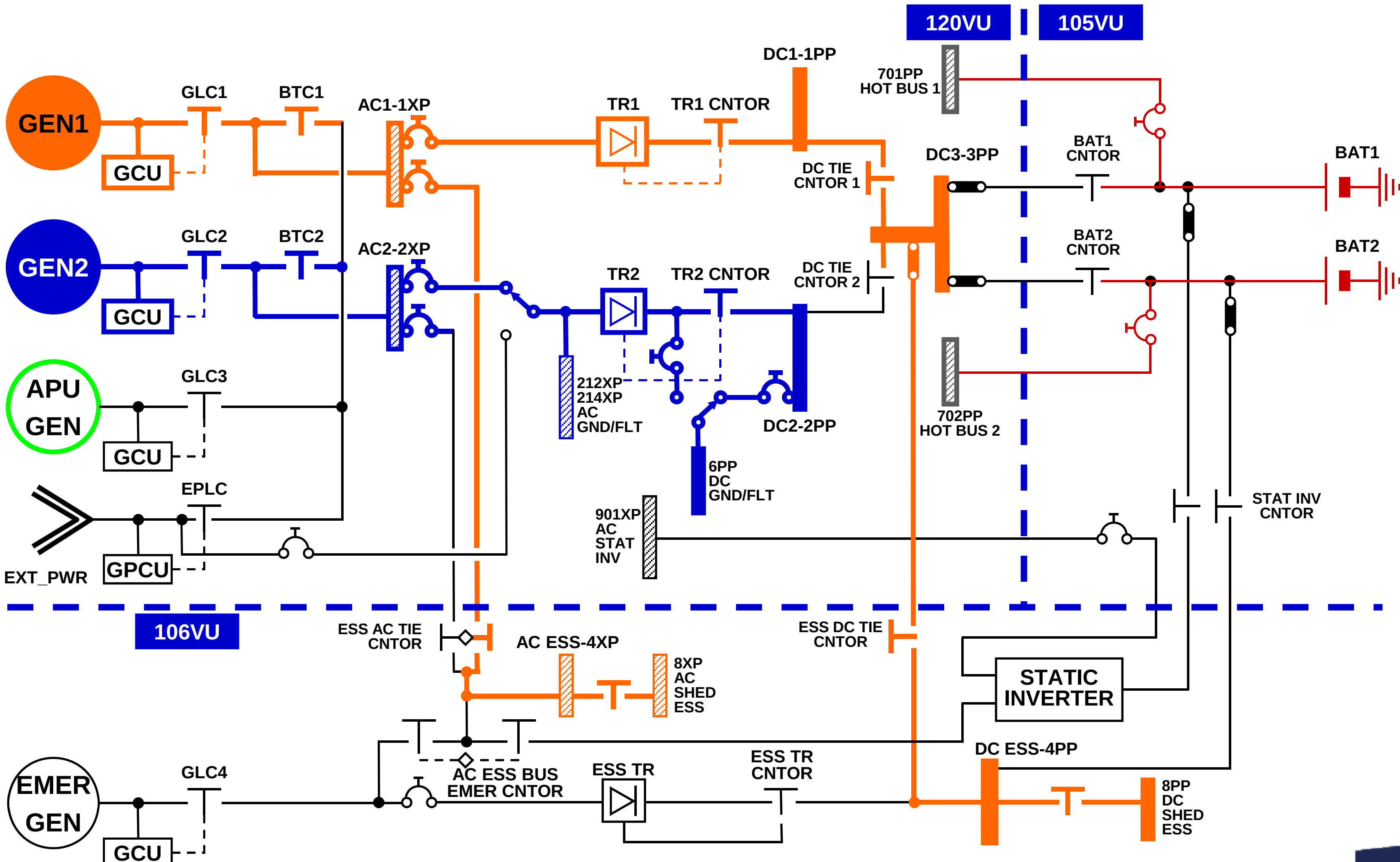
5 – ELECTRICAL POWER SUPPLY:

* in normal configuration
* with one generator loss
* with one generator loss and APU GEN ON
* in case of failure of AC bus 1
* in case of failure of TR1
* in case of failure of TR1 and 2
* during the RAT extension
* in emergency configuration on RAT
* sequence in emergency configuration

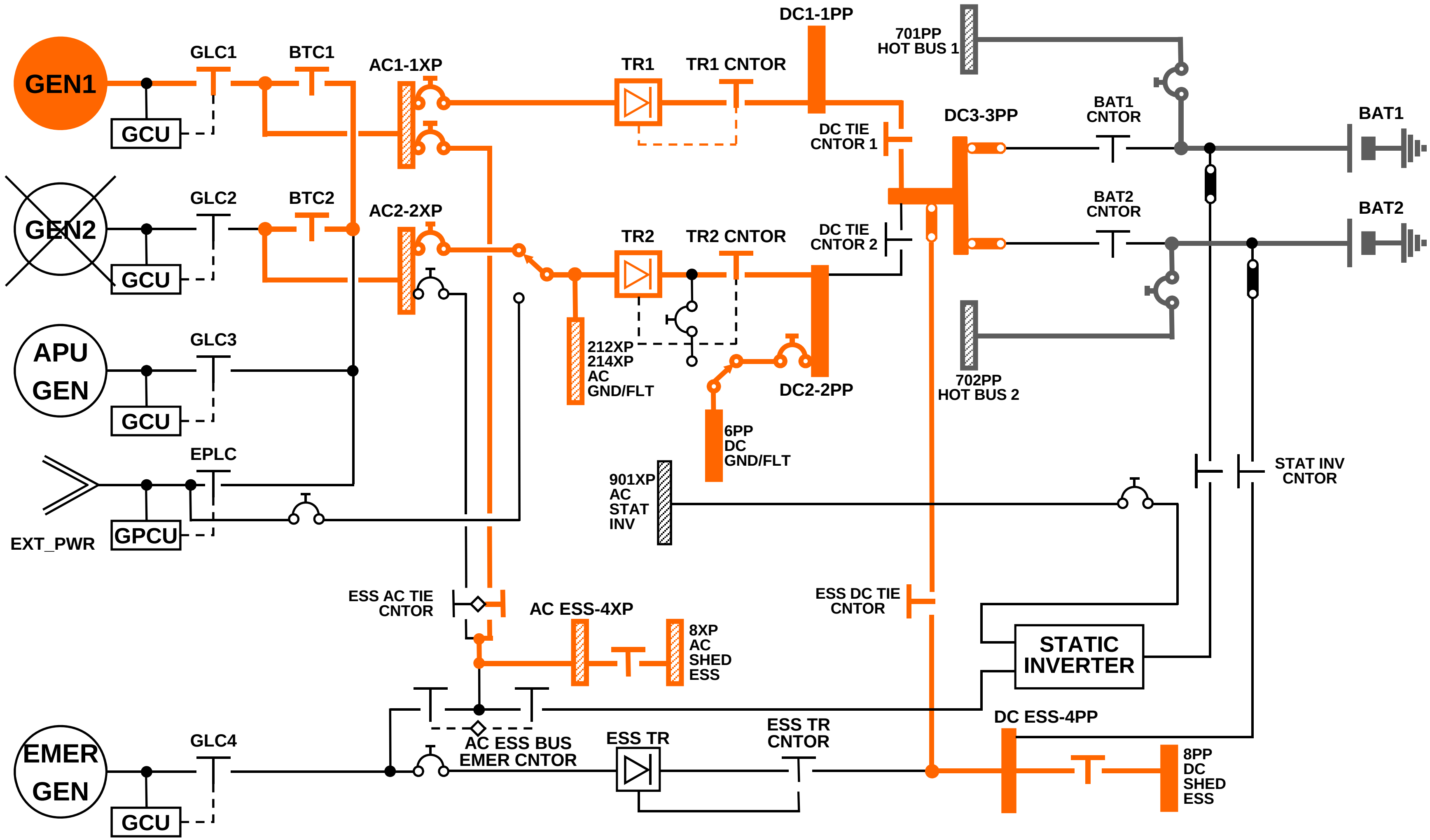
6 – CERTIFICATION

APPENDIX

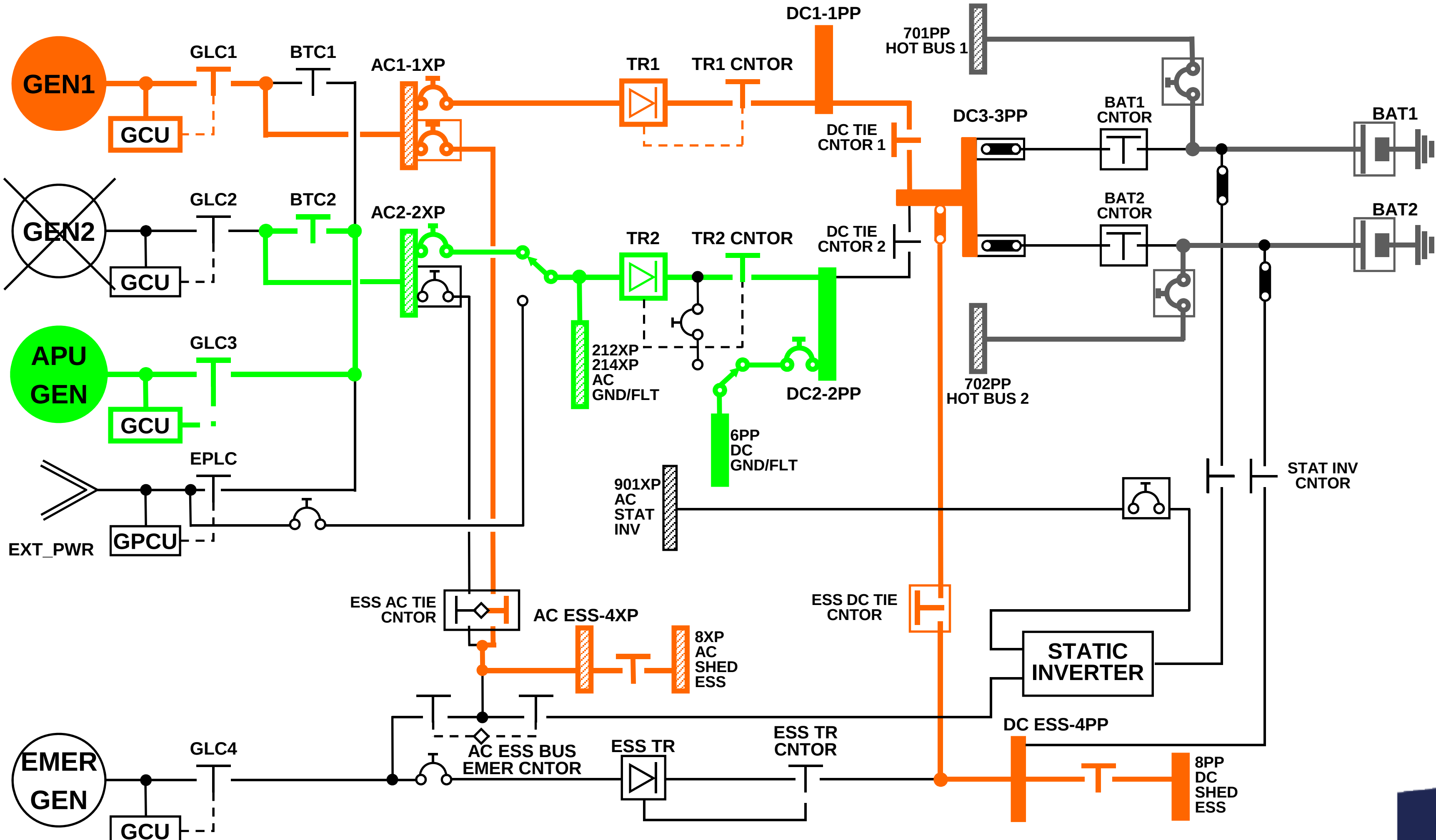
5 – ELECTRICAL POWER SUPPLY : in normal configuration with 2 generators



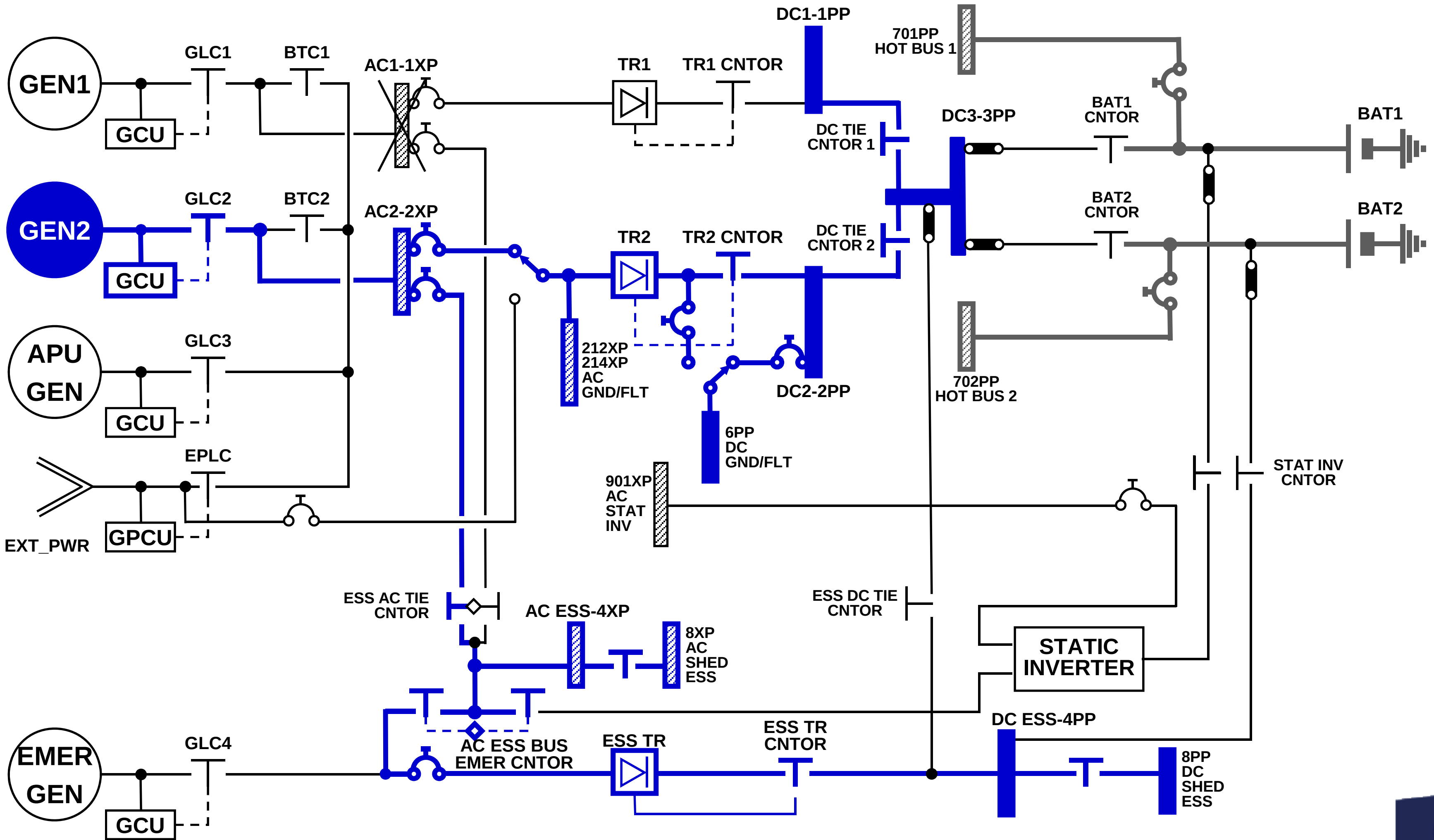
5 – ELECTRICAL POWER SUPPLY : with one generator loss



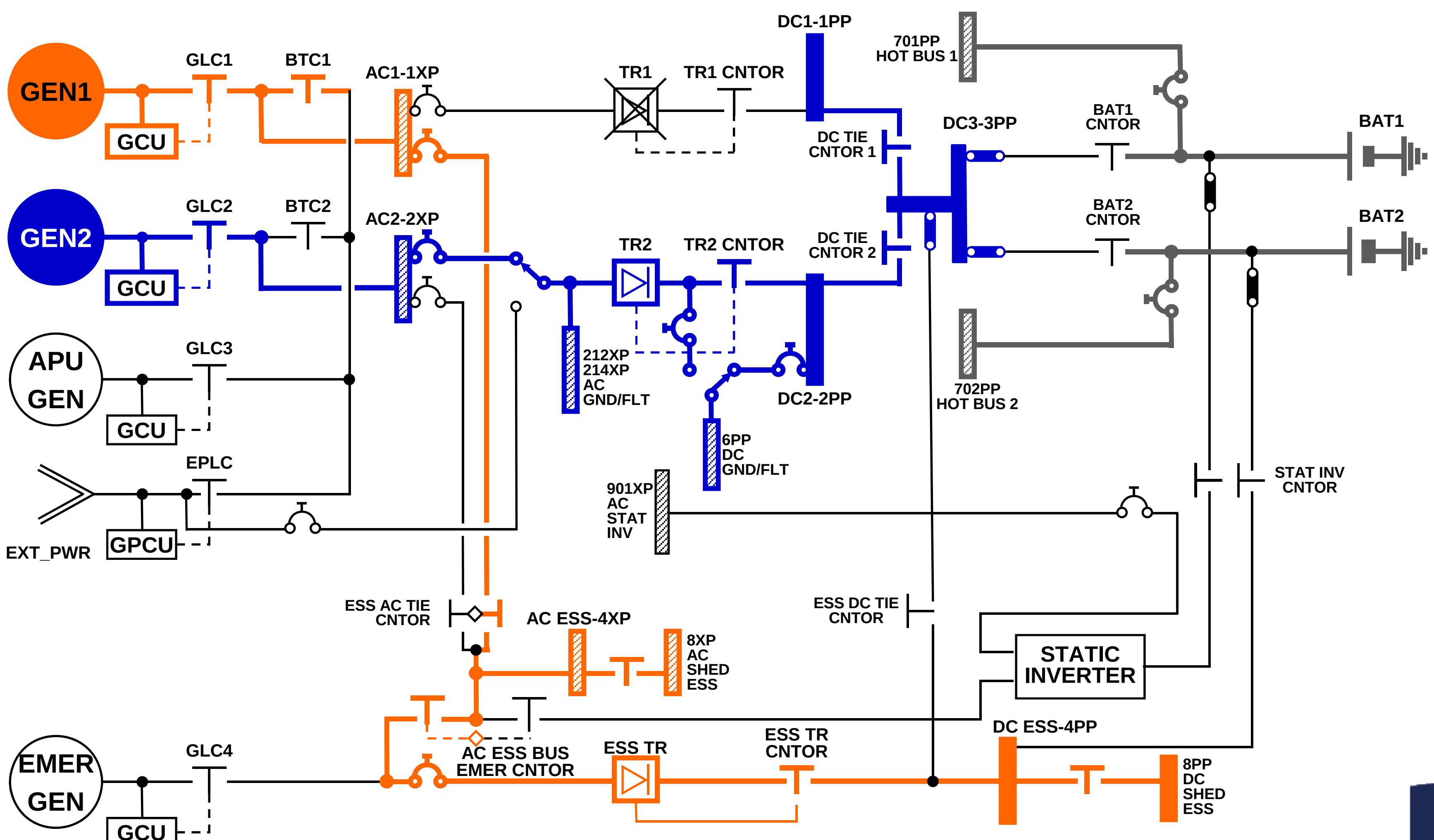
5 – ELECTRICAL POWER SUPPLY : with one generator loss and APU GEN ON



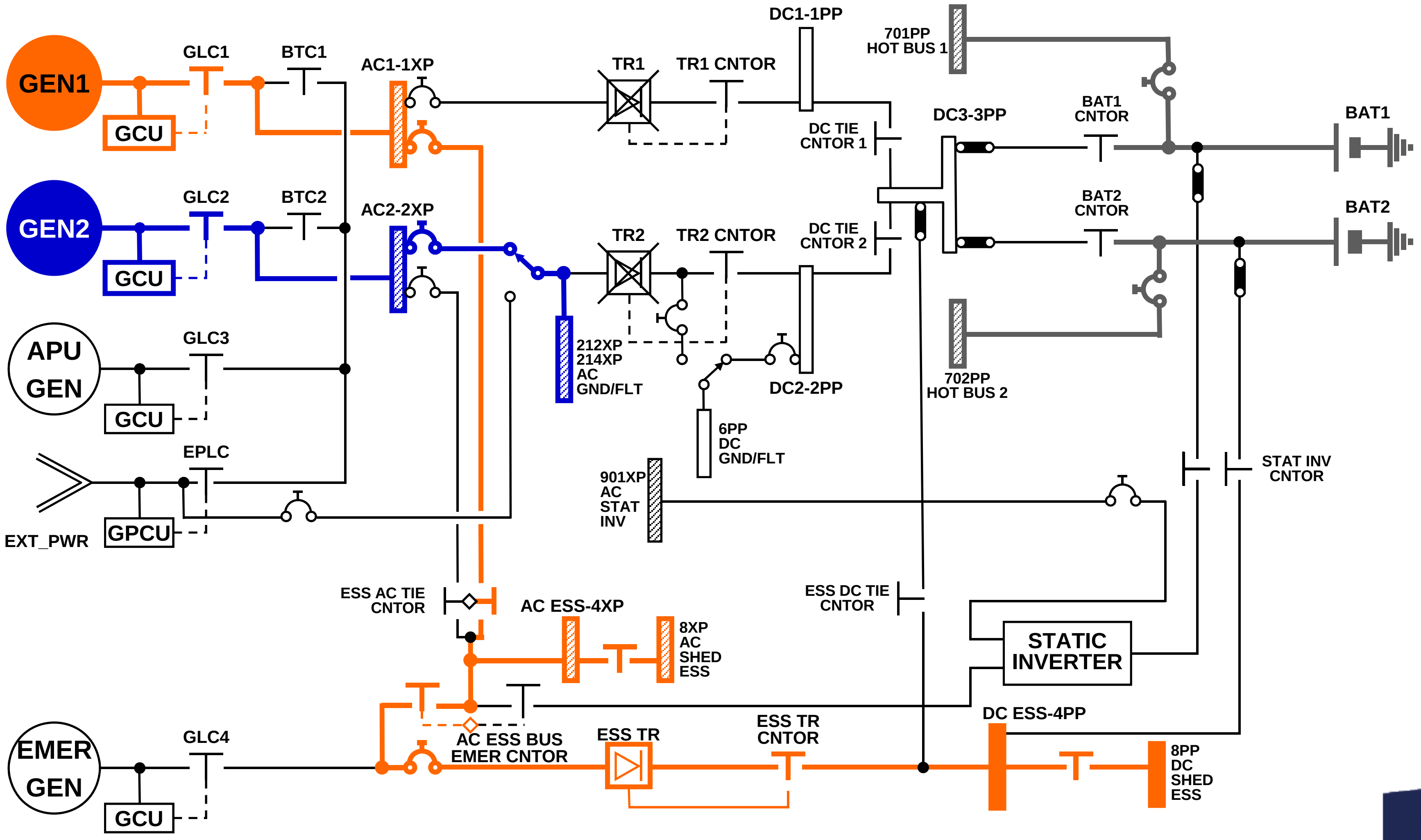
5 – ELECTRICAL POWER SUPPLY : in case of failure of AC bus 1



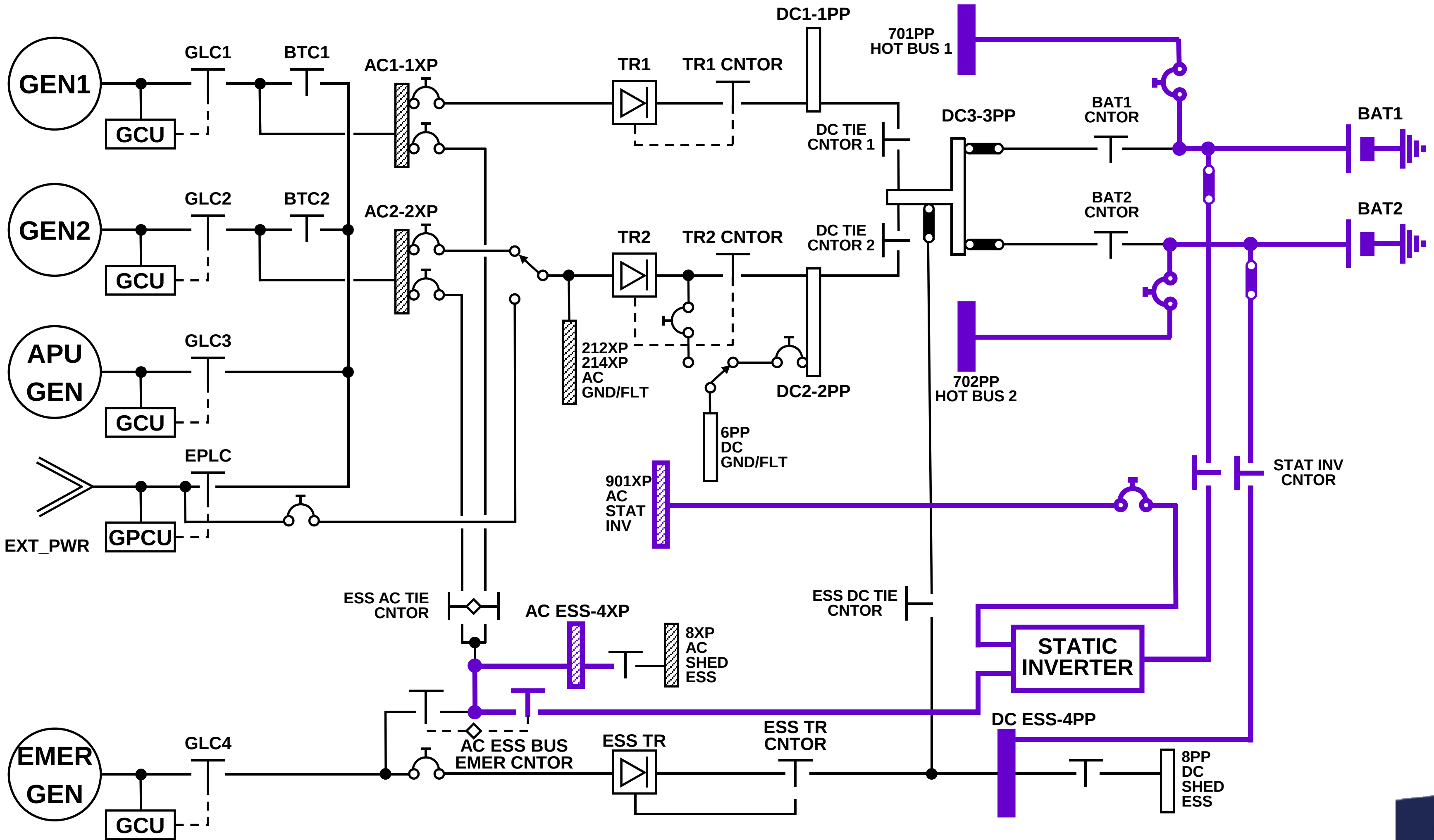
5 – ELECTRICAL POWER SUPPLY : in case of failure of TR1



5 – ELECTRICAL POWER SUPPLY : in case of failure of TR1 and 2

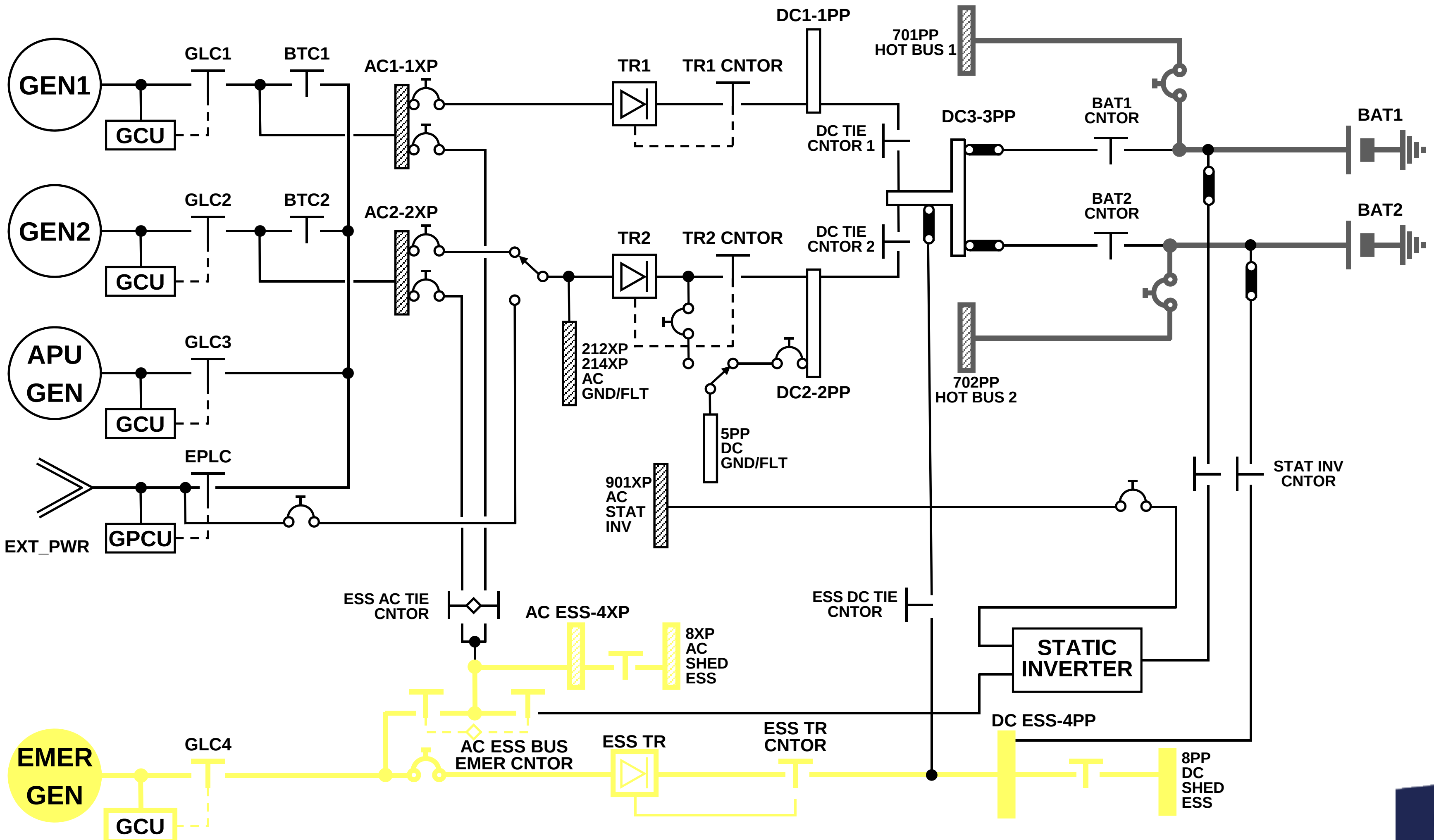


5 – ELECTRICAL POWER SUPPLY : during the RAT extension

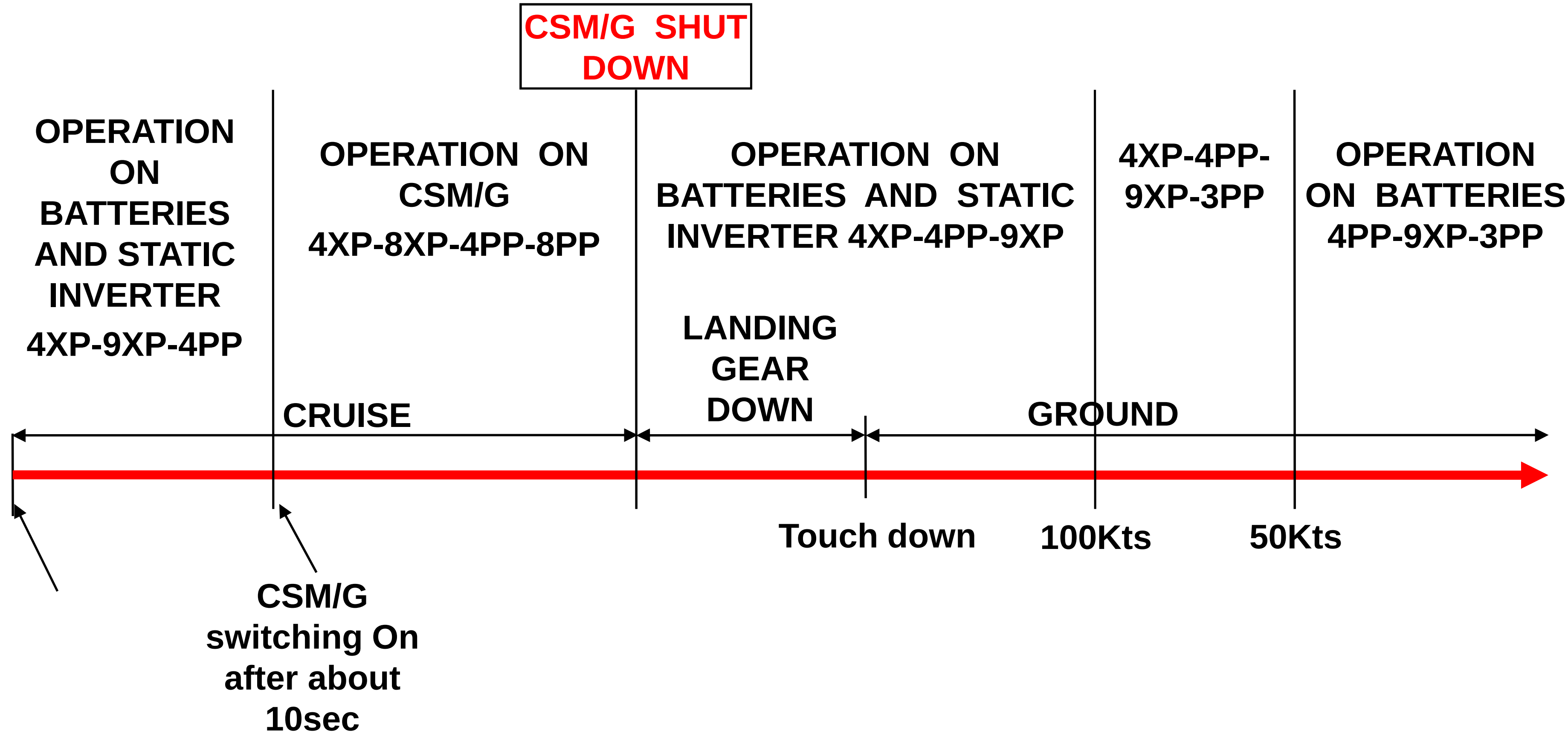


AIRBUS

5 – ELECTRICAL POWER SUPPLY : in emergency configuration on RAT



5 – ELECTRICAL POWER SUPPLY : sequence in emergency configuration



1 - SYSTEM SEGREGATION

2 - CREW INTERFACE

3 - COMPONENTS OF THE SYSTEM

4 - LOCATION OF THE ATA 24 COMPONENTS

5 – ELECTRICAL POWER SUPPLY:

6 – CERTIFICATION

* certification basis
* JAR 25 compliance
* CRI S-52 compliance

APPENDIX

AIRBUS

6 - CERTIFICATION : Certifications basis

JAR 25 change 11
+
CRI SE 2405 : Aircraft electrical wiring
+
CRI SE 2406 : Ram Air Turbine reliability
+
CRI SE 2407 : Emergency electrical power system
+
CRI S54 : Circuit protective device
+
IM S52 : Operation without electrical power (replace JAR 25.1351(d))

6 - CERTIFICATION: JAR 25 compliance

18 documents have been delivered to JAA for compliance to JAR 25 and CRI's

REFERENCE	TITLE	CONTENT
00D240P0001/C00	Electrical power compliance record sheet	Give for each airworthiness requirement the document (s) which show the compliance
00D240P1001/C01	Electrical generation and distribution system description	Describes the electrical system
00D240P1002/C0S	IDG specification and qualification test program	Airbus IDG specification and qualification program
00D240P1003/C01	Laboratory test bench description	Description of the AIRBUS laboratory installation
00D240P1004/C01	Equipment : electrical power supply	Contain the ABD 0013. The ABD 0013 is an AIRBUS directive which defines all the characteristics of the electrical busbars(voltage, transients, limits…).
00D240P1005/C01	Electrical wiring segregation	Gives the principles of the wiring segregations applied in the definition of the A320 electrical installation
00D240P1007/C0S	Technical specification and qualification test program for emergency generation system	Airbus IDG specification and qualification program
00D240P2001/C02	Electrical load analysis	Gives the electrical load on each power source in normal configuration and in failure conditions (loss of power sources)
00D240P2002/C02	IDG excess speed analysis	Demonstrate the self contain of the IDG in case of overspeed, overpressure and verify the proper functioning of the disconnection in case of failure
00D240P3001/C03	Electrical Power System Safety Analysis	Document for demonstration of the safety objectives
00D240P4001/P04	Electrical system test program	Airbus laboratory test program for ATA 24
00D240P4002/C04	Electrical system test report	Airbus laboratory test report for ATA 24
00D240P6001/C06	Electrical system flight test report	Airbus flight test report for ATA 24
00D240P7001/C07	Electrical system inspection record	Report of the aircraft inspection performed with JAA
00D240P9001/C09	Electrical system list of DDP	Gives the list of the synthesis qualification documents for each equipment
00D240P9002/C09	IDG qualification report	Report of the IDG qualification
00D240P9003/C09	Emergency generating system qualification report	Report of the emer GEN qualification
00D240P9004/C09	APU generator qualification report	Report of the APU GEN qualification

6 - CERTIFICATION: CRI S52 compliance

AIRBUS INDUSTRIE OFFICE OF AIRWORTHINESS	A320 COMPLIANCE RECORD					
25. 1351d *SC-S52 OPERATION WITHOUT NORMAL ELECTRICAL POWER						
	F/C	ATA	MoC	PROOF OF COMPLIANCE	DOCUMENT	ISSUE
EC-S52 (See IM-S52) (d) OPERATION WITHOUT NORMAL ELECTRI-CAL POWER (1) Unless it can be shown that the loss of the normal generated electrical power system is Extremely Improbable, an alternate high integrity electrical power system, independent of the normal electrical power system(s), must be provided to power those services necessary to complete a flight and make a safe landing. The services to be powered must include: (i) those required for immediate safety and which must continue to operate, following the loss of all normal electrical power without the need for flight crew action. (ii) those required for continued controlled flight. (iii) those required for descent, approach and landing. (2) Failures, including junction box, control panel or wire bundle fires, which could result in the loss of both the normal and alternate systems must be shown to be Extremely Improbable.	240	240	1 3 6	"Requirement satisfied" An alternate high integrity electrical power system is used including an emergency generator and batteries The services powered comply with this requirement, they are listed in the AFM. The emergency power system is fully segregated from the normal power centre; the power centres related to this system are physically separated from the main power centre, and also their C/B's and bundles.	00D240P1001/C01 (SDN) 00D240P1007/C0S (technical spec. for Emer Elec Gen System) 00D240P3001/C03 (SSA) 00D240P6001/C06 (Flight Test Report)	ISS03 ISS01 ISS02 ISS01

AIRBUS

• **Appendix 1:** systems supplied in emergency configuration

LIST OF AVAILABLE FUNCTIONS	SUPPLY ONLY BY BATTERIES (FLIGHT)	SUPPLY BY EMERGENCY GEN (FLIGHT)	SUPPLY ONLY BY BATTERIES	SUPPLY ONLY BY BATTERIES (GROUND)
	LOSS OF MAIN ELECTRICAL GENERATION			
	DURING RAT DEPLOYMENT	CSM/G RUNNING	AFTER L/G EXTENSION	V < 50 Kts
ATA 21: AIR CONDITIONING				
AUTO PRESSURIZATION SYSTEM 1	X	X	X	X
EXTRACTION BY ΔP (ONLY FLIGHT)	X	X	X	
BLOWING BY AIR CONDITIONING	X	X	X	
RAM AIR INLET	X	X	X	X
ATA 22: AUTO FLIGHT				
FAC 1		X		
FCU 1	X	X	X	X
ATA 23: COMMUNICATION				
VHF 1	X	X	X	X
AUDIO MANAGER UNIT (CAPT-F/O)	X	X	X	X
RADIO MANAGER UNIT 1 (RMP1)	X	X	X	X
FLIGHT INTERPHONE	X	X	X	X
CIDS	X	X	X	X
CVR		X		

• **Appendix 1:** systems supplied in emergency configuration

LIST OF AVAILABLE FUNCTIONS	SUPPLY ONLY BY BATTERIES (FLIGHT)	SUPPLY BY EMERGENCY GEN (FLIGHT)	SUPPLY ONLY BY BATTERIES	SUPPLY ONLY BY BATTERIES (GROUND)
	LOSS OF MAIN ELECTRICAL GENERATION			
	DURING RAT DEPLOYMENT	CSM/G RUNNING	AFTER L/G EXTENSION	V < 50 KTs
ATA 24: ELECTRICAL				
BAT CHG LIM 1&2 SUPPLY	X	X	X	X
VOLT REF BAT 1&2	X	X	X	X
CSM/G ELECTROVALVE AUTO SUPPLY		X		
GEN 1&2 WARNING LIGHT	X	X	X	X
ATA 26: FIRE PROTECTION				
ENG 1 FIRE DET LOOP A	X	X	X	X
ENG 2 FIRE DET LOOP B	X	X	X	X
ENG 1&2 FIRE EXTINGH BTL 1	X	X	X	X
APU FIRE AND OVHT DET LOOP A&B		X		X
APU FIRE EXTINGH SQUIB A	X	X	X	X
CARGO SMOKE DET CHAN 1				X
CARGO FIRE EXTINGH				X

• **Appendix 1:** systems supplied in emergency configuration

LIST OF AVAILABLE FUNCTIONS	SUPPLY ONLY BY BATTERIES (FLIGHT)	SUPPLY BY EMERGENCY GEN (FLIGHT)	SUPPLY ONLY BY BATTERIES	SUPPLY ONLY BY BATTERIES (GROUND)
	LOSS OF MAIN ELECTRICAL GENERATION			
	DURING RAT DEPLOYMENT	CSM/G RUNNING	AFTER L/G EXTENSION	V < 50 KTs
ATA 27: FLIGHT CONTROL				
ELAC 1	X	X	X	X
ELAC 2	X		X	X
SEC 1	X	X	X	X
ASSOCIATED ELECTROVALVES	X	X	X	X
TRIM (THS) (MOT 1)	X			
TRIM (THS) (MOT 2)		X		
FCDC 1		X		
SFCC 1	X	X	X	X
FLAPS/SLATS POSITION IND.	X	X	X	
ATA 28: FUEL (see nota)				
FUEL QUANTITY IND 1		X		
FUEL CROSS FEED VALVE		X		
LP FUEL FIRE SHUT OFF CTL	X	X	X	X
INTERCELL TRANSFERT VALVE		X		
Note: for smoke configuration 1 fuel pump per engine is supplied by gen1 upstream GLC1.				

• **Appendix 1:** systems supplied in emergency configuration

LIST OF AVAILABLE FUNCTIONS	SUPPLY ONLY BY BATTERIES (FLIGHT)	SUPPLY BY EMERGENCY GEN (FLIGHT)	SUPPLY ONLY BY BATTERIES	SUPPLY ONLY BY BATTERIES (GROUND)
	LOSS OF MAIN ELECTRICAL GENERATION			
	DURING RAT DEPLOYMENT	CSM/G RUNNING	AFTER L/G EXTENSION	V < 50 KTs
ATA 29: HYDRAULIC POWER				
HYDRAULIC FIRE VALVE ENG 1 AND 2	X	X	X	X
ATA 30: ICE AND RAIN PROTECTION				
NACELLE ANTI-ICE (PNEUMAT OPENING)	X	X	X	X
CAPTAIN S PITOT ANTI-ICE	X	X	X	
PROBE ICE PROTECTION (CTL&MONG)	X	X	X	X
RAIN REPELLENT	X	X	X	X
ATA 31: INDICATING/RECORDING SYSTEM				
DMC 1 OR 3	X	X	X	
PFD CAPT	X	X	X	
ECAM DU UPPER	X	X	X	
SDAC 1	X	X	X	
FWC 1	X	X	X	
COCKPIT LOUD SPEAKER 1	X	X	X	X
ELECTRICAL CLOCK	X	X	X	X
ECAM CTL PANEL	X	X	X	X

• **Appendix 1:** systems supplied in emergency configuration

LIST OF AVAILABLE FUNCTIONS	SUPPLY ONLY BY BATTERIES (FLIGHT)	SUPPLY BY EMERGENCY GEN (FLIGHT)	SUPPLY ONLY BY BATTERIES	SUPPLY ONLY BY BATTERIES (GROUND)
	LOSS OF MAIN ELECTRICAL GENERATION			
	DURING RAT DEPLOYMENT	CSM/G RUNNING	AFTER L/G EXTENSION	V < 50 KTs
ATA 32: LANDING GEAR				
LGCIU 1 (L/G EXTENSION AND RETRACTION FUNCTION)	X	X	X	X
EMERGENCY BRAKE	X	X	X	X
PARKING BRAKE	X	X	X	X
TRIPLE BRAKE PRESS INDICATOR	X	X	X	X
ATA 33: LIGHTS				
STANDBY COMPASS LIGHTING	X	X	X	X
EMERGENCY COCKPIT LIGHTING (CAPT)	X	X	X	X
EMERGENCY CABIN LIGHTING	X	X	X	X
ATA 34: NAVIGATION				
VOR 1	X	X	X	
ILS 1	X	X	X	
DME 1		X		
STANDBY HORIZON	X	X	X	X
ADIRS 1	X	X	X	X
VIBRATOR FOR STANDBY ALTIMETER		X		
ATC 1 & CTL BOX		X		
STBY VOR DME RMI	X	X	X	

• **Appendix 1:** systems supplied in emergency configuration

LIST OF AVAILABLE FUNCTIONS	SUPPLY ONLY BY BATTERIES (FLIGHT)	SUPPLY BY EMERGENCY GEN (FLIGHT)	SUPPLY ONLY BY BATTERIES	SUPPLY ONLY BY BATTERIES (GROUND)
	LOSS OF MAIN ELECTRICAL GENERATION			
	DURING RAT DEPLOYMENT	CSM/G RUNNING	AFTER L/G EXTENSION	V < 50 KTs
ATA 35: OXYGEN				
CREW OXYGEN CTL	X	X	X	X
Passenger OXYGEN CTL & IND		X		
ATA 36: PNEUMATIC				
AIR BLEED ENG & MON 1 CTL		X		
ATA 49: APU				
**ECB		X		X
**APU FUEL PUMP		X		X
** APU FUEL LP VALVE		X		X
Nota: ** only if master switch "ON";only 2 start attemps are allowed				
ATA 72-78/ ENGINE CONTROL				
ENGINE 1&2 REVERSE CONTROL (INCL FADEC)			X(GND ONLY)	X(GND ONLY)
FADEC 1 & EIU1	X	X	X	X
FADEC 2 & EIU2	X	X	X	X
CONTINUOUS RELIGHT SYS A	X	X	X	X
HP FUEL SOLENOID ENG 1 & 2	X	X	X	X

Appendix 2: Glossary:

APU: Auxiliary Power Unit

BCL: Battery Charger Limiter

BITE : Built In Test Equipment

GCU: Generator Control Unit

GPCU: Ground Power Control Unit

IDG: Integrated Drive Generator

MCDU: Multi Control Display Unit

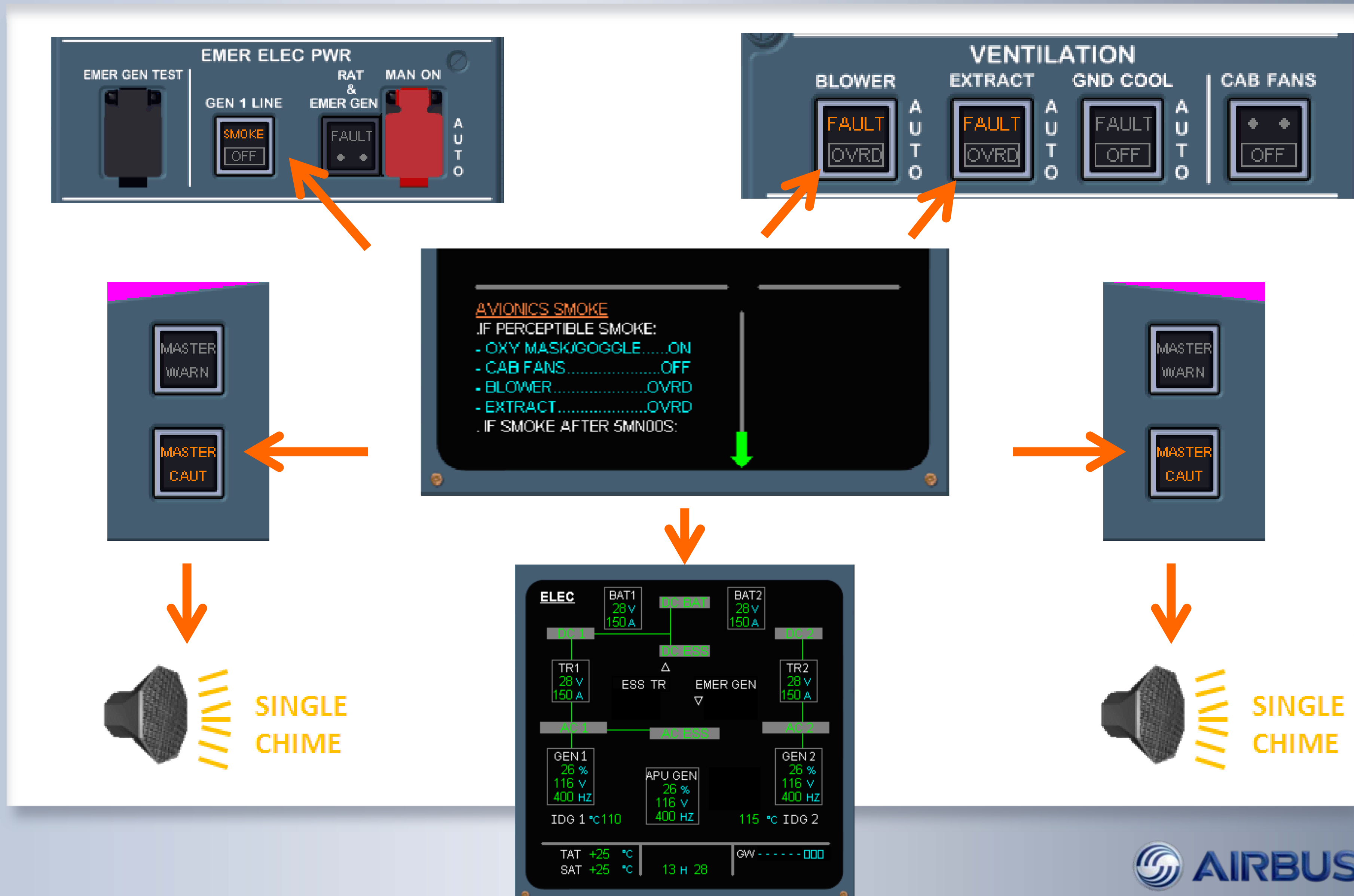
RAT: Ram Air Turbine

TRU: Transformer rectifier Unit

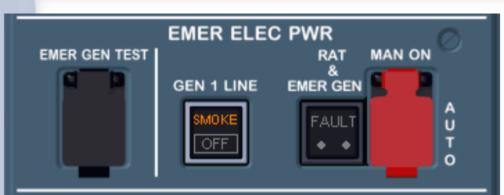
AIRBUS

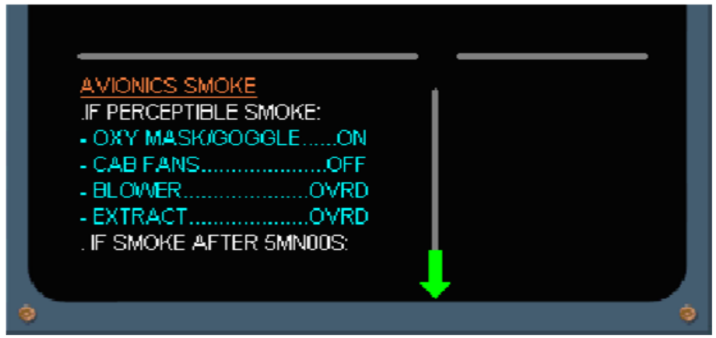
AN EADS JOINT COMPANY
WITH BAE SYSTEMS

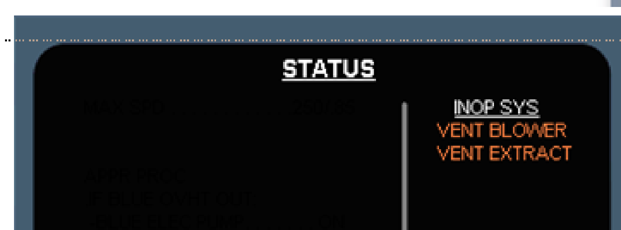
ON GROUND – CKPT effects



MMEL ENTRY







ECAM Alert: **AVIONICS SMOKE**

Ident.: ME-26-00007920.0001001 / 11 MAR 10
Applicable to: ALL

AIRCRAFT STATUS	CONDITION OF DISPATCH
Actual alert	NO DISPATCH

AIRCRAFT STATUS	CONDITION OF DISPATCH
False alert	*Refer to Item 26-15-01 Avionics Smoke Detection System*

26-15-01	Avionics Smoke Detection System

Ident.: MI-26-15-00008485.0001001 / 22 MAR 10
Applicable to: ALL

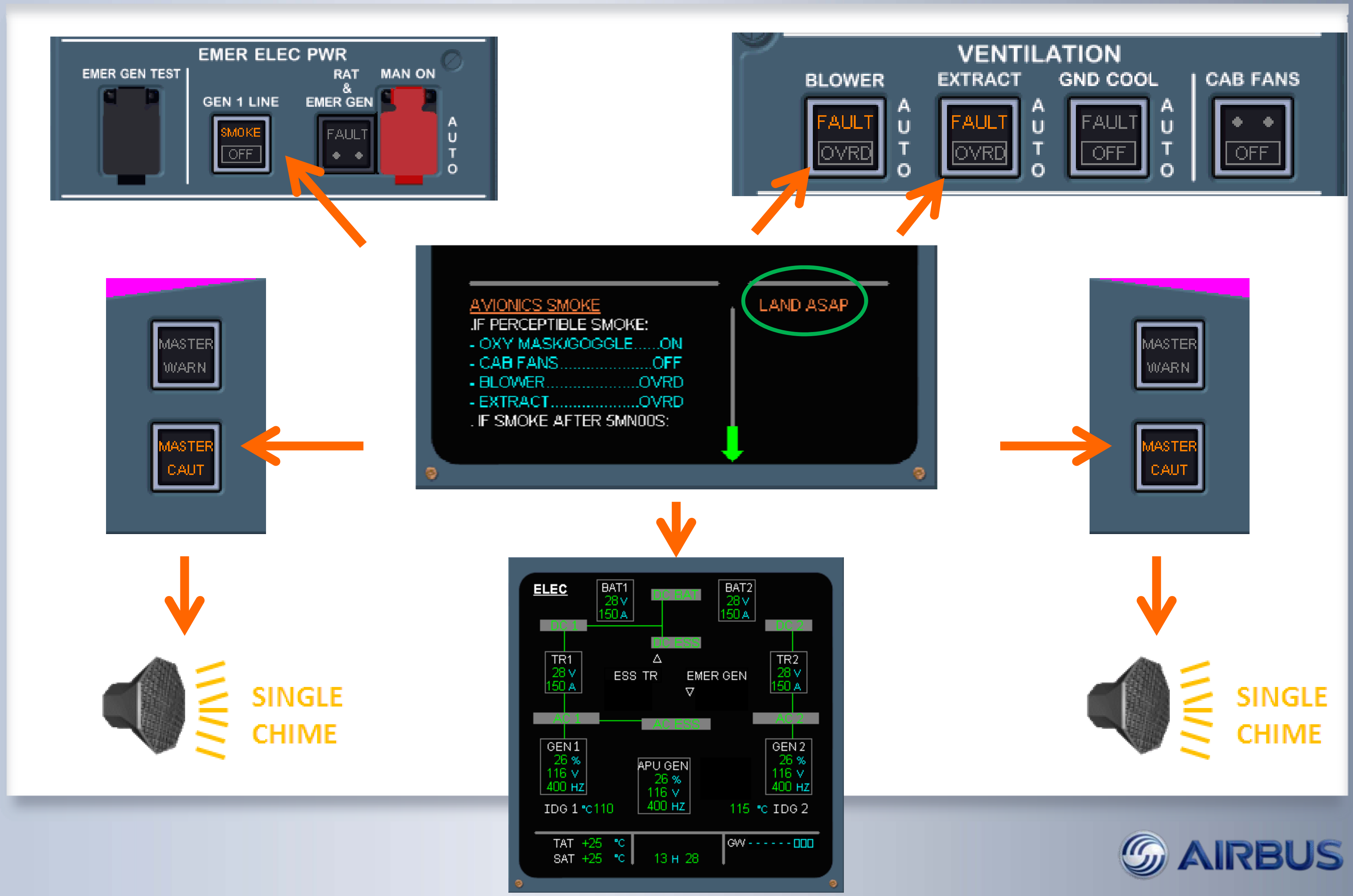
26-15-01A

Repair interval	Nbr installed	Nbr required	Placard
C	**1**	**0**	**No**

(o) May be inoperative provided that ETOPS is not conducted.

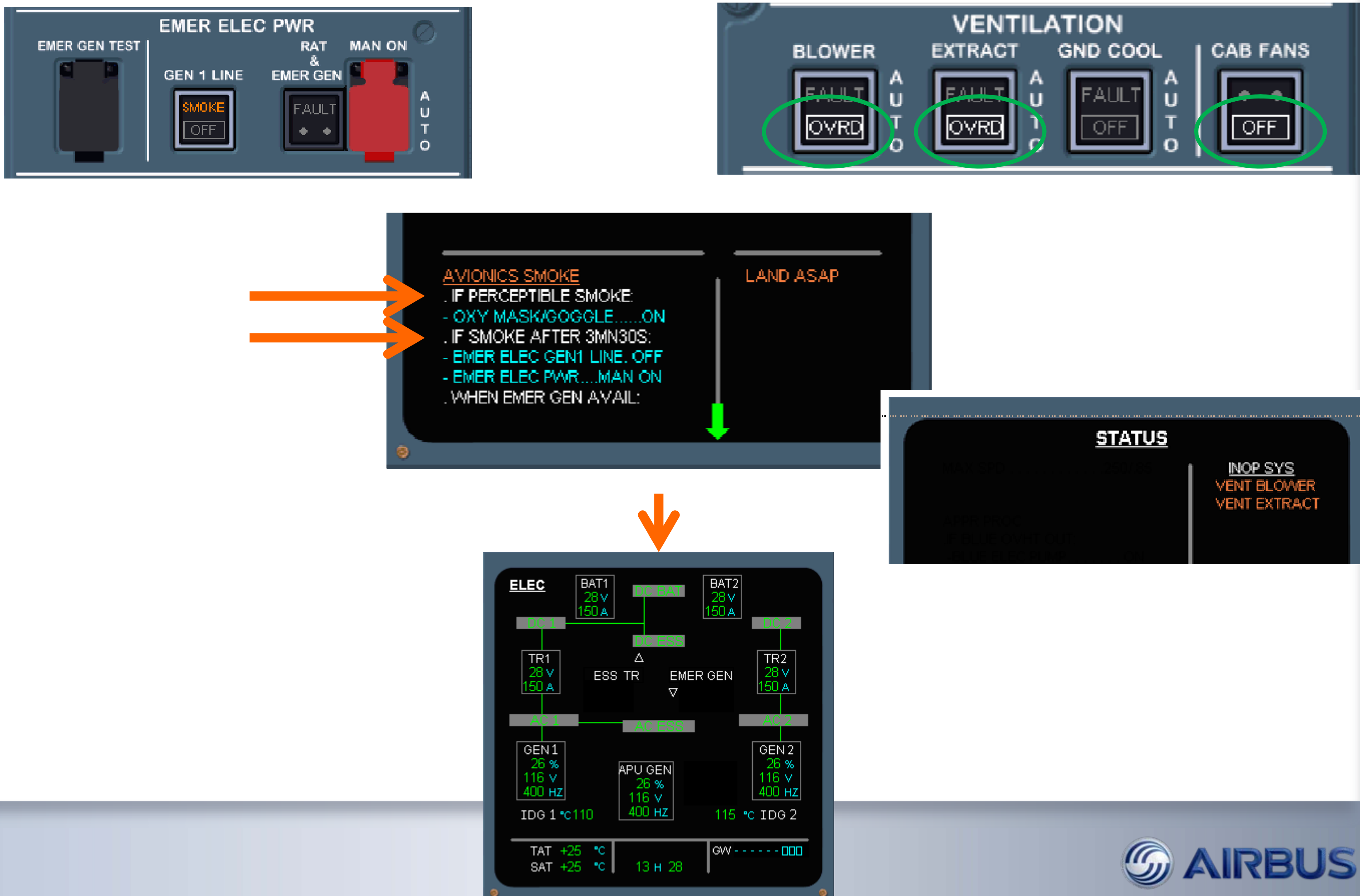
AIRBUS

IN FLIGHT – CKPT effects



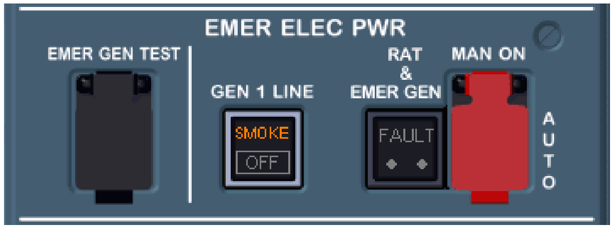
AIRBUS

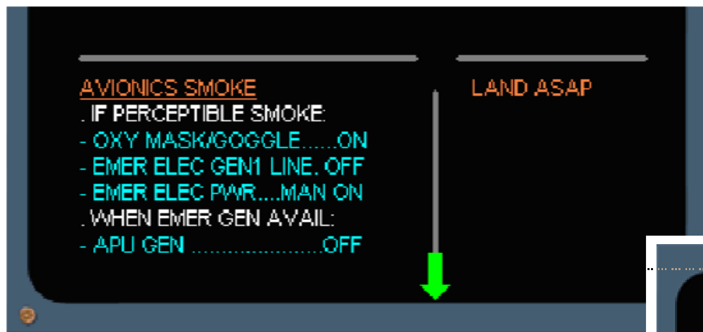
ECAM checklist

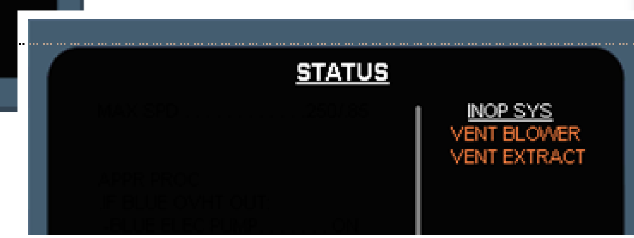


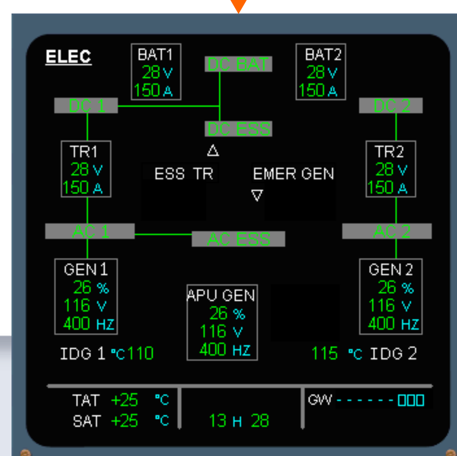
AIRBUS

ECAM checklist after 5 minutes



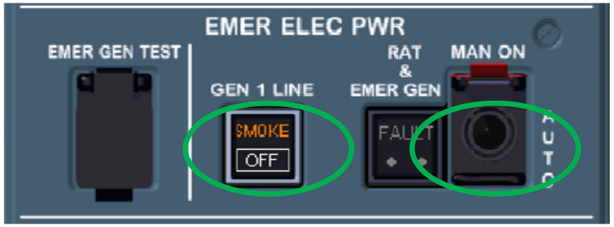


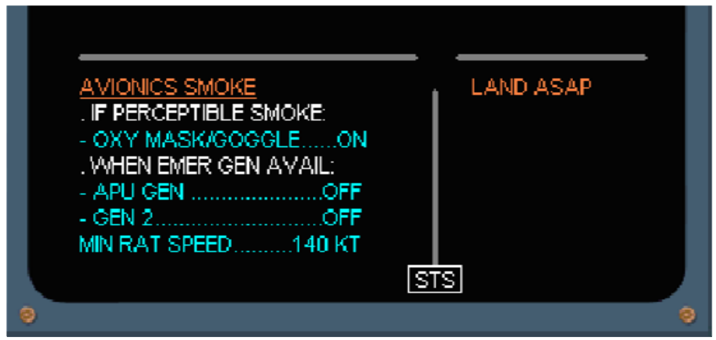




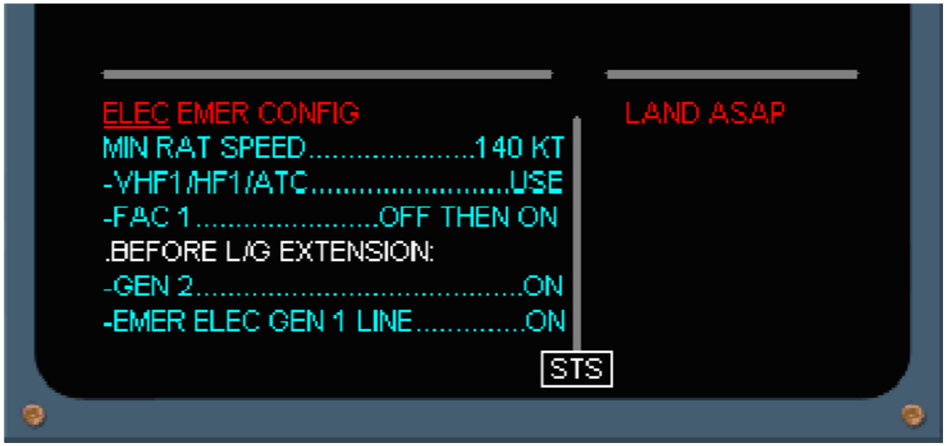
AIRBUS

ECAM checklist after 5 minutes





ELEC EMER CONFIG checklist



After recovery of Normal Elec. Config.

Recovery of normal braking and all reversers

If Normal Elec. Config. Not recovered

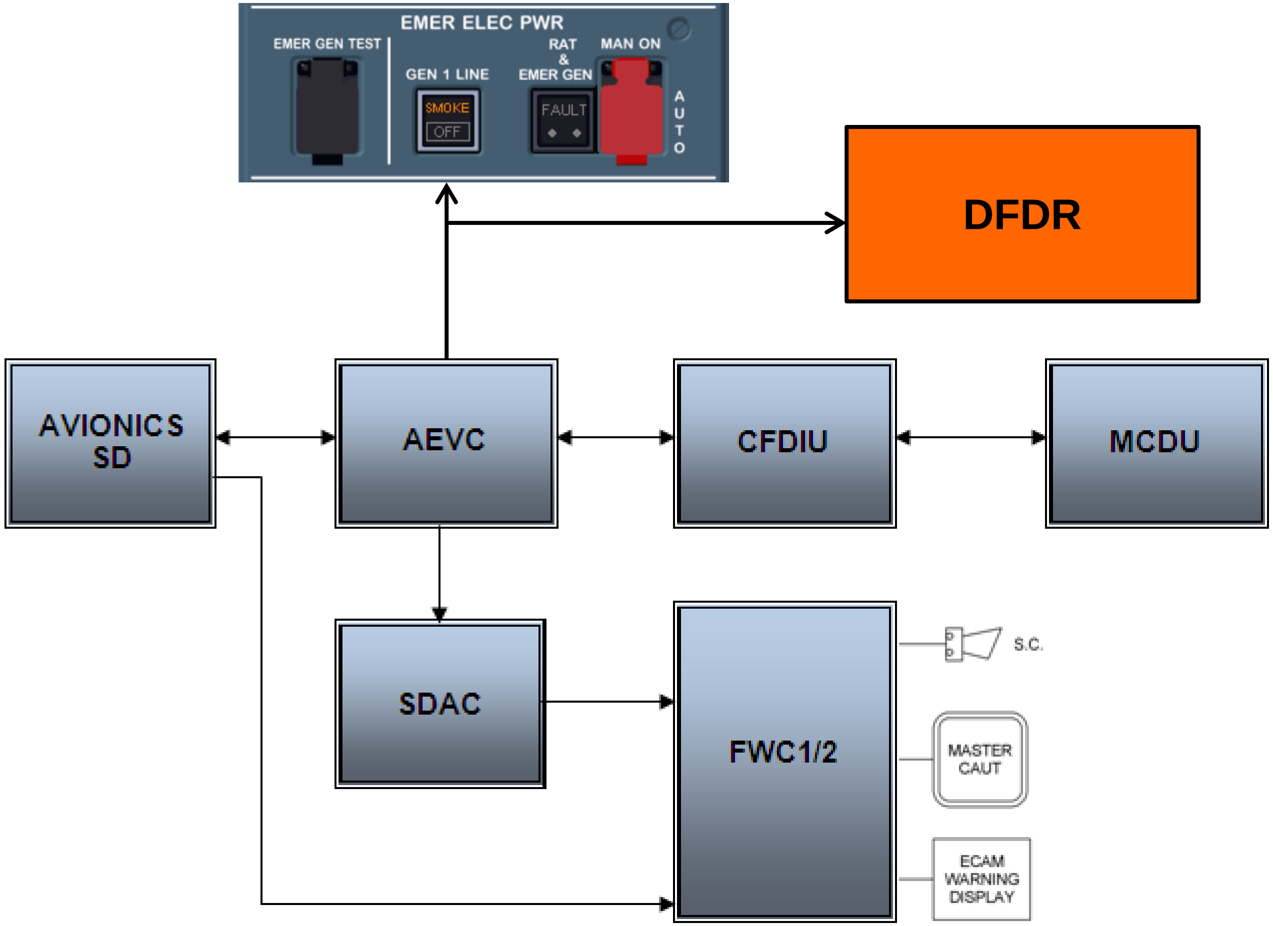
Anti skid, nose wheel steering and reverser 2 not recovered

AGENDA

- AVIONICS SMOKE procedure
- AIRBUS Analysis
- Answers to NTSB questions

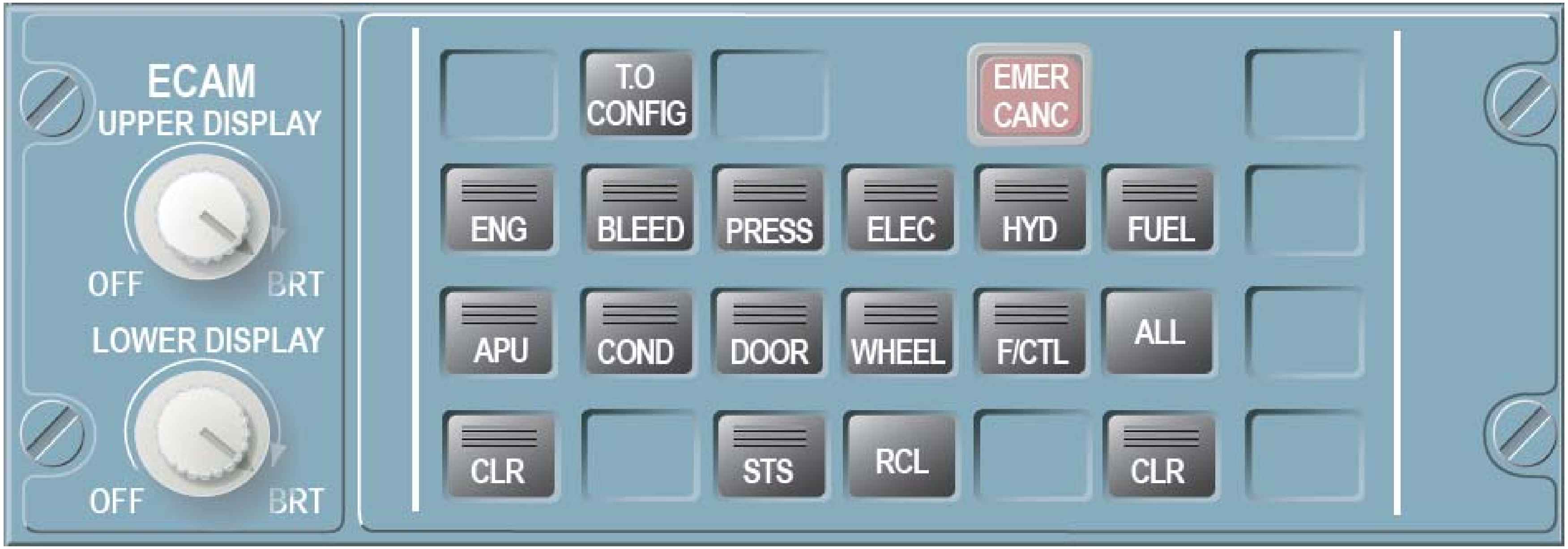
AIRBUS

Smoke detection

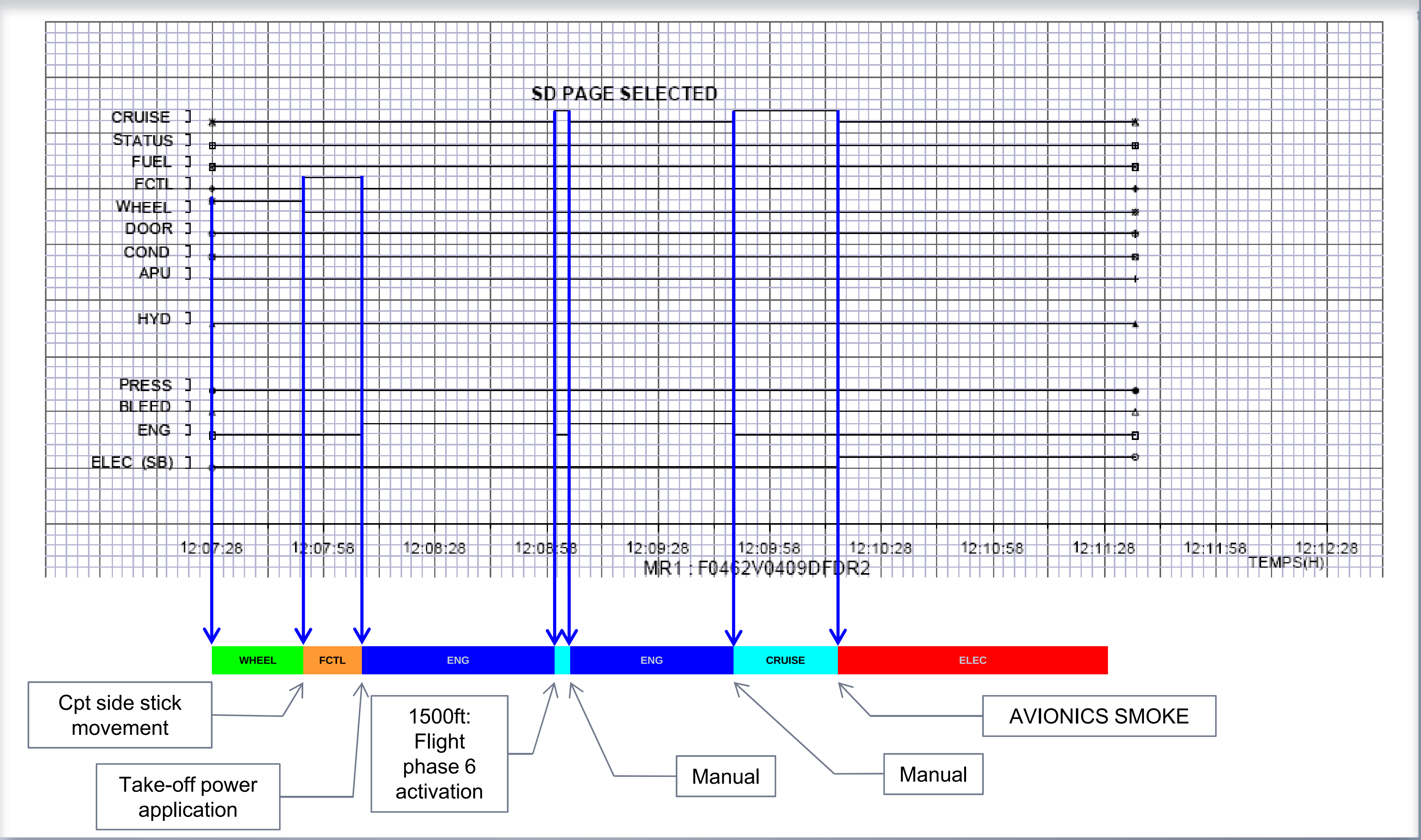


System display pages

- ECAM Control Panel

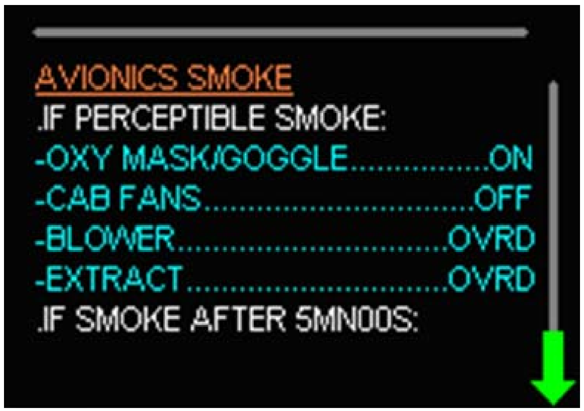


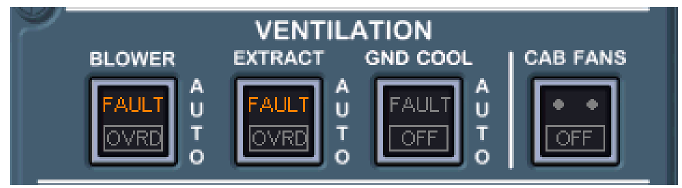
System display pages from DFDR



Sequence of events

- Aircraft parked at MSY (powered)
- “AVIONICS SMOKE” caution triggered (No Go item)





Sequence of events

- "AVIONICS SMOKE" caution
  - False
  - Before engine start
    - How long?
  - Caution cleared
    - By Who?
    - TSM procedure not followed

```
A. If smoke warnings come into view in the cockpit without smoke:

   (1) Do a reset of the AEVC (10HQ):
       - open the circuit breaker 5HQ for some seconds before you close it.

       (a) If the fault continues:
           - replace the DET-SMOKE, AVNCS COMPT (1WA) (Ref. AMM TASK 26-15-
             15-000-001) and (Ref. AMM TASK 26-15-15-400-001).

           1  Reset of the FWC1 and FWC2
```

Sequence of events

- Preliminary cockpit preparation
- Recall done?
  - Recall in UAL procedures?

A319/A320/A321 UNITED AIRLINES FLIGHT CREW OPERATING MANUAL	STANDARD OPERATING PROCEDURES	3.03.04	P 7
	PRELIMINARY COCKPIT PREPARATION	SEQ 100	REV 42

*** ECAM**

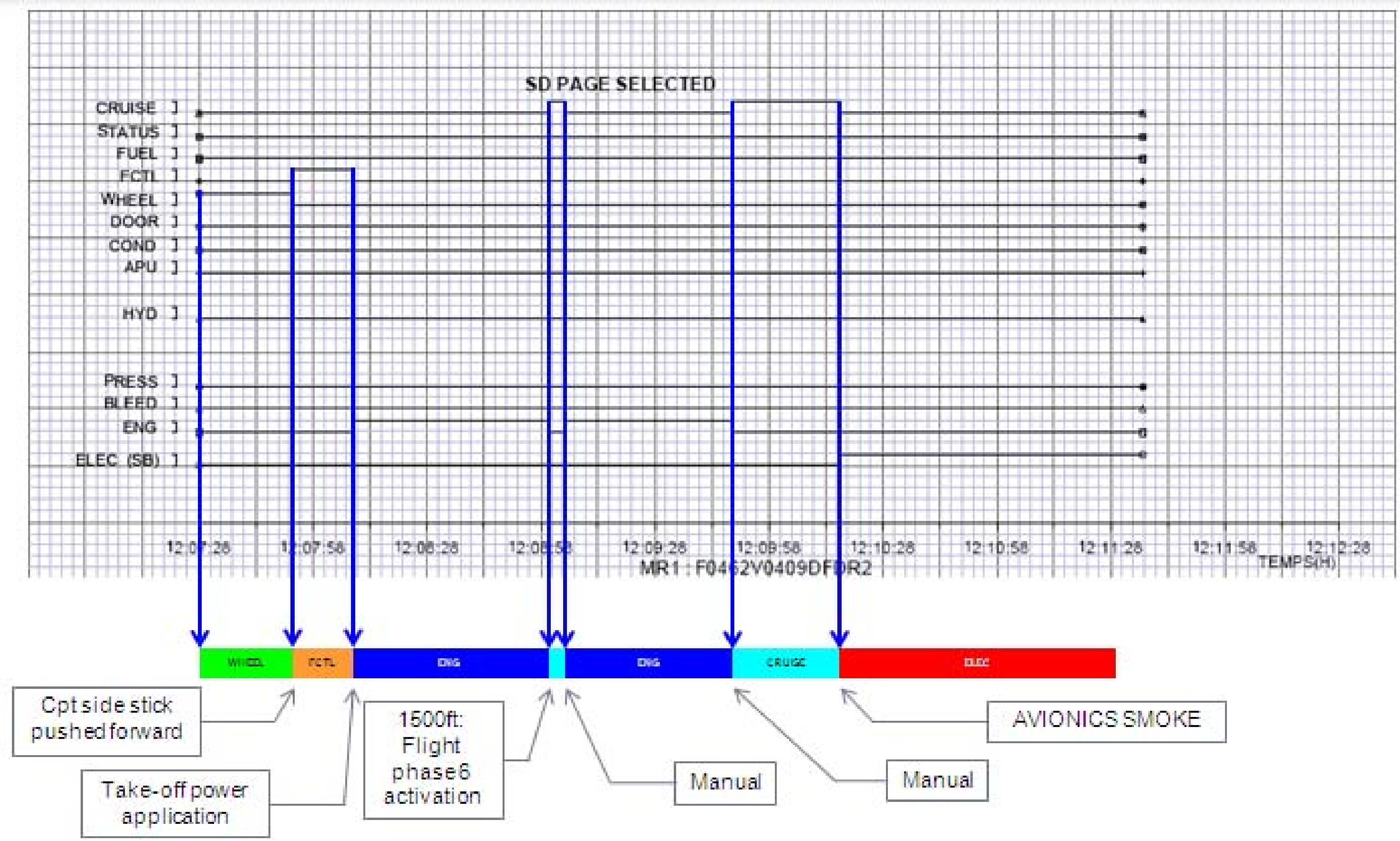
*– **RECALL** . . . . **PRESS**

- Press the RECALL pushbutton for at least 3 seconds, to recall all warnings that have been cleared or canceled.
- If applicable, check warnings are compatible with the MEL, then CLEAR or CANCEL them.

  If any action is required, call maintenance personnel as soon as possible.

Sequence of events

- Take-off
  - LAND ASAP displayed



Sequence of events

- Recall done at 3400ft
  - AVIONICS SMOKE procedure displayed on ECAM
    - Without 5min timer
  - ELEC page automatically displayed
- The crew applied the AVIONICS SMOKE procedure
  - However, this procedure is only applicable “IF PERCEPTIBLE SMOKE”.
  - Restoration of normal electrical generation before landing gear extension not done.
    - Antiskid and Nose Wheel Steering unavailable
    - RH thrust reverser not available

Sequence of events

- Evacuation
  - Slide 1R started to inflate (frangible links broken) but deflated due to aspirator flap blocked.
    - Packing issue suspected

AGENDA

- AVIONICS SMOKE procedure
- AIRBUS Analysis
- Answers to NTSB questions

AIRBUS

Answers to questions from NTSB

- NTSB question:
  - *Avionics Smoke ECAM indication logic and rationale, including discussion of:*
    - *System design of Avionic smoke indications and ECAM messaging*
    - *Indications of Avionic Smoke message when on ground*
    - *Inhibition of Avionic Smoke message between 80 knots and 1500 feet*
    - *Avionic Smoke message timer*
    - *Bundling of Avionics Smoke indication with other ECAM messages*
    - *Scenarios for suppression of Avionic Smoke message*
    - *Amber versus Red messaging in ECAM*
    - *Reliance on crew perception of smoke, including effects of ventilation*

Answers to questions from NTSB

- NTSB question:
  - *Avionics Smoke ECAM indication logic and rationale, including discussion of:*
    - *System design of Avionic smoke indications and ECAM messaging*
    - *Indications of Avionic Smoke message when on ground*
    - *Inhibition of Avionic Smoke message between 80 knots and 1500 feet*
    - *Avionic Smoke message timer*
    - *Bundling of Avionics Smoke indication with other ECAM messages*
    - *Scenarios for suppression of Avionic Smoke message*
    - *Amber versus Red messaging in ECAM*
    - *Reliance on crew perception of smoke, including effects of ventilation*

Avionics Smoke detection – System description (1/2)

AEROSPATIALE

A 320

SYSTEM DESCRIPTION NOTE

AVIONICS COMPARTMENT SMOKE DETECTION

1. General

A. The avionics compartment smoke detection system allows control of smoke emission from avionics.

B. In case of smoke, pneumatic and electrical procedures are initiated.

R C. The system includes :
R - direct detection by the crew
R - secondary detection by a detector which is considered as a help.
R

Avionics Smoke detection – System description (2/2)

AEROSPATIALE
A 320
SYSTEM DESCRIPTION NOTE

R 2. <u>Localisation</u> (Ref. Fig. 001)
The smoke detector is installed in the avionics compartment on the air extraction duct of the avionics cooling system just upstream of the extract
R fan.

3. <u>System Description</u>

A. Definition
R (1)Smoke emission from avionics is detected directly by the crew.
R (2)A pneumatic procedure is applied (EXTRACT and BLOWER OVRD positions),
R which involves :
R - Conditioned air inlet valve (F) opening
R - Skin air outlet valve (B) partial opening
R - Skin exchanger inlet by pass valve (A), skin exchanger outlet bypass
R valve (E) and skin exchanger isolation valve (D) closing.
- Blower fan (A) stopping, extract fan (B) remained ON.
R

This procedure allows :
- air to be blown without smoke
- smoke extraction outside the aircraft
R (3)An electrical procedure is applied to eliminate the origin of the smoke
R if the smoke emission persists more than 5 minutes.
R (4)A smoke detector helps the detection system; it confirms the detection
R and transmits the information (Ref. Fig.002 and 003).

Crew perception of smoke

FLIGHT TEST RESULTS - A/C 4. Nov 18th 1987

TEST N° (GMT)	BURNT MATERIAL FAA POWDER	SMOKE LOCATION	CLIMATISATION	AVIONICS COOLING CONFIGURATION	RESULTS
14H 07' 00''	120 gr	NEAR 80 VU rack	ON	GROUND	37 sec : smoke smelt in cockpit and smoke warning. Smoke Procedure 30 sec after the procedure : warning out
14H 40' 30''	120 gr	NEAR 80 VU rack	ON	FLIGHT 10000 feet	22 sec : smoke smelt in cockpit. 47 sec : smoke warning. 53 sec : smoke procedure 3 min after the smoke procedure : Warning out.
15H 03' 00''	120 gr	NEAR 80 VU rack	ON	FLIGHT 37000 feet	16 sec : smoke visible in the cockpit on pilots side. 30 sec : smell in cockpit No smoke warning
15H 22' 30''	240 gr	NEAR 80 VU rack	ON	FLIGHT 37000 feet	34 sec : smoke smelt in cockpit. 50 sec : smoke warning 55 sec : smoke procedure 2'25 : cargo smoke 4 min after the procedure warning out

SMOKE WARNING : BLOWER and EXTRACT FAULT + ALARM SMOKE on the overhead panel.
SMOKE PROCEDURE : BLOWER and EXTRACT OVRD.

N°466.119/87-A

AIRBUS

Amber versus Red messaging in ECAM

- ECAM / FCOM alert & procedure consistent with avionics smoke detection design & certification.

→Level 2 ECAM alert is consistent with secondary detection mean:

Detection needs to be confirmed prior to procedure application

→Procedure is applicable « IF PERCEPTIBLE SMOKE »

Inhibition of Avionic Smoke message

- Avionics smoke ECAM alert display on ground:
  - Alert is displayed if computed in
    - Flight phase 1&10 (on ground, engines OFF)
    - Flight phase 2, 3, 9 (on ground, engines running, below 80kt)
  - Alert is inhibited if computed in
    - Flight phase 4 & 8 (on ground, above 80kt).

« Inhibited » means that the alert, if triggered while inhibited, is not displayed. If the alert was triggered in an earlier flight phase and has not been cleared through ECAM control panel, it remains displayed on EWD.

AIRBUS

Inhibition of Avionic Smoke message

- Avionics smoke ECAM alert display in flight:
  - Alert is displayed if computed in
    - Flight phase 6 (above 1500ft at take-off until 800ft at landing)
  - Alert is inhibited if computed in
    - Flight phase 5 (from lift-off to 1500ft at take-off)
    - Flight phase 7 (from 800ft to touchdown upon landing)

« Inhibited » means that the alert, if triggered while inhibited, is not displayed. If the alert was triggered in an earlier flight phase and has not been cleared through ECAM control panel, it remains displayed on EWD.

Answers to questions from NTSB

- NTSB question:
  - *Airbus's views on Crew response to Avionics Smoke message on ECAM – including incorrectly followed procedures*
    - *Training in use and response to ECAM messages*

Answers to questions from NTSB

- SMOKE training during Type rating (AIRBUS training centre)
- PHILOSOPHY

Answers to questions from NTSB

- Tools used:
  - APT Trainer: flat panel device used as procedure trainer
  - FFS
  - Procedure Data Packages (PDP): suite of slides displayed on one of the APT Trainer screens, reminding the procedure, and used as a tutorial
  - Briefing Guide (BG): suite of slides used in the briefing room before the FFS session, reminding the procedure
- Sessions:
  - APT 6: study of the procedure. The SMOKE caution is triggered in cruise at FL 350
  - FFS 4: Air conditioning smoke with visible fumes: the aim is to go through all the procedure, including fumes removal

Answers to questions from NTSB

- During the briefings, review of all smoke procedures (Avionics, air conditioning,…)
- Briefing Guide BG
- In line with Flight Crew Training Manual FCTM

Answers to questions from NTSB

- NTSB question:
  - *Restoration of power and functions*
    - *difference in crew description and what systems functionality indicate*
    - *Transformer/rectifier inability to reset in flight.*

Answers to questions from NTSB

- TRU FAULT CONDITIONS

- EMER ELEC CONDITIONS ISSUED FROM AN AVIONICS SMOKE PROCEDURE: FCOM PROCEDURE AND UAL EVENT

TRU FAULT CONDITIONS

- THE ONLY 2 CONDITIONS THAT COULD TRIGER A TR FAULKT ARE:
  - LOW CURRENT DELIVERED
  - OVERHEAT
- IT IS NOT POSSIBLE TO RESET A TR LATCH IN FLIGHT AS PER DESIGN IN ORDER TO AVOID ANY TR OCCURENCE.

EMER ELEC: FCOM PROCEDURE AND UAL EVENT

- EMER ELEC CONFIGURATION: FOR DETAILS CONFER TO FCOM 3-02-26-6a
  - FUEL PUMP 1 LEFT & RIGHT KEPT

- EMER ELEC CONFIGURATION: FOR DETAILS CONFER TO FCOM 3-02-26-6a
  - FUEL PUMP 1 LEFT & RIGHT KEPT

EMER ELEC: FCOM PROCEDURE AND UAL EVENT

ELEC EMER CONFIG SYS REMAINING		EMER GEN RUNNING	BAT ONLY	
			IN FLIGHT	ON THE GROUND
AIR COND PRESS	PRESS AUTO SYS 1	NORM	NORM	NORM
	MAN PRESS CTL	INOP	INOP	INOP [a]
	RAM AIR	NORM	NORM	NORM
	PACK VALVE 1	NORM	Closure Inop	Closure Inop
	PACK VALVE 2	Closure Inop	Closure Inop	Closure Inop [a]
	AVIONIC VENT	NORM	NORM	Partial
	AFT CRG ISOL VALVES	NORM	INOP	INOP
	AFT CRG HEAT	NORM	INOP	INOP
FMGS	FMGC (NAV FUNCTION)	N°1 only	Inop	Inop
	MCDU	N°1 only	Inop	Inop
	FAC	N°1 only	Inop	Inop
	FCU	ch 1 only	ch 1 only	ch 1 only
COM	VHF 1	NORM	NORM	NORM
	HF 1	NORM	INOP	INOP
	RMP 1	NORM	NORM	NORM
	ACP (CAPT, F/O)	NORM	NORM	NORM
	CIDS	NORM	NORM	NORM
	INTERPHONE	NORM	NORM	NORM
	CVR	NORM	INOP	INOP
	LOUDSPEAKER 1	NORM	NORM	NORM
EMER EQPT	CREW OXY	NORM	NORM [b]	NORM [b]
	PAX OXY mask release (auto + man)	NORM	INOP	INOP
	SLIDES ARM/WARN	NORM	NORM	NORM
FIRE	ENG 1 LOOP	A only	A only	A only
	ENG 2 LOOP	B only	B only	B only
	APU LOOP	INOP	INOP	INOP [a]
	CARGO SMOKE DET	Channel 1	INOP	INOP
	ENG FIRE EXT.	Bottle 1 only	Bottle 1 only	Bottle 1 only
	APU FIRE EXT.	Squib A only	Squib A only	Squib A only
	CARGO FIRE EXT.	INOP	INOP	INOP [a]
	APU AUTO EXT.	INOP	INOP	INOP [a]
APU	ECB-STARTER	NORM [g]	INOP	INOP [a]
	FUEL LP VALVE	NORM	NORM	NORM
	FUEL PUMP	NORM	NORM	NORM
PWR PLT	FADEC	A+B [h]	A+B [h]	A+B [h]
	IGNITION	A only	A only	A only
	REVERSER	Not avail	Not avail	1 only
	HP FUEL VALVE closure	NORM	NORM	NORM

ELEC EMER CONFIG SYS REMAINING		EMER GEN RUNNING	BAT ONLY	
			IN FLIGHT	ON THE GROUND
FLT CTL	ELAC	N°1 only	N°1 + 2	N°1 + 2 [a]
	SEC	N°1 only	N°1	N°1 [a]
	FCDC	N°1 only	INOP	INOP
	SFCC	N°1 only	N°1 only	N°1 only
	Flaps pos ind	NORM	NORM	NORM [a]
FUEL	LP VALVE	NORM	NORM	NORM
	FQI channel 1	NORM	INOP	INOP
	X FEED VALVE	NORM	INOP	INOP
	TRANSFER VALVE	NORM	INOP	INOP
HYD	FIRE VALVES	NORM	NORM	NORM
ICE-RAIN	WING A.ICE	NORM	INOP	INOP
	ENG A.ICE VALVE	OPEN	OPEN	OPEN
	CAPT PITOT	NORM	NORM	NORM [a]
	CAPT AOA	NORM	INOP	INOP
	RAIN REPELLENT (CAPT)	NORM	NORM	NORM
EIS	PFD 1	NORM	NORM	NORM [a]
	ND 1	NORM	INOP	INOP
	ECAM upper disp.	NORM	NORM	NORM [a]
	DMC 1 or 3	NORM	NORM	NORM [a]
	SDAC 1, FWC 1	NORM	NORM	NORM
	ECAM CONT. panel	NORM	NORM	NORM
FLT INS	CLOCKS	NORM	NORM	NORM
L/G	LGCIU SYS 1	NORM	NORM	NORM
	BRK PRESS IND	NORM	NORM	NORM
	PARK BRK	NORM	NORM	NORM
LIGHTS	EMER CKPT	NORM	NORM	NORM
	EMER CAB	NORM	NORM	NORM
NAV	IR	N°1 only [f]	N°1 only [f]	N°1 only [f]
	ADR	N°1 only	N°1 only	N°1 only
	VOR-ILS	N°1 only	N°1 only	N°1 only [e]
	DME	N°1 only	INOP	INOP
	VOR/DDRMI	NORM	NORM	NORM [e]
	ATC	N°1 only	INOP	INOP
	STBY HORIZON	NORM	NORM	NORM
	STBY COMP (LT)	NORM	NORM	NORM
	STBY ALTI (VIB)	NORM	INOP	INOP

EMER ELEC: FCOM PROCEDURE AND UAL EVENT

- BEFORE L/G EXTENSION → GEN 2 & GEN 1 LIN ON
  - ALL SYS RECOVERED EXCEPT :
    - IR 2&3 (ATT MODE ONLY AVAILABLE) → ALTN LAW
  - BRAKING AND STEERING RECOVERED
  - THRUST REVERSER 2 RECOVERED

- AFTER L/G EXTENSION
  - TRANSITION FROM ALTN LAW TO DIRECT LAW
  - AC/DC ESSENTIAL BUSBAR SWITCH FROM THE CSM/G TO THE NORMAL NETWORK

- BEFORE L/G EXTENSION → GEN 2 & GEN 1 LIN ON
  - ACTION NOT PERFORMED → above configuration not modified

- AFTER L/G EXTENSION
  - TRANSITION FROM ALTN LAW TO DIRECT LAW
  - AC/DCESSENTIAL BUSBAR SWITCHED FROM CSM/G TO BATTERIES
  - LOSS AC/DC SCHEDDABLE BUSBAR (8XP & 8PP)
    - For example:
      - ND CAPT
      - MCDU 1
      - FAC 1
      - FMGC 1
  - BRAKING & STEERING NOT RECOVERED
  - THRUST REVERSER 2 NOT RECOVERED

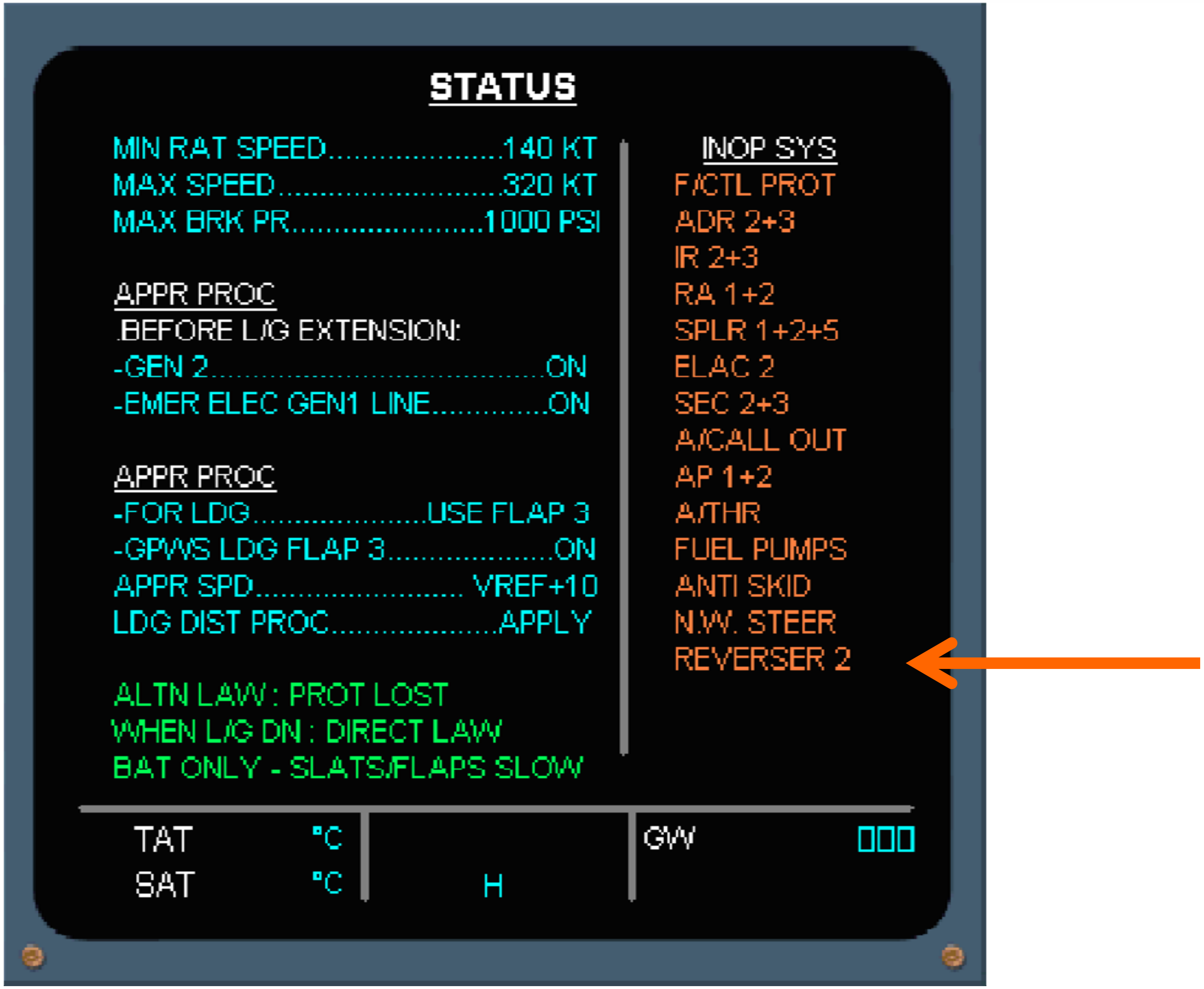
Answers to questions from NTSB

- NTSB question:
- *Single Thrust reverser deployment when in emergency electrical configuration*
  - *Means for flight crews to know if their airplane is so configured*

ELEC EMER CONFIG checklist

ECAM Control Panel

ELEC EMER CONFIG ECAM status

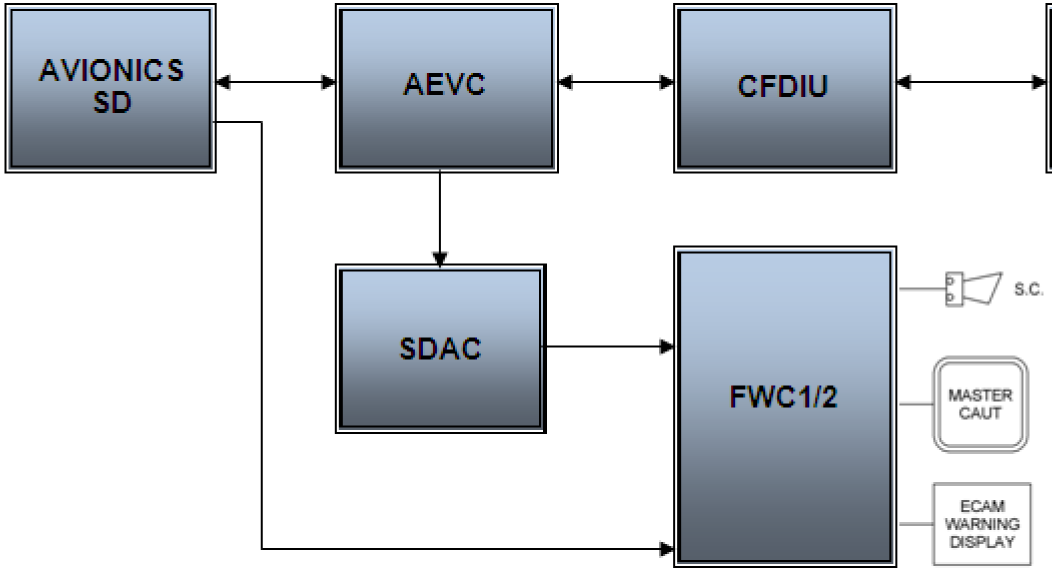


Answers to questions from NTSB

- NTSB question:
  - *Airbus reports within industry of avionic smoke messages, both real and false*
    - *differences with replacement of detectors*
  - *Does Airbus have any information of reports back of similar types of instances of false avionic smoke indications from other operators of the A320?*

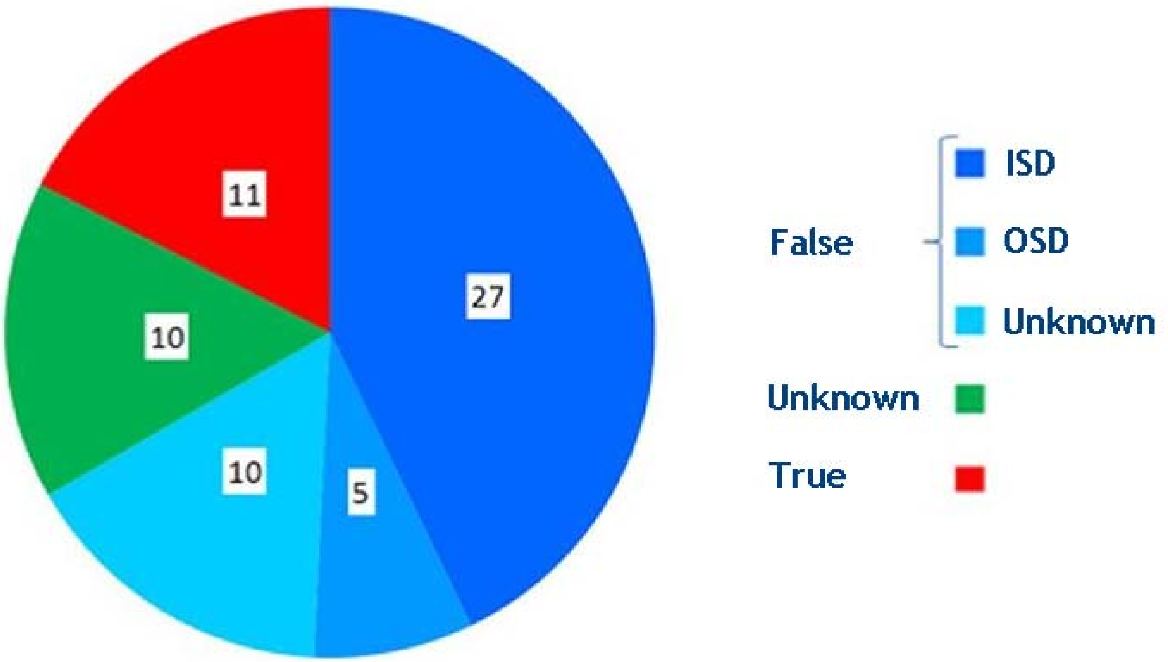
“AVIONICS SMOKE” caution troubleshooting

- <u>Troubleshooting as per TSM:</u>
  - TSM TASK 26-15-00-810-803 : “Smoke Warning without smoke”
    - Do a reset of the AEVC 10HQ (open C/B 5HQ and close after 5 seconds).
    - If the fault continues, replace the avionics Smoke Detector (SD) 1WA
    - Reset the FWC1 and FWC2 (C/B 2WW and 3WW) to clear the fault
    - Do the ground scanning of the Central Warning System



AVIONICS SMOKE CAUTIONS KNOWN TO AIRBUS

63 cases of avionics smoke caution have been reported on A320 family aircraft since 1996. The repartition between true and false detections is given in the chart below. For false detections, the type of detector, ionic (ISD) or optical (OSD) is also given.



Answers to questions from NTSB

- NTSB question:
  - *Are there other Airbus aircraft that are equipped with this type of sensor?*

Answers to questions from NTSB

- The ionic smoke detector PN CG7G0 has been installed on the following aircraft:
  - A300/A310: this duct mounted ionic smoke detector has been installed in avionics compartment (circuit WA), in lavatories (circuit WQ) and in main deck cargo on some aircraft (Circuit WU).
  - A320 family: this ionic smoke detector has been installed on Avionics Compartment only (FIN 1WA) and has been replaced by the optical smoke detector since MSN1541 (A319), MSN1523 (A320) and MSN1554 (A321). Never installed on A318.
  - A330/A340/A380: this PN has never been installed on these aircraft.
- The installation of the avionics bay ventilation is quite different on A320 family and on A300/A310.
  - On A320 family, when the aircraft is on ground, the air used to ventilate the avionic bay is picked from outside the aircraft since outside temperature is above 12°C. On A300/A310, the air is always picked from the avionics compartment, even if aircraft is on ground.
  - Therefore outside high humidity effects may have slight different effects on A320 family and on A300/A310.

Answers to questions from NTSB

- NTSB question:
  - *Does Airbus have any information with regard to the upgrade of the avionic smoke sensors to the newer type? How many have been replaced, and when is the fleet wide replacement expected to occur?*
  - *If there is a Service Bulletin that describes the upgrade to the newer type of avionic smoke sensor, the NTSB is requesting a copy of the SB.*

Related Documentation

- <u>Related Documentation:</u>
  - TFU REF 26.15.15.001 issued JUL1999, last release Dec 2002
    - Subject: spurious avionics smoke leading to “AVIONICS SMOKE” or “LAND ASAP”
    - Permanent solution: replacement of the ionic SD PN CG7G0 by optical SD PN CGDU2000-00
  - SB 26-1052 “FIRE PROTECTION − AVIONICS COMPARTMENT SMOKE DETECTION − INSTALL AN OPTICAL SMOKE DETECTOR”

TFU 26.15.15.001 (1/2)

OWNER/EXT M. GARNIER Tel : +33 562110731 Fax : +33 561934438	Reporting A/L : CYP, SWR, MXA A/C affected : A319, A320, A321 Engine affected :	TFU ISSUE DATE : Dec 2002 TFU FIRST ISSUE DATE : Jul 1999 TFU NEXT ISSUE DATE : ISSUE NB : 13	IMPACT ON : LINE MAINTENANCE EFFECT ON FLIGHT : YES CATEGORY : ECONOMIC VISIBILITY ON PAX : NO

DESCRIPTION :
SOME OPERATORS HAVE REPORTED MANY CASES OF SPURIOUS AVIONICS SMOKE WARNINGS, LEADING TO "AVIONICS SMOKE" OR "LAND ASAP" ECAM MESSAGES. THESE WARNINGS HAVE MAINLY BEEN REPORTED ON GROUND, HOWEVER THERE HAVE BEEN A FEW CASES GENERATED IN FLIGHT, SHORTLY AFTER TAKE-OFF AND GEAR RETRACTION.

CONSEQUENCES :
N/A

INVESTIGATION STATUS :
THE AIRCRAFT FLIGHT PHASE CONFIGURATION WHERE AVIONICS SMOKE WARNINGS HAVE BEEN GENERATED FALL INTO TWO MAIN CATEGORIES; ON GROUND AND TAKE-OFF.

* ON GROUND - WITH THE AIRCRAFT ON GROUND THE AVIONICS VENTILATION IS SET TO 'OPEN LOOP', WHEREBY OUTSIDE AIR IS USED TO PROVIDE VENTILATION FOR THE AVIONICS COMPARTMENT. IN ENVIRONMENTS WHERE HIGH HUMIDITY AND/OR CONTAMINATION EXISTS (JET EFFLUX/BLOWN DUST ETC). IT IS POSSIBLE FOR THE SENSITIVITY OF THE AVIONICS SMOKE DETECTOR TO BE AFFECTED CREATING AN ALARM CONDITION.

* TAKE-OFF - THE AVIONICS SMOKE WARNINGS ARE INHIBITED FROM 80KTS TO 1500 FEET. DURING THIS TIME IF THE AVIONICS DETECTOR GOES INTO ALARM THEN A 'LAND ASAP' (IN AMBER) IS GENERATED ON ECAM. THE ONLY WAY TO IDENTIFY THE CAUSE OF THE AMBER WARNING IS BY DEPRESSING THE RECALL BUTTON ON THE ECAM CONTROL PANEL. INVESTIGATIONS HAVE DETERMINED THAT SOME OF THESE 'LAND ASAP' WARNINGS HAVE BEEN GENERATED DUE TO A PREVIOUSLY LATCHED, BUT INHIBITED AVIONICS SMOKE WARNING THAT HAD BEEN GENERATED WHILST THE AIRCRAFT WAS ON GROUND.

INVESTIGATIONS HAVE SHOWN THAT THE IONIZATION TYPE SMOKE DETECTORS SENSITIVITY IS SUBJECT TO THE AMBIENT TEMPERATURE, PRESSURE AND AIR CONTAMINATION WITH MOISTURE, DUST OR POLLUTION. THE HIGHEST SENSITIVITY TRANSLATED INTO A VOLTAGE SHIFT BEING ON THE GROUND AND DURING TAKE-OFF.

INTERIM SOLUTION :
N/A

MAINTENANCE ADVICE :
R IN CASE OF AN 'AVIONICS SMOKE' WARNING TRIGGERED AND LATCHED ON GROUND, FWC1 AND FWC 2

SERVICE BULLETIN

Airbus

Ref.	Rev.	Date	AIB Mod
26-1052 (A319) Emb. Point : 1541	00	Iss 30-Aug-2001	30353
26-1052 (A320) Emb. Point : 1523	00	Iss 30-Aug-2001	30353
26-1052 (A321) Emb. Point : 1554	00	Iss 30-Aug-2001	30353

Vendor

RELEVANT DOCUMENTATION

Airbus OPS documentation

Airbus Maintenance documentation

Other documentation

VENDOR and P/N affected

CERBERUS SA
CG7GO

SPURIOUS AVIONICS SMOKE WARNINGS	TFU REF : 26.15.15.001	TFU STATUS : CLOSED/SOLUTION AVAILABLE

TFU 26.15.15.001 (2/2)

OWNER/EXT
M. GARNIER
Tel : +33 562110731
Fax : +33 561934438

Reporting A/L : CYP, SWR, MXA
A/C affected : A319, A320, A321
Engine affected :

TFU ISSUE DATE : Dec 2002
TFU FIRST ISSUE DATE : Jul 1999
TFU NEXT ISSUE DATE :
ISSUE NB : 13

IMPACT ON : LINE MAINTENANCE
EFFECT ON FLIGHT : YES
CATEGORY : ECONOMIC
VISIBILITY ON PAX : NO

R SHOULD BE RESETED ONE AT A TIME BY MEANS OF THEIR C/B (3WW C/B 49VU FOR FWC1 AND 2WW C/B
R 121VU FOR FWC2). THIS WILL CLEAR THE LATCHED CONDITION OF THE WARNING IF THE AVIONICS
R SMOKE CONDITIONS HAVE DISAPPEARED. THEN AN UNDUE 'LAND ASAP' ALARM WILL BE AVOIDED.

OPS ADVICE :

N/A

REPERCUSSION ON A/C DISPATCH :

N/A

PERMANENT OR FINAL SOLUTION :

A NEW GENERATION OF SMOKE DETECTOR PN CGDU2000-00 USING AN OPTICAL TECHNOLOGY HAS BEEN DEVELOPED IN ORDER TO
REPLACE THE 'OLD' GENERATION OF IONIZATION TYPE SMOKE DETECTOR. THIS NEW GENERATION TYPE OF SMOKE DETECTOR HAS A DIFFERENT TRIGGERING PRINCIPLE AND IS THEREFORE NOT AFFECTED BY THE TEMPERATURE AND PRESSURE CONDITIONS.

IN SERVICE EVALUATION (6 MONTH PERIOD) OF AVIONICS OPTICAL SMOKE DETECTOR PN CGDU2000-00 HAS BEEN PROPOSED TO TWO OPERATORS. DEDICATED SB A320-26-1052 HAS BEEN RELEASED MID JULY 2000. THE IN SERVICE EVALUATION HAS BEEN COMPLETED SUCCESSFULLY. SB A320-26-1052 REVISION HAS BEEN RELEASED THE 30TH OF AUGUST TO INCORPORATE ALL AIRLINES IN THE EFFECTIVITY.

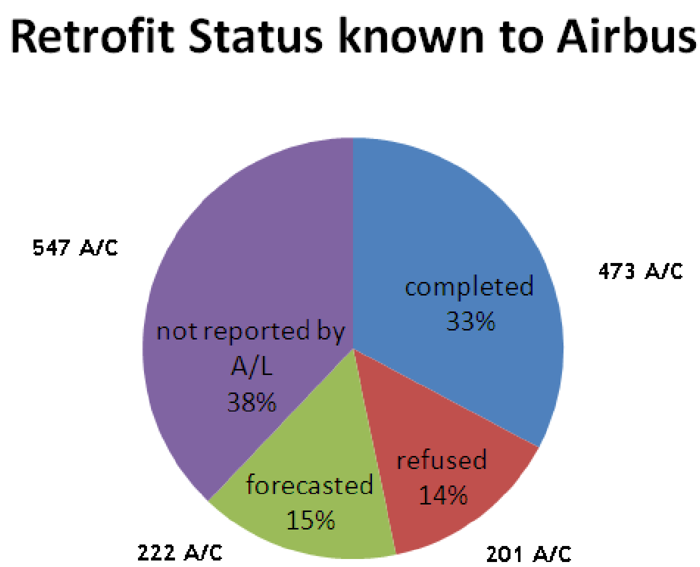
SPURIOUS AVIONICS SMOKE WARNINGS

TFU REF : 26.15.15.001

TFU STATUS : CLOSED/SOLUTION AVAILABLE

Avionics Optical Smoke Detector Introduction

- FORWARDFIT:
  - Optical Smoke Detector (OSD) PN CGDU2000-00 was introduced in production on MSN 1523 (delivery July 2001) to replace former Ionic Smoke Detector.
- RETROFIT:
  - Optional SB 26-1052 “FIRE PROTECTION − AVIONICS COMPARTMENT SMOKE DETECTION − INSTALL AN OPTICAL SMOKE DETECTOR”:
  - Covers the installation of OSD by retrofit fleetwide (1443 aircraft)
  - Issued 30-Aug-2001



Answers to questions from NTSB

- NTSB question:
  - *Related to the ECAM Page Select parameter and the System Page Origin parameter we discussed when you were here, I just need to clarify what they actually mean. The ECAM Page Select indicates what is being displayed on the ECAM to the pilots in the cockpit. Is this correct that it is on the display and for which pilot? Sometimes there is an indication on the ECAM Page select that lasts for a few seconds. Does the pilot actually see this flicker?*
  - *For the System Page Origin – it indicates “auto” or “manual” and always for this recorder it is in “auto”. Does that definitely mean that the ECAM Page Select parameter is never manually called up by the pilots but that the system always automatically pulls it up? Or is it maybe that the system is pulling that up based on what the aircraft is doing but the pilot could manually select another page and display it? I just want to be clear on these parameters because the timing is strange.*

Answers to questions from NTSB

Answers to questions from NTSB

- The ECAM Page Select parameter is recorded in the 128 words/second DFDR frame of the FDIU ED43A1D6 in Word 28 Subframe 4 Bit 2.
- Comes from DMC Label 275, bit 28.

Bits 28	29	:	MODE
1	0	:	ENG/W image displayed
0	1	:	SYST (manual or adv called) or STS
1	1	:	SYST (automatically called)
0	0	:	ENG/W image displayed in mono mode

- Bit 28 alone is not able to fully explain ECAM display mode
- Bit 29 also recorded in the 256 words/second DFDR frame.

Answers to questions from NTSB

- NTSB question:
  - *There are 2 parameter related to ATS. ATS Active and ATS Engaged. Can you tell me what exactly those are supposed to record. ie what is the source of the data? IS there a way to tell is the ATS is manually disconnected or if the system shut off? I want to ensure we correctly determine why the ATS disengaged in this case.*

Answers to questions from NTSB

- A/THR can be disengaged or engaged.
- If engaged, A/THR can be armed or active.
- Example:
  - On ground, when the pilot advances the thrust levers to FLEX or TOGA, the A/THR engages.
    - It is engaged but not active.
  - At thrust reduction altitude, the pilot moves the thrust levers to CLIMB
    - A/THR becomes active.

Answers to questions from NTSB

- During the incident flight:
  - ATHR engaged when the thrust levers were advanced to FLEX.
  - A/THR became active when the thrust levers were moved to CLIMB.
  - Both A/THR engaged and A/THR active switched to 0 at the same time.
  - DFDR data alone cannot confirm the reason of disengagement.
    - Manual disconnection suspected due to actions on the thrust levers.