NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

November 4, 2020

Group Chairman's Factual Report

OPERATIONAL FACTORS/HUMAN PERFORMANCE

DCA18LA163

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A. ACCIDENT

Location: Atlanta, Georgia
Date: April 18, 2018
Time: 1809 EDT[1]
2209 UTC
Airplane: Airbus A330-323; N806NW; Serial No. 578; Ship No. 3306; Delta 30

B. OPERATIONAL FACTORS/HUMAN PERFORMANCE GROUP

Shawn Etcher
Group Chairman
Operational Factors Division (AS-30)
National Transportation Safety Board

Katherine Wilson
Group Chairman
Survival Factors/Human Performance (AS-60)
National Transportation Safety Board

Todd Gentry
Air Safety Investigator
Accident Investigation & Prevention (AVP-100)
Federal Aviation Administration

Taylor Smith
Air Safety Investigator
Flight Safety Department
Delta Air Lines, Inc.

Craig Hildebrandt
Senior Director Safety & Flight Operations
Airbus

Mike Schilz
Aircraft Accident Investigation Board
Airline Pilots Association

C. SUMMARY

On April 18, 2018, at about 1809 eastern daylight time, a Delta Air Lines Airbus A330-323, N806NW, equipped with two Pratt & Whitney PW4168A-1D engines, experienced a No. 2 engine fire during initial climb from Hartsfield-Jackson Atlanta International Airport (ATL[2]), Atlanta, Georgia. The flight crew reported a No. 2 engine fire electronic centralized aircraft monitor (ECAM) indication at about 700 feet above ground level (AGL) declared an emergency, shutdown the No. 2 engine, discharged both fire bottles, and initiated an air turn back to ATL. During the return to ATL, the fire warning indication cleared and was replaced by a fire detection fault indication. The flight crew made an uneventful overweight single engine landing. After landing, airport rescue and firefighting (ARFF) crews met the airplane on the runway and observed smoke and flames emanating from the No. 2 engine. ARFF sprayed the engine with fire retardant foam and extinguished the fire. The airplane was towed to the gate and the passengers disembarked. There were no injuries to the passengers or crew and the airplane sustained substantial damage. The flight was being operated in accordance with 14 *Code of Federal Regulations* Part 121 and was a regularly scheduled flight from ATL to London Heathrow International Airport (EGLL), London, England.

[1] All times in the report will be in eastern daylight time, also known as local lime, except as noted. At the time of the accident local time was UTC -4 hours.
[2] The ICAO identifier for ATL was KATL.

D. DETAILS OF THE INVESTIGATION

The Operational Factors/Human Performance Group was formed on April 7, 2020. Several of the listed party members were assigned to the group, and others were assigned later during the investigation. Due to the time since the accident, some of the flight crewmembers had retired from Delta Air Lines and an interview of the crew was not possible; however, crew statements were provided to the group.

On September 28, 2020, the Operational Factors/Human Performance Group convened at Delta Air Lines, Inc. training facility to conduct simulator evaluation[3] and engine fire training review in a Delta Air Lines training simulator.

On October 15, 2020, the Operational Factors/Human Performance Group participated in a teleconference with the entire accident team to discuss the findings of the simulator evaluation. Also discussed were Airbus' DFDR[4] timeline reconstruction report, and the powerplant investigation report.

E. FACTUAL INFORMATION.

1.0 History of Flight[5]

According to the relief first officer's statement, he had conducted the exterior walk around inspection of the airplane prior to departure and there was nothing unusual or abnormal noted.

According to the captain's statement, he was the pilot flying (PF) at the time of the engine fire and was receiving a six-month line check, his first line check in type, at the time of the event. The flight departed from runway 26L and was cleared for the PLMMR departure. Between 500 ft and 1,000 ft agl, they received an ECAM[6] message of ENG FIRE 2 and the associated warning messages. He further stated that during the first minute of the ECAM messages all of the non-normal messages disappeared for approximately 2 to 3 seconds and then the engine fire and associated checklists reappeared. He transferred control of the aircraft to the first officer in order to perform the ECAM checklists, which subsequently required discharging both fire extinguishing bottles. An emergency was declared with air traffic control (ATC).

According to the first officer's statement, after he assumed control of flying the aircraft, the captain began the ECAM action items and was aided by the relief first officer and the line checkairman seated in the cockpit. The flight was given a climb to 5,000 ft and was later cleared to 7,000 ft by ATC.

According to the line checkairman seated in the second observer's seat in the cockpit located aft of the first officer's seat, his statement indicated that when the captain transferred

[3] Source: Operational Factors/Human Performance Attachment 3 - Simulator Evaluation.
[4] Digital Flight Data Recorder.
[5] Source: Operational Factors/Human Performance Attachment 1 - Flight Crew Written Statements.
[6] Electronic Centralized Aircraft Monitor.

control of the airplane to the first officer, he changed his role from a line check pilot to a regular crew member in order to assist the crew. While the crew completed the ECAM checklist actions, he assisted and made a public address to the passengers and coordinated communication with the cabin crew, while supporting the captain with the checklist procedures. Once the checklist had been completed, he contacted the purser to inform the cabin crew about the nature of the problem, that they would be returning to ATL, and to prepare the cabin for landing. In addition, he made an announcement to the passengers advising them that the airplane had engine trouble, the flight would be returning to ATL, once on the ground the flight would be stopping on the runway, and emergency vehicles would be approaching the flight in order to inspect the airplane. He then asked the flight attendant located at the 2R door to look out the cabin window to assess if there was any damage or if a fire existed; however, she was unable to definitively answer the question.

According to the captain, the fire indication remained "on for some time after" discharging both fire bottles and the No. 2 engine was shutdown. The crew briefed the ILS[7] 27R approach and elected to use the autoland function and the medium autobrake setting.

While the flight was being vectored by ATC for their approach the first officer coordinated and transferred control of the aircraft back to the captain and the first officer assumed the duties of the pilot monitoring (PM).

ATC voice recordings and radar data indicated that about 1831 the accident aircraft contacted the tower controller and was subsequently cleared to land on runway 27R. About 1832, the tower controller advised the crew that the right engine appeared to still be smoking, which correlated to an approximate 5 mile final. Radar data indicated the airplane touched down about 1834. About 1835, during landing rollout, the flight crew queried the controller if they still could see a fire on the right engine; the controller responded "affirmative."

After landing, the autobrakes remained engaged until about 40 kts and the captain stopped the aircraft on the runway, prior to taxiway "U", approximately 7,800 ft from the approach end of the runway. The crew informed ARFF via the tower frequency that they had an indication of hot brakes as well.

After the fire was extinguished, the crew shutdown the No. 1 engine and were towed to the gate where the passengers deplaned via the jetbridge.

2.0 Flight Crew Information

2.1 Captain

The captain, age 60, held an Airline Transport Pilot (ATP) certificate with a rating for

[7] Instrument Landing System.

airplane multiengine land and included type ratings in the A-330[8], B-707[9], B-720, B-737[10], B-757[11], B-767, B-777[12] with limitation of A-330, B-737, B-777 CIRC APCH. – VMC[13] ONLY. At the time of the accident he was based at ATL.

Specific training related to and preceding this event that the captain accomplished was:

Engines and APU[14]	November 2, 2017

2.2 Line Check Airman

The line check airman, age 62, held an ATP certificate with a rating for airplane multiengine land with type ratings in the A-330, B-737, B-757, B-767, B-777 with limitation of A-330, B-737, B-757. B-767, B-777 CIRC APCH. – VMC ONLY. He held a commercial pilot certificate for airplane single-engine land. At the time of the accident he was based out of New York City, New York[15].

Specific training related to and preceding this event that the line check airman accomplished was:

System Review – A330 Engines and APU[16]	September 1, 2017
Engines and APU	June 22, 2015

According to a representative of Delta Air Lines, the following policy was provided to line check airmen on conducting a line check where an emergency occurs, during the specific fleet standards meetings:

> *Our guidance to line check pilots (LCP) is that during Line Checks the LCP is an independent observer. And this should be part of the Line Check briefing. If conditions deteriorate to the point that the safety of the flight is in jeopardy, and with the Captains*

[8] Airbus (formerly known as Groupement d'Inerte Economique Airbus Industries, France) A-330-200/300 Series, A-330-200F. Source: FAA Order 8900.1 Figure 5-88, dated July 15, 2019.
[9] The Boeing Company, 707-100 Long Body, 707-100B Long Body, 707-100B Short Body, 707-200, 707-300, 707-300B, 707-300C, 707-400, 720 Series, 720B series and includes military designators KC-135 (all variants), C-135, C-18B, E3-A/B/C, E6-A/B, E-8C, EC-18B, EC-18D, VC-137. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.
[10] The Boeing Company, B-737-100, B-737-200, B737-300, B-737-400, B737-500, B737-600, B-737-700C, B-737-800, B737-900. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.
[11] The Boeing Company 757-200 Series, 757-200PF Series, 757-200CB Series, 757-300 Series, 767-200 Series, 767-300 Series, 767-300F Series, 767-400ER Series, 767-2C Series. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.
[12] The Boeing Company, 777-200 Series, 777-300 Series, 777-300ER Series, 777-200LR Series, 777-F Series. Source: FAA Order 8900.1 Figure 5-88, dated July 15, 2019.
[13] Visual Meteorological Conditions.
[14] Engines and APU training were conducted as part of the A330 Aircraft System Initial Qualification.
[15] Pilots based in New York City were able to cover all 3 major New York City airports; however, Airbus A330 crews based in New York City typically only covered John F. Kennedy International Airport.
[16] Systems Review training was conducted as part of the Q3 CQ cycle, originally scheduled for Q2 distribution but was delayed due to a technical issue. **Of note:** the accident captain did not receive this training as he was not trained in the A330 at the time this specific review was offered.

(PIC) direction/concurrence, the LCP can lend any assistance as directed. Status of the completion of the Line Check will be determined in coordination with the chief line check pilot (CLCP). Good use of CRM/TEM and expanding your team.

2.3 First Officer

The first officer, age 50, held an ATP certificate with a rating for airplane multiengine land with type ratings in the A-330 , B-757, B-767, DC-9[17], L-188[18] with limitation of A-330, B-757, B-767, DC-9 CIRC APCH. – VMC ONLY. He held a commercial pilot certificate for airplane single-engine land. At the time of the accident he was based at ATL.

Specific training related to and preceding this event that the first officer accomplished was:

System Review – A330 Engines and APU[19]	September 9, 2017
Engines and APU	April 22, 2017

2.4 Relief First Officer

The relief first officer, age 39, held an ATP certificate with a rating for airplane multiengine land and included type ratings in the A-330, B-737, B-757, B-767, CL-65[20] with limitation of A-330, B-737, B-757, B-767, CL-65 CIRC APCH. – VMC ONLY. He held a commercial pilot certificate for airplane single-engine land and a flight instructor certificate in airplane single and multiengine land, and instrument airplane. At the time of the accident he was based at ATL.

Specific training related to and preceding this event that the relief first officer accomplished was:

System Review – A330 Engines and APU[21]	October 3, 2017
Engines and APU	May 30, 2016

2.5 Flight Crew Training

Documentation provided by Delta Air Lines indicated that during several training events, on the initial qualification syllabus dated March 1, 2016, on the A330 aircraft, in ground school,

[17] The Boeing Company DC-9-11, DC-9-12, DC-9-13, DC-9-14, DC-9-15, DC-9-15F, DC-9-21, DC-9-31, DC-9-32, DC-9-32F, DC-9-33F, DC-9-34, DC-9-34F, DC-9-41, DC-9-51, DC-9-81, DC-9-82, DC-9-83, DC-9-87, MD-88, MD-90-30, 717-200. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.

[18] Lockheed Martin Corporation 188A, 188C, P-3 Series. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.

[19] Systems Review training was conducted as part of the Q3 CQ cycle, originally scheduled for Q2 distribution but was delayed due to a technical issue.

[20] Bombardier Inc. CL-600-2B19, BL-600-2C10, CL-600-2D24, CL-600-2D15. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.

[21] Systems Review training was conducted as part of the Q3 CQ cycle, originally scheduled for Q2 distribution but was delayed due to a technical issue.

computer based training, and simulator training, crew were expected to conduct engine fire checklists.

A330 flight crew Continuing Qualification (CQ) training that occurred from the time period of January 2017 to December 2019 consisted of 64 eLearning and/or briefing requirements. Some of those requirements that pertained to this event were "*Perform Fire Protection System Operations," "Demonstrate Workload Management Skills," "Demonstrate Situational Awareness Skills," "Demonstrate decision Making Skills,"* and *"Demonstrate Threat and Error Management Skills."* Additionally, the CQ curriculum that covered the time period from January 2014 thru December 2016 contained those same five requirements. It should be noted that the accident flightcrew had been exposed to at least one of those CQ training events.

Additionally, according to information provided by Delta Air Lines, during the CQ training cycle between October 2017 and June 2018, flight crews were given special purpose operational training (SPOT) event for an inextinguishable engine fire during the CQ training cycle between October 2017 and June 2018, after a similar event that occurred in 2016 on a Delta Air Lines flight departing Seattle-Tacoma International Airport (SEA), Seattle, Washington. Both first officers on the accident flight were potentially exposed to that training; however, the completion of the SPOT was not tracked as it was considered a time-permitting training event.

3.0 Aircraft Information

The accident airplane was an Airbus A-330-323. The airplane was built in 2004, registered to and operated by Delta Air Lines, Inc., and held a transport category airworthiness certificate dated April 9, 2004. The airplane was powered by 2 Pratt & Whitney PW4168A engines and each were rated at 68,600 pounds of takeoff thrust. The airplane was configured with 2 pilot seats, 2 cockpit observer seats, 12 flight attendant seats, and 293 passenger seats.

Photo 1: Stock Photo of Accident Airplane. (Source: Jetphotos.com)

4.0 Meteorological Information

Airport weather observations for ATL were obtained from the National Weather Service. Airport weather information found in the METAR[22] originated from an Automated Surface Observing System (ASOS). The following METARs were issued for ATL for the time period surrounding the accident:

[1852 EDT] METAR KATL 182252Z 22013G21KT 10SM FEW250 27/07 A2991 RMK AO2 PK WND 23028/2230 SLP122 T02670072=

[1752 EDT] METAR KATL 182152Z 24015G25KT 10SM FEW250 27/07 A2992 RMK AO2 PK WND 21033/2134 SLP124 T02720067=

5.0 Company Overview

Delta Air Lines, Inc. operated Delta Air Lines ("Delta") and Delta Shuttle. Delta Air Lines along with their code share agreements provided scheduled air transportation both within the United States and international markets.

According to the Delta Air Lines Operation Specification A001-1, Delta Air Lines was authorized to conduct operations in accordance with FAA-approved Operation Specification, certificate number DALA026A. Delta was authorized to conducted Domestic, Flag, Supplemental operations, and 14 *CFR* Part 91 flights. The following items document the operations Delta Air Lines was authorized to conduct:

- Delta Air Lines OpSpecs
- Delta Air Lines Flight Control Operations Manual
- Delta Air Lines Flight Operations Manual
- FAA-approved manuals and programs

Delta Air Lines was based in Atlanta, Georgia. Delta Air Lines began in 1924 as a crop-dusting operation and in 1929 began operating its first passenger flights from Dallas, Texas, to Jackson, Mississippi, via Shreveport and Monroe, Louisiana. In 2008, Northwest Airlines merged with Delta Air Lines and began a single operation on January 31, 2009. Delta Air Lines began operating A330 series aircraft as part of the merger. As of July 1, 2016, Delta Air Lines had a total of 820 aircraft of which 150 were considered for "Transoceanic" use, 620 were considered for "domestic" use, and 51 of the total aircraft were the A330 series aircraft.

Delta Air Lines pilots were each based at one of nine pilot bases, including ATL and NYC.

6.0 Relevant Systems

6.1 ECAM

Delta Air Lines A330 Quick Reference Handbook, located in Section NNCI "*Non-Normal Checklist Instructions*" stated:

[22] Meteorological Terminal Air Report.

The Non-Normal Checklists chapters contain checklists used by the flight crew to manage non-normal situations. Most checklists contained in the Non-Normal Checklists chapters correspond to an ECAM message. ECAM messages are generated by manufacturer-developed software. Because the ECAM is not customized for specific airlines, it does not always reflect the current operating philosophy of Delta Air Lines. Consequently, Delta provides QRH emergency/non-normal procedures to provide additional information/guidance for Delta standardization, to address situations that are not recognized by the ECAM, or for the remote case of an ECAM failure.

Checklists without an ECAM message are called unannunciated checklists. Most unannunciated checklists are in the associated system section. For example, Engine Fuel Leak is in section 12, Fuel. Unannunciated checklists with no associated system (such as Volcanic Ash) are in section 0, Miscellaneous. In addition, the Miscellaneous section contains checklists titled "Considerations." These checklists are designed to assist crewmembers in the decision making process to accomplish a non-normal maneuver (such as a decision to perform an overweight landing), assist in the preparation and execution of a non-normal maneuver (such as preparation for a ditching), and/or provide considerations that should be taken into account after a non-normal maneuver has been executed (such as post RTO). These checklists should be referenced as time and conditions allow.

All checklists have condition statements. The condition statement briefly describes the situation that caused the ECAM alert message.

Checklists may include memory items. Memory items are critical steps that must be done from memory before reading the checklist. Condition and precaution statements, and notes associated with memory items (i.e., above the dashed line) support action steps and are not considered memory items. The last memory item is followed by a dashed horizontal line.

Checklists that need a quick response are listed in the Quick Action Index on the front cover of the QRH. Some checklist titles are shown in a larger font (such as Evacuation) to make them easier to read under conditions where crew members may be wearing an oxygen mask or under conditions of reduced visibility (e.g., smoke in the flight deck). In the table of contents of each system section, Quick Action Index checklists are listed first, followed by all other checklists. The titles of Quick Action Index checklists are printed in bold type.

Checklist titles in upper case (such as BRAKES HOT) are annunciated by an ECAM alert message. Checklist titles in title case (such as Cracked Flight Deck Window) are not annunciated.

6.2 Fire Protection

The A330's fire indication system consisted of indications for both engines, the auxiliary power unit, cargo smoke, avionics smoke, and lavatory smoke. Each system consisted of 2 detection loops that sensed a high temperature. The system, when it indicated a high temperature, would then illuminate the FIRE push button light (see figure 1), located on the center overhead

panel and sound an audible continuous repetitive chime (CRC), if not in takeoff or landing inhibit mode.

Figure 1: Engine Fire Pushbutton Located on Center Overhead Panel.
(Note: ENG 1 FIRE light is illuminated)

ENG FIRE IN FLIGHT emergency checklist (see section 7.5 for the entire emergency checklist) provides guidance to crews when there is an engine fire. Step 3 of the ENG FIRE checklist stated "*ENG Fire p/b (affected engine) CONFIRM* [and] *PUSH".* According to training guidance provided by Delta Air Lines pushing and releasing the ENG FIRE pushbutton will automatically accomplish the following:

- *Silences the CRC*
- *Arms the fire extinguisher squibs*
- *Closes the hydraulic fire valves*
- *Closes the LP[23] fuel valve*
- *Closes the pack flow control valve*
- *Closes the engine bleed valve*
- *Deactivates the engine generator*
- *Cuts off FADEC[24] power*

7.0 Relevant Procedures

7.1 Non-Normal Checklist Operation

Delta Air Lines A330 Quick Reference Handbook, located in Section NNCI "*Non-Normal Checklist Instructions,*" subsection "*Non-Normal Checklist Operation*" stated:

> *Non-normal checklists start with steps to correct the situation. If needed, information for planning the rest of the flight is included. Flight patterns for some non-normal situations are located in the Maneuvers section of the Flight Crew Training Manual (FCTM), and show the sequence of configuration changes.*
>
> *If a checklist or a step in a checklist is not applicable to all airplanes, airplane effectivity information is included in the checklist. Airplane effectivity can be listed by ship number or airplane model. If a checklist is applicable to some, but not all airplanes, airplane effectivity is centered below the checklist title. If a step in a checklist is applicable to some,*

[23] Low Pressure.
[24] Full Authority Digital Engine Control.

but not all airplanes, airplane effectivity is included above the step. If a checklist or a step in a checklist is applicable to all airplanes, airplane effectivity information is not included.

While every attempt is made to supply needed non-normal checklists, it is not possible to develop checklists for all conceivable situations. For example, in some smoke, fire or fumes situations, the flight crew may need to move between the Cabin Smoke/Fire/Fumes checklist and the Removal of Smoke/Toxic Fumes checklist. In some multiple failure situations, the flight crew may need to combine the elements of more than one checklist. In all situations, the captain must assess the situation and use good judgment to determine the safest course of action.

7.1.1 Land as Soon as Possible

Delta Air Lines A330 Quick Reference Handbook, located in Section NNCI "*Non-Normal Checklist Instructions*," subsection "*Land as Soon as Possible*" stated:

It must be stressed that for persistent smoke or a fire that cannot be positively confirmed to be completely extinguished, the earliest possible descent, landing, and evacuation must be done.

If a smoke, fire or fumes condition becomes uncontrollable, "Land As Soon As Possible" implies immediate diversion to a runway. However, the smoke, fire or fumes situation may be severe enough that the captain should consider an overweight landing, a tailwind landing, an off-airport landing, or a ditching.

7.1.2 Landing at the Nearest Suitable Airport

Delta Air Lines A330 Quick Reference Handbook, located in Section NNCI "*Non-Normal Checklist Instructions,*" subsection "*Landing at the Nearest Suitable Airport*" stated:

There are some situations where the crew must always land at the nearest suitable airport. These situations include, but are not limited to, conditions where:

- *The ECAM displays "LAND ASAP" in red;*
  - *Note: If the ECAM displays "LAND ASAP" in amber, consideration should be given to landing at the nearest suitable airport.*
- *Fire or smoke continues;*
- *Normal aircraft pitch, roll, or yaw cannot be maintained using aircraft trim systems;*
- *There is only one AC power source (such as an engine or APU generator);*
- *One hydraulic system remains; or.*
- *Any other situation determined by the crew to have a significant adverse effect on safety if the flight is continued.*

7.2 Non-Normal Checklist Use

Delta Air Lines A330 Quick Reference Handbook, located in Section NNCI "*Non-Normal Checklist Instructions,*" subsection "*Non-Normal Checklist Use"* stated:

Non-Normal checklist use starts when the airplane flight path and configuration are correctly established. Only a few situations need an immediate response (such as CAB PR EXCESS CAB ALT). Usually, time is available to assess the situation before corrective action is started. Flight path control must never be compromised.

Use the following guidelines:

•Fly the aircraft
•Do not hurry
•Cancel the warning
•Identify the emergency or Non-Normal
•Accomplish recall items from memory (if applicable)
•Read the checklist

The following guidance recognizes:

- *Non-Normal procedure completion and PF duties (flying, navigation, communication with ATC) each require the full attention of the pilot performing the task in order to ensure accuracy and maintain safety.*
- *One pilot cannot effectively perform or monitor all required tasks.*
- *During high workload periods where time is critical, the PF may not be able to monitor ECAM operation.*
- *Unnecessary distractions increase the likelihood of errors.*
- *Accidents have occurred in situations where all pilots were concentrating on the Non-Normal procedures and nobody was actively monitoring the airplane.*
- *Human Factors studies indicate that reading checklist procedures aloud decreases the likelihood of human error. It also provides the PF the opportunity to monitor and acknowledge the accomplishment of the ECAM/QRH procedure. In order to ensure proper checklist selection and completion it is important that the PF actively participate and monitor the accomplishment of the non-normal procedure as long as his/her workload permits. The PF primary responsibility must be to keep control of the aircraft.*

Calling for the Checklist

At the onset of the ECAM annunciation or when a non-normal situation becomes apparent:

- *The pilot recognizing the non-normal will state the ECAM annunciation (Title). If un-annunciated, the pilot will state the condition.*
- *Both pilots will accomplish memory items (if applicable).*
- *The PIC will assign PF and PM duties. PF duties will include control of the aircraft and communication with ATC. The PM will complete the non-normal ECAM and QRH procedures. The principles of CRM, TEM, the nature of the*

non-normal, time criticality, and the need to coordinate operational decisions with external resources will aid in the decision of which pilot will perform each task.

- *The PF will conduct the flight as directed by the PIC (e.g., maintain course, initiate a diversion), communicate with ATC, and configure the aircraft as necessary. FMS operations should be performed on a time permitting basis.*
- *The PM will complete the non-normal ECAM (if any), followed by the QRH procedure (time permitting).*

7.3 Non-Normal Checklist Legend

Delta Air Lines A330 Quick Reference Handbook, located in Section NNCI "*Non-Normal Checklist Instructions,*" subsection "*Non-Normal Checklist Legend"* stated:

The procedures are written according to a prescribed format whenever possible. An understanding of this format makes following the procedures easier and more efficient to complete.

Each emergency and non normal procedure includes the following elements, as appropriate to the situation:

- *TITLE - If the title is all in capital (UPPER CASE) letters, it represents an ECAM message. If the title is not all in capital letters (lower case), an ECAM message is not available, and the title is a description of the emergency or non normal condition.*
- *CONDITION - Describes the condition causing the emergency or non- normal situation.*
- *ACTION STEPS - Procedure to contain or correct the emergency or non normal situation. The initial steps of the procedure are normally identical to the ECAM procedure and may have already been accomplished. Subsequent steps in the QRH include company procedures, approach procedures, and additional information.*

Note: The action steps in the procedure are preceded by a number or a bullet. "If" statements are preceded by a black triangle, a single caret or a double caret.

- *A NUMBERED ITEM (1,2,3, etc.) indicates a step in the procedure that must always be accomplished as long as an end symbol has not been reached.*
- *A BLACK TRIANGLE (▶) indicates an "if" statement or a variable condition exists and the steps may or may not apply. Further "if" statements that depend on previous "if" statements are preceded by a single (>) or double (>>) caret.*
- *A BULLET (•) identifies a sub-step that applies to the "if" statement or variable condition.*
- *Informational text that does not require a specific action is not preceded by a bullet or number.*

The following end symbol may appear in the middle of a procedure and indicates that the emergency or non-normal procedure is complete based on the existing conditions. Approach procedures may still be applicable and should be complied with.

■ ■ ■ ■

As the procedure is performed, all numbered steps must be accomplished. When a triangle or caret is reached, the pilot must decide if the stated condition applies to that specific

situation. If the condition does apply, the sub-step indicated by the indented black bullets must be performed or further conditions indicated by multiple carets should be examined. If the condition following the triangle does not apply, the pilot should continue to the next caret or numbered step in the same vertical column without performing the intermediate steps. In all cases, all numbered steps must be completed and all triangles in the left most margin must be examined to see if they apply, unless the statement end symbol is encountered.

Some procedures contain the statement: "No action is required. This message is for crew information only." This statement is used when there is no procedure or action required to stabilize the non normal and the ECAM message provides information only.

*Some procedures, when executed, change the aircraft/system status; this may result in the annunciation of additional ECAM messages. These messages are for information only. For example, "**F/CTL ALTN LAW (PROT LOST).**"*

*If a non-normal procedural step is intended to re-direct the pilot to another procedure, it will so specify with the statement "**Refer to (the desired non-normal procedure) on page xx.x.**"*

Redirection Symbol

Note: (Not currently used in this manual)
The redirection symbol is used in two ways:

- *In the Table of Contents of a system section, to direct the flight crew to a different system section.*
- *In a non-normal checklist, with the word "Go to", to direct the flight crew to a different checklist or to a different step in the current checklist.*
- *The words "see" or "refer to" are also used to direct the continuation of the procedure to another location.*

Separator Symbol

The separator symbol is used in two ways:

- *In certain system section tables of contents, to separate the titles of QAI checklists from non-QAI checklists.*
- *In a non-normal checklist, to separate the memory items from the reference items.*

7.4 Dual Verification of Critical Controls

Delta Air Lines A330 Quick Reference Handbook, located in Section NNCI "Non-Normal Checklist Instructions," subsection "*Dual Verification of Critical Controls*" stated:

The word "confirm" is added to checklist items when both crew members must verbally agree before action is taken. During an in-flight non-normal situation, verbal confirmation is required prior to the movement of the following critical controls:

•An engine thrust lever
•An engine Master Switch
•An Engine or APU Fire pb
•An IDG Disconnect pb
•The ADIRS panel
•The pilot performing the action (PM) must visually and verbally identify the affected control
•The pilot performing the action (PM) will place his hand on the affected control
•The pilot monitoring the action (PF) will visually and verbally confirm the proper control has been selected.
•The pilot performing the action then actuates the affected control.
***Note**: This does not apply to the ALL ENGINE FLAME OUT procedure. After determination that a critical control must be actuated in flight, the following steps must be taken:*

7.5 Completing the Non-Normal Procedure

Delta Air Lines A330 Quick Reference Handbook, located in Section NNCI "*Non-Normal Checklist Instructions,*" subsection "*Completing the Non-Normal Procedure"* stated:

ECAM Operation

Note: For "no time" emergencies reference FOM chapter 17 regarding the captain's emergency authority.

The ECAM abnormal procedure is divided into three specific areas of information. The first area (ECAM checklist on the E/WD[25]) displays the affected system (underlined) in red or amber, followed by the title of the failure. Action steps (listed in blue) required to stabilize the aircraft are listed below the title; for example:

ENG 1 FAIL
ENG START SEL……IGN

The second area of information (right side of the E/WD) displays special messages (such as LAND ASAP) and secondary affected systems impacted by the non-normal. The third area of information displayed is the STATUS page, which supplies information on inoperative components and non-normal configurations required for landing (if required).

After the PIC assigns duties and an overall plan of action, the PF should call "ECAM Actions". The PM will confirm the failure by checking/inspecting the overhead panel and/or associated SD. The PM shall manage the ECAM checklist procedure. The PM will read aloud each message and step in order, and complete the ECAM checklist procedure to a lights out condition. Lights out refers to the CLR light being extinguished on the ECAM

[25] Engine Warning Display

Control Panel. The ECAM checklist can include monitored and non-monitored items. When a monitored action step is completed it will disappear, and the remaining steps will replace it in order. A non-monitored action step, such as "NOTIFY ATC", will remain displayed.

Note: The CLR PB will never clear blue action items.

When completing an ECAM action item (e.g. moving a control), the PM will read aloud the action to be taken (e.g., "ENG START SEL…IGN"). As the action item is completed, the crewmember taking the action will again state the checklist response (e.g., "Ignition" for IGN), confirming that action was taken.

After all of the actions listed under the title are completed, the PM will verbally challenge the PF to clear the failed system message (e.g., "Clear Engine 1 Fail?"). The PF should visually confirm that the referenced ECAM actions have been completed, and then state "Clear Engine 1 Fail." Before the PM presses the CLR key, the PM should visually confirm the ECAM failure title that will be cleared. The PM will then press the CLR key. This ensures that any additional Master Warnings or Cautions will be advanced to the top of the ECAM checklist section. Complete each subsequent ECAM checklists using the same procedure before proceeding to the system and status pages.

When the ECAM displays several failures at one time, the flight crew should repeat the same sequence for each failure (ECAM actions, request "CLEAR" and confirm "CLEAR" before clearing). When all necessary actions are completed, amber and red failure titles will no longer appear on the E/WD. The affected systems pages will be displayed on the lower ECAM (Systems Display) and provides an easy way to assess overall system status. Before the PM clears a system page, the PM will analyze it and verbally challenge the PF to clear the system page (e.g., "Clear BLEED?"). The PF should check the displayed system page and respond to the challenge (e.g., "Clear BLEED."). If the ECAM displays several systems pages, the flight crew should repeat the same sequence for each SD (analyze, request "CLEAR" and confirm "CLEAR" before clearing).

Note: If an extended interruption occurs (ATC call, Flight Attendant call, etc.) or a configuration change is necessary, the PF should have the PM stop the ECAM procedure. When ready, the PF should ask the PM to continue the ECAM].

When reaching the STATUS page during the ECAM abnormal procedure, the crew should complete any outstanding normal checklists (e.g., After Takeoff Checklist) and consider any applicable computer resets. If there are no actions to complete or when the actions are complete, the crew should continue the ECAM.

The status page summarizes the status of the aircraft as well as provides minimum information for an approach. Status page approach procedures (i.e., blue action/ informational steps) will be addressed at this time. When workload permits, the PM should brief the PF on the status of relevant inoperative aircraft systems as well as limitations displayed on the STATUS page. If the status page indicates limitations, the PM will read

them out loud. In many cases, a significant number of items may be displayed on the STATUS page INOP SYS list. The most effective briefing identifies the significant items from the list so they are properly understood and considered.

Note: When it is necessary to review a system page while completing STATUS page procedures, the PM should press the desired system page key to display requested page (e.g., Fuel page). After reviewing that page, the PM should press the STS Key to return to the STATUS page and continue the procedure.

After all STATUS page approach procedures are complete and system/limitations have been briefed, the PM will challenge the PF to clear the STATUS page (e.g., "Clear Status?") the PF should confirm and state "Clear Status." The PM will press the CLR key and confirm the light remains extinguished. At that time the PM should announce "ECAM procedure complete."

Note: The STATUS page will appear automatically when Baro-reference is selected or slats are extended to one, if there are items in the STATUS page. The PM should state "STATUS" and review the page for any changes. Once reviewed, the PM should ask "Clear STATUS?" The PF will review the STATUS page and state "Clear STATUS."

ECAM Advisories

An advisory is generated when a system parameter exceeds the normal range but has not exceeded a preset limit. When an advisory is activated, the associated systems page is automatically displayed on the SD, and the affected parameter pulses in green.

When an advisory is displayed, refer to the associated Advisory Displayed page (e.g. FUEL ADVISORY DISPLAYED) in NNC.0, ECAM Advisories.

QRH Use

Upon completion of the ECAM procedure to "lights out", the corresponding QRH procedures should also be accomplished, time permitting. The QRH often provides amplifying information in the form of notes, cautions and clear language that is not provided in the ECAM procedure.

When reading the QRH procedure, the PM reads aloud:

- *The checklist title*
- *The airplane effectivity (if applicable) as needed to verify the correct checklist title.*
- *As much of the condition statement as needed to verify that the correct checklist has been selected*

The PF does not need to repeat this information but must acknowledge, time and workload permitting, that the information was heard and understood.

For checklists with memory items, the PM first verifies that each memory item has been completed. The checklist is normally read aloud during this verification. The PF does not need to respond except for items that are not in agreement with the checklist. The item numbers do not need to be read.

Some QRH procedures contain a line of inverted Ts in the checklist. All of the items above the line of inverted Ts were contained within the ECAM procedure. The PM should silently verify that the steps above the inverted Ts have been accomplished during the ECAM procedure, and verbalize any applicable notes, cautions, or warnings. The PM should then continue with the QRH checklist by reading out loud the remaining items of the checklist.

Upon completion of the QRH procedure, the PM will brief the PF on additional QRH items and approach procedures. Review the QRH Approach Procedures early enough to allow for sufficient time to plan an alternate course of action before beginning the approach. Use the normal Approach and Landing checklists, in conjunction with the ECAM/QRH Approach Procedures, to verify correct flight deck and aircraft configuration for landing.

The PF will update the PM on aircraft's position, navigation, communication, and other status items including tasks completed and those still needing to be accomplished, as appropriate.

The captain will coordinate with Flight Control and the flight leader, or designate as appropriate.

If not landing immediately, review relevant approach items from the non-normal procedure when the approach briefing is conducted.

7.6 Engine Fire in Flight

Delta Air Lines A330 Quick Reference Handbook, non-normal checklist Section 8 "*Fire Protection*" stated:

ENG 1 (2) FIRE (In Flight)

Condition: An engine fire has been detected in flight.

LAND ASAP

1. THR LEVER (affected engine) . . . . Confirm . . IDLE

Note: If after selecting the THR LEVER to idle, all FIRE indications abate (disappear), engine shut down is not mandatory. As a precaution, if the engine is at idle, use single-engine approach/land procedures (flaps 3, etc.).

2. ENG MASTER (affected engine) . . Confirm . . OFF
3. ENG FIRE pb (affected engine) . . . Confirm .. PUSH
4. APU BLEED (if engine 1 affected) . . . . . OFF

► If the crossbleed does not close automatically:

- X BLEED . . . . . CLOSE

5. AGENT 1 AFTER 10 S . . . . . DISCH
6. ATC . . . . . NOTIFY

► IF FIRE AFTER 30 S:

- AGENT 2 . . . . . DISCH

ENG 1 (2) SHUTDOWN

7. ENG START SEL . . . . . IGN
8. FUEL IMBALANCE . . . . . MONITOR

Note: After ensuring that a fuel leak does not exist, the WING X FEED valve may be opened to prevent fuel imbalance.

9. TCAS MODE SEL . . . . . TA

▼ Continued on next page ▼

▼ ENG 1 (2) FIRE (in flight) continued ▼

AIR ABNORM BLEED CONFIG

Note: Keep the X BLEED valve closed to prevent spreading of the fire or contamination of bleed air.

10.AVOID ICING CONDITIONS

- **When** flaps & slats UP:
  > If Y ELEC PUMP is running:
    - Y ELEC PUMP (lower pb) . . . . . .OFF
- Turn off wing anti-ice and do **not** use APU BLEED air for wing ant-ice purposes.
- For approach, if ice has formed on the aircraft, use an approach speed of V_{LS} (FULL) + 10 knots and apply the landing distance procedure (refer to ODM).
- Start the APU (if available) and use the APU generator for an additional source of electrical power.
- Do **not** attempt a restart of the affected engine.

Caution! Use caution if speeds below V_{LS} (e.g., windshear) are encountered with full asymmetric power. Control authority is limited as speeds approach V_{MCA}.

▼ Continued on next page ▼

▼ ENG 1 (2) FIRE (in flight) continued ▼

STATUS

CAT III approach not authorized.

APPROACH PROCEDURES	*INOP SYS*
► IF ENG 1 SHUT DOWN and G HYD SYS lost: BEFORE S/F EXTENSION: • BLUE ELEC PUMP. . . . . OFF ► IF ENG 2 SHUT DOWN and G HYD SYS lost: BEFORE S/F EXTENSION: • YELLOW ELEC PUMP. . . OFF 1. PERF APPR . . . select CONF 3 2. FOR LDG . . . . .USE FLAPS 3 3. Monitor fuel balance. 4. LDG DIST PR . . . . . APPLY (refer to ODM) 5. If a go-around is necessary, use FLAPS 2 for the go-around. **Note:** If landing overweight, see "Overweight Landing" on page 0.27.	GEN 1 (2) PACK 1 (2) ENG 1 (2) BLEED REV 1 (2) G ENG 1 (2) PUMP PART GALLEY PART SPLRS BLUE HYD (if ENG 1) ALTN BRK (if ENG 1) YELLOW HYD (if ENG 2) YAW DAMPER 2 (if ENG 2)

■ ■ ■ ■

7.7 Engine Shutdown Procedures

Delta Air Lines A330 Quick Reference Handbook, non-normal checklist Section 7 "*Engines, APU*" stated:

ENG 1 (2) SHUT DOWN

Condition: The affected engine has intentionally been shut down using the master switch.

LAND ASAP

1. ENG START SEL. . . . . .IGN
2. FUEL IMBALANCE . . . . . .MONITOR
3. TCAS MODE SEL . . . . . .TA

AIR ABNORM BLEED CONFIG

4. Start the APU (if available) and use the APU generator as an additional source of electrical power.
5. ***Write down*** the fuel tank quantity in each fuel tank and monitor them over time to determine if a fuel leak exists. Only after ensuring that a fuel leak does not exist, the WING X FEED valve may be opened to prevent a fuel imbalance.
   - **When** flaps & slats UP:
     > If Y ELEC PUMP is running:
       - Y ELEC PUMP (lower pb) . . . . . .OFF

Continued on next page

▼ ENG 1 (2) SHUT DOWN continued ▼

► If the ENG FIRE pb was **not** pushed:

- Associated engine driven hydraulic pump:
  - > If ENG 1 fail:
    - BLUE ENG 1 pump . . . . . .OFF
  - > If ENG 2 fail:
    - YELLOW ENG 2 pump . . . . . .OFF

  (Prevents spurious HYD SYS LO PR messages on approach.)
  - > If icing conditions are encountered:
    - X BLEED selector . . . . . .OPEN
    - PACK (affected side) . . . . . .OFF
    - WING ANTI ICE . . . . . ON

► If the ENG FIRE pb was pushed:

A/THR may be inoperative.

- Avoid icing conditions.
- X BLEED . . . . . .CLOSE
- WING ANTI ICE . . . . . .OFF
  - > If icing conditions cannot be avoided:
    - Use an approach speed of V_{LS} + 10 knots.
    - Landing distance procedure . . . . . .Apply (Refer to ODM)

Caution! Use caution if speeds below V_{LS} are encountered with full asymmetric power. Control authority is limited as speeds approach V_{MCA}.

▼ Continued on next page ▼

▼ ENG 1 (2) SHUT DOWN continued ▼

STATUS

CAT II approach is authorized if autothrust is available.
CAT III approach not authorized.

APPROACH PROCEDURES	*INOP SYS*
► IF ENG 1 SHUT DOWN and G HYD lost (zero pressure): BEFORE S/F EXTENSION: • BLUE ELEC PUMP ..... OFF ► IF ENG 2 SHUT DOWN and G HYD lost (zero pressure): BEFORE S/F EXTENSION: • YELLOW ELEC PUMP . OFF 1. PERF APPR . . select CONF 3 2. FOR LDG . . . . . USE FLAP 3 3. LDG DIST PR . . . . . APPLY (Refer to ODM) 4. Use FLAPS 2 for go-around. **Note:** If landing overweight, see "Overweight Landing" on page 0.27.	BLUE HYD (if ENG 1) or YELLOW HYD (if ENG 2) PART SPLRS REV 1 (2) GEN 1 (2) PACK 1 (2) ENG 1 (2) BLEED B. ENG 1 PUMP or Y ENG 2 PUMP PART GALLEY YAW DAMPER 2 (if ENG 2) ALTN BRK (if ENG 1)

■ ■ ■ ■

7.8 Electric IDG[26] Low Oil Pressure

Delta Air Lines A330 Quick Reference Handbook, non-normal checklist Section 6 "*Electrical*" stated:

[26] Integrated Drive Generator

ELEC IDG 1 (2) OIL LO PR

Condition: The oil pressure on an Integrated Drive Generator is low.

Press the IDG pb until the GEN FAULT light comes on but not for more than 3 seconds.

1 IDG 1 (2) ..... Confirm . . . . . OFF

Note: The IDG cannot be disconnected when the engine is shut down.

- Start the APU (if available) and use the APU generator as an additional source of electrical power.

> If the APU does not start or if the APU generator is not available:

- See NNOI.1, Mechanical Irregularities After Airborne (ETOPS Decision Making), for possible ETOPS limitations.

STATUS

If the APU Generator is not operational: Cat III approach not authorized.

	INOP SYS
	GEN 1 (2) PARTIAL GALLEY

■ ■ ■ ■

7.9 Electrical Generator Fault

Delta Air Lines A330 Quick Reference Handbook, non-normal checklist Section 6 "*Electrical*" stated:

6.36

DELTA
A330 Operations Manual

ELEC GEN 1 (2) FAULT

Condition: A protection trip opened the generator line contactor with the GEN pb ON.

1. GEN 1 (2). . . . . OFF THEN ON
   - ► IF UNSUCCESSFUL:
     - GEN 1 (2). . . . . OFF

⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥⊥

- Start the APU (if available) and use the APU generator as an additional source of electrical power.

> If the APU does not start or if the APU generator is not available:

- See NNOI.1, Mechanical Irregularities After Airborne (ETOPS Decision Making), for possible ETOPS limitations.

STATUS

If the APU Generator is not operational: Cat III approach not authorized.

	INOP SYS
CONSIDER APU GEN USE	GEN 1 (2) PARTIAL GALLEY

■ ■ ■ ■

6.36 September 9, 2016

7.10 Air Abnormal Bleed Configuration

Delta Air Lines A330 Quick Reference Handbook, non-normal checklist Section 2 "*Air Systems*" stated:

AIR ABNORM BLEED CONFIG

Condition: One or more bleed systems are inoperative or selected off.

Note: Page 2.3 is applicable for MEL relief.

Note: If both bleed systems are inoperative or unavailable, immediately refer to Air Dual Bleed Fault on page 2.9

► IF BLEED NOT RECOVERED (due to bleed leak, engine fire, start valve failed open, or bleed valve failed open):

- X BLEED . . . . . CLOSE
- WING ANTI ICE . . . . . OFF
- AVOID ICING CONDITIONS

> If severe ice accretion:

- MIN SPD . . . . . V_{LS} + 10 KT/Green Dot
- Maneuver with care

Note: Do not use APU Bleed air after an ENG 1 Fire or for wing anti-ice purposes.

▼ Continued on next page ▼

▼ AIR ABNORM BLEED CONFIG continued ▼

STATUS

Consult with Dispatch concerning fuel requirements if a reroute is necessary due to en route icing conditions.

	INOP SYS
AVOID ICING CONDITIONS	WING ANTI ICE ENG 1 (2) BLEED FWD CRG TEMP PACK 1 (2)
APPROACH PROCEDURES ► IF SEVERE ICE ACCRETION: • APPR $SPDV_{LS}$ + 10 KT • LDG DIST PR.....APPLY (refer to ODM)	

■ ■ ■ ■

► IF BLEED NOT RECOVERED (all other cases):
- X BLEED. . . . . .OPEN

> If wing anti-ice OFF and no engines failed:
- PACK FLOW . . . . . .LO
- FWD CRG COOLING. . . . . .OFF

> If wing anti-ice is ON or if one engine is failed:
- PACK (affected) . . . . . .OFF

STATUS

Consult with Dispatch concerning fuel requirements if a reroute is necessary due to en route icing conditions.

	INOP SYS
ONE PACK ONLY IF WAI ON	ENG 1 (2) BLEED FWD CRG TEMP PACK 1(2) (if selected off)

■ ■ ■ ■

7.11 Engine Fire Detect Fault

Delta Air Lines A330 Quick Reference Handbook, non-normal checklist Section 8 "*Fire Protection*" stated:

ENG 1 (2) FIRE DET FAULT

Condition: Both fire loops on one engine are inoperative.

Note: Fire detection on the affected engine is inoperative.

1. Monitor engine parameters more closely than normal for signs of fire and/or over temperature.

Note: Consult with Dispatch regarding ETOPS considerations.

	STATUS
	INOP SYS
	FIRE DET 1 (2)

■ ■ ■ ■

ENG 1 (2) FIRE LOOP A (B) FAULT

Condition: Fire loop A or fire loop B is inoperative on one engine.

1. No action is required. This message is for crew information only.

	STATUS
	INOP SYS
	ENG LOOP A (B)

■ ■ ■ ■

8.0 Training Information

8.1 Crew Resource Management and Threat and Error Management

Delta Air Lines A330 Flight Crew Training Manual, section "*General Information*," subsection "*Crew Resource Management*" stated:

> *The nature of training requires that pilots have a clear understanding of human factors in chapter 9 prior to training.*

The "train the way you fly" philosophy requires that pilots have a good understanding of CRM and Delta Air Lines' Threat and Error Management (TEM) model. TEM is integrated into every training program at Delta Air Lines. Pilots are expected to perform the following TEM actions during training:

- *Conduct effective briefings to deal with expected threats*
- *Proactively identify threats and ways to manage them*
- *Identify errors and ways to manage them as they are detected, and*
- *Mitigate the consequences of an error after detection.*

In addition to TEM strategies, pilots will use the following CRM tools during training:

- *Situational awareness*
- *Decision making*
- *Planning*
- *Communication*
- *Workload management, and*
- *Professional management.*

Delta Air Lines A330 Flight Crew Training Manual, section "*Human Factors*," subsection "*Unexpected Threat Management Tool*" stated, in part:

Unlike expected threats that can be planned for in advance, unexpected threats can occur at any time from initial pushback from the gate to block-in at the destination. Generally, pilots react to these types of threats as they occur, using their CRM skills acquired from past experience or training. The goal of Delta TEM is to give pilots a CRM process to proactively handle these threats and manage resultant error. Properly utilized, this threat management process enables crews to know what to do to manage a threat before it occurs. The following TEM model orders crew CRM skills into a process that allows the crew to proactively manage both expected and unexpected threats.

The "Unexpected Threat Management Tool indicates "Fire" to be a "NO TIME Threat", and the section further states, in part:

NO TIME Threats - Include unexpected threats that are time critical in nature and usually require landing as soon as safely possible.

- *NO TIME threats require that the captain have a plan of action in mind (Plan B) to enact as soon as the threat occurs.*
- *NO TIME threats may be aircraft specific. For example, a simple engine failure in a Cessna 150 would be considered a NO TIME threat where it is not in a A330. NO TIME threats listed here are common to all Delta aircraft. Individual fleets may consider additional NO TIME threats based on the needs of their particular type of aircraft.*
- *NO TIME threats may be flight segment specific and are not listed in the TEM model. Examples of these threats are engine failure on a WATRS route and rapid depressurization over critical*

terrain. Threats of this type and an intended plan of action (Plan B) must be pre-briefed by the crew prior to each applicable flight segment.

- *Even during a NO TIME threat, TEM never has an aircraft land as soon as possible, but rather as soon as is safely possible.*

(4) Fire - Fires of an unknown origin, intensity or disposition should always be considered a NO TIME Threat. Even fires that appear to be extinguished may have caused unknown damage to components and landing should not be delayed (exception, lavatory waste fire, etc.)

8.2 Engine Fire Detection

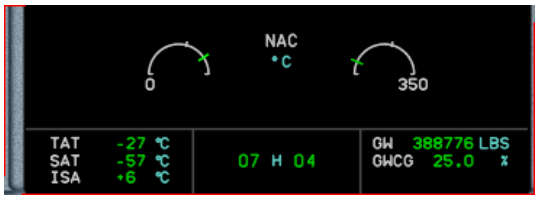
The A330 ground school Lesson 1: Fire Protection, Module 1 provided the following information on the Engine Fire Detection and Extinguishing[27]:

Each engine has a dedicated fire detection which consists of two gas-filled loops, labeled loop A and loop B. Each engine fire detection loop consists of three sensing elements, one located in the pylon and one on each side of the engine core. A signal is sent to the fire detection unit when the loops detect an excessive rise in temperature. The fire detection unit generates a fire warning when:

Both engine fire detection loops detect a fire.
One loop has failed and the remaining loop detects a fire.

Or, both loops have failed within five seconds of each other.

There is also a temperature sensor located within each engine nacelles. These sensors operate independently, and will not cause an engine fire warning. However, if the temperature exceeds a preset limit, a pulsing green indication is displayed on the lower ECAM.



When an engine fire is detected, the flight deck indication includes:

The continuous repetitive chime sounds and the red master warning lights flash.
The red engine fire and LAND ASAP messages are displayed on the upper ECAM
The engine page appears automatically on the lower ECAM
The red fire light illuminated next to the respective engine master switch to identify the correct switch to use during engine shutdown

[27] Dated February 26, 2020. The training presentations the crew received were unable to be retrieved. However, according to a representative of Delta Air Lines, the systems training presentations typically stays static.

The engine fire pushbutton on the overhead engine fire panel illuminates

These indications will remain on as long as a fire is detected.

8.3 Engine Fire Extinguishing

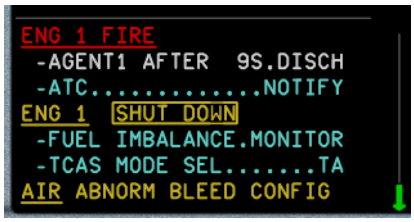
The A330 ground school Lesson 1: Fire Protection, Module 1 provided the following information on the Engine Fire Detection and Extinguishing:

Each engine is equipped with two halon fire bottles. Either or both bottles can be discharged into their respective engine. These bottles are armed when the engine fire pushbutton is pressed. Lift the guard on the engine 1 fire pushbutton, and select the pushbutton to release it. This releases the pushbutton out about an inch from the engine fire panel. When the pushbutton is release, the following sequence occurs:

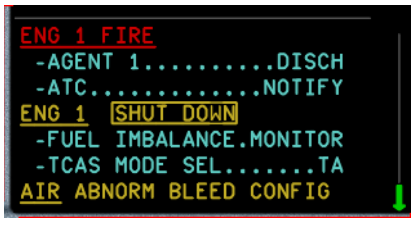
The continuous repetitive chime is silenced, if not already accomplished by pressing a master warning pushbutton

Both fire bottle squibs are armed
They hydraulic fire valves close, preventing the circulation of hydraulic fluid tin the area of the fire
The low pressure engine fuel valve is closed
The respective electrical generator is deactivated
The Respective pack flow control valve is closed
The respective engine bleed valve is closed
The engine's full authority digital engine control is unpowered

A ten-second countdown appears on the ECAM after the engine fire pushbutton has been pressed

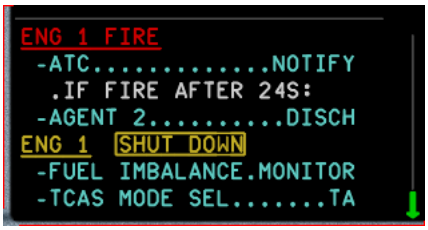


When the countdown is complete, you are prompted to fire the first halon bottle.



The SQUIB light illuminates white when the respective squib is armed. A halon bottle is discharged by selecting its respective squib pushbutton. Press the agent one pushbutton. The discharge light illuminates amber when the bottle is depressurized indicating the

discharge was successful. An additional 30-second countdown now commences on the ECAM. This allows time for the first agent to work before firing the second bottle.



F. LIST OF ATTACHMENTS

Attachment 1 – Simulator Evaluation
Attachment 2 - Quick Reference Handbook [Excerpts]
Attachment 3 – Flight Crew Training Manual [Excerpt]
Attachment 4 – Flight Crew Training Email
Attachment 5 – Delta Air Lines Training Curriculum [Excerpts]
Attachment 6 – Delta Air Lines A330 Instructor Guide [Excerpts]

Submitted by:

_____	_____
Shawn Etcher	Katherine Wilson
Operational Factors Investigator	Human Performance Investigator

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