United Arab Emirates

GCAA

دولة الإمارات العربية المتحدة
الهيئة العامة للطيران المدني
UAE General Civil Aviation Authority

Accident Reference: 13-2010

Air Accident Investigation Interim Report

Boeing 747-44AF
N571UP
Dubai
United Arab Emirates
September 03 2010

General Civil Aviation Authority of the United Arab Emirates

United Arab Emirates

INTRODUCTION

This Interim Accident Report is an update of the previously released Preliminary Accident Report and contains the factual information of the investigation into an accident involving a Boeing 747-44AF, registration N571UP, on the 3rd September 2010, near Dubai in the United Arab Emirates.

The information contained in this Interim Accident Report is published to inform the aviation industry and the public of the general circumstances of the accident.

Readers are cautioned that there is the possibility that new information may become available that alters this Interim Accident Report prior to the availability of the Final Accident Report.

The GCAA as the investigation authority in charge of the investigation is working in close cooperation with an Accredited Representative from the National Transportation Safety Board (NTSB) and the European Aviation Safety Agency (EASA).

The Accredited Representatives are assisted by technically qualified advisors from the aircraft manufacturer, the Federal Aviation Administration (FAA), the aircraft operator, and the labour union representing the pilots of the operator.

In accordance with Annex 13 to the Convention on International Civil Aviation the sole objective of the investigation is to determine the probable cause of the accident and to make safety recommendations intended to prevent a reoccurrence.

It is not the purpose of this activity to apportion blame or liability - this investigation has been conducted to investigate factual information, analyze the available data and determine the probable cause of the accident.

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ACCIDENT SYNOPSIS

Date of the accident: 03 SEPT 2010

Aircraft/Type: Boeing 747-44AF

Operator: United Parcel Services Company

Site of the accident: 9nm south of Dubai International Airport, United Arab Emirates

Type of operation: Scheduled Cargo (International)

Crew: 2

Summary:

On September 3rd 2010 a Boeing 747-44AF departed Dubai International Airport (DXB) on a scheduled cargo flight to Cologne, Germany.

Twenty two minutes into the flight, at approximately 32,000 feet, the flight crew advised Bahrain Air Traffic Control (BAH-C) that there was an indication of an onboard fire.

The crew declared an emergency and requested a return to Dubai International Airport.

The crew further advised ATC that the cockpit was ‘full of smoke’ and that they ‘could not see the radios’.

The Cockpit Voice Recorder (CVR) detailed a pitch control problem discussed by the crew in the first five minutes of the emergency.

After the airplane turned back toward DXB, on the descent one of the crew experienced an emergency oxygen problem, leading to the probable incapacitation of the crew member.

Due to the Audio Control Panel (ACP)/Radio frequency selection problem all communication was through BAH-C directly when in VHF range or via a relay airplane when out of VHF range. BAH-C then relayed the information to the Emirates Area Control Center (EACC) in the UAE.

As the airplane approached DXB the crew were advised that they were ‘too high and too fast’ as they approached the airport and that a ‘360° turn was required’. The crew responded ‘Negative, negative, negative’ to the 360° turn request. The airplane overflew the airport.

Following the airport over flight a relay aircraft advised the flight crew that an alternate airport , Sharjah International Airport (SHJ), was available to the airplane’s left at approximately 10 nm.

Following confirmation of the heading change by the crew, the airplane reduced speed, entered into a descending right turn south of Dubai International Airport before radar contact was lost.

BACKGROUND INFORMATION TO THE INVESTIGATION

In accordance with requirements of ICAO Annex 13 the GCAA have issued this Interim Report into the accident which occurred in the UAE on the 3rd September 2010.

The key areas of the accident event sequence have been identified. Further detailed investigation is ongoing to validate the findings and determine the contributing significant factors, the culmination of which will form the basis for determining the probable cause of this accident and the associated recommendations.

The investigation has centered on a probable uncontained fire on the cargo main deck as the primary significant factor.

The probable location of the fire has been determined through analyzing the available data in conjunction with onsite investigation of debris and assumptions based on investigative engineering judgment.

The investigation is focusing on several possible ignition sources, primarily the location in the cargo of lithium and lithium derivative batteries that were onboard.

The consequential effects of the fire regarding the compromised flight controls, flight crew supplemental oxygen system, the environmental control system, fire suppression and cockpit visibility are understood, however, further detailed investigation is ongoing to determine the requisite safety recommendations to address the findings.

The wider systemic risks associated with cargo fires and the carriage of hazardous air cargo will be addressed in the accident final report's safety recommendations.

Several safety advisory notices were appended to the Preliminary Accident Report to alert ground handlers, ground handling agents, flight crews and airline operators to the risks associated with the undeclared hazardous cargo. These recommendations are still valid, all concerned parties are advised to review the safety advisory notices concerning the carriage of Hazardous Materials (HazMat).

ABBREVIATIONS/TERMINOLOGY/PHRASES USED IN THE REPORT

ABBREVIATIONS/TERMINOLOGY/PHRASES	
ACARS	Aircraft Communications Addressing and Reporting System
ACP	Audio Control Panel
AP	Autopilot
ATC	Air Traffic Control
BAH-C	Bahrain Air Traffic Control
BALUS	Waypoint
CAPT	Captain
CAVOK	Ceiling and Visibility are OK
CET	Civil Evening Twilight
CGN	Cologne Airport [IATA Code]
COPPI	Waypoint
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
deg	Degree (a degree of arc)
DFDR	Digital Flight Data Recorder
DME	Distance Measuring Equipment
DOH	Doha International Airport [IATA Code]
DXB	Dubai International Airport [IATA Code]
DXB - ATC	Dubai Air Traffic Control
EACC	Emirates Area Control Center
EASA	European Aviation Safety Agency
ECS	Environmental Control System
EGPWS	Enhanced Ground Proximity Warning System
EICAS	Engine Indication and Crew Alerting System
FAA	Federal Aviation Authority
FL	Flight Level
FCC	Flight Control Computer
FIR	Flight Information Region
FLC	Flight Level Change
FMS	Flight Management System
F/O	First Officer/Co-pilot
GCAA	General Civil Aviation Authority
GMT	Greenwich Mean Time
GST	Gulf Standard Time
HazMat	Hazardous Material
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
KT/kt	Knot
MCP	Mode Control Panel
MD	Main Deck
MMEL	Master Minimum Equipment LIst
MMR	Multi Mode Receiver (s)

MOM	Multi Operator Message
NNC	Non Normal Checklist
NTSB	National Transportation Safety Board
OMDB	Dubai International Airport [ICAO Code]
PACK	Preconditioned Air Unit
PANS - ATM	Procedures for Air Navigation Services
PF/PH	Pilot Flying/Pilot Handling
PNF/PM	Pilot Non-Flying /Pilot Monitoring
RANBI	Waypoint
RTF	Radiotelephone - Communication
RW12L	Runway 12 Left
SFF	Smoke/Fire/Fumes
SHJ	Sharjah International Airport
SMACCS	Smoke Mode Air Conditioning Control System
TAF	Terminal Aerodrome Forecast
TSO	Technical Standard Order
UTC	Coordinated Universal Time
ZULU	Refer to GMT

Note for readers unfamiliar with the ICAO Annex 13 chronological number sequencing for accident report sections.
Sections have been omitted from this report as they are either covered in the accident Preliminary Report or are not considered relevant to this specific accident Interim Report.

1. FACTUAL INFORMATION

    1.1 History of the flight.
    1.3 Damage to aircraft.
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    1.5 Personnel information:
    1.6 Aircraft information:
    1.7 Meteorological information:
    1.8 Aids to navigation.
    1.9 Communications
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    1.12 Wreckage and impact information.
    1.13 Medical and pathological information.
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    1.17 Organizational and management information.
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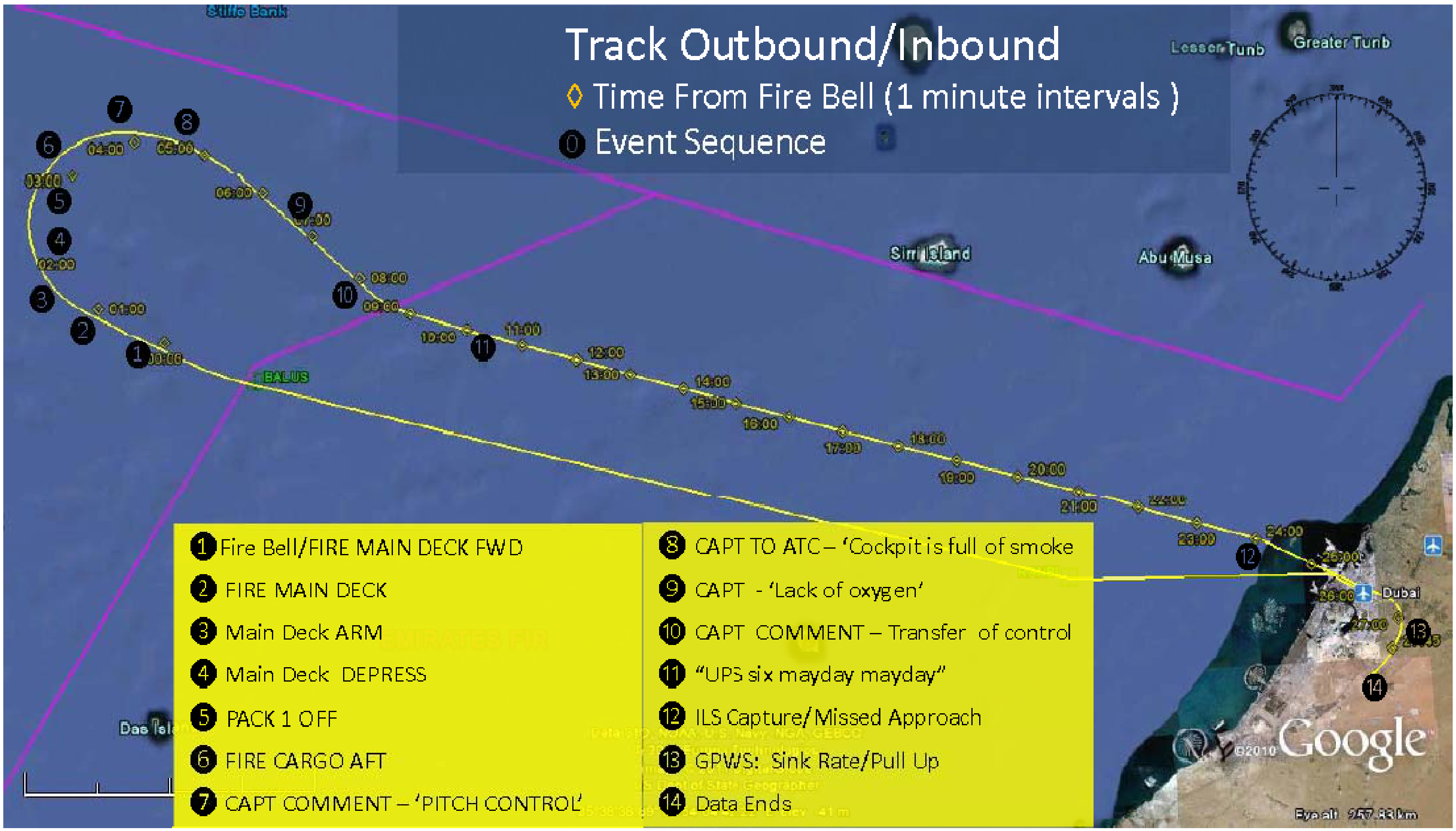
    1.19 Useful or effective investigation techniques.

2. ANALYSIS

1. FACTUAL INFORMATION

Map 1 : Overview of the airplane track – Time from the Fire Bell/Main Deck Fire Forward Alarm (in one minute intervals)



1.1 HISTORY OF THE FLIGHT

The following is an updated description of the flight. The following chronology and the analysis of the event timeline concerning the history of the flight is derived using the DFDR data, Air Traffic Control transcripts, Aircraft Health Monitoring (AHM) System information, the ACARS transmissions and excerpts from the Cockpit Voice Recorder (CVR).

The elapsed time between the take off (T/O) and the end of the data recording is approximately 51 minutes. The history of the flight covers the period of elapsed time from the take off at Dubai International Airport (DXB) until the data recording ends at 15:41:36[1]

1.1.1 TAKEOFF/DEPARTURE/CLIMB OUT

The DFDR data shows that the airplane performed a normal takeoff at time 14:50:53[2] . The climb out from DXB was uneventful. The flight crew flew the airplane manually to an altitude of 11,300 feet, then engaged the AP for the climb to a selected cruise altitude of 32,000 feet.

At approximately 10,000 ft, there was a Pack 1 fault. Pack 1 was reset by the PNF at 15:00:17, at around and altitude of 12,500 ft. The Pack 1 reset was successful.

As the aircraft was climbing to the designated cruise altitude of 32,000 ft, the master warning light Illuminated followed by an audible alarm warning the crew of a Main Deck Fire Forward - this occurred at 15:12:54 as the airplane transited from the United Arab Emirates Flight Information Region (FIR) into the Bahrain FIR.

Following the main deck fire alarm, the CAPT advised the Bahrain ATC (BAH-C) that there was a fire indication on the airplane, informing the Air Traffic Controller(ATC) that the crew needed to land as soon as possible.

The controller advised the crew that Doha International Airport (DOH) was at the aircraft's 10 o'clock position at about 100 NM[3]. The crew elected to return to DXB, declaring an emergency and configured the airplane for the in-flight turn back to DXB.

As the crew began the descent and turn back towards DXB, the CAPT assumed control of the aircraft as PF, also taking control of the radio communication. The F/O reverted to PNF while managing the fire warnings and cockpit checklists.

1.1.2 IN-FLIGHT TURN BACK TO DXB/EMERGENCY DESCENT

At 15:14:02, the AP disconnected, followed at 15:15:59 by a second fire bell. The crew put on their oxygen masks and goggles. Following the turn back the CAPT requested an immediate descent to 10,000 feet (ft).

CVR Excerpt:

CAPT: 15:15:23 - 'I need a descent down to ten thousand right away sir'

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[1] All times are UTC

[2] For the sector DXB-CGN, the CAPT was the Pilot Non Flying(PNF), the F/O was Pilot Flying (PF).

[3] DOH was the nearest airport at the time the emergency was declared (100 nm track miles). DXB was approximately 180 nm track miles

BAH-C: 15:15:26 - '…. descend and maintain one zero thousand your discretion'.

The Fire Main Deck switch was depressed and the cabin began to depressurise, PACKS 2 and 3 shut down automatically, and PACK 2 and 3 switch positions were then manually selected to OFF on the overhead panel in accordance with the checklist[4] and as evidenced on the CVR.

CVR Excerpt:
CAPT:' packs two and three off. get your oxygen mask on'
F/O: 'okay. pack two and three off'

The crew changed the selected altitude from 32,000 feet to 28,000 feet.
A/T began decreasing thrust to start the decent.
The AP was manually disconnected, then AP ON, followed by the AP manually disconnected over a short time period.
Pack 1 goes off line (All packs are now off), with no corresponding discussion recorded on the CVR.

1.1.3 CONTROL ANOMALY – PITCH

A short interval after the AP was disengaged, the CAPT informed the F/O that there was limited pitch control of the aircraft when flying manually[5].

CVR Excerpt[6]:
CAPT: 'I have no control of the airplane'
F/O: 'okay... what?'
CAPT: 'I have no pitch control of the airplane'
F/O: 'you don't have control at all?'
CAPT : 'Alright…find out what… going on, I've barely got control of the airplane'.

The DFDR data indicates that there was a control column movement anomaly between the input by the crew on the control column and the travel of the elevators. The DFDR elevator data indicates nil to marginal elevator deflection while there are large deflections in column position[7].

While engaged, the AP effectiveness in controlling pitch appears to be unaffected by the flight controls issues observed in the data and reported by the crew.

1.1.4 VISIBILITY IN THE COCKPIT

Smoke in the cockpit is a significant factor in the investigation. During the in-flight turn back, the crew informed ATC and the relay aircraft that the cockpit was 'full of smoke' several times during the emergency.

CVR Excerpt:
CAPT: 'UPS six we are full, the cockpit is full of smoke attempting to turn to flight to one thirty please have….standing by in Dubai.
F/O: 'Can you see anything?

[4] See Boeing MOM for the checklist revision
[5] The AP controls the elevators directly from the aft quadrant, the zone in the aft of the airplane where the AP actuators are located
[6] All CVR excerpts are verbatim. Missing words or phrases have not been recorded on the CVR transcript.
[7] Refer to Section 2/Analysis/2.3 Digital Flight Data Analysis–747-400F Accident, Dubai, UAE – 3 September 2010

CAPT : 'No, I can't see anything'

1.1.5 FLIGHT MANAGEMENT COMPUTER (FMC)

15:18:00 – There was a discussion between the crew about trying to input DXB into the FMS. The PNF expressed some difficulty inputting the data based on the reduced visibility[8]. However the Instrument Landing System (ILS) was tuned to a frequency of 110.1 (The ILS frequency for DXB Runway 12L is 110.1[9])

1.1.6 OXYGEN SUPPLY/PROBABLE PILOT INCAPACITATION

At approximately 15:20, during the emergency descent, at 21,000 ft cabin altitude, the CAPT made several comments concerning the supply of oxygen into the mask.

Following a brief exchange between the CAPT and F/O regarding the oxygen problem, the CAPT transferred control of the aircraft to the F/O as PF[10]

At this point the recorded CVR is consistent with the CAPT leaving his seat, after which there is no further CVR information that indicates any further interaction from the CAPT for the remainder of the flight.

CVR excerpt indicates the following exchange between the Captain and F/O.

15:20:11 - CAPT: 'get me oxygen'.
15:20:19 - F/O: 'I don't know where to get it'.
15:20:23 - CAPT: 'you fly'

The F/O assumes the PF role. This remains unchanged for the duration of the flight as there is no further interaction from the CAPT.

1.1.7 MISSED APPROACH TO DXB RW 12L

Airplane condition inbound for DXB

- Computed Airspeed 350 knots
- Heading 105 degrees
- Altitude 9,000 feet

The Glide Slope (G/S) deviation parameter goes from negative to positive at the approach to DXB. This indicates that the airplane was passing from below to above the beam. Based upon the distance from the Runway 12L G/S transmitter (at DXB) and the altitude of the airplane, the beam that was crossed was the 3 degree beam. G/S mode was not armed at this time.

Based on the DFDR data, the PF selected the 'Approach' push button on the MCP. This selection triggers the G/S and localizer modes to arm. At the same time, the left and right AP channels armed. The airplane system detects the DXB Runway 12L Glide Slope beam and the criteria for G/S capture are satisfied. This causes a switch from G/S Armed to G/S Capture Mode. The distance/altitude combination

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[8] Sections of the FMC were recovered, however, due to the fire damage analysis of the components for non volatile memory recorded information has not been possible

[9] Based on the DFDR data

[10] Portable oxygen is located on the flight deck and in the supernumerary area, aft of the flight crew's positions when seated

at the time of capture corresponds to the 6 degree false node of the Glide Slope signal for Runway 12L. The AP did not transition into the Localizer Mode while the Localizer was armed.

ATC through the relay airplane advised the PF , ‘you're too fast and too high can you make a 360? Further requesting the PF to perform a ‘360° turn if able’. The PF responded ‘Negative. Negative, negative’ to the request.

The landing gear lever was selected down at 15:38:00, followed approximately 20 seconds later by a sound similar to the aural warning alarm indicating a new EICAS caution message, which based on the data is a landing gear disagree caution. At 15:38:20 the PF states: ‘I have no, uh gear’.

Following the over flight of DXB, on passing the south eastern end of RW12L, the aircraft was cleared direct to Sharjah Airport (SHJ) as an immediate alternate – SHJ was to the aircraft’s left and the SHJ runway is a parallel vector. The relay pilot asked the PF if it was possible to perform a left hand turn.

The PF responded in the affirmative, requesting the heading to SHJ.

The PF was advised that SHJ was at 095° from the current position at 10 NM and that this left hand turn would position the aircraft on final approach for SHJ (RW30).

The PF acknowledged the heading change to 095° for SHJ. The PF selected 195° degrees on the MCP, the AP was manually disconnected at 15:40:05, the aircraft then entered a descending right hand turn at an altitude of 4000 ft as the speed gradually reduced to 240 kts, followed by a steep descent, which was arrested with pitch inputs, followed by pitch oscillations that continue during the shallow descent until the data ends.

1.6 AIRCRAFT INFORMATION

1.6.1 FIRE WARNINGS/FIRE DETECTION

The smoke detection system monitors the main deck cargo compartment. There are a total of sixteen zones and seventy-seven smoke detectors. The smoke detectors are distributed to minimize the time necessary to detect smoke in any location on the main deck. Zones 3, 4, 5, 12 and 13 each have six detectors. Zones 1, 6 and 11 have five detectors each.

Zones 2, 7, 8, 9, 10, 14, 15 and 16 each have four detectors. The photocell in each smoke detector monitors the air for smoke. When smoke is detected a signal is relayed to the flight deck.

The requirements for Class E cargo fire suppression are defined in 14 CFR 25.857(e) as follows:

Class E. A Class E cargo compartment is one on airplanes used only for the carriage of cargo and in which:

- There is a separate approved smoke or fire detector system to give warning at the pilot or flight engineer station;
- There are means to shut off the ventilating airflow to, or within, the compartment, and the controls for these means are accessible to the flight crew in the crew compartment;
- There are means to exclude hazardous quantities of smoke, flames, or noxious gases, from the flight crew compartment; and
- The required crew emergency exits are accessible under any cargo loading condition.

Although airplane depressurization is not required per the regulations applicable to Class E cargo compartments, it is an industry and regulatory accepted method of providing additional fire protection to airplanes equipped with Class E cargo compartments.

Boeing has selected the altitude of 25,000 feet for Class E cargo compartment firefighting altitude as optimal based on studies of National Fire Protection Association (NFPA), FAA and other literature available. NFPA data indicates the minimum re-ignition energy varies inversely with the square of the pressure. The FAA certified standard for Class E fire suppression, and the way that it is represented in the crew checklist NNC (for the B747) instructs the crew to 'climb or descend to FL250' as the only method of suppressing a main deck fire after airplane depressurization.

1.6.2 FIRE WARNING/ARMING/DISCHARGE SEQUENCING CHECKLIST

The cargo fire arming and suppression sequencing is detailed below

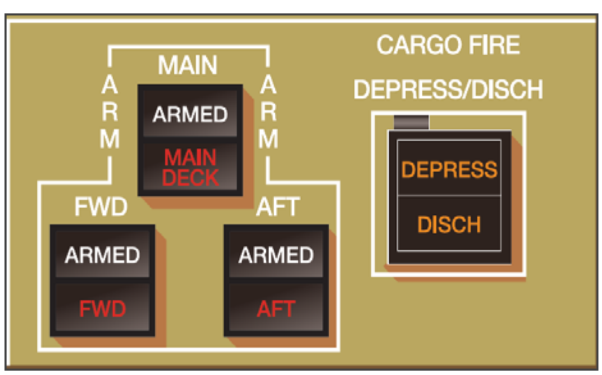


FIG 1: OVERHEAD PANEL – FIRE WARNING/ARMING/DISCHARGE PANEL

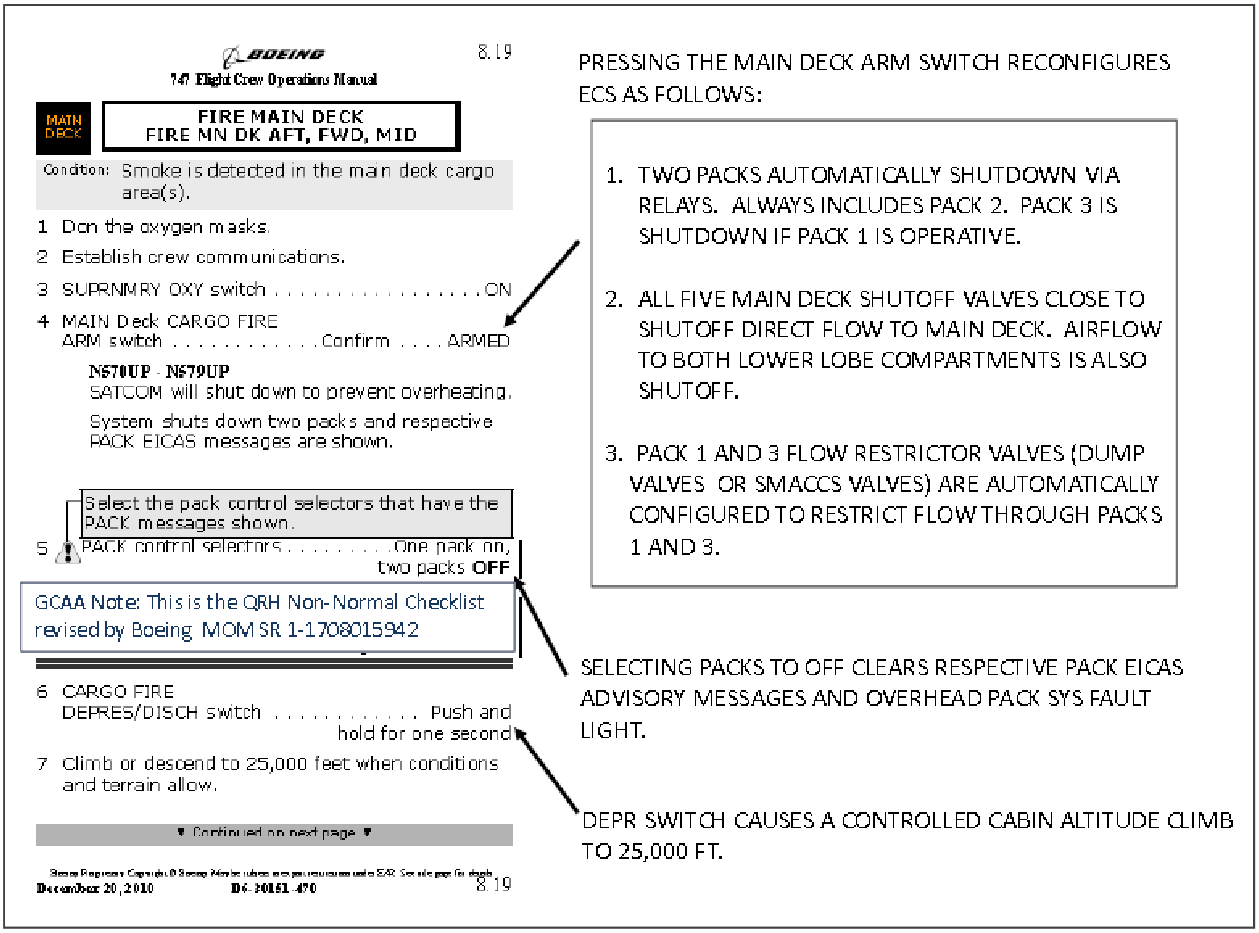


Fig 2: QRH NNC - FIRE MAIN DECK CHECKLIST

1.6.3 OXYGEN SYSTEM - SYSTEM LOCATION/OXYGEN DISTRIBUTION TO FLIGHT DECK

The distribution of oxygen from the bottles to the flight deck is primarily provided through corrosion resistant steel (CRES) 21-6-9 tubes, except there are short CRES flex hoses at the output of the high-pressure regulator on the two forward bottles. The three outputs from the high-pressure regulators are connected together near the bottles to form one distribution tube. This tube is routed forward along the right sidewall, below the main deck, from station 680 to station 380. The tube is then is routed up the right sidewall to the flight deck floor. It turns forward and is then routed up to the low-pressure regulator, located about 30 inches above the flight deck floor at STA 365, near the first observer's position. The output of the low pressure regulator enters a T-fitting, one side is connected to a flexible hose which connects to the first observer's oxygen mask stowage box, the other side, to a tube which travels down to the floor and forward to Station 340. Here the tube enters another T-fitting, with one side routed forward to station 300 where it connects to a short flex hose to the first officer's oxygen mask stowage box, and the other travels across the floor beam to the left side of the flight compartment floor. On the left side, the tube enters another T-fitting, with one side connecting outboard and up to a flexible hose which attaches to second observer's oxygen mask stowage box, the other tube goes forward to station 300, where it goes up and connects to a short flex hose to the captain's oxygen mask stowage box.

The investigation is continuing to assess the potential for elevated oxygen supply temperatures in the oxygen supply system in the event of an uncontained fire in the immediate vicinity of the oxygen tubing routing CRES Tube.

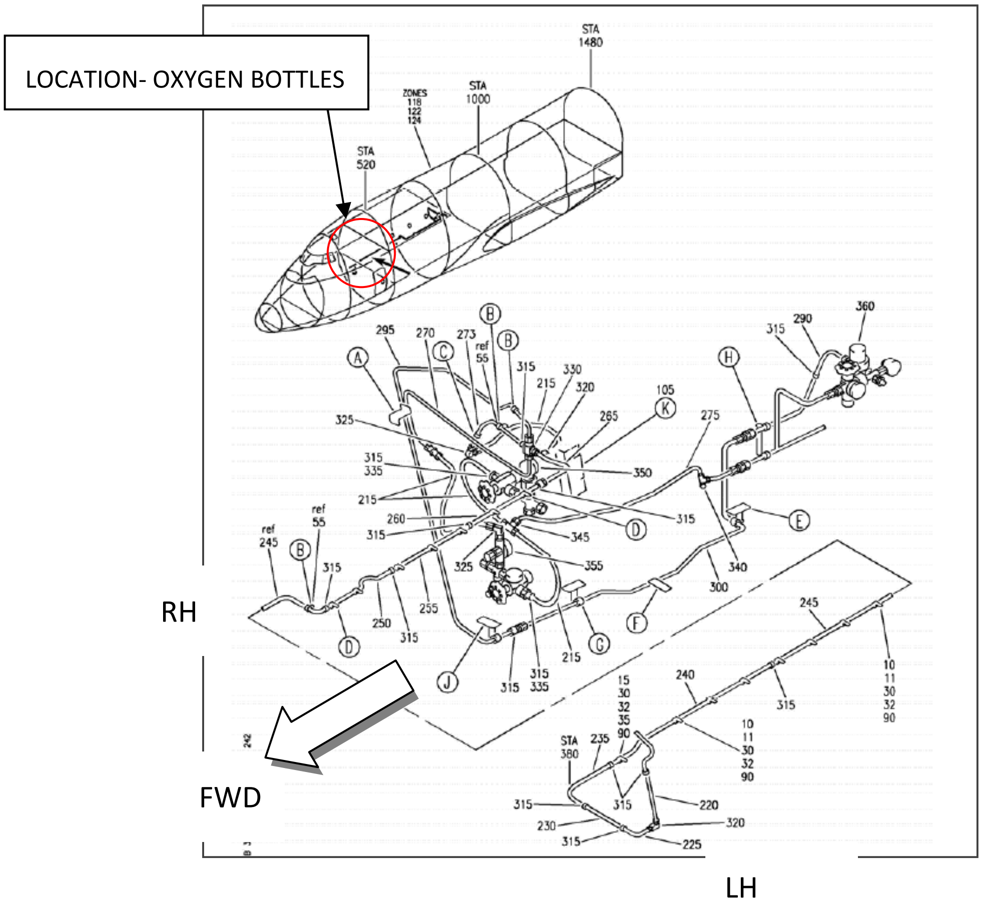


FIG 3: CREW OXYGEN TUBING ROUTING AFT OF STN380 BEFORE THE SECOND STAGE REGULATOR.
[Crew Oxygen Tubing Routing Tubing material specifications: 0.3125 in. OD x .020 in. LG 21-6-9 CRES Tube (Stainless steel)]

1.6.3.1. CREW OXYGEN MC 10 MASK/REGULATOR TSO REQUIREMENT

The TSO C99 upper limit for the oxygen supply temperature into the mask is +55°C. Further testing is underway to establish data on mask function under elevated inlet temperatures

1.6.4 FIRE PROTECTION – CARGO LININGS

The investigation is quantifying the fire threat posed by a cargo container fires by examining the overall energy output, growth rate and detectability of a fire originating within a container. Due to the great diversity of commodities being shipped and the shipping materials used to package those commodities, the baseline fire load for the cargo container fire tests was chosen to consist of ordinary cellulosic combustibles. Traditional construction (aluminum/Lexan) rigid containers as well as collapsible design (polypropylene) containers were used to evaluate the role of the container type and construction material on the fire's characteristics.

1.6.5 - FIRE PROTECTION OF FLIGHT CONTROLS, ENGINE MOUNTS, AND OTHER FLIGHT STRUCTURE

Essential flight controls, engine mounts, and other flight structures located in designated fire zones or in adjacent areas which would be subjected to the effects of fire in the fire zone must be constructed of fireproof material or shielded so that they are capable of withstanding the effects of fire.

The linings in the proximity to the probable location of the fire zone are shown below in green.

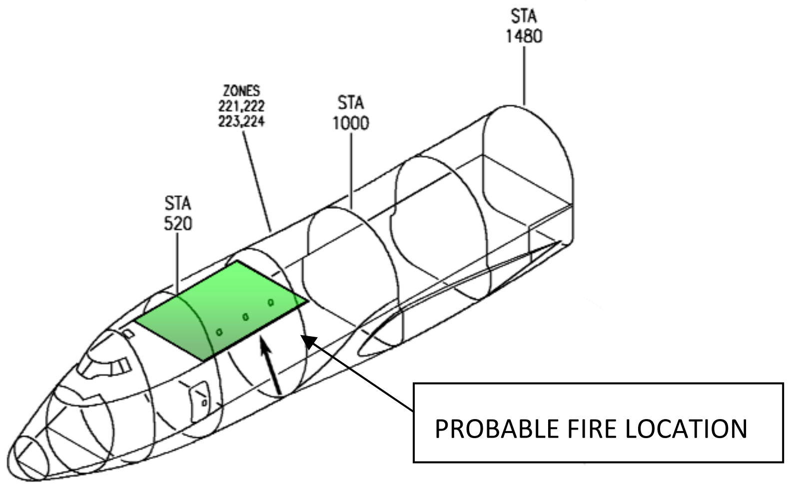


FIG 4: MAIN DECK CEILING PANEL DIAGRAM STATION 400 TO 718.40

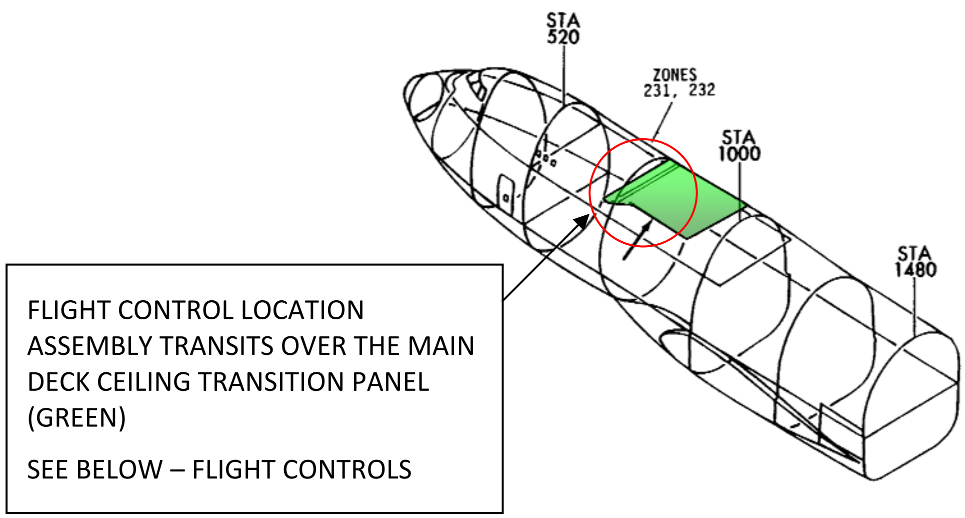


FIG 5: MAIN DECK TRANSITION CEILING PANEL DIAGRAM STATION 718.74 TO 900

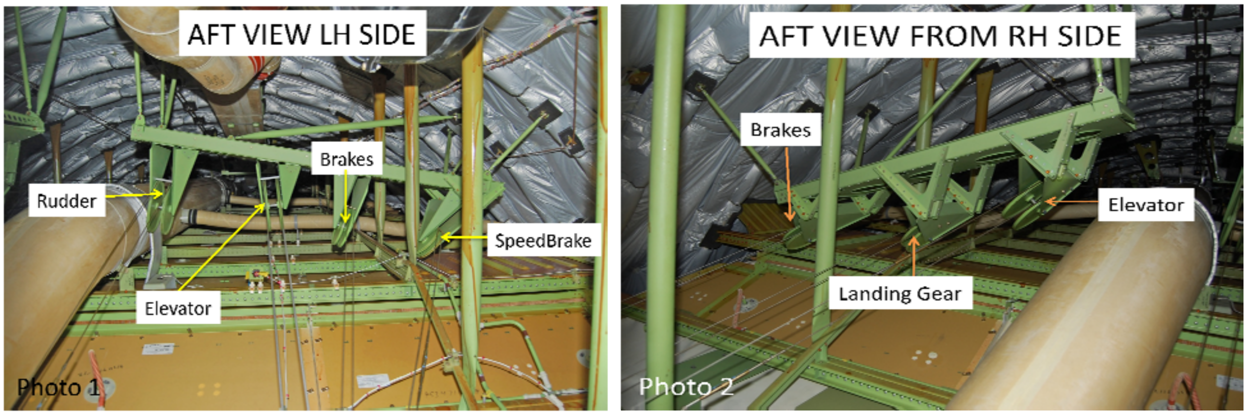


Photo 1 & 2 – Flight Control Locations

The flight control cables, pulleys and support trusses at the location of the main deck transition ceiling panel, located above the probable fire zone.

1.6.6 ENVIRONMENTAL CONTROL SYSTEMS

The ECS ducting, in particular the ducting that supplies the preconditioned air to the cockpit, runs through the main deck transition ceiling panel location above the control cables[11].

1.9 COMMUNICATIONS

1.9.1 GENERAL INFORMATION

At approximately 15:22 the aircraft entered the Emirates FIR heading east, tracking direct to the DXB RW12L intermediate approach fix.

The aircraft was now out of effective VHF radio range with BAH-C.

In order for the crew to communicate with the Bahrain ATC, BAH-C advised transiting aircraft that they would act as a communication relay between BAH-C and the emergency aircraft. BAH-C would then communicate to the UAE controllers managing the traffic in the Emirates FIR via a landline.

The crew advised relay aircraft that they would stay on the Bahrain frequency as they could not see the ACP to change frequency.

CVR Excerpt F/O: '….we're gonna have to stay with you (on this frequency[12]) we cannot see the radios'

1.9.2 TRANSMISSION/RECEPTION ON THE VHF 121.5 /GUARD FREQUENCY

Based on the Preliminary Report , there has been some discussion based on the radio communication between the accident airplane, relay aircraft and the ground stations regarding radio transmission and reception on the VHF 121.5 frequency[13].

The crew of the accident airplane remained on the Bahrain frequency for the duration of flight.
There are VHF 121.5 transmissions from and to the accident airplane as detailed below.
A brief summary is as follows:

- EACC transmitted on the guard frequency from 15:22 for approximately 14 minutes.

[11] The brown ducts near the top of the crown in 'LH – view looking aft' photo
[12] GCAA insert for clarification
[13] A full breakdown of the inter airplane and ground stations communication will be detailed in the final report

- Several relay aircraft transmit on 121.5 during the accident airplanes descent and approach to DXB
- The accident aircraft transmits on 121.5 on several occasions, in particular at 15:35:10, the F/O calls on 121.5:
  CVR Excerpt: 'UPS six mayday mayday mayday can you hear me?'
- The accident aircraft does not respond to transmissions from the relay aircraft or the ground stations on the 121.5 (guard) frequency.

1.10 AERODROME INFORMATION/UAE/DXB/RW12L

- UAE AIP Information as published for DXB RW 12L

LOC RWY 12L/1.3°E (2005)/CAT III/E/4IDBL 110.100 MHZH24/LAT: 251444.6N / LONG :0552304.3E

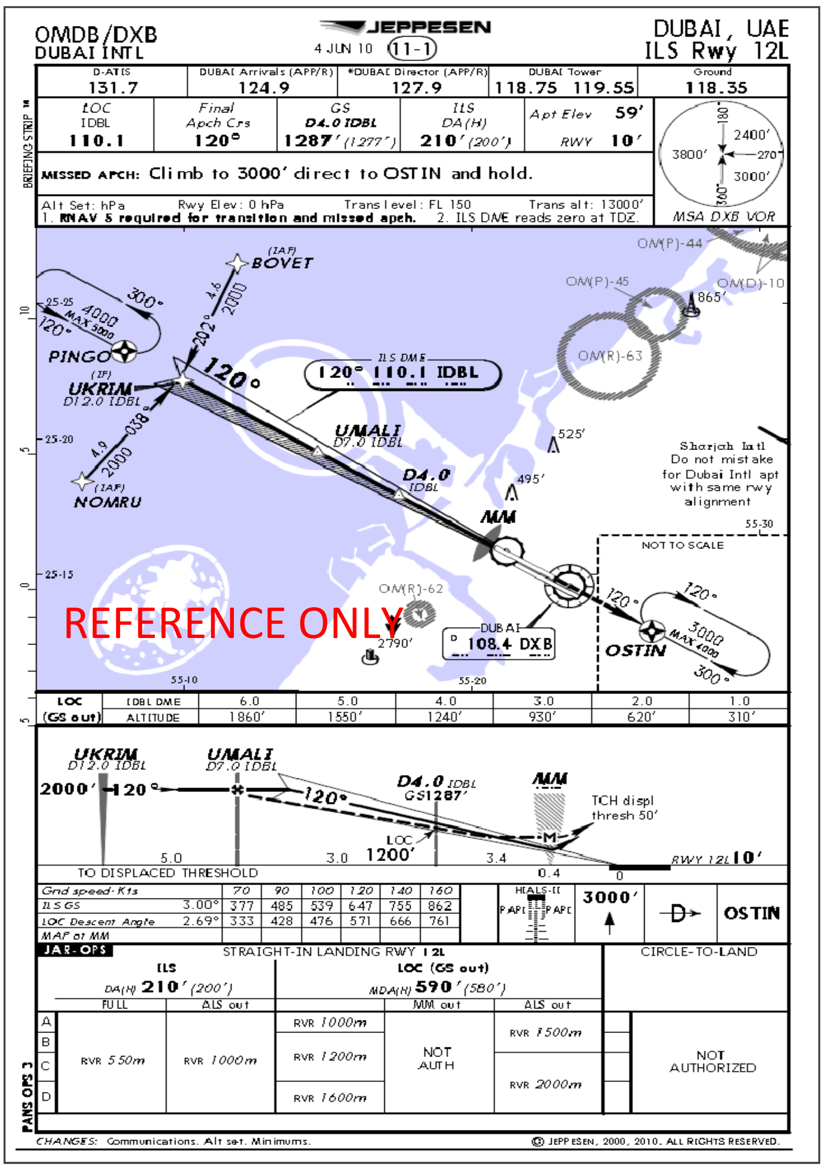


FIG 6 – AERODROME INFORMATION [OMBD/DXB]

1.10.1 THE UAE AERONAUTICAL INFORMATION PUBLICATION (AIP)

Radio and radar failure procedures as published in the UAE AIP

1. In case of communication failure aircraft shall conform to the procedures specified in Annex 2, Chapter 3, para. 3.6.5.2
2. Following unsuccessful attempts to established RTF contact, aircraft equipped with satellite and / or mobile telephones shall attempt to contact EMIRATES ACC on telephone number +971 2 599 6969.

3. DESDI and BUBIN are designated holding fixes for traffic landing Dubai and Sharjah, refer to table ENR 3.6. Issuance of EAT as per ICAO Doc 4444 PANS - ATM, paragraph 6.5.7.

4. ENR 3.6 EN - ROUTE HOLDING
   3.6.1 En-route holding procedures are established at the positions indicated in the adjoining table.

   3.6.2 En-route aircraft may be required to hold elsewhere for traffic purposes. Traffic required to hold en-route will be passed holding instructions by ATC.

   3.6.3 Holding aircraft will be radar monitored to ensure separation from other aircraft and if necessary terrain clearance.

1.16 TESTS AND RESEARCH

1.16.1 FLIGHT TESTING - BOEING 747-44AF / BOEING 747-45EF

Several flight tests have been conducted using a representative Boeing 747-44AF or Boeing 747-45EF airplane.

The purpose of the flight testing has been to verify operational requirements, systems functioning, human performance and CVR data.

This testing included the check and verification of the flight deck ergonomics, crew accessibility of the emergency equipment within the flight deck, including the donning of the mask/goggles and to record the oxygen mask function for further CVR analysis (as detailed in Analysis 2.1 below)

1.16.2 LEVEL D B747-4 SIMULATOR BASED PERFORMANCE TESTING: SMOKE FILLED FLIGHT DECKS

The CVR data has numerous references to the smoke and reduced visibility preventing the crew from viewing the information displayed, or being able to view the instruments to affect or manage the ACP/ Mode Control Panel (MCP). The investigation into the human performance aspects of limited visibility in the flight deck is ongoing.
The GCAA/NTSB have performed several simulator sessions simulating smoke filled flight deck environment to assess the human factors, Smoke-/Fire /Fumes (SFF) checklist procedures, in addition to reviewing alternative SFF emergency viewing systems that provide a method of viewing the primary flight instruments in smoke filled flight decks.

2. ANALYSIS

2.1 CVR ANALYSIS - ZODIAC OXYGEN REGULATOR

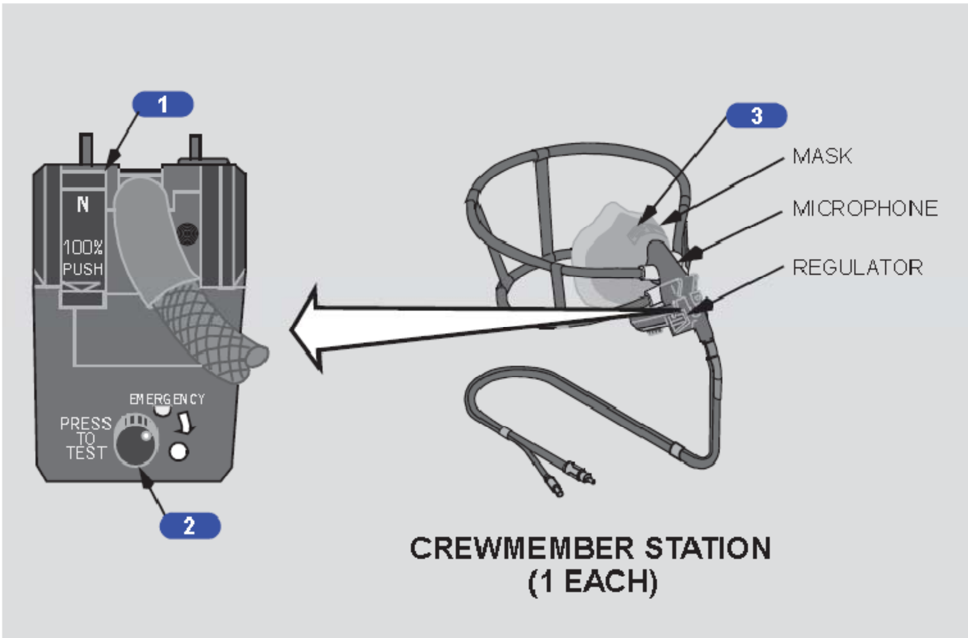
When the oxygen regulator is set to the 'Normal' mode selection, the oxygen delivery ratio depends on the cabin altitude, i.e. the higher the cabin altitude, the lower the ratio of ambient air to the oxygen mixture, and vice versa as the cabin altitude is decreased.

2.1.1 ZODIAC OXYGEN REGULATOR OXYGEN MASK OPERATION

The oxygen mask/goggle sets available to the flight crewmembers were diluter-demand oxygen masks with mask-mounted regulators.
This type of mask, which is common for air carrier operations with pressurized cabins, has two selectable regulator switches.
The first is the Normal/100% oxygen switch, which allows selection of diluted oxygen with ambient air (depending upon cabin pressure altitude) when set to Normal or 100% oxygen regardless of cabin altitude.
The second is the Normal/Emergency flow switch, which allows selection of normal flow rate into the mask upon demand and emergency flow rate that provides constant pressurized air flow.

(PHOTO 3 - OXYGEN MASK SELECTOR)

N570UP - N577UP



1 NORMAL/100% Switch

N - supplies an air/oxygen mixture on demand (the ratio depends on cabin altitude).

100% - supplies 100% oxygen on demand (not an air/oxygen mixture).

2 Oxygen Mask Emergency/Test Selector

Rotate (in the direction of the arrow) - supplies 100% oxygen under positive pressure at all cabin altitudes (protects against smoke and harmful vapors).

PRESS TO TEST- tests the positive pressure supply to the regulator.

3 Observer's Smoke Vent Valve Selector

N578UP, N579UP

Up - vent valve closed.

Down - vent valve open, allowing oxygen flow to smoke goggles.

FIG. 7 CREW MEMBER OXYGEN – EMERGENCY EQUIPMENT

2.2 CVR - SOUND SPECTRUM ANALYSIS

In order to determine if the oxygen mask was functioning correctly and that the crew had selected the required setting for a smoke filled cockpit, a test regime was devised to capture audio from a representative flight and compare this data to the accident flight CVR recording[14].

BACKGROUND INFORMATION

Testing of an exemplar oxygen mask in the NTSB laboratory revealed that the sound of air moving through the mask (i.e. normal auditory aspiration noises) are distinctly different when the mask is used in the three different modes:

1. Normal[15]
2. 100%
3. Emergency

The Cockpit Voice Recorder (CVR) Group for this investigation noted that both crewmembers had some unidentified issues with the crew oxygen system. Both crew had donned their oxygen masks after the fire bell sounded at approximately 15:14:30 .

At approximately 15:20 the Captain indicated that oxygen was not getting to the mask, and the Captain's breathing into the mask (as captured by the oxygen mask microphone) ceased abruptly.

CVR excerpt indicates the following exchange between the Captain and F/O.

15:20:11 - CAPT: 'get me oxygen'.
15:20:19 - F/O: 'I don't know where to get it'.
15:20:23 - CAPT: 'you fly'

The Captain then leaves the seat, the CVR indicates that the Captain had moved aft of the flight deck area.

At about 15:22, the F/O breathing sound is not audible for about 20 seconds.

A further 20 seconds later the F/O said "I'm looking for some oxygen" during a radio transmission.

Shortly thereafter, the F/O breathing sounds stopped again for about 20 seconds.

Following the interruptions, the F/O's breathing sounds are audible until the end of the recording (about 20 minutes later).

However, about 10 minutes before the end of the recording, the First Officer transmitted '…we are running out of oxygen.'

In order to better understand how the oxygen system was being used (i.e. the mask configuration of 'Normal' vs. '100%', the 'Emergency' setting, and the smoke vent setting), a flight test was conducted using oxygen masks of the same make/model as was installed on the accident airplane.

The methodology required that the masks were operated in flight and on the ground, using all possible configuration settings. During these tests, the audio from the mask microphones and the cockpit area microphone was captured by the airplane's CVR, and used for comparison with the audio from the accident flight.

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[14] Detailed flight testing and analysis of the sound spectrum mask function has been completed and will be included in the final report.

[15] The ambient air to emergency air ratio is a function of altitude and the volumes/flow rates are inversely proportional.

2.2.1. SOUND SPECTRUM ANALYSIS REVIEW

The audio from the flight test was also examined using a software frequency analysis program. Spectrogram charts[16] of the audio were generated for each of the test segments, and these charts were reviewed for any signatures that were unique to specific settings of the oxygen masks.

The results of this analysis of the sound spectrum data from the accident flight indicate that the data is consistent with the following oxygen mask settings for the crew:

- Captain's mask setting: **100%**
- First Officer's mask setting: **Normal**
- Based on the data, neither mask appears to be in the 'Emergency' mode

The required mask setting for Smoke/Fire/Fumes (SFF) is the 100% setting.

Note - Mask setting controls are explained below:

Selector set to **NORMAL:** mixes ambient air in the cockpit with emergency oxygen at ratio determined by the cabin pressure altitude

Selector set to **100%:** provides direct emergency oxygen undiluted

Selector set to **EMERGENCY:** provides 100% direct emergency oxygen with a slight positive pressure.

The results of the SFF simulator testing and the use of enhanced smoke filled cockpit vision systems will be included in the accident investigation final report.

[16] Three dimensional presentations of time, frequency and energy

2.3 DIGITAL FLIGHT DATA FACTUAL ANALYSIS - FLIGHT PROFILE

The following data is a factual DFDR report of the accident flight with factual statements to support the recorded data and associated control anomalies.

2.3.1 SUMMARY:

The DFDR data show the airplane performing a normal takeoff and climb. Prior to reaching cruise altitude, airplane systems warned the flight crew of a main deck cargo fire.
The flight crew initiated descent and elected to make an emergency return to Dubai International Airport (DXB).
During descent the flight crew experienced a decrease of manual elevator and rudder control.
The decrease of manual elevator and rudder control is consistent with a loss in column and pedal cable tension, respectively.
The autopilot (AP) does not rely on these cable systems and functioned while engaged for the duration of the flight.

DIGITAL FLIGHT DATA FACTUAL ANALYSIS – FLIGHT

The following analysis and event timeline has been created using DFDR data, Air Traffic Control (ATC) transmissions and excerpts from the Cockpit Voice Recorder (CVR).

The following description is a subset of events that occurred in chronological order.
- The number is the approximate elapsed time, in UTC, from the engine start.

The following text describes the event.

- ATC – Air Traffic Control transmission
- CAPT – Comment on the CVR by the captain
- F/O - Comment on the CVR by the First Officer/Co-pilot
- PF – Pilot Flying (i.e. the handling pilot)
- GPWS – Ground Proximity Warning System aural alert recorded on CVR
- *Events in italics describe a discrete change*

Following the event description there may be additional text providing additional details
Example:
15:15:48 CAPT - Second comment about lack of control
15:16:47 CAPT - Comment about no pitch control
15:16:57 - *Fire Zone 2 Aft Cargo (lower deck)*

2.3.2 TAKEOFF

The DFDR data show that airplane performed a normal takeoff at time 14:50:53 UTC.

2.3.3 CLIMB OUT/ASCENT/PACK 1 ON-OFF-ON

Pack 1 discrete indicated OFF at time 14:58:30 . Pack 1 was reset and discrete indicated ON at time 15:00:18 . The flight crew flew the airplane manually to an altitude of 11,300 feet, then engaged AP for ascent to a cruising altitude of 32,000 feet.

Just prior to reaching the selected altitude 15:12:53 the master warning light illuminated. The master warning coincided with a discrete for fire on the forward main deck.

The AP controls the elevators directly to the aft quadrant. AP commands appear to be unaffected by the flight controls issues experienced by the crew[17].

2.3.4 FIRE WARNINGS

When the first fire warnings occurred, the airplane was configured for Climb/Ascent:

- Flaps up
- Speed 302 knots
- Heading 295 degrees
- Altitude ~32,000 feet
- 100% Engine N1
- AP engaged in Vertical Navigation (VNAV) / Lateral Navigation (LNAV) modes

Following indication of fire on-board the airplane, the flight crew initiated a descent and in-flight turn back to DXB.

15:12:58 - *Fire Main Deck Fwd*
15:13:02 - Captain assumed control of the airplane and decided to return to DXB. Captain took control of the radio and instructed F/O to run the checklist.
15:13:09 (ATC) Captain contacted Bahrain.

- AP Modes: LNAV was changed to Heading Select and VNAV was changed to Flight Level Change (FLC).
- Auto throttle (A/T) transitioned from climb to cruise mode, as the target altitude was reached, and thrust decreased.

15:13:31 - Selected heading on the Mode Control Panel (MCP) was changed from 295 to 90 degrees for the turn back to DXB. Selected heading was changed again to 130 degrees 170 seconds later.

Descent – flight crew began a turn back to DXB while descending to 10,000 feet. The first indications of flight control issues are present in the FDR data, and the flight crew's CVR comments[18].

15:13:46 - Fire Main Deck

- The flight crew changes their selected altitude from 32,000 feet to 28,000 feet. A/T began decreasing thrust to start the decent.

15:14:02 - *AP manually disconnected*
15:14:05 - *Pack 2, 3 OFF*
15:14:16 - *AP ON*
15:14:28 - *AP manually disconnected*
15:14:40 - *Fire Main Deck Zone 12*
15:15:00 - Altitude Select 10,000 feet
15:15:15 - *Crew Rest Smoke*
15:15:21 - *Pack 1 OFF (All packs off)*

- The flight crew was flying, manually inputting positive and negative column deflections.

[17] See Flight Controls section
[18] The flight control anomalies are reviewed further in the Flight Controls section.

The data labeled ‘F/O Column Force’ tracks the ‘Captain Column Force’ for the entire flight until time 15:15:21 seconds. From this point to the end of data, F/O column force reads close to zero.

15:15:28 - *Fire Main Deck AFT*

2.3.5 LACK OF CONTROL

15:15:37 - CAPT - Comment about lack of control

- The FDR column deflection began to deviate from zero in the nose-down direction. The captain column force indicates that the captain was actively inputting nose-down and nose up forces on the column.
- The FDR data show multiple left rudder pedal inputs but there was no corresponding rudder pedal force. The rudder pedal movement does not have a corresponding rudder deflection.

15:15:40 - *Cabin Altitude Warning*

15:15:48 - CAPT - Second comment about lack of control

15:15:59 - *Fire Cargo Aft / Zone 1 (lower deck)*

- Column deflection moves to full nose-down deflection. The elevator deflection is not consistent with the nose-down deflection recorded for the column deflection parameter.
- FDR elevator data show little to no deflection while there are large deflections in column position. The flight path of the airplane, following the fire indications, is consistent with the elevator deflections.

FIGURE 8 - 15:15:57 UTC - IN-FLIGHT TURN BACK – PITCH CONTROL

15:16:42 CAPT - Comment about no control
15:16:47 CAPT - Comment about no pitch control
15:16:57 - *Fire Zone 2 Aft Cargo (lower deck)*
15:17:05 - *Fire Zone 3 Aft Cargo (lower deck)*
15:17:19 (ATC) - Captain informed ATC that cockpit was full of smoke
15:17:39 CAPT - Comment about inability to see
15:17:44 - *AP On*

- The AP controls the elevators directly from the aft quadrant (AP commands appear to be unaffected by the flight controls issues observed in the data and reported by the crew.

2.3.6 FMS INPUT

15:17:51 - CAPT - First discussion about trying to input DXB into the FMS
15:19:20 - The Instrument Landing System (ILS) was tuned to a frequency of 110.1

- The ILS frequency for DXB Runway 12L is 110.1

15:20:21 - CAPT - Comment about transfer of aircraft control to F/O (now PF)
15:26:09 - Selected Altitude was captured at 10,000 feet
15:33:19 - Altitude Select 9,000 feet

2.3.7 APPROACH TO DXB

Airplane configuration on the approach to DXB RW 12L

- Flaps up
- Computed Airspeed 350 knots
- Heading 100 degrees
- Altitude 9,000 feet
- Throttle Resolver Angle: 60 degrees

The glide slope (G/S) deviation parameter goes from negative to positive at this time. This indicates that the airplane was passing from below to above the beam. Based upon the distance from the Runway 12L glide slope transmitter (at DXB) and the altitude of the airplane, the beam that was crossed was the 3 degree beam. G/S mode was not armed at this time.

15:36:46 - *G/S Armed, Localizer Armed*

- The flight crew selects the "Approach" push button on the MCP. This selection triggers the G/S and localizer modes to arm. At the same time, the left and right AP channels armed.

Altitude Select 4,000 feet
15:37:06 - *G/S mode engaged*

- The airplane receivers detect DXB Runway 12L glide slope beam and the criteria for G/S capture are satisfied. This causes a switch from G/S Armed to G/S Capture Mode. The distance/altitude combination at the time of capture corresponds to the 6 degree false node of the glide slope signal for Runway 12L.

15:37:21 - *AP 1 and 3 Off, V/S, Descent*

- Engaging V/S Mode disarms the left and right AP channels
- The Vertical Mode for AP was V/S Descent (disengages G/S Mode)

- The Lateral Mode remains in Heading Select Mode. The AP never transitioned into
- Localizer Mode while Localizer was armed.

15:37:45 - V/S Select -2000 fpm
15:38:00 - V/S Select -2700 fpm
15:38:02 - V/S Select -3500 fpm

2.3.8 MISSED APPROACH TO DXB

Missed Approach - The flight crew continues to prepare the airplane for landing. MCP inputs are not consistent with the phase of flight and ATC directions.

Airplane configuration:

- Flaps up
- Speed 353 knots
- Heading 115 degrees
- Altitude 6,500 feet
- Throttles: Approach Idle
- Speed Brakes: Armed

15:38:04 (ATC) - The relay airplane advised the crew that the airplane was 'too high and too fast', and asks if the crew can make a 360 degree turn. The PF responds 'Negative, negative, negative'

15:38:05 - Gear Lever Down
15:38:09 - Speed Brakes Extended

- Speed brake handle was extended to in-flight detent. Spoilers deflected less than expected[19].

15:38:12 - Flap Lever Selected to 20
15:38:17 - Flap Lever Selected to 30

- The Flap load alleviation system prevents the flaps from deflecting to 30 degrees. This was due to the fact that the airspeed was above flaps 20 placard speed (225 knots).

15:38:20 - Transition to Altitude Capture
15:38:20 - PF comment that the landing gear was not functioning

- Airspeed began to deviate below the Selected MCP Speed. When the A/T was engaged in Speed Select Mode and the airspeed was above placard speed (Flaps 20 - 225 knots), A/T will limit the airspeed to the placard speed for the given flap setting.

15:38:30 - Altitude Select 1500 feet
15:38:37 - *Gear Disagree*

- This discrete indicates that the landing gear are not in agreement with the position of the gear lever. This correlates with comments made about the gear not functioning.

[19] See the section – Flight Controls

15:38:39 (ATC) - relay asks if the crew can make a left turn toward Sharjah airport, 10 nm to the airplanes left which has a parallel runway. The PF responds asking for the heading. The relay aircraft responds ‘095 deg’
15:38:45 - Heading bug to 110 deg
15:38:50 - Flaps 20
15:38:59 - Speed Select 360
15:39:00 - Heading bug to 115 deg
15:39:07 - Heading bug to 195 deg
15:39:12 - (Comms ATC) - PF acknowledges a heading of 095 for Sharjah airport

- The flight crew, after being cleared to Sharjah Airport (SHJ), selected a different heading than cleared, the MCP input is 195 deg for an undetermined reason.

15:39:19 - GPWS - Bank Angle

- The airplane rolls rapidly to acquire the new selected heading, reaching a max right bank angle of 37.5 degrees, see below

FIGURE 9 - 15:39:19 UTC - GPWS: BANK ANGLE WARNING

15:39:29 - Thrust increased manually (airspeed is still above flap placard of 225 knots)
15:39:56 - Speed Select 325kts

- Airspeed increases so A/T again returns throttle to idle in an attempt to maintain the flaps 20 placard speed (225 knots).

15:40:05 - *AP manually disconnected*

- Following the disengagement of the AP, the airplane pitched down to -14 degrees and began to descend. The transducer measuring the Captains column force and column deflection display rapid nose-up pitch commands during the final 40 seconds. Elevators moved with the nose-up column inputs but the deflection was inconsistent with the relationship seen at the beginning of the flight.
- Airplane heading crossed through the target (195 deg.) and continues as there was no wheel input to return to wings level.

FIGURE 10 - 15:40:25 UTC – GPWS/'SINK RATE'

15:40:28 - *Sink Rate*
15:40:28 GPWS – "sink rate", "pull up"
15:40:28 - *Pull-Up*

15:40:33 GPWS – “terrain,”, “terrain”
15:40:45 Speed Select 280

- Airplane crosses through the target altitude of 1,500 feet and levels off as pitch attitude recovers.

15:40:50 - GPWS - “too low”, “terrain”
15:40:56 - Gear Config (Too Low – Gear)
15:40:58 - GPWS - ‘Sink Rate’
15:41:00 - GPWS - ’Too Low - Terrain’
15:41:07 - GPWS - ‘Five Hundred’
15:41:23 - GPWS - ’Too Low - Terrain’
15:41:25 - GPWS - ‘Sink Rate. Pull-Up’. Pull-Up’
15:41:29 - GPWS - ‘Pull-Up’
15:41:30 - GPWS - ‘Pull-Up’
15:41:32 - GPWS - ‘Pull-Up’
15:41:33 - GPWS - ‘Pull-Up’
15:41:34 - LOC- I: Loss of Control In-flight/Data Ends.

FIGURE 11 - 15:41:30 UTC - LOC-I/LOSS OF CONTROL/DATA ENDS

2.4 DIGITAL FLIGHT DATA FACTUAL ANALYSIS - FLIGHT CONTROLS

2.4.1 BACKGROUND:
At 15:15:37 and 15:15:48 the flight crew commented that there was a lack of control while manually flying the airplane. Approximately one minute later, the captain commented that he had no control and no pitch control. The response of the flight crew was to engage the AP.
The AP was able to effectively control the elevator and lateral control system.
The column position data are consistent with column force inputs from takeoff through the first indications of fire. Following the fire warnings the F/O column force drops to zero. Column position deviates nose-down until it was at the maximum deflection. Elevator data during the same period shows only small deflections. This indicates that the column and elevator deflection are inconsistent.

NOTE: The following issues are observed in the data and recorded from the flight crew comments:

- inconsistency between column input and elevator deflection
- decrease in column forces
- decrease/loss of pitch control
- control column resting at maximum nose-down
- minimal impact on the AP's ability to control aircraft state through elevator commands

All of these indications are consistent with a decrease in elevator control cable tension.

The elevator control system schematic is shown in Figure(12). The cable that connects the forward and aft quadrants requires tension for the column movements to translate into elevator movements.

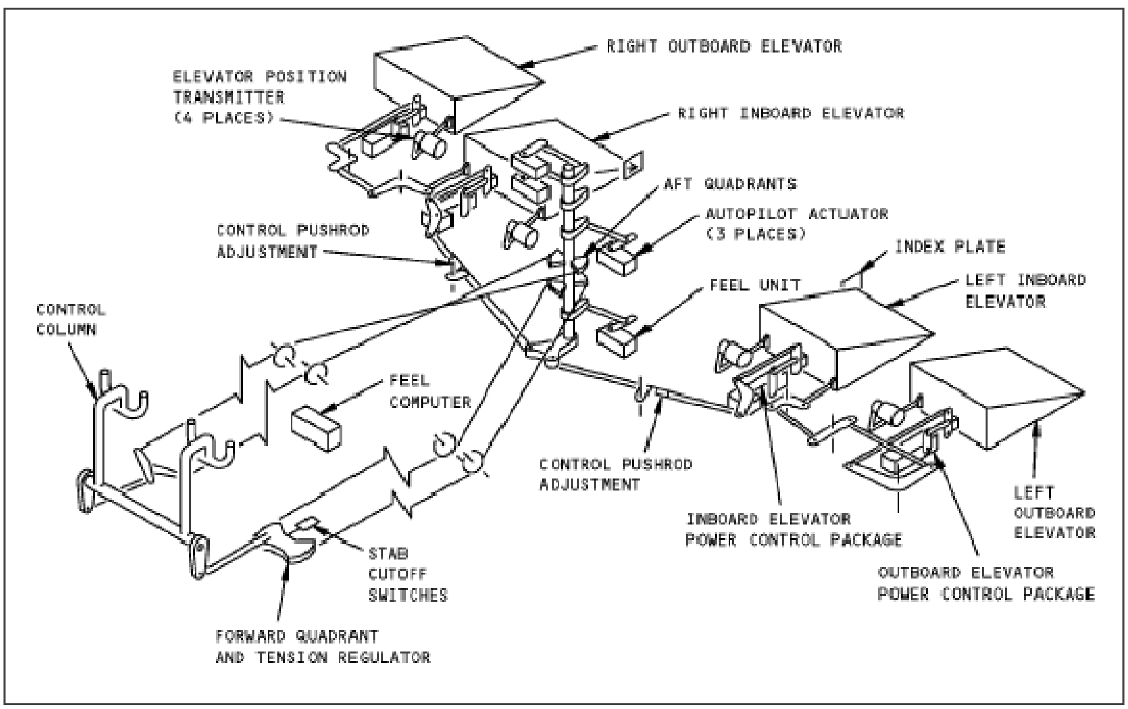

FIGURE 12: ELEVATOR CONTROL SYSTEM SCHEMATIC FROM THE AIRPLANE MAINTENANCE MANUAL

2.4.2 INCONSISTENCY BETWEEN COLUMN INPUT AND ELEVATOR DEFLECTION

The elevator control system in Figure 12 above is designed so that a unit of column deflection creates a unit of movement in the aft quadrant (which in turn moves the elevators). The consistency of this system requires a prescribed tolerance of tension in the elevator control cable.

Figure 13 below indicates the control column sweep and takeoff rotation of the event flight.

This represents a normally functioning longitudinal control system as control column input translates to a proportional and predetermined elevator deflection.

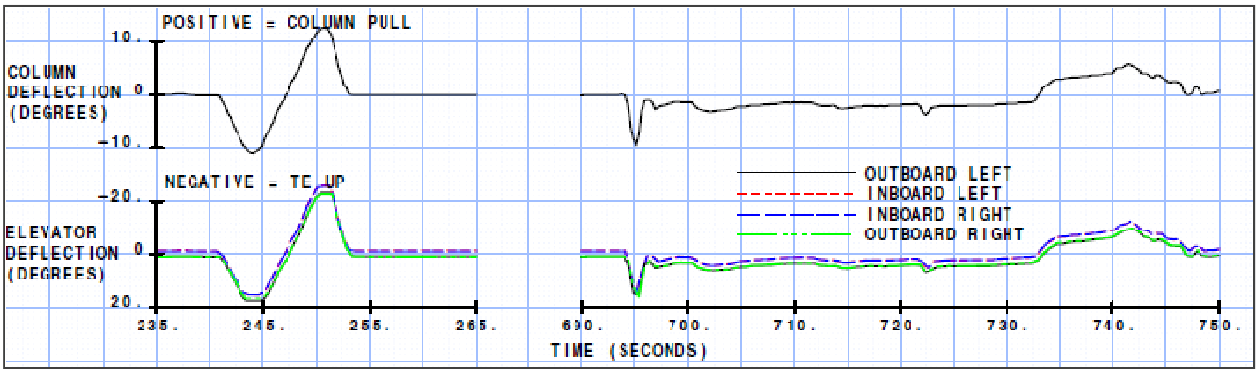

FIGURE 13: COLUMN SWEEP AND TAKEOFF ROTATION

Column sweep and takeoff rotation display the normal relationship between column and elevator. If the tension is below the allowable tolerance, the column and elevator will no longer be consistent.

Following the initial fire warnings the column moved nose-down with no corresponding change in elevator deflection (left plot Fig. 13 above).

Near the end of the data, the FDR data shows nose-up column inputs (right plot Fig. 13 above).

The elevator was deflecting with the column inputs but not with the relative magnitude seen in Figure 13. This indicates that there was some column cable tension but not enough to maintain normal column to elevator gearing

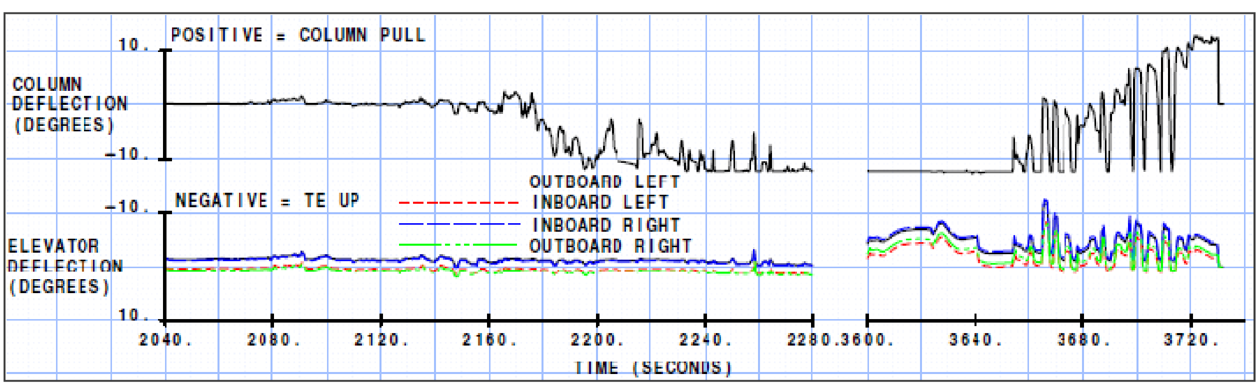

FIGURE 14 – COLUMN TO ELEVATOR DEFLECTIONS FOLLOWING THE INITIAL FIRE WARNINGS AND JUST PRIOR TO END OF DATA.

Decrease in column forces – the column force transducers are located in the forward quadrant.

The system relies on cable tension to provide the force recorded on the FDR. Actual column force is then determined by adding the transducer on the captain side with the transducer on the F/O side and multiplying by the mechanical gearing from the transducer to the column. In raw FDR data,

with zero cable tension, the force transducer on that quadrant will read zero.
This effect is observed in the F/O column force parameter (Figure 15 below).
The captain's column force parameter does not go to zero but it does require less force for the same change in column deflection. This is likely due to the fact that the captain's forward quadrant contains a tension regulator that was designed to remove slack from the elevator control cable. In effect the tension for the captain was less than normal but greater than zero while the tension for the F/O was effectively zero.

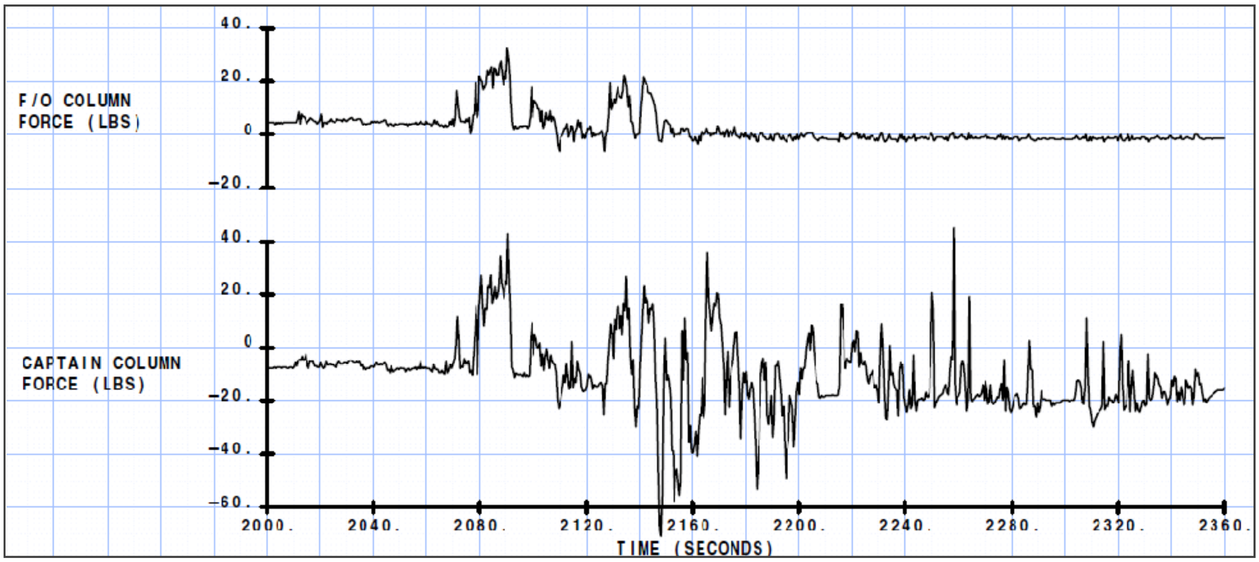

FIGURE 15: – CAPTAIN AND FIRST OFFICER COLUMN FORCES FOLLOWING THE FIRE WARNINGS

2.4.3 NOTE ON THE DIRECTIONAL CONTROL SYSTEM:

- **Decrease/loss of pitch control** – the combination of inconsistency between column and elevator and decrease in column force would cause the flight crew to experience a decrease and/or loss of control in the pitch axis.
- **Control column resting at maximum nose-down** – the control column on the 747-400F (or derivate types) will move to the forward stop when there is no tension on the elevator control cable.
- **Minimal impact on the AP's ability to control elevator** – the AP actuator inputs directly into the aft quadrant removing the dependency on elevator control cables.
  A loss in cable tension would has no effect on the AP's ability to control the elevators.

The DFDR data indicates that the rudder pedal/rudder directional control system were exhibiting a similar control reduction authority as the column/elevator system.
Figure 16 (below) shows the relationship between rudder pedal force, rudder pedal deflection, and rudder position.
During the first segment the pedal force moves the pedal. For the rest of the time segment much larger changes in pedal are seen with no pedal force. In addition the 10 degree rudder pedal inputs are not deflecting the rudder. Both of these effects can be caused by a loss in tension of the rudder control cable.

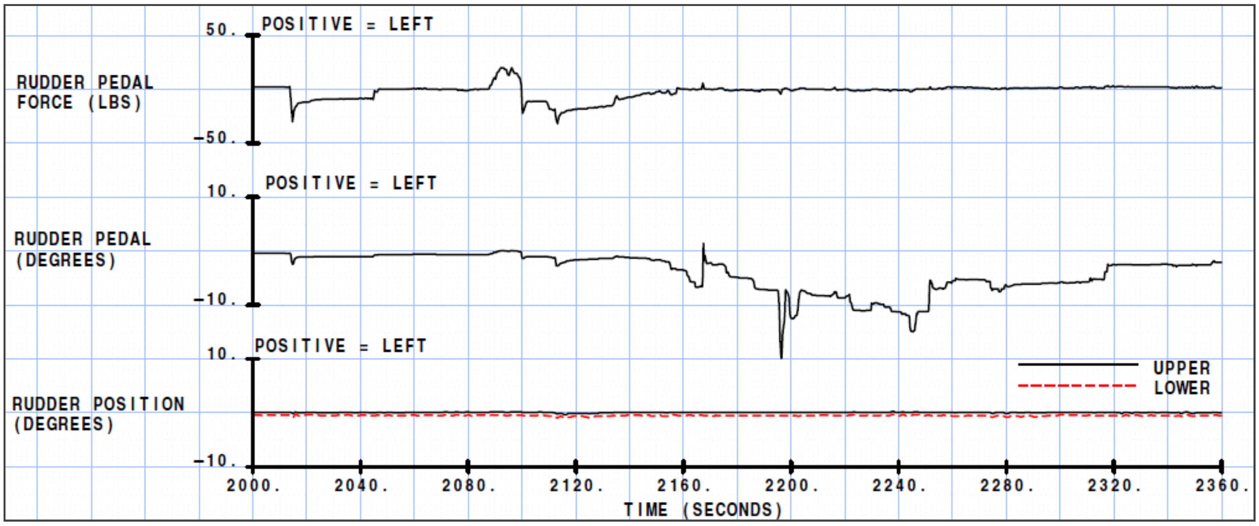

FIGURE 16: – RUDDER AND RUDDER PEDAL DATA

Figure 17 (below) demonstrates the inconsistency between speed brake handle and spoiler deflection – At 15:38:09 to end of flight the spoiler response to speed brake handle when moved to flight detent position was only 3 to 4 surface degrees for flight spoilers #4 and #9 (Figure 18). Normal response to speed brake flight detent for these spoiler surfaces would be greater than 25 degrees at the flight conditions. The spoiler panels responded normally to wheel inputs during this time period which demonstrates that these spoiler surfaces had capability to move further. Spoiler deflections are consistent with the flight path of the airplane

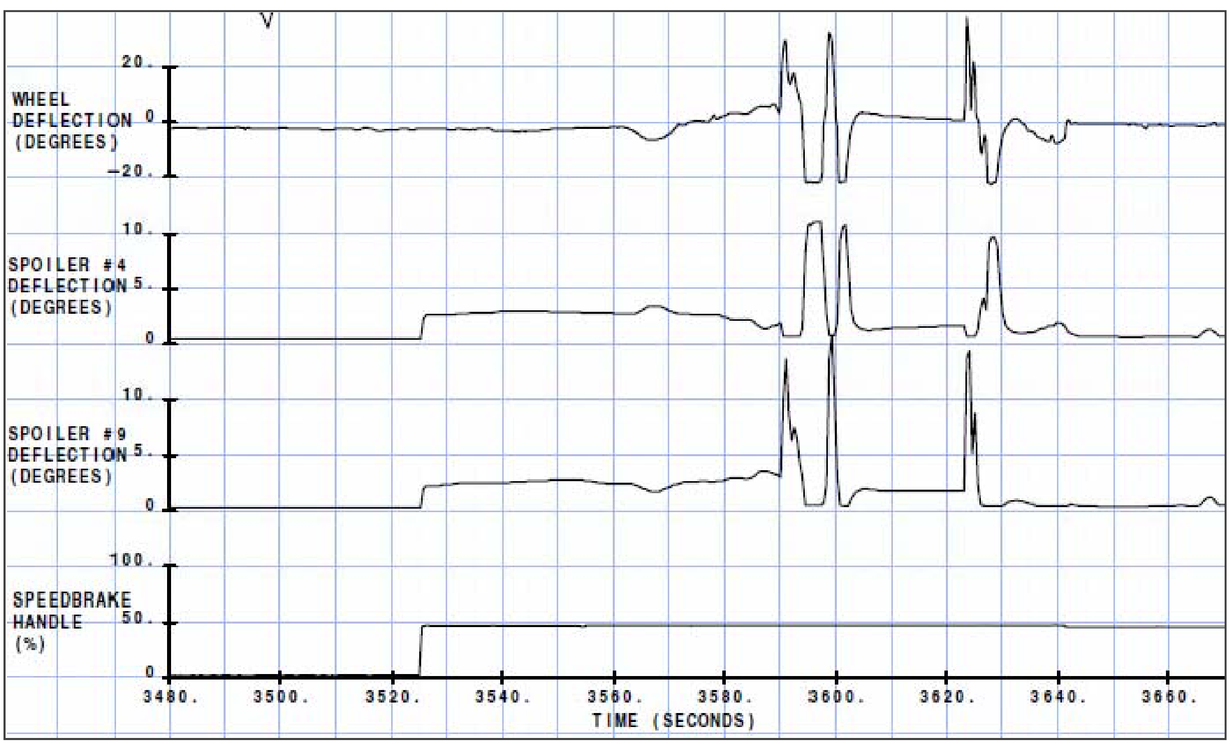

FIGURE 17: – SPOILER DEFLECTION FROM SPEED BRAKE HANDLE AND WHEEL DEFLECTION

2.5 AUTO LAND SYSTEM AVAILABILITY

The DFDR data indicates that the auto land system was functioning, as described below:

- The AP was able to control the airplane's pitch axis through the AP elevator servo, and the roll axis through the AP aileron servo.
- It is not possible to determine the availability of the AP rudder servos as they are not engaged until multi-channel AP engagement. However the preliminary indications are that there was no data to suggest that they would not be available.
- At no time during the flight did the auto land system redundancy downgrade to fail-passive, 'NO LAND 3', or less than fail-passive, "NO AUTOLAND". This suggests that all of the required sensor data were available.
- The ILS approach was tuned, and that the data supports that valid ILS data were being provided by the Multi-Mode Receivers (MMRs).
- the data supports that the radio altimeters were providing valid radio altitude data.
- At one point during the approach, the AP approach mode was selected and the AP transitioned to a multi-channel armed configuration. Some multi-channel pre-engage testing would have been conducted at this time. No failures were annunciated as a result of this multichannel pre-engage testing.
- With the landing gear retracted, the MMRs obtain G/S deviation data from the G/S antennas in the nose of the airplane (capture antennas). With the landing gear extended, the MMRs obtain G/S deviation data from the G/S antennas on the nose gear doors (track antennas).
- In the event that it had not been possible to extend the landing gear, it is expected that the auto land system would have been able to conduct a satisfactory approach utilizing G/S deviation data from the capture antennas.
- The AP would have transitioned to FLARE mode between 40 feet and 60 feet of radio altitude, and attempted to land the airplane.
- Based on the airplane manufacturers analysis, it is not possible to determine the outcome of a gear up automatic landing.

2.6 SIMULATION

A 747-400 desktop engineering simulation was used to model the airplane's flight path for this analysis . The simulation was set up with similar initial conditions (e.g. weight, speed, etc.) and control surface inputs, throttles inputs, and brake inputs to the recorded FDR data.
The indications are a close match in pitch attitude, airspeed and altitude.
This confirms that the elevator inputs[20] and the other flight control surface inputs were consistent with the flight path of the airplane and support the recorded data that the elevator deflection recorded on the FDR represents the actual surface deflections experienced during the event flight.

[20] As distinct from the control column inputs

2.7 SUMMARY/ASSESSMENT OF THE DFDR DATA (FLIGHT CONTROLS)

- The DFDR data show the airplane performing a normal takeoff and climb.
- Prior to reaching cruise altitude, airplane systems warned the flight crew of a main deck cargo fire.
- The flight crew initiated a descent and elected to make an emergency return to Dubai International Airport (DXB).
- During descent the flight crew experienced a decrease of manual elevator and rudder control.
- The decrease of manual elevator and rudder control was due to a loss in column and pedal cable tension, respectively.
- The autopilot (AP) does not rely on these cable systems and functioned as expected for the duration of the flight.

3.SAFETY INFORMATION

Refer to the GCAA Air Accident Preliminary Report for the list of full safety advisory hazardous material notifications related to this accident.

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4. GCAA ACCIDENT INVESTIGATION PROGRESS UPDATE NOVEMBER 2011

In complex air accident investigations there are multiple lines of enquiry and analysis.
To date the investigation has identified several areas to pursue in relation to indentifying the root cause, the associated significant factors and the probable cause of this accident.

The GCAA Air Accident Investigation Dept will provide updates on the investigation in line with the recommendations of ICAO Annex 13.

This Interim Accident Report has been made available to update on the progress of this investigation.

The investigation is continuing with further testing and detailed analysis currently ongoing.
The main testing milestones should be completed by the end of 2011.
Following a detailed period of in-depth data analysis and reviewing all factual information, an Air Accident Final Report will be available in 2012.

Any specific safety issues identified during the course of the investigation will be advised to all parties through the GCAA Safety Recommendations (SR) procedures.

GCAA Accident/Incident Investigation reports can be on the GCAA website under E-Publication/Accident-Incident Reports.

APPENDIX

1. NTSB FACTUAL REPORT - CARGO (ABRIDGED)

National Transportation Safety Board
Washington, D.C. 20594

Report Date: December 21, 2010

Cargo Group Chairman's Factual Report

A. Accident Identification

Accident No.:	DCA10RA092
Transportation Mode:	Aviation
Location:	Dubai, United Arab Emirates (UAE)
Date:	September 3, 2010
Time:	1151 Eastern Standard Time (EST)
Operator:	United Parcel Service Co. (UPS)
Aircraft:	Boeing 747-400F (N571UP)
Fatalities:	2

B. The Accident

At about 7:51 pm local time (1551 UTC), United Parcel Service (UPS) Flight 6, a Boeing 747-400F (N571UP), crashed while attempting to land at Dubai International Airport (DXB), Dubai, United Arab Emirates (UAE). The flight had departed from Dubai approximately 45-minutes earlier as a scheduled cargo flight to Cologne, Germany, but the flight crew declared an emergency and requested an immediate return to DXB. The airplane impacted inside an Emirati army base near a busy highway intersection, approximately nine miles from Dubai's international airport. The two flight crew members were fatally injured.

C. Hazardous Materials Information

There were no declared shipments of hazardous materials onboard the accident flight. The Cargo Group examined shipping invoices for the cargo onboard UPS 6, and at least two shipments of lithium batteries which should have been declared as hazardous materials, were identified. Please refer to Section F of this report for further information on these items.

D. Loading of Cargo in DXB

Prior to the flight to Dubai, cargo was loaded into all positions in Hong Kong. Upon arriving in Dubai, the Unit Load Devices (ULD) in positions 13L, 14L, 14R, 18L, 19L, and 20 were removed from the aircraft. Some of these ULD's were replaced with other out-bound ULD's. The following section describes the sequence of events associated with the offloading and reloading of UPS Flight 6.

Cargo Handling Sequence

The following cargo was removed from inbound UPS flight 6, as final destination cargo at Dubai, UAE: 14LS, 18L, 19L, and 45 pieces of loose cargo located in Aft Bulk (AB). Additionally, approximately 2,770 lbs of cargo was transferred from the ULD in position 13L to the AB loose load position to establish the new AB cargo weight of 4,020 lbs. At this point, a bulge in the collapsible ULD in position 18R was identified by Dnata[21] loaders working the aircraft. The bulge indicated that a load shift of packages occurred inside the ULD. According to UPS personnel at DXB, one package fell out of the ULD, from a height of approximately 5 feet. In order to remove the ULD in position 18R, the ULD in position 14R was removed and placed on the ramp. The ULD from position 18R was removed and transferred to the UPS operations hub at DXB to be reconstructed. Following the reconstruction of the ULD from position 18R, UPS indicated that a ULD serviceability check was performed. New ULD's were loaded into positions 13L (3,969lbs), 14L (4,697lbs), 18L (6,240lbs), and 19L (2,963lbs). Along with these ULD's, the reconstructed ULD from position 18R and the ULD from position 14R were reloaded onto the aircraft into their respective positions. Figure 1 shows the cargo configuration of the UPS Flight 6 aircraft main deck.

The Cargo Group posed questions with regards to the possible relocation of packages from the ULD's in positions 14R or 18R, or ULD's in any other positions of the aircraft, the reconstruction of the load from the ULD in position 18R, and training records. GCAA responded that the work was performed by the *Transguard Group (Transguard)*, using DNATA equipment; DNATA personnel did not perform the

[21] Dnata is the largest supplier of ground handling, cargo and travel services in the Middle East and an accredited member of the International Air Transport Association (IATA).

work. GCAA indicated that they interviewed the *Transguard* personnel who built up the cargo one or two days prior to the flight, but were unable to locate the personnel specifically responsible for performing the rearrangement of the collapsible container in question. GCAA indicated the *Transguard* would identify the personnel on duty during the time the rebuild occurred and report to GCAA. Further information on any relocation of the packages and training records of loading personnel were obtained directly by GCAA. GCAA indicated that no relocation or unscheduled movement of packages occurred. Additionally, GCAA indicated that training records were requested; however these records have not been received.

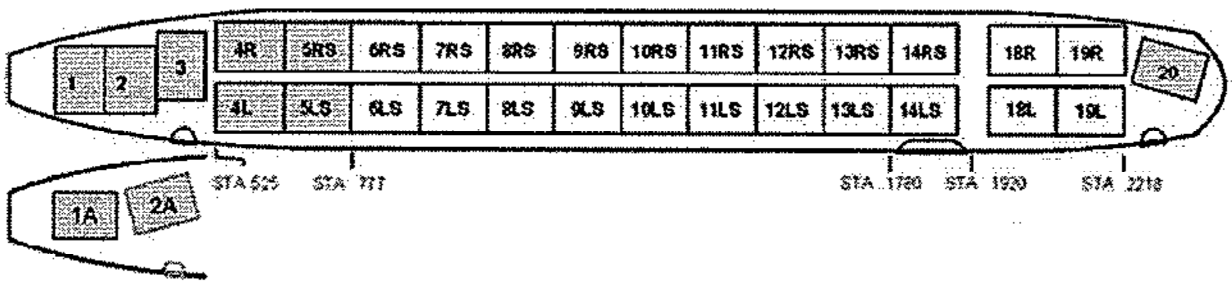

Figure 1 - Cargo Configuration of UPS6 aircraft main deck

E. Cargo Shipment Identification

The Cargo Group obtained package details for shipments contained in all positions onboard UPS Flight 6. The Cargo Group reviewed the package details and collaboratively identified any shipments that had generic shipment descriptions or appeared to potentially contain items that could be hazardous. The group identified many shipments of lithium batteries and electronic equipment that contained or was packed with lithium batteries. The Cargo Group obtained invoices for all identified items of interest. The group reviewed these invoices and determined 19 of the shipments to be of special interest. These invoices were found to contain discrepancies or lack the necessary information to ascertain what the items were or if they were shipped correctly. The 19 shipments of special interest are highlighted in pink on the following chart.

ULD Position	Shipment Information		
	No. Packages	Item Description	No. Pieces
1	1 of 10	LED flashlight & hoister (**incl. primary lithium battery)	1381
1	3 of 5	LED flashlight & displays (**incl. primary lithium battery)	190
1	**6 of 6**	**Lithium-ion batteries ("BRR-L, BRR-F5, BDF-4, DFLY, BRR-LA")**	**648**
2	1 of 1	Dry Batteries - silver oxide SR626SW	5000
2	1 of 1	Android tablet containg lithium battery	1
2	1 of 1	Phone	1

3	**8 of 10**	**"E-book" - Invoice lists various electronics (batteries?) & 'torches'**	**?**
3	9 of 13	Electric nail drill (various qty/pkg)	?
4L	**2 of 2**	**Marine Radio - lithium metal batteries**	**12**
4R	**1 of 1**	**Power supply**	**128**
4R	2 of 2	Various electronics (incl. lithium batteries)	?
4R	1 of 1	Various electronics (incl. lithium batteries)	?
5L	2 of 2	Mobile phones	100
5L	1 of 1	Phones	10
5R	**7 of 7**	**Laptop power packs - lithium ion batteries**	**121**
5R	**27 of 27**	**Laptop batteries & adapters**	**393**
5R	2 of 2	Watch phones (lithium battey powered)	31
6L	1 of 1	Mini E-Book	1
6L	5 of 5	Eyewear video recorder	210
6L	6 of 6	Power Supply	222
6L	**13 of 13**	**Lithium Batteries - lithium polymer "lead out two wires and connector, the wire length: 160mm"**	**50**
6L	3 of 3	Battery Pack - NiMH	110
6R	**58 of 58**	**Lithium Batteries - lithium iron for electric vehicle**	**125**
7L	**2 of 26**	**Laptop Batteries (various qty/pkg)**	**?**
7L	2 of 2	Phone	60
7R	26 of 26	Mobile phones w/ lithium-on battery "Non-working Dummy Phone"	1280
7R	40 of 40	Mobile phones w/ lithium-on battery "Non-working Dummy Phone"	2000
7R	40 of 40	Mobile phones w/ lithium-on battery "Non-working Dummy Phone"	2000
7R	10 of 10	Mobile phones w/ lithium-on battery "Non-working Dummy Phone"	500
7R	30 of 30	Mobile phones w/ lithium-on battery "Non-working Dummy Phone"	1500
7R	1 of 1	Mobile phones w/ lithium-on battery "Non-working Dummy Phone"	1
7R	9 of 9	Mobile phones w/ lithium-on battery "Non-working Dummy Phone"	250
7R	1 of 1	Mobile phones w/ lithium-on battery "Non-working Dummy Phone"	1
7R	1 of 1	Mobile phones w/ lithium-on battery "Non-working Dummy Phone"	1

7R	1 of 1	Mobile phones w/ lithium-on battery "Non-working Dummy Phone"	1
7R	6 of 6	Mobile phones w/ lithium-on battery "Non-working Dummy Phone"	300
7R	1 of 1	Mobile phones w/ lithium-on battery "Non-working Dummy Phone"	1
7R	1 of 1	Mobile phones w/ lithium-on battery "Non-working Dummy Phone"	1
7R	20 of 20	Mobile phones w/ lithium-on battery "Non-working Dummy Phone"	1000
8L	1 of 1	Lithium-ion batteries("Battery Sample")	200
8L	8 of 8	LED Flashlight & filter adapter (**incl. primary lithium battery)	930
8L	2 of 5	LED flashlight & displays (**incl. primary lithium battery)	190
8L	9 of 10	LED flashlight & hoister (**incl. primary lithium battery)	1381
8L	6 of 6	Mobile phones	88
8L	1 of 1	"Power supply for laptops"	65
8R	9 of 9	Lithium-ion batteries("Rechargeable battery packs")	110
8R	**10 of 10**	**Marine Power Supply**	**300**
9R	21 of 21	Computer desktops, mobile products & parts	?
10L	10 of 10	Batteries for headset	8
10L	9 of 9	Lithium-ion batteries (2S103450 & 3A2500)	820
10L	7 of 7	Lithium polymer batteries	250
10L	3 of 3	NiMH batteries	214
10R	**16 of 16**	**Lithium ion battery (Lithium Manganese Dioxide)**	**9670**
10R	**31 of 31**	**Lithium-ion battery (lifepo4)**	**30**
10R	**3 of 3**	**Battery (Electric zinc for bike)**	**3**
10R	1 of 1	E-Books	10
10R	1 of 1	Mobile phones	65
10R	1 of 1	Mobile phones	6
10R	1 of 1	Mobile phones	10
10R	1 OF 1	E-Books	1
10R	10 of 10	Lithium-ion batteries (PC batteries)	365
10R	1 of 1	Mobile phones and phone parts?	255
12L	1 of 1	Mobile phones w/ lithium-ion batteries	200

12R	1 of 1	Laptop packed w/ lithium-ion battery	1
12R	2 of 2	Apple iPad containing lithium batttery	2
13L	2 of 2	Laptops	2
13L	1 of 1	Mobile phone	1
18L	**1 of 1**	**Fuel Pump for aircraft**	**1**
18R	**2 of 10**	**"E-book" - Invoice lists various electronics (batteries?) & 'torches'**	**?**
18R	2 of 13	Electric nail drill (various qty/pkg)	?
18R	**1 of 1**	**Laptop battery sample**	**2**
18R	**1 of 1**	**Laptop battery sample**	**2**
18R	**20 of 20**	**Watch batteries ("Dry battery & Lithium metal battery")**	**54,800**
19R	5 ctns	Mobile Internet Devices w/ lithium ion battery contained in equipment	?
P1	22 of 22	Mobile phone w/o battery (??)	?
P1	**2 of 12**	**Electronic Vaporizors (sani-cigs) - 12 pallets**	**?**
P2	3 OF 3	NiMH batteries	195
P2	1 of 1	Lihtium-ion batteries (laptop batteries)	11
P3	**4 of 12**	**Electronic Vaporizors (sani-cigs) - 12 pallets**	**?**
P4	**1 of 12**	**Electronic Vaporizors (sani-cigs) - 12 pallets**	**?**
P7	**5 of 12**	**Electronic Vaporizors (sani-cigs) - 12 pallets**	**?**
P8	**13 of 26**	**Laptop Batteries (various qty/pkg)**	**?**
P9	1 of 1	NiMH batteries	20
P9	6 of 6	NiMH batteries	600
P9	4 of 4	Lithium-polymer batteries and motors for models	122
P9	1 of 1	Lithium-ion batteries	18
P9	**8 of 8**	**Lithium-ion batteries**	**50**
P9	1 of 1	Lithium-polymer batteries	10
P9	1 of 1	Lithium-ion batteries	20
P9	1 of 1	Primary lithium battery	2
P9	1 of 1	Lithium-polymer battery pack	10
P9	1 of 1	Lithium Maganese dioxide battery	50

P9	3 of 3	NiMH batteries	500

Figure 2 – Items of Interest onboard UPS Flight 6

In order to obtain further information on these 19 shipments, the Cargo Group requested assistance from the Government of Hong Kong's Civil Aviation Department (HKCAD) and the Civil Aviation Administration of China (CAAC). The group developed a set of questions that a HKCAD or CAAC representative may use when contacting the shippers/freight forwarders of these 19 shipments in an attempt to fill in the missing information and/or verify that the shipments were correctly offered for transportation by air.

HKCAD and CAAC Responses to Inquiries on Items of Special Interest

To date, the Cargo Group has received responses to 13 of its 19 inquires. Of these 13 responses, 10 confirmed that the shipments contained lithium batteries; either individually packaged, or contained in/packed with equipment. Two of the 13 responses revealed that there were no lithium batteries in the shipments, and one of the 13 responses from a freight forwarder indicated that it was uncertain whether their shipment contained lithium batteries (Figure 3).

Item No.	Position	Item Description	Battery Type?	Cell or Battery Pack?	Voltage	Watt-hour rating	Amp-hour rating	Eqivalent lithium content	UN Test Report? (Y/N)	Battery Meets UN Standards?	MSDS? (Y/N)
1	1	lithium ion batteries contained in equipment (scanners)	Lithium ion	Battery Packs (P/N(s): B25000005 & B25000006)	3.7V	8.14Wh, 1.1Wh	2.2Ah, 300mAh	0.66g, 0.09g	Y (battery type listed does not match P/N)	Y (battery type listed does not match P/N)	Y (MSDS does not match P/N)
3	4L	battery packed with equipent (marine radios S/N: SR892EUL)	Lithium ion	Battery Pack (M/N: 454169)	7.4V	10.36Wh	1.4Ah	0.42g	Y	Yes, UN 38.3 Test report no. TP20100421 454169	Y
5	5R	laptop power packs	Lithium ion	Battery Packs	various (21 types)	?	various (21 types)	?	N	N	Y
7	6L	lithium polymer batteries - 'lead wires'	Lithium ion	Battery Packs (M/N: AE50100100P4 HE-4S4P)	14.8V	284Wh	19.2Ah	5.76g	Y	Y	Y
8	6R	LiFePO4 batteries for electric vehicle	Lithium ion	Battery Packs (P/N: 9070260, 7070260, 70173248)	48V, 36V, 24V	1056Wh, 972Wh, 480Wh	22Ah, 27Ah, 20Ah	6.6g, 8.1g, 6.0g	N	?	Y (MSDS does not match P/N)
13	10R	LiFePO4 batteries for electric vehicle	Lithium Ion	Battery Packs (P/N: 9070260)	48V	1056Wh	22Ah	6.6g	N	?	Y (MSDS does not match P/N)
15	18R	laptop battery sample	Lithium ion	Battery Packs (P/N: 213282-001)	14.8 V	33 Wh	2.2Ah	0.66g	N	N	Y (Inconsistencies noted)
16	18R	laptop battery sample	Lithium ion	Battery Pack (P/N: 213282-001)	14.8 V	33 Wh	2.2Ah	0.66g	N	N	Y (Inconsistencies noted)
17	18R	calculator batteries	Lithium metal	Coin cells (CR2016 & CR2025)	3V	n/a	n/a	0.03g, 0.05g	Y	Y	Y
18	P1, P3, P4, P7	Lithium-Polymer batteries for electronic vaporizors	Lithium ion	Cells (M/N: M08500P)	3.7 V	0.9 Wh	240 mAh	0.072g	Y	Y	Y

Figure 3 –Information concerning 10 lithium battery shipments identified from responses received from inquiries about 19 Items of special interest onboard UPS Flight 6

Of the 10 shipments that contained lithium batteries, nine were lithium ion batteries and one was of the lithium metal variety. According to the information provided by the shippers, three of these nine shipments, Item #7, Item #8, and Item #13, contained lithium ion battery packs with Watt-hour (Wh) ratings significantly greater than 100Wh, which classifies them as Class 9 materials. Accordingly, these shipments should have been shipped as regulated materials per ICAO Technical Instructions, and thus should have appeared on the cargo manifest. Two of these three shipments, Item #7 and Item #8, were located inside containers situated in positions 6L and 6R, respectively; which are located beneath the area of interest due to systems indications on the flight recorders, Item #13 was located at position 10R. The same shipper was responsible for Item #8 and Item #13. While the shipper indicated that testing of the batteries was completed in accordance with UN Standards, no UN Test Report was provided to verify that such tests were completed. Additionally, the MSDS provided did not coincide with the battery model numbers given by the shipper. Further, the product leaflets provided by the shipper do not match the description of the battery types listed on packing lists and the battery specifications are contradictory to those provided by shipper. The shipper of Item #7 provided UN Tests Reports and MSDS for the batteries in the shipment; all information appeared to be in order.

Some additional discrepancies were noted in the responses received from the shippers of Item #5, Item #15, and Item #16. Each of the shippers' responses indicated that the battery packs they shipped were not tested in accordance with UN Standards; tests which are required. Additionally, several discrepancies were noted in the MSDS provided the shipper of Item #15 and Item #16. Additionally, the shipper of Item #1 provided a UN Test Report and MSDS that did not appear to go with the battery packs contained in the shipment. The information provided by the shippers of the remaining items not discussed appeared to be in order, and the items contained in the shipments were not required to be regulated. All of the information gathered from the responses received has been compiled into a spreadsheet.

F. Lithium Battery Transportation Standards

Lithium batteries transported in commerce are regulated by both the Department of Transportation (DOT) Hazardous Material Regulations (HMR) and International Civil Aviation Organization Technical Instructions (ICAO TI). Both sets of regulations classify most lithium batteries as DOT Class 9 hazardous materials; however the regulations do except certain shipments of lithium batteries from being shipped as dangerous goods. These exceptions allow some shipments of lithium batteries to be offered for transport without shipping papers, and not subject them to marking and most labeling requirements. Requirements specific to domestic and international shipments are described below.

International Standards

International air transportation of lithium batteries must comply with the International Civil Aviation Organization Technical Instructions (ICAO TI). These shipments must be classified, prepared, documented, marked and labeled as specified in the TI. Specific instructions for packaging lithium batteries are located in Part 4 of the ICAO TI (Packing Instructions 965-970). These instructions provide the shipper with specific guidance on how lithium batteries are to be packaged. Each packing instruction is divided up into two sections. Section I provides packing instructions for fully regulated batteries (Class 9). Section II provides the shipper relief from function specific training, shipping paper, specification packaging and labeling requirements if the section II instructions are followed properly. Additionally, column 7 of the ICAO TI Dangerous Goods List refers the shipper to

(Part 3, Chapter 3), Special Provisions. The Special Provision section provides the shipper additional guidance and direction for unique shipments of lithium batteries.

The following is an abbreviated version of the ICAO TI packing instructions (965 – 970). These packing instructions are specific to lithium batteries. A complete copy of these instructions can be found in ATTACHMENT 9.

- *Packing instruction 965 - Passenger and cargo aircraft for UN 3480*

  This entry applies to lithium ion or lithium polymer batteries in Class 9 (Section I) and lithium ion or lithium polymer batteries subject to specific requirements of these instructions (Section II).

- *Packing instruction 966 - Passenger and cargo aircraft for UN 3481 (packed with equipment)*

  This entry applies to lithium ion or lithium polymer batteries packed with equipment in Class 9 (Section I) and lithium ion or lithium polymer batteries packed with equipment subject to specific requirements of these Instructions (Section II).

- *Packing Instruction 967 - Passenger and cargo aircraft for UN 3481 (contained in equipment)*

  This entry applies to lithium ion or lithium polymer batteries contained in equipment in Class 9 (Section I) and lithium ion or lithium polymer batteries contained in equipment subject to specific requirements of these Instructions (Section II).

- *Packing Instruction 968 - Passenger and cargo aircraft for UN 3090*

  This entry applies to lithium metal or lithium alloy batteries in Class 9 (Section I) and lithium metal or lithium alloy batteries subject to specific requirements of these Instructions (Section II).

- *Packing Instruction 969 - Passenger and cargo aircraft for UN 3091 (packed with equipment)*

  This entry applies to lithium metal or lithium alloy batteries packed with equipment in Class 9 (Section I) and lithium metal or lithium alloy batteries packed with equipment subject to specific requirements of these Instructions (Section II).

- *Packing Instruction 970 - Passenger and cargo aircraft for UN 3091 (contained in equipment)*

  This entry applies to lithium metal or lithium alloy batteries contained in equipment in Class 9 (Section I) and lithium metal or lithium alloy batteries contained in equipment subject to specific requirements of these Instructions (Section II).

Domestic Regulations

Domestic air transportation of lithium batteries must comply with the HMR. The specific packaging instructions for lithium batteries are found in 49 Code of Federal Regulations (CFR) Part 173.185. Additionally, column 7 of the Hazardous Materials table refers the shipper to Special Provisions found in 49 CFR Part 172.102, which provides additional shipper guidance and direction.

Currently the DOT is proposing to exceed the international regulation requirements for the air transportation of lithium batteries. See Notice of Proposed Rule Making: PHMSA-2009-0095 (HM-224F); Transportation of Lithium Batteries attachment ABC.

G. Dangerous Goods Advisory Bulletin

The Government of Hong Kong's Civil Aviation Department issued a Dangerous Goods Advisory Circular in March 2007. The department's Dangerous Goods Office recognized that many air cargo consignments containing batteries departing Hong Kong International Airport were accompanied with incorrect shipping documentation. This shipping documentation included forged or sub-standard laboratory certificates and Material Safety Data Sheets (MSDS). The Advisory Circular condemned these actions and described the requirements for transporting batteries as general cargo on aircraft according to the International Civil Aviation Organization (ICAO) Technical Instructions and the International Air Transport Association (IATA) regulations. The Advisory Circular requested that freight forwarders and airlines exercise due diligence in verifying that laboratory certificates and/or MSDS submitted for the batteries are reasonable and logical. It also encouraged freight forwarders and airlines to cooperate and exchange information regarding mis-declaration of dangerous goods.

The cargo group has requested a status update on this safety issue from the Hong Kong Civil Aviation Department as part of its investigation.

H. UN Sub-Committee of Experts on the Transportation of Dangerous Goods

Provisions for the transport of lithium batteries are considered by a number of international bodies including the United Nations Sub-Committee of Experts on the Transport of Dangerous Goods (UN Sub-Committee). The UN Sub-Committee publishes model regulations which are incorporated into international and domestic standards world-wide, including the ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air and the International Maritime Dangerous Goods Code which cover the vast majority of international air and sea shipments.

Prior to its current work cycle, the UN Sub-Committee adopted a number of amendments relative to the packaging and hazard communication requirements for lithium batteries. With this work considered largely complete, the sub-committee shifted its focus to modernizing the design-type testing requirements for such batteries. These test methods, contained in the UN Manual of Tests and Criteria, are designed to ensure the integrity and safety of the battery. During its current working biennium (2009-2010), the UN Sub-Committee convened an intercessional working group which met to consider revisions to the current design type test methods applicable to lithium batteries. Many of these revisions are intended to address emerging battery technologies; for example large format lithium batteries used in hybrid/electric vehicles. The U.S. participated actively in this meeting, as did a number of other UN Sub-Committee members and observers. The resulting recommendations made by the working group have been submitted for consideration by the UN Sub-Committee at its upcoming session scheduled to be held November 29-December 7, 2010.

I. History of Lithium Battery Accidents in the Aviation Industry

Since the UPS Flight 1307 onboard fire occurred in February 7, 2006 [NTSB Report No. AAR-07-07] there have been 34 battery and battery-powered devices aviation incidents reported to the Federal Aviation Administration (FAA) involving batteries that involved smoke, fire, extreme heat or explosion. Approximately 22 of these aviation incidents involved lithium-ion batteries, with 14 of these incidents having resulted in an actual fire. The remaining 12 aviation incidents involved lithium-metal batteries, with eight of these incidents having resulted in an actual fire. Attachment 13 contains the entire battery incident chart, which is maintained by the FAA. This chart dates back to March 20, 1991.

J. **<u>HAZMAT Intel Portal (HIP)</u>**

The HAZMAT Intelligence Portal (HIP) is a web-based hazardous materials intelligence data warehouse that provides centralized access to information to support risk management, transparency, and decision support objectives for several modal sources. The following modal agencies contribute data to the system:

- PHMSA: Pipeline and Hazardous Materials Safety Administration
- FMCSA: Federal Motor Carrier Safety Administration
- FRA: Federal Railroad Administration
- FAA: Federal Aviation Administration
- USCG: US Coast Guard
- EPA: Environmental Protection Agency
- ATSDR: Agency for Toxic Substances and Disease Registry Division of the CDC

Company data, including names and addresses, are provided by modal agencies and indexed in the Master Company Hub. The Master Company Hub aggregates company data from many sources. The company data is sent to Dun and Bradstreet (D&B) for their initial matching and cleansing service on a weekly basis. If the company data matches D&B data , then D&B returns the name and address and the Master Company Hub assigns a number as the unique identification for that facility. On a quarterly basis, the Master Company Hub initiates another transaction to update the complete set of 90 plus data fields, including US parent company, financial data, and demographic data, is refreshed. If a D&B match is not found, then the Master Company Hub stores that company with the original source data. This usually results in only that single transaction or transactions from a single source being associated to that unmatched facility.

There are almost 10,000 companies that meet the criteria of PHMSA's National Business Strategy. PHMSA conducts operations based on a data-driven risk-based National Business Strategy, which identifies the level of priorities and risk factors. Daily Ranking Report in HIP prioritizes company rankings based on a systematic algorithm. This algorithm is based on National Business Strategy's priorities and risk factors. By using HIP, PHMSA was able to create a report that used these factors in ranking companies in HIP. The report is refreshed on a daily basis, providing PHMSA's investigators with a list of companies that meet the criteria of inspection priorities.

The following is the National Business Strategy Priority Definition:

- *<u>DARK RED</u>* – Maximum Priority Accident and Incident Investigations; Failure analysis/investigations; Complaints,

- *<u>RED</u>* – High Priority Serious incidents (non-bulk and intermediate bulk); Incidents involving TIH, Class 1, Class 7, PG I and Aircraft; Large package quantity (not cargo tank or tank cars) Chlorine and other Div 2.3 and 6.1 PG I shippers; Fitness reviews; PHMSA verified undeclared shipments,

- *ORANGE* – Medium Priority Abatements; High Incident Frequency (> 10 in 3 years); High certification markings reported by the third party laboratories; UN Non-bulk, Intermediate Bulk Package, Inter-modal tank, and Cylinder Manufacturers, Package Self-certifiers and re-manufacturers; Third Party Certification Agencies; Package Rebuilders and Re-conditioners; Re-inspections,

- *YELLOW* – Priority FAA repair stations and secondary shippers (O2 generators); Nurse tank and Propane Special Permit Holders (13554 and 13341); Entities and previous registrants prior notified of registration requirements w/o response; Never Inspected High Pressure and Acetylene Cylinder Requalifiers; High Hazard Registered Entities or Shippers (TIH, Class 1 or Class 7); Flagged Registration Entities, Select Agent Shippers; Joint Agency Enforcement Activity in PHH jurisdictional area.

HIP houses more than 40 Million records with activities, some of them being incident-related data. The incident data in the HIP comes from multiple sources: 5800 reports, National Response Center Telephonics, Unreported Incidents and Agency for Toxic Substances and Disease Registry. HIP collects the information for management and analysis, so that the data can be used at all levels with knowledge and insight for better decision-making. PHMSA uses incident data to help assess and manage risk surrounding the transportation of hazardous materials. To this end, incident data is used in a variety of ways such as identifying hazardous materials trends, statics for regulatory evaluations and rulemakings, and providing focus areas for field operation inspections and investigations. Recent incident data is also being used as one facet of evaluating a company's level of fitness when applying for a special permit or approval.

HIP also houses over 2 million company records, which includes both domestic and international companies. All the companies in the HIP are validated against D&B's database. Up until now, PHMSA's contract with D&B has been with only the domestic companies. This allowed for HIP to provide the user groups with company information such as the DUNS#, demographics data, revenues data, and etc. However, PHMSA has just entered a new agreement with D&B that will be in effect in the upcoming months that will allow for the same type of validation for certain International companies (Canada, Mexico, Puerto Rico and China).

K. Shipper History

The Cargo Group used HIP to determine the number of special permit/approval, incidents and inspections associated with the shippers/freight forwarders listed on the shipping documentation from UPS Flight 6. It was determined that both *A & A Worldwide International* and the *U.S. Air Force,* which were both listed on the shipping documentation for UPS Flight 6, had incidents listed in HIP. None of the other shippers/freight forwarders listed on the shipping documentation were involved in an incident or issued a special permit/approval. Furthermore, no compliance inspections were conducted for the shippers/freight forwarders listed on the shipping documentation.

L. UPS Procedures for Accepting Shipments

All Air Cargo procedures are documented in the UPSCO Cargo Handling Procedures Manual in its current revision. All shipments accepted from a Pre-Built Shipper or Container Freight Station is required to comply with UPSCO Cargo Handling Procedures Manual. These procedures are referenced in Chapter 1 (pages 41 and 42) and Chapter 2 (page 51).

The required training certifications for a Container Freight Station and/or Pre-built shipper for UPS movement consist of ULD Serviceability, Build-Up, Shoring, Dangerous Goods Acceptance and/or Dangerous Goods Recognize and Reject. All training completed must be performed by a certified UPS Corporate Air Trainer/Cargo Specialist prior to shipment acceptance.

Freight Forwarders are required to have an approved and current contract to move Dangerous Goods within the UPS Network. All dangerous goods must be tendered loose to a certified dangerous goods acceptance location. UPS Air Cargo does not accept dangerous goods from Pre-Built shippers. UPSCO training is documented and audited per the UPSCO National Air Audit (l-b-2, 1b-3-a &b, l-b-4-a&b).

Regardless of build up method, all shipments accepted and moving on UPSCO comply with the guidelines outlined in the UPSCO Cargo Handling Procedures Manual.

M. Audits of Hong Kong and Dubai Facilities

UPS

The UPS Air Audit Department conducts audits of UPS Gateway Operations as part of the company's Internal Evaluation Program for Continuous Analysis Surveillance System (CASS). Adherence to the process and procedure contained in the CASS allows involved personnel to perform their duties and responsibilities with a high degree of safety.

Audits were conducted on both the Dubai and Hong Kong Facilities in April 2009, and March 2010, respectively. As a result of these audits the UPS facilities in Dubai and Hong Kong received regulatory compliance ratings of 98% and 99%, respectively, both passing scores. Please refer to Attachments 17 and 18 for further information on these audits.

Federal Aviation Administration

The Federal Aviation Administration does not conduct hazardous materials inspections in international locations.

End of Interim Accident Report