

# Submission of the Air Line Pilots Association, International to the National Transportation Safety Board Regarding the Incident Involving

United Flight 497 Airbus 320-232, N409UA DCA11IA040 Louis Armstrong New Orleans International Airport (MSY) April 4, 2011



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### **Executive Summary**

On April 4, 2011, United Airlines flight 497 performed an emergency return to Louis Armstrong New Orleans Airport (MSY) following an ECAM<sup>1</sup> message for 'Avionics Smoke'. At the end of the landing roll, the aircraft's nose gear departed the left side of runway 19 and an emergency evacuation was conducted. There were no reported injuries and the aircraft experienced minor damage.

This incident, like all significant events in modern air carrier aircraft, was the result of an interaction of a number of various factors, any one of which would not likely have resulted in the same outcome. By analyzing all the facts and information, these complex causal factors can be identified. ALPA's analysis indicates areas of aircraft system performance and crew performance that did not occur as expected. However, in order to truly improve aviation safety, the investigation must ultimately determine not only the "whats", but also understand the "whys" of these unexpected events and make recommendations to put safeguards in place to ensure similar events do not occur.

While the analyses of the facts are contained herein, the critical aspects that must be addressed are the recommendations. ALPA is recommending seven corrective actions that need to be addressed. These recommendations are in the areas of: A320 systems, pilot training, dissemination of pertinent information to flight crews, and the addition of ECAM exceptions<sup>2</sup> to the Airbus fleet.

<sup>&</sup>lt;sup>1</sup> Electronic Centralized Aircraft Monitoring

<sup>&</sup>lt;sup>2</sup> Abnormal procedures where the crew would reference and follow the QRC instead of the ECAM



# **1.0 Factual Information**

## **1.1 History of Flight**

On April 4, 2011, United Airlines flight 497 performed an emergency return to Louis Armstrong New Orleans Airport (MSY) following an ECAM message for 'Avionics Smoke'. At the end of the landing roll, the aircraft's nose gear departed the left side of runway 19 and an emergency evacuation was conducted. There were no reported injuries and the aircraft experienced minor damage.

The crew reported well-rested<sup>3</sup> for duty at 0600 on April 4, 2011, and the flight preparation was normal. The flight departed the gate at 0658 and subsequently took off at 0708 on runway 19, which is 7,001 feet long. The longer runway at MSY, runway 10/28, which is 10,104 feet long, was closed.

The first officer (FO) was the pilot flying and the crew had planned a flaps 3 full power takeoff. The FO said that they flew runway heading with an initial altitude clearance of 4000 feet MSL<sup>4</sup>. The crew was switched to Departure and was told to turn right to heading 250 and climb to 15,000 feet. Climbing through approximately 4000 feet, the captain saw two ECAM messages, 'Avionics Smoke' and 'Autothrust'. The FO attempted to re-engage the autothrust<sup>5</sup>, but was not successful. The 'Avionics Smoke' ECAM is, by design, accompanied by an amber 'LAND ASAP' message. The captain directed the FO to fly the aircraft and communicate with ATC while he accomplished the ECAM response procedures. The FO leveled off at 5000 feet and retarded the thrust levers. The captain started to accomplish the ECAM procedure and run the 'to-do'<sup>6</sup> items on the ECAM. In accordance with that procedure, the captain turned off generator 2. The FO then noticed that he had lost his primary and navigation displays and began to fly the aircraft using the captain's instruments. The captain noticed that the FO's instruments were inoperative and took control of the aircraft from the FO and told the FO that the ECAM procedures were done.

The FO declared an emergency with air traffic control (ATC) and the captain subsequently told ATC that they had a "smoke issue." The crew was focused on flying the aircraft and getting it on the ground "due to the severity of the emergency"<sup>7</sup> which was reinforced in their minds by the "LAND ASAP" message. The captain asked for a vector back to MSY and requested the longest runway. ATC issued a 030 degree heading and a descent to 4000 feet and advised flight 497 that runway 10 was closed due to personnel and equipment on the runway, but that they would attempt to clear and reopen the runway prior to the flight's arrival. The FO attempted to communicate with the flight attendants via the interphone system, but was unable to contact them. The FO then opened the cockpit door and advised them of the

<sup>&</sup>lt;sup>3</sup> Interview Summaries, Pages 5 and 8

<sup>&</sup>lt;sup>4</sup> Mean Sea Level

<sup>&</sup>lt;sup>5</sup> The autothrust is automatically engaged after takeoff when the thrust levers are moved to the CL (Climb Thrust) detent and the 'Autothrust' ECAM message indicates that the autothrust became disengaged.

<sup>&</sup>lt;sup>6</sup> Blue 'to-do' are ECAM items that require action by the pilot

<sup>&</sup>lt;sup>7</sup> Interview Summaries, Page 3



emergency and that they would be landing shortly. ATC issued an additional right turn to heading 140 and a descent to 2000 feet, and cleared them for the ILS to runway 10. The captain advised ATC that they had lost all their instruments. According to interview statements the captain had his primary flight display (PFD) and navigation display (ND), but the captain also said that his screens started to fade during the approach.

Based on conditions they experienced on departure, the captain expected to break out of the instrument meteorological conditions (IMC) at 1000 feet AGL<sup>8</sup> and was planning on flying a 3 degree visual path to the airport. The captain continued the descent through 2000 feet and leveled off at 700 feet in visual meteorological conditions (VMC). ATC provided the location of the airport and the captain verified that he did see the airport. ATC provided the crew the current winds of 180 degrees at 16 knots gusting to 20 knots and cleared flight 497 to land.

The captain landed the aircraft with flaps full and used the PAPI<sup>9</sup> for vertical guidance approximately 1,000 to 1,500 feet down the runway. The captain said that he "got on the brakes," used full reverse thrust, as well as right rudder to keep the aircraft on the centerline. During the end of the landing rollout the right main landing gear tires failed and the aircraft started to go left and the captain applied more brake pressure. Since the right main gear tires had failed, the left brakes were more effective causing the aircraft to continue to drift to the left. The aircraft came to a stop with the nose gear off the paved runway surface.

Once stopped the flight crew used the QRC<sup>10</sup> to command and execute the evacuation. The passengers and crew evacuated the aircraft using the emergency exit slides, with the exception of the 1R slide, which failed to deploy.

<sup>&</sup>lt;sup>8</sup> Above Ground Level

<sup>&</sup>lt;sup>9</sup> Precision Approach Path Indicator

<sup>&</sup>lt;sup>10</sup> Quick Reference Checklist

# 2.0 Analysis

# 2.1 Flight Crew Actions

#### 2.1.1 Preflight Preparation

When the flight crew arrived at the aircraft to prepare for flight 497, the FO powered up the aircraft, completed the 'Initial Cockpit Preparation' checklist, and did not see any ECAM messages on the Engine and Warning Display (E/WD). The captain had gone into Operations to obtain the flight paperwork.

The flight paperwork contained 'Avionics Smoke' write-ups that the captain did not notice. This information demonstrated that this aircraft had recently experienced several false 'Avionics Smoke' messages and would have provided the flight crew with additional situational awareness. During the cockpit preflight, the captain also was required to depress the 'RCL' key for three seconds to recall any warnings or cautions that had been cleared by the 'CLR' key or cancelled by the 'EMER CANC' key. This action should have brought up the 'Avionics Smoke' ECAM that was *latched*<sup>11</sup> in the system. The FO is not required to look at the aircraft logbook, nor perform any of the ECAM checks required for the captain.

According to the DFDR, the 'Avionics Smoke' discrete was activated from the beginning of the recording until the DFDR stopped working due to the loss of AC electrical power to AC Bus 2. If the 'Avionics Smoke' ECAM message was activated there would have been three amber lights (FAULT light on Blower, FAULT light on Extract, and the SMOKE light on the Gen 1 line) illuminated on the overhead panel, as well as two additional status messages. On the CVR, the crew discussed a 'CFDS' status message that was on previously and checked the 'ECAM status' during the 'Before Takeoff Checklist'<sup>12</sup> but did not mention either the "Vent Blower" or "Vent Extract" that would have been visible if the 'Avionics Smoke' message was *latched*.

#### 2.1.2 ECAM Actions

After departing from MSY, the crew observed an 'autothrust' and 'Avionics Smoke' caution. In compliance with United's procedures, the captain instructed the FO to fly the aircraft and communicate with ATC, while the captain managed the emergency. The captain performed ECAM actions associated with the 'Avionics Smoke' ECAM message, but the FO did not hear or observe what actions were being accomplished by the captain. This ultimately led to both generators being offline and the FO instruments going dark.

As part of the 'Avionics Smoke' ECAM, there is a five minute countdown timer built into the ECAM checklist and displayed lower ECAM or system display (SD). In the event that the smoke persists after the five minutes, it directs the crew to place the aircraft into the emergency electrical configuration. In the case of flight 497, the 'Avionics Smoke' message was *latched* prior to the crew arriving for the flight,

<sup>&</sup>lt;sup>11</sup> If the Avionics Smoke ECAM comes on and stays on for five minutes it becomes locked in the 'on' position within the Flight Warning Computer. Once the ECAM is *latched* it can only be cleared by pulling and resetting the associated Flight Warning Computer (FWC) circuit breakers.

<sup>&</sup>lt;sup>12</sup> CVR Factual, Page 12-18

so the five minute countdown timer had expired and was not present on the ECAM to the crew. The captain therefore did not wait five minutes, but continued with the ECAM and placed the aircraft in the emergency electrical configuration.

The Airbus family of aircraft utilizes these ECAM checklists to provide flight crews with immediate access to checklist items. They are designed to aid the flight crew in responding to an abnormal or emergency event. Also included in the ECAM is the status page on SD. This status provides flight crews with an operational summary of the airplane's system status and for certain ECAM messages, additional checklist items. In the case of an 'Avionics Smoke' event there is a possibility that a crew may have to put the aircraft in the emergency electrical configuration. In this case, the SD will go blank and the only way to bring up the information that would be displayed on the SD would be to depress and hold the 'STS' key to display the ECAM on the engine warning display (E/WD). For flight 497, the crew did in fact lose the lower ECAM display. When the captain took over control of the aircraft, the FO was not sure what had or had not been accomplished and did not know how to bring up the ECAM on the upper display. ALPA looked at some other airlines' procedures and found that a few have ECAM exceptions and several have an ECAM exception for 'Avionics Smoke'. An ECAM exception would provide crews with a paper copy of the ECAM for certain abnormals or emergencies where the SD would be lost. This enables crews to ensure continuity of the checklist even after the loss of the SD.

#### 2.2 Avionics Smoke System

In general, the avionics compartment smoke detection system senses smoke emission from the avionics bay. According to Airbus, the system includes direct detection by the crew as the primary detection tool and secondary detection by a smoke detector, which is considered a help. Once the smoke detector is activated a five minute timer starts. If the signal is still present after five minutes (i.e. if the system continues to sense smoke for five minutes) then the ECAM is *latched* in the Flight Warning Computer (FWC) and can only be cleared by pulling and resetting the associated FWC circuit breakers.

As discussed earlier, the DFDR showed that the 'Avionics Smoke' message was *latched* the entire time the DFDR was recording. If the system logic was operating properly, the 'Avionics Smoke' ECAM would have come up on the E/WD, three amber lights would have illuminated on the overhead panel, and two status messages would have been displayed on the SD under INOP SYS (VENT BLOWER and VENT EXTRACT). Since the crew did not discuss the 'Avionics Smoke' ECAM or the associated lights/ status messages it is likely that the 'Avionics Smoke' was activated during the overnight hours while the aircraft was still powered, the timer associated with the ECAM expired during that time, and the discrete was *latched* in the system. Airbus has said that once the discrete is *latched* the lights on the overhead panel and status messages would remain on.

ALPA believes that the system logic did not operate as documented. While recognizing that flight crews can and do miss items on checklists, it is extremely improbable that the crew did not observe the three lights on the overhead panel, as well as the status messages on a page that they both checked, as



documented in the CVR Factual<sup>13</sup>, during the 'Before Takeoff' checklist and on the FDR Factual<sup>14</sup>. At 7:05:05.1, the First Officer says "takeoff configuration complete. ECAM status check is complete. I thought we had a status message before. Did it fix itself?" This is an indication that the FO did in fact notice the *absence* of the messages. At approximately 07:05:15, the FDR plot shows that the Status page was selected on the ECAM. Based on the data from the FDR and the comments from the crew with regards to the status check, ALPA believes that it is very unlikely that the status messages were annunciated on the ECAM and the corresponding lights on the overhead panel were illuminated.

One likely scenario is that after the smoke detector stopped sensing smoke, the message did remain *latched* in the FWC, but the lights and messages went out. If the smoke detector sensed smoke again during the takeoff roll, the message would have been inhibited until 1,500' AGL or 2 minutes, whichever occurs first. If that was the case, the ECAM would have come back up on the E/WD, the lights would have illuminated, and the status messages would have been regenerated, without the associated single-chime caution since the message was still *latched* in the FWC.

#### **2.3 Human Factors**

ALPA identified two specific human factors areas during the flight that may have contributed to the outcome. By understanding these two areas it may be possible to develop a model that explains many of the human factors questions.

The first area was the reaction of the crew to the ECAM and the decision that the 'Avionics Smoke' message was an immediate life threatening situation. Based on recent training that had highlighted the Swissair electrical fire and crash and the fire in the ValuJet crash<sup>15</sup>, the crew had developed a strong bias regarding electrical fires and the criticality of immediate decisions. This bias predisposed the captain, in particular, to believing that any delay in getting the aircraft on the ground could result in loss of the aircraft. Due to the documented danger that even relatively light smoke may signal a serious, hidden fire, the industry training philosophy since Swissair and Valujet has been to train pilots not to delay getting the aircraft on the ground in the event of a smoke or fire event. The mitigation for these types of bias errors would be to provide an analysis of incidents like the subject of this investigation, as well as more dire situations which would allow pilots to make more accurate, timely decisions.

The second area that led to the incident was the complex ECAM procedure. The ECAM on the A-320 is complex and can be difficult to complete. The 'Avionics Smoke' ECAM has several white conditional statements; for example "IF PERCEPTIBLE SMOKE" to direct the crews actions, but no guidance as how to proceed in the absence of perceptible smoke. These conditional statements can be missed or misinterpreted in a perceived emergency situation, as was the case for flight 497. The combination of inadequate initial ECAM training, the absence of familiarity with complicated ECAMs, and long periods between interacting with complicated ECAMs such as the 'Avionics Smoke' or 'Emergency Electrical Configuration' increases the risk of improper completion of the ECAM actions. Due to the crew's

<sup>&</sup>lt;sup>13</sup> CVR Factual, Page 12-18

<sup>&</sup>lt;sup>14</sup> FDR Factual, Figure 1

<sup>&</sup>lt;sup>15</sup> Interview Summaries, Page 3 and 7



perceived seriousness of the emergency, they were forced to divide cockpit duties, and multi-task complicated critical ECAM steps in a very rushed environment.

### 2.4 Pilot Training

#### 2.4.1 ECAM Training

As part of United's A320 training program ECAM checklists were trained both in the fixed base simulator, as well as the full flight simulator. Although the training included scenarios based on FOQA and FSAP events, which ALPA believes is very beneficial, the training of ECAMs was weak.<sup>16</sup> One United A320 Instructor said, "[h]e thought pilots were "pretty marginal" performing ECAM responses when they got to him in initial training." A United A320 Standards captain said, "[u]se of ECAM was a concern with some crews. A common problem was a crew rushing through or going part way through the ECAM, doing the blue "to do's," and then going to the manual to find the procedure and not finishing the ECAM steps."<sup>17</sup>

#### 2.4.2 Land ASAP

During this event the crew observed both an amber and red 'LAND ASAP' message during the event. The amber message was associated with the 'Avionics Smoke' ECAM, while the red message was associated with the emergency electrical configuration. A United A320 Standards captain said that "[s]he would not do anything different if she received a red 'LAND ASAP' message versus an amber 'LAND ASAP' message. There was no training regarding this."<sup>18</sup> She also stated, "[i]f she received an Avionics Smoke ECAM but did not perceive any smoke, she would still follow the 'LAND ASAP' message."<sup>19</sup> It is clear within United's training department that there was no training or guidance provided to A320 flight crews on how to handle a 'LAND ASAP' message or the difference between an amber or red 'LAND ASAP' message.

Subsequent to this incident, United made a change to the flight manual, dated 2 September 2011, to include recommended actions based on the two 'LAND ASAP' messages. If a red 'LAND ASAP' message is displayed, land at the nearest suitable airport where a safe approach and landing can be accomplished. If an amber 'LAND ASAP' message is displayed, consider landing at the nearest suitable airport.

#### 2.5 A320 Avionics Smoke Detector

The smoke detector located in the avionics compartment of the incident aircraft was an lonic Smoke Detector. These smoke detectors are prone to spurious warnings due to sensitivity to ambient temperature, pressure, and air contamination with moisture, dust, or pollution. Airbus had issued Service Bulletin SB 26-1052 to retrofit A320 aircraft with new optical smoke detectors that do not have this sensitivity. Prior to the incident, United had not accomplished the Service Bulletin<sup>20</sup> on several of

<sup>&</sup>lt;sup>16</sup> Interview Summaries, Page 16

<sup>&</sup>lt;sup>17</sup> ECAM steps refers to items on the ECAM checklist

<sup>&</sup>lt;sup>18</sup> Interview Summaries, Page 16

<sup>&</sup>lt;sup>19</sup> Interview Summaries, Page 16

<sup>&</sup>lt;sup>20</sup> Service Bulletin 26-1052 was not required by Airbus or the FAA to have been completed

their affected A320 aircraft, including the incident aircraft. As of November 10, 2011, United completed the installation of the optical smoke detectors in the avionics compartment of the entire A320 fleet.

### 2.6 Dissemination of Pertinent Aircraft Information to Flight Crews

Airbus issues Technical Follow-Up (TFU) messages to its operators as 'customer information dialogue'. These messages are typically addressed to maintenance personnel in respect to certain aspects of the particular fleet. In July 1999, Airbus issued TFU 26.15.15.001 to address spurious Avionic Smoke ECAM messages. A revision was issued in December of 2002, in both cases they were addressed to maintenance personnel and although these events can have a significant impact to flight crews, neither Airbus nor United disseminated this information to flight crews. ALPA believes that if this flight crew had been aware of the spurious warnings that were prevalent in the A320 family fleet, they would have responded differently to the event.



# **3.0 Findings**

- 1. The flight crew was properly certified and qualified under Federal Regulations.
- 2. The incident aircraft was properly certified and maintained according to Federal Regulations.
- 3. The 'Avionics Smoke' ECAM appears to have been activated prior to the flight, although neither the captain nor first officer reported seeing an ECAM during their preflight.
- 4. Although the Avionics Smoke Warning was *latched according to the DFDR*, neither the captain nor the first officer reported seeing any caution lights on the overhead panel or related messages on the Status page.
- 5. The incident aircraft had experienced two spurious Avionics Smoke Warnings in the last 8 days. These events were documented in the maintenance log for the aircraft, but were inadvertently overlooked by the captain prior to the flight.
- 6. After departure, the flight crew observed both an 'Autothrust' and 'Avionics Smoke' message on the ECAM.
- 7. The captain followed the 'Avionics Smoke' ECAM to the point where the aircraft was placed into the emergency electrical configuration.
- 8. The flight crew decided to return to New Orleans due to the nature of the event and believed that the aircraft was experiencing a critical smoke/ fire event.
- 9. The long runway at New Orleans was closed and not available to the flight due to personnel and equipment on the runway.
- 10. The flight landed on runway 19 and the nose gear exited the left side of the runway east of the intersection of runways 10/28 and 1/19.
- 11. The flight crew commanded an evacuation and during the evacuation the 1R slide failed to deploy.



# 4.0 Recommendations

To the Federal Aviation Administration...

- 1. Issue an Airworthiness Directive to air carriers to comply with SB 26-1052 requiring the retrofit of the ionic smoke detector with the optical smoke detector.
- 2. Require A320 family operators to incorporate an ECAM exception for 'Avionics Smoke'. This paper ECAM exemption would be used in place of the Avionics Smoke ECAM to ensure continuity of the procedure in the event that the aircraft is placed in the emergency electrical configuration.
- 3. Require airlines to include Flight Operations personnel in Technical Follow Up dissemination and if operationally relevant ensure dissemination to flight crews.
- 4. Require A320 family operators to enhance training of complex ECAM procedures during both ground and flight simulator events during initial, recurrent, transition, and upgrade training.
- 5. Require A320 family operators to provide additional training and guidance to flight crews on the amber and red message 'Land ASAP.'
- 6. Require A320 family operators to provide additional training and guidance to flight crews on conditional ECAM questions. For example, if a crew with an Avionics Smoke message does not have perceptible smoke, what actions are required by the flight crew.
- 7. Require Airbus to review the system logic for the avionics smoke detection system and the related ECAM/ warning lights.