PART 1.1 – COVERING NOTE

3 Oct 14

DG MAA

SERVICE INQUIRY INVESTIGATION INTO AN INCIDENT INVOLVING VOYAGER ZZ333 ON 9 FEB 14

1. The Service Inquiry (SI) Panel assembled at MilAAIB Farnborough, on the 14 Feb 14 by order of the DG MAA for the purpose of investigating the incident involving Voyager ZZ333 on 9 Feb 14 and to make recommendations in order to prevent recurrence. The Panel has concluded its inquiries and submits the provisional report for the Convening Authority's consideration.

PRESIDENT

[redacted]
Wing Commander
President
ZZ333 SI

MEMBERS

[redacted]
Lieutenant Commander
Air Member
ZZ333 SI

[redacted]
Squadron Leader
Engineering Member
ZZ333 SI

2. The following inquiry papers are enclosed:

Part 1 (The Report)
Part 1.1 Covering Note
Part 1.2 Convening Orders & TORs
Part 1.3 Narrative of Events
Part 1.4 Findings
Part 1.5 Recommendations
Part 1.6 Convening Authority Comments

Part 2 (The Record of Proceedings)
Part 2.1 Diary of Events
Part 2.2 List of Witnesses
Part 2.3 Witnesses Statements
Part 2.4 List of Attendees
Part 2.5 List of Exhibits

Part 2.6 Exhibits
Part 2.7 List of Annexes
Part 2.8 Annexes
Part 2.9 Schedule of Matters Not Germane to the Inquiry
Part 2.10 Master Schedule

GLOSSARY

Acronym/ Abbreviation	Explanation
A4	Air Logistics
AAIB	Air Accident Investigation Branch (Civil)
AAR	Air-to-Air Refuelling
ACDS (Log Ops)	Assistant Chief of Defence Staff Logistics Operations
ADIRU	Air Data and Inertial Reference Units
AEA	Aircrew Equipment Assemblies
AGE	Aircraft Ground Engineer
Air Tanker Services	ATrS
agl	Above Ground Level
ALARP	As Low As Reasonably Practicable
AOA	Aircraft Operating Authority
AOC	Air Officer Commanding
AP	Autopilot
APOD	Air Point of Disembarkation
ASIMS	Air Safety Information Management System
ASMP	Air Safety Management Plan.
ASMS	Air Safety Management System
ASOs	Air Staff Orders
ATC	Air Traffic Control
ATSB	Australian Transport Safety Board
BMI	British Midland International
BSW	Base Support Wing
BZAOs	RAF Brize Norton Air Orders
CAA	Civil Aviation Authority
CAM	Continuing Airworthiness Manager
Cat	Category
CAR	Civil Aircraft Register
CDS	Chief of Defence Staff
CDSDO	Chief of the Defence Staff Duty Officer
CJO	Chief of Joint Operations
CT	X Ray Computed Tomography
CVR	Cockpit Voice Recorder
D-SLR	Digital Single Lens Reflex Camera
DA	Duty Authoriser
DAOS	Design Approved Organization Scheme
DASOR	Defence Air Safety Occurrence Report
DCA Psych	Defence Consultant Advisor in Psychiatry
DDH	Delivery Duty Holder
DE&S	Defence Equipment and Support
DEX	Duty Executive
DFDR	Digital Flight Data Recorder
DO	Design Organisation
DSCOM	Defence Supply Chain and Operational Movements
DSS	Duty Senior Supervisor
EASA	European Air Safety Agency
ECAM	Electronic Centralized Aircraft Monitoring
Eng	Engineering

EPC	Error Promoting Condition
FCTM	Flight Crew Training Manual
FDM	Flight Data Monitoring
FL	Flight Level (Altitude based on Standard Pressure Setting of 1013hPa)
FOB	Forward Operating Base
Flt Lt	Flight Lieutenant (OF2 Rank)
FMHT	Field Mental Health Team
FRC	Flight Reference Cards
ft	Feet
Gp	Group
Gp Capt	Group Captain (OF5 rank)
GPS	Global Positioning System
HF	Human Factors
HQ 22(Trg) Gp	Headquarters 22 (Training) Group
hrs	Hours
IFF	Identification Friend or Foe
IFR	Instrument Flight Rules
INTA	Spanish National Institute of Aerospace Technology
J1	Joint Administration
J3	Joint Operations
JARTS	Joint Aircraft Recovery and Transportation Squadron
JCCC	Joint Compassionate and Casualty Cell
JFSp(A)	Joint Force Support Afghanistan
JSP	Joint Service Publication
kg	Kilograms.
KIAS	Indicated Air Speed in Knots
Km	Kilometres
MAA	Military Aviation Authority
MAOS	Maintenance Approved Organization Scheme
MAR	Military Aircraft Register
MIG	Materials Integrity Group
MilAAIB	Military Air Accident Investigation Branch
min	Minute
Mk	Mark
MPCM	Manual of Post Crash Management
MRP	Military Aviation Authority Regulatory Publication
MOD	Ministry of Defence
MSN	Mission Serial Number
MSO	Mission System Operator
NAS	Naval Air Squadron
NHP	Non-Handling Pilot
nm	Nautical Mile
OAT	Outside Air Temperature
OC	Officer Commanding
ODH	Operational Duty Holder

OEM	Original Equipment Manufacturer
Ops	Operations
OPCOM	Operational Command
OPCON	Operational Control
OR-9	Other Rank Level 9
OSI	Occurrence Safety Investigation
PA	Public Announcement
PCMIO	Post Crash Management Incident Officer
PCM	Post Crash Management
PMS	Personnel Management Squadron
PJHQ	Permanent Joint Headquarters
PT	Project Team
QFI	Qualified Flying Instructor
RA	Regulatory Article
RAF	Royal Air Force
RAFCAM	Royal Air Force Centre of Aviation Medicine
RAFLO	Royal Air Force Liaison Officer
RR	Risk Register
RtL	Risk to Life
RTS	Release To Service
secs	Seconds
SFSO	Station Flight Safety Officer
SI	Service Inquiry
SID	Standard Instrument Departure
SME	Subject Matter Expert
SMO	Station Medical Officer
SO	Senior Operator
SOP	Standard Operating Procedure
SQEP	Suitably Qualified and Experienced Person
Sqn	Squadron
Sqn Ldr	Squadron Leader (OF3 rank)
STANEVAL	Standards and Evaluation
Stn	Station
Stn Cdr	Station Commander
SUTTO	Start Up, Taxi and Take Off
TAA	Type Airworthiness Authority
TCAS	Traffic Collision Avoidance System
TMW	Tactical Medical Wing
TOGA	Take-Off Go Around
TRANSOP	Transport Operation Order
TRiM	Trauma Risk Management
USAF	United States Air Force
UTC	Universal Time Constant
VFR	Visual Flight Rules
VOM	Voyager Operations Manual
Wg Cdr	Wing Commander (OF4 Rank)

MAA SI Convening Order

13 Feb 14

SI President
SI Members

Hd MilAAIB
MAA-Legad 1

Copy to:
PSO/CAS
DComOps

CofM (Air)
AOC 2 Gp
Stn Cdr Brize Norton
Air Tanker Director of Fight Ops

MAA DG/SI/01/14 – CONVENING ORDER FOR SERVICE INQUIRY INTO AIRCRAFT OCCURRENCE INVOLVING VOYAGER ZZ333 ON 9 FEB 14 AT 1549Z

1. A Service Inquiry (SI) is to be held under Section 343 of Armed Forces Act 2006 and in accordance with JSP 832 – Guide To Service Inquiries (Issue 1.0 Oct 08).

2. The purpose of this SI is to investigate the circumstances surrounding the subject aviation occurrence and to make recommendations in order to prevent recurrence.

3. The SI Panel is to assemble at the MilAAIB Farnborough[2] on 13 Feb 14 at 1600Z.

4. The SI Panel comprises:

President: [redacted]
Members: **Air Member:** [redacted]
Eng Member: [redacted]

5. The legal advisor to the SI is [redacted] and technical investigation/assistance is to be provided by the Military Air Accident Investigation Branch (MilAAIB).

6. The SI is to investigate and report on the facts relating to the matters specified in its Terms of Reference (TOR) and otherwise to comply with those TOR (at Annex). It is to record all evidence and express opinions as directed in the TOR.

7. Attendance at the SI by advisors/observers is limited to the following:

Hd MilAAIB / DepHd MilAAIB– Unrestricted Attendance.

MilAAIB investigators in their capacity as advisors to the SI Panel – Unrestricted Attendance[3].

[2] Or via VTC in extremis.

[3] On a case by case basis as authorised by Hd MilAAIB.

[redacted], RAFCAM HF Accident Investigator – Unrestricted Attendance.

8. The Panel will initially work from Farnborough facilities, equipment and assistance suitable for the nature and duration of the SI, as requested by the SI President will be requested in due course.

9. Reasonable costs will be borne by DG MAA under UIN D0456A.

Original Signed

R F Garwood
AM
DG MAA – Convening Authority

Annex:

A. Terms of Reference for SI into Aviation Occurrence Involving Voyager ZZ333 on 9 Feb 14 over the Black Sea.

ANNEX A TO
Voyager Convening Order
DATED 13 Feb 14

TERMS OF REFERENCE FOR SI INTO AVIATION OCCURRENCE INVOLVING VOYAGER ZZ333 ON 9 FEB 14 AT 1549Z OVER THE BLACK SEA.

1. As the nominated Inquiry Panel for the subject SI, you are to:

   a. Investigate and, if possible, determine the cause of the occurrence, together with any contributory, aggravating and other factors and observations.

   b. *Ascertain whether Service personnel involved were acting in the course of their duties.*

   c. *Examine what policies, orders and instructions were applicable and whether they were complied with.*

   d. *Determine the state of serviceability of the aircraft and relevant equipment.*

   e. *Establish the level of training, relevant competencies, qualifications and currency of the individuals involved in the accident.*

   f. *Review the levels of authority and supervision covering the task during which the incident occurred.*

   g. *Identify if the levels of planning and preparation were commensurate with the activities' objectives.*

   h. *Investigate and comment on relevant fatigue implications of individuals' activities prior to the matter under investigation.*

   i. *Ascertain if aircrew escape and survival facilities were fully utilized and functioned correctly.*

   j. *If appropriate, investigate the level of any injury sustained and whether such injury will be the exciting cause of later disability, as established from expert testimony.*

   k. *Determine any relevant equipment deficiencies.*

   l. *Confirm that the Aircraft Post-occurrence Management procedures were carried out correctly and that they were adequate.*

   m. Determine and comment on any broader organizational and/or resource factors.

   n. *Assess whether the security of personnel, equipment or information was compromised and if so to what degree.*

   o. *Ascertain value of loss/damage to the Service and/or extent (and, if readily available, the value) of loss/damage to civilian property.*

   p. *Assess any Health and Safety at Work and Environmental Protection implications in line with JSP 375 and JSP 418.*

q. Report and make appropriate recommendations to DG MAA.

r. Produce an Aircraft occurrence Summary, to be completed within 2 wks of DG MAA signing off the SI.

2. You are to ensure that any material provided to the Inquiry by the United States, or any other foreign state, is properly identified as such, and is marked and handled in accordance with MOD security guidance. This material continues to belong to those nations throughout the SI process. Before the SI report is released to a third party, authorization should be sought from the relevant authorities in those nations to release, whether in full or redacted form, any of their material included in the SI report, or amongst the documents supporting it[3]. You are not to make a judgement on the origin of any classified material[4]. In addition, the relevant PDR directorate should be informed early when dealing with the US or other foreign state material, and should be engaged in the process where doubt exists.

3. During the course of your investigations, should you identify a potential conflict of interest between the CA and the Inquiry, you are to pause work and take advice from your MAA Legal Advisor, Hd MilAAIB and DG MAA. Following that advice it may be necessary to reconvene reporting directly to MOD PUS.

[3] For intellectual intelligence material this should be done through DIS (DICSD-SEC).

[4] If you are unable to positively identify the origin of the material, you must contact INFO-ACCESS DPAD or, for intelligence material, DIS (DI CSD-SEC).

PART 1.3 – NARRATIVE OF EVENTS

Synopsis

1.3.1 On Sun 9 Feb 14, the crew of ZZ333 briefed at 0925 UTC (Co-ordinated Universal Time) for a non-stop air transport flight from RAF Brize Norton (BZZ) to Camp Bastion Airfield (QOZ), Afghanistan. ZZ333 taxied approx 20 minutes late with a total flight crew of 9, plus 189 passengers. The departure was delayed slightly by a transponder Electronic Centralized Aircraft Monitoring (ECAM) warning just prior to line-up which was quickly resolved. With a call-sign of ISF 63JW, ZZ333 departed BZZ at 1200 UTC for an anticipated 8hr 20min leg to QOZ. Witnesses 1 & 2

1.3.2 Initially the flight progressed without incident, with the exception of at least one instance of turbulence, significant enough to warrant the illumination of the seat belt signs. At 1549 UTC (night time), with the aircraft in the cruise at Flight Level (FL)330 and autopilot 1 engaged, the Co-pilot had left his seat and was in the forward galley in the vicinity of the forward left passenger door. The Captain (occupying the left-hand flight deck seat) suddenly felt a sensation of weightlessness and being restrained by his harness, accompanied by a rapid pitching down of the aircraft. He attempted to take control by pulling back on his side-stick controller and pressing the autopilot disconnect button but these actions were ineffective. Witnesses 1 & 2

1.3.3 Immediately prior to the pitch-down, the Co-pilot felt a sensation similar to turbulence. Other crew in the cabin reported a similar sensation, describing it as a 'jolt'. The Co-pilot then experienced weightlessness and struck the cabin roof but was able to re-enter the flight deck through the open door. He reported a disorderly scene with audio alarms sounding and a violent shaking of the aircraft. He reached down to pull back on the side-stick control. Both pilots report hearing a 'dual input' audio warning, indicating simultaneous inputs by both pilots on their respective side-sticks. As the aircraft began to recover from the dive, excessive speed was building. The thrust levers were selected to idle and as the aircraft re-established a climb, the speed rapidly reduced. The Captain set Take-off and Go-around (TOGA) power and subsequently re-established a power attitude combination for straight and level flight at FL310. Witnesses 1, 2 & 3

1.3.4 The aircraft had lost 4,400 feet in 27 seconds, registering a maximum rate-of-descent of approximately 15,800 feet per minute, before recovering to straight and level flight. The speed had reached 358 knots Indicated Air Speed (KIAS), or Mach 0.9, and 'g' forces had ranged from minus 0.58 'g' (at the onset of the dive), to plus 2.06 'g' during the recovery. The aircraft was diverted to Incirlik Airbase in southern Turkey without further incident. Exhibit 1 Exhibit 2

1.3.5 The resulting negative 'g' forces were sufficient for a significant number of passengers and crew to be thrown towards the cabin roof. Twenty-five passengers and 7 crew reported injuries, and were attended in flight by medical personnel travelling as passengers, and subsequently at the on-base medical facilities. No major injuries were reported at the time of the incident. Exhibit 3

Background

1.3.6 Voyager is a modified Airbus A330-243, procured under a comprehensive service delivery contract with AirTanker Ltd which owns the aircraft. Exhibit 4

AirTanker is a joint venture made up of Cobham, Airbus Group, Rolls-Royce, Thales and Babcock. AirTanker Ltd holds the contract with the Ministry of Defence and contracts AirTanker Services Ltd to deliver the programme. Airbus Group is also contracted by AirTanker Ltd to deliver the aircraft through its business unit Airbus Defence and Space, supported by Cobham, Rolls Royce and Thales[1].

1.3.7 The commercial service provides for aircraft, infrastructure, inventory, certain manpower and training. The supporting structure and personnel are accommodated in a purpose-built AirTanker Services Hub, owned by industry and located at RAF Brize Norton. The contract was signed in Mar 08 and will expire in Mar 35. Exhibit 4

1.3.8 The aircraft must be able to switch between the Civil Aircraft Register (CAR) and the Military Aircraft Register (MAR). Thus, each aircraft must be maintained to civilian standards by an appropriately licensed organisation and using licensed staff. Accordingly, the service is administered by AirTanker Services in the military role and controlled by them in the civil environment. Exhibit 4

1.3.9 A considerable proportion of operating personnel are military, and around 75% of deployable manpower (engineers and operations personnel) are military staff placed with AirTanker Services Ltd (the remaining 25% are civilian Sponsored Reserves). Operational Control (OPCON) of RAF personnel working within AirTanker Services lies with the Company. Operational Command (OPCOM) remains within the military chain-of-command. Aircrew are assigned to either 10 Sqn or 101 Sqn and are entirely within the military chain-of-command. Exhibit 4

1.3.10 The Voyager's key capabilities include probe and drogue air-to-air re-fuelling (AAR) for all RAF receiver aircraft, plus a carriage capacity of up to 291 passengers and 8 NATO freight pallets. The initial conversion and modification work of aircraft ZZ333 (Airbus Manufacturers Serial Number (MSN) 1312) was conducted by Airbus between 25 May 12 and 13 Mar 13. The aircraft entered service with the RAF on 15 Aug 13 and by 9 Feb it had completed 417 flying hours and 133 flight cycles. Exhibit 5 Exhibit 6

1.3.11 **Crew composition**

a. **Captain (ZZ333 Handling Pilot).** [redacted] Exhibit 7

[1] AirTanker, Corporate Information, http://www.airtanker.co.uk/corporate-information (accessed 16 Jun 14), and Airbus Group, http://www.airbus-group.com/airbusgroup/int/en/our-company/What-we-do.html (accessed 16 Jun 14).

[redacted] Exhibit 8

Co-Pilot (ZZ333 Non-handling Pilot). [redacted]

c. **Purser: Total hours:** [redacted] Exhibit 9 Exhibit 10

[redacted] Exhibit 11

d. **Cabin Crew**: All the Cabin Crew completed the A330 Cabin Crew conversion course with either British Airways or British Midland International (BMI) prior to conducting Voyager training with AirTanker Services. Exhibit 12

1.3.12 **Flight planning and authorization**. The flight on 9 Feb was in support of the Operation HERRICK air-bridge, which provides the military air link between the UK and Afghanistan. The task was assigned by Defence Supply Chain & Operational Movements (DSCOM) HQ under Transport Operation Order (TRANSOP) 201402002. The flight was authorized on Fri 7 Feb 14 by the 10 Sqn Duty Executive with the authorization sheet (F1575B) signed by the Authorizer and the Captain. The scheduled departure time was 1125 UTC on 9 Feb and the flight was expected to last approximately 8 hours. Exhibit 13 Exhibit 14 Exhibit 15

1.3.13 The crew of two pilots and eight Cabin Crew members were scheduled to check in at 0925 UTC on 9 Feb. Accompanying the flight were two Aircraft Ground Engineers (AGE), who would be responsible for ground maintenance on arrival at QOZ. At approximately 0900 UTC, the Captain arrived at Voyager operations to complete some additional flight planning, prior to the rest of the crew arriving. At 0915 UTC, a member of the Cabin Crew rang in sick. Operating with less than eight Cabin Crew members would require one Cabin Crew member to cover two emergency exits, for which dispensation was sought. This was subsequently approved by phone at 0955 UTC by Officer Commanding (OC) 10 Sqn. Reviewing the weather information and the Jetplan[2] for the route, the Captain assessed that the required fuel load would cause the aircraft's weight limit to be exceeded. In order to reduce the required fuel load, the Captain requested the use of Kandahar Airfield in Afghanistan as a destination alternate airfield, instead of Minhad in the UAE. This was approved at 1030 UTC by ASCOT Operations at RAF Brize Norton, who were acting for the tasking authority. A combination of issues with crew transport, missing freight paperwork and in-flight catering led to a delay to engine start of approximately 20 minutes. Witness 1 Exhibit 16

Pre-event

1.3.14 **Start-up and taxi**. The aircraft start was normal, including the standard wait for the LAIRCM[3] system to reach operating temperature in order to have its serviceability checked. On taxi out, the ECAM System displayed a failure of the Identification Friend or Foe 1 (IFF1) transponder. The crew informed Air Traffic Control (ATC) that they would hold short of the main runway while they addressed the fault. While following the procedure for an IFF reset, the ECAM indicated that IFF2 had also failed. Several resets of both transponders did not remedy the faults and the AGEs were called forward to the flight deck to provide advice. The pilots were informed by the AGEs that nothing could be done to resolve the faults without taxiing back to the stand and shutting down. While preparing to return to the stand the IFF1 fault cleared, thus satisfying the crew that they could proceed with the flight. Take-off clearance was obtained from ATC. Exhibit 17 Witness 1 & 2

1.3.15 **Take-off**. The aircraft was only 0.7 Tonnes below its Maximum Take-Off Weight (MTOW) and thus required the full length of Runway 26 for take-off. Adopting a standard technique for improving the aircraft's take-off performance, the crew switched off the air conditioning packs and selected the thrust levers to TOGA power. The take–off roll was normal and, as the aircraft climbed through 300 ft above ground level, the autopilot was engaged. The rest of the departure was uneventful, following the Standard Instrument Departure (SID) from RAF Brize Norton, before conducting a relatively unrestricted climb to cruising altitude (Flight Level (FL) 330) with London ATC. Witness 1 & 2

1.3.16 **The cruise**. Initially the flight progressed without incident, with the exception of at least one instance of turbulence, significant enough to warrant the switching on of the seatbelt signs. A meal service was conducted, cleared away and followed by an in-flight movie which was being shown on the in-flight entertainment system. Witness 3

---

[2] Jetplan is a commercial software planning aid (produced by a Boeing subsidiary known as Jeppesen) which assists the crew in determining the fuel requirements for the flight.

[3] Large Aircraft Infrared Counter Measures.

1.3.17 At 1532 UTC, around 18 minutes before the incident, the Co-pilot left his seat for a break. Approximately two and a half minutes later, he returned briefly to the flight deck to deliver refreshment to the Captain before adjourning to the forward galley in the vicinity of the L1 station (forward left passenger door). He remained at this location until the incident took place, talking to the Purser and a former colleague who was on board as a passenger. Witness 2 & 8 Exhibit 2

1.3.18 While on his own and in his seat, the Captain was taking photographs of the flight deck with his Nikon digital SLR camera. The last photograph was taken at 1546:38 UTC, three minutes and twenty seconds before the incident, and co-incident with the Purser entering the flight deck. The Purser and the Captain had a brief conversation about the progress of the flight, before the Purser left the flight deck at 1548:04 UTC, one minute and 54 seconds before the incident. Exhibit 18 Exhibit 19

The event

1.3.19 At 1549:58 UTC, the Captain felt a sensation of weightlessness and being restrained by his harness, accompanied by a rapid pitching down of the aircraft. He attempted to take control by pulling back on his side-stick and pressing the autopilot disconnect button, but these actions were ineffective. The Captain was unaware of any alarms but reported an increase in cabin ambient noise and a sensation similar to being under water. In less than ten seconds the aircraft had pitched to 17 degrees nose-down, was descending at 15,800 feet per minute, and was accelerating rapidly through 300 KIAS. Witness 1 Exhibit 20

1.3.20 Immediately prior to the nose-down attitude, the Co-pilot felt a sensation similar to turbulence. The Purser also reported a similar sensation, describing it as a 'jolt'. As the aircraft pitched down, the Co-pilot was lifted to the cabin roof and, while experiencing weightlessness, re-entered the flight deck through the open door. He described a confusing scene with audio alarms and flashing lights, as well as a violent shaking of the aircraft. The Captain shouted repeatedly that he could not disengage the autopilot. With his feet on the flight deck roof, the Co-pilot reached down and attempted to disengage the autopilot by pulling back on his side-stick; an action which appeared to have no effect. As he resumed his seat and pulled back again on his side-stick, the aircraft began to pitch up. As the aircraft pitched up, 'dual input' audio warnings were heard, indicating simultaneous side-stick inputs by both pilots. By now (around 14 seconds into the incident), excessive speed had built, leading the pilots to reduce the thrust levers to idle. The aircraft began pitching upwards, and as it did so the speed decreased. The Co-pilot warned the Captain of the decaying speed, who consequently set TOGA power as straight and level flight was re-established at FL310. The crew then re-engaged autopilot 1. Witness 1, 2 & 3 Exhibit 2 Exhibit 20

1.3.21 Meanwhile, in the cabin a large number of passengers and crew had been thrown towards the ceiling. A significant volume of loose articles, including bags, personal effects, teapots, paper cups and bins were flying around the cabin, while some passengers were shouting. As the negative 'g' force from the initial pitch-down subsided, and as the aircraft accelerated in the dive, some of the unrestrained passengers and crew were able to find their way towards vacant seats and strap in. As the aircraft recovered to straight and level flight, the Purser made a brief check of the flight deck, before beginning a survey of the situation Witness 3 Exhibit 21

throughout the cabin.

1.3.22 The aircraft had lost 4,400 feet in 27 seconds, registering a maximum rate-of-descent of approximately 15,800 feet per minute, before recovering to straight and level flight. The speed had reached 358 knots IAS, and 'g' forces had ranged from minus 0.58 'g' (at the onset of the dive), to plus 2.06 'g' during the recovery. Exhibit 20 Exhibit 1

Post Event

1.3.23 Once in level flight the Captain decided to land the aircraft as soon as possible. An initial Mayday call, transmitted by the Co-pilot during the event, was followed by another call in which he requested a diversion 'to a suitable airfield of our choice'. On the advice of Turkish ATC, the aircraft was turned towards Trabzon, a civilian airfield approximately 60nm away. The Captain judged that the close proximity of Trabzon would not allow enough time to descend in good order, and was unsure as to its suitability. Instead, he elected to divert to Istanbul International Airport, some 500nm away. After a few more minutes however, ATC suggested that they should divert to Incirlik Airbase in southern Turkey, some 340nm from the aircraft's position at the time. The Captain agreed and the aircraft was turned south. Exhibit 19 Exhibit 20

1.3.24 During the diversion the Captain and Purser addressed the passengers a number of times using the Public Announcement (PA) system, repeating seat belt instructions, advising on timings and informing them before large attitude or configuration changes. In the immediate aftermath of the incident, the Captain used the PA system to inform passengers that the reason for the incident was unknown and that the aircraft was being diverted. He asked all passengers to remain seated with seat belts fastened. The Purser informed the flight deck crew that all passengers had their seatbelt fastened. During the Purser's assessment of the rear cabin, it became apparent that one of the passengers was suffering from an acute stress reaction. The Purser made a PA announcement asking for any doctor to make himself known to the Cabin Crew, before informing the pilots of the situation. From amongst the passengers, a doctor attended to the distressed individual, administering breathing Oxygen which had been provided by the Cabin Crew. Members of the Cabin Crew sought to calm down the remaining passengers before beginning a clear-up of the cabin. The Cabin Crew member at position R1 had been hyperventilating, but was being assisted by another crew member. The Purser re-assured this crew member and checked that they were fit to continue with their duties. The Purser conducted a second survey of the cabin with one of the AGEs to review damage to ceiling panels and to inspect a visible void for any obvious signs of structural damage. No external damage could be seen and an update was provided to the pilots. The Purser made a PA announcement, re-assuring passengers and explaining that the Cabin Crew would be removing loose panels in preparation for landing. The Purser made a further PA announcement, informing passengers that the aircraft was back under control, providing details of the diversion and thanking them for remaining calm. Finally, the Purser visited the flight deck to check for any further instructions before making a PA announcement preparing passengers for landing. Exhibit 2 Witness 1 & 3

1.3.25 Both pilots remained in their seats and guarded the controls at all times. A passenger, a Tornado Weapon Systems Operator (WSO), was brought onto the flight deck to assist with retrieving in-flight documents from the flight deck

bags. The aircraft landed at Incirlik Airbase from a straight-in approach without further incident. The aircraft was taxied to an aircraft parking bay and a normal disembarkation was conducted with the emergency services present. Witness 1, 2 & 3 Exhibit 19

Damage to aircraft

1.3.26 The damage to the aircraft comprised: 50 in-flight entertainment sockets broken or headphone pins sheared inside; seven ceiling panels dented; five florescent light tubes broken; five hand rails damaged; two seat belt brackets bent and one emergency exit sign broken (adjacent to door 2R). Initially, the rear facing lens of the exit sign at door 2R was missing (Figure 1), but it was subsequently found and put back in place for landing. Its cracked frame was sufficiently stable to accept and hold the replaced lens in order that the emergency function was not compromised for the landing. Exhibit 22 Exhibit 23

Figure 1: Internal damage to ZZ333.

1.3.27 There was no reported damage to the flight deck. During a post-occurrence review by Airbus, it was assessed that the forces placed upon the side-stick during the recovery from the incident were beyond its design specification; therefore, the side-stick was deemed unserviceable. Annex A

1.3.28 There was no reported damage to the external structure of the aircraft. Annex A

Post Occurrence Management

1.3.29 **Context**. Incirlik Airbase in southern Turkey is the home of the 39th Air Base Wing of the USAF and combat elements of the Turkish Air Force. The base is well found with a range of support facilities, and has been used by the RAF in recent years for a variety of operational purposes. Currently, a permanent RAF Liaison Officer (RAFLO) is based there to facilitate RAF C-17s which use the base to transit between the UK and Afghanistan. At RAF Brize Norton, the Post Occurrence Management of Voyager incidents depends on whether the aircraft in question is civilian registered or military registered. In this case, as a military Witness 9

aircraft incident, the station lead for Post Occurrence Management rested with the military chain-of-command, as distinct from AirTanker Services' own emergency response cell. Witness 7

1.3.30 **Sun 9 Feb**. The first notification that ZZ333 was diverting to Incirlik came when the RAFLO was contacted by USAF Operations (Ops) staff at Incirlik approximately 15 minutes before the aircraft landed. This notification included a warning that there were casualties on board the aircraft. The RAFLO contacted ASCOT operations (acting for the tasking authority) who, in turn, notified the staff of OC Ops, RAF Brize Norton. After the aircraft landed, the sequence of events was as follows: Witness 9 Witness 19

a. **Incirlik**. The aircraft was met by the USAF Passenger Service Supervisor and the passengers were attended on the aircraft by USAF medics. One passenger, who had suffered an acute stress reaction, was taken to the nearby Acibadem Hospital. In the meantime, passengers without NATO Travel Orders were required by the Turkish authorities to pay £10 cash for a visa before being permitted to pass through immigration. Credit cards were not accepted, and many individuals were not in possession of sufficient cash. In an effort to obtain cash, the RAFLO contacted the British Embassy in Ankara. The Embassy was unable to conduct a funds transfer that evening, and it would take six hours by road for them to deliver cash in person. The USAF was also unable to assist. Eventually, the passengers managed to pool enough money between them to purchase visas for those who required them. Witness 3 Witness 9 Witness 5 Witness 15

[redacted] Exhibit 118

[redacted] the RAFLO had organised accommodation, food and continued medical support for those who needed it. During the evening the passengers were briefed by the Purser on the need to preserve operational security, particularly with respect to personal communications and the use of social media.

b. **UK**. On receiving the initial notification of the incident, OC Ops, RAF Brize Norton began calling in a number of key executive Station (Stn) personnel, comprising the Stn Cdr, OC Base Support Wing (BSW) and OC 10 Sqn. The executive team was joined by an RAF Brize Norton Media and Communications officer. Simultaneously, Voyager Ops in the AirTanker Services Hub had received an electronic message from the aircraft which indicated it had made an unscheduled landing in Incirlik; they established contact with the aircraft Captain by satellite phone to ascertain the details. Soon, all parties at RAF Brize Norton were exchanging information with each other about the diversion of the aircraft, with the primary external channel of communication now established between the Incirlik RAFLO and the small executive team which had convened in the OC Ops' office. The executive team embarked on a process of information gathering and providing support for the crew and passengers of ZZ333. Stn personnel were placed on stand-by to potentially deploy to Incirlik. The Joint Compassionate and Casualty Cell (JCCC) at Innsworth was notified of the incident and Witness 5 Witness 6 Witness 7 Witness 13 Exhibit 16

informed that there may be casualties. JCCC had, in fact, already been contacted by AirTanker Services' own emergency response cell, which had now stood up in order to provide support. RAF Brize Norton also notified the HQ Air Command Duty Officer, the MAA Duty Officer and the MOD Directorate of Media and Communications. A phone call subsequently took place between OC Personnel Management Sqn (PMS), for the executive team, and Permanent Joint Head Quarters (PJHQ) Joint 3 (J3), during which it was decided that RAF Brize Norton would be in the lead for the ongoing management of the situation; this was relayed to PJHQ J1/J4. The Stn Cdr spoke by phone throughout the evening to Air Officer Commanding (AOC) 2 Group. By now, the executive team was already considering options for the launching of a TriStar to either recover the passengers or move them onwards to theatre. Based on their assessment of the developing situation in Incirlik, the executive team decided that a small team of the Stn's personnel would deploy to Incirlik as soon as possible to provide basic administrative and welfare support to the crew and passengers of ZZ333. The executive team also asked the RAFLO to convey restraint amongst the passengers regarding personal communications and the use of social media.

Witness 5
Witness 13
Witness 5
Witness 5

1.3.31 **Mon 10 Feb**. By Mon morning, the incident had been briefed to all domains at PJHQ and the Brize Norton support team was en-route to Incirlik.

a. **UK**. Responding to reports of acute stress reactions amongst the passengers, PJHQ J4 Medical contacted HQ Air A4 Medical Ops to discuss the situation. HQ Air A4 Medical Ops was not aware of the incident but, following a call to RAF Brize Norton, agreed with PJHQ J4 Medical that any support team deploying to Incirlik should include mental health professionals. Two mental health nurses from RAF Brize Norton were duly deployed to Incirlik, following behind the lead element of the RAF Brize Norton support team. PJHQ J4 Medical informed the Defence Consultant Advisor in Psychiatry (DCA Psych) and SO1 Mental Health Nursing at the Defence Primary Healthcare Service. Meanwhile, OC BSW RAF Brize Norton was liaising with PJHQ J1 regarding Brize Norton's plan for the passengers, the composition of the support team and the possibility that some passengers may no longer be fit to travel by air. PJHQ J1/J4 embarked on contingency planning for the event that passengers needed to return to the UK by surface means.

Witness 21
Witness 21
Witness 6
Witness 16
Witness 18

b. **Incirlik**. The passenger who had been admitted to Acibadem Hospital was discharged during the afternoon of 10 Feb. Deploying by commercial air, the lead element of four RAF Brize Norton personnel arrived at Incirlik by the early evening. Headed by OC PMS (OF3 rank) and carrying a cash imprest, the team included a Trauma Risk Management (TRiM) practitioner and a padre. On the same flight, two Voyager aircraft engineers had travelled separately from AirTanker Services. OC PMS convened a meeting with all passengers during the evening to provide a stress awareness brief, explaining how to look for the early signs of stress/trauma and what support was available to the passengers. The crew was not included in the initial briefing. Aware by now of RAF Brize Norton's plan to deploy a TriStar to recover the passengers, the support team set about evaluating the suitability of each

Exhibit 24
Witness 13

passenger to fly. With the assistance of three medical professionals and three TRiM practitioners from amongst the passengers, the team conducted one-to-one assessments of each passenger to establish: whether there were any reasons, physical or otherwise, why the individual would not be able to fly in the next 24-48 hours; whether the individual felt able to deploy to Afghanistan; whether the individual might require follow-on support (medical or pastoral) on returning to the UK. This was logged and sent back to the executive team at RAF Brize Norton. Separately, the British Embassy Defence Section had spoken to the Captain of ZZ333 and the RAFLO to check if any assistance was required.

Witness 13
Exhibit 3
Witness 15

1.3.32 **Tue 11 Feb**. By Tue 11 Feb, RAF Brize Norton had scheduled a TriStar to arrive in Turkey, while the mental health nurses from RAF Brize Norton and representatives from the Military Air Accident Investigation Branch (MilAAIB) had arrived in Incirlik.

a. **UK**. On board the TriStar from the UK were a number of additional RAF Brize Norton personnel, including the Senior Medical Officer (OF4 rank) and other medical staff. By now, a decision had been made at RAF Brize Norton that the aircraft would recover the passengers to the UK and not proceed to Afghanistan; it transpired that a single onwards move of all passengers to Afghanistan would not have been possible, since diplomatic clearances were not in place for a reserve TriStar task to Theatre. The crew of ZZ333 would remain in Incirlik for the time being.

Witness 20
Witness 6
Witness 20
Exhibit 25

b. **Incirlik**. The British Embassy Defence Section again contacted the RAFLO to offer support. Investigators from the MilAAIB began interviewing the crew in order to inform an assessment by DG MAA on the need for a Service Inquiry. Following a stress awareness brief with the crew, the support team refined its assessment of who was fit to fly by means of individual consultations with the RAF Brize Norton mental health nurses and USAF medics; this included some 18 personnel who were reluctant to fly. By the time of boarding at around 1700 hrs (local time) several passengers were exhibiting signs of distress, with some requiring counselling from the mental health nurses or medication from the Brize Norton medical staff. Under the close supervision of the support team and medical staff, all of ZZ333's passengers boarded the TriStar and completed the flight back to the UK.

Witness 15
Witness 13

c. **Return of passengers to the UK**. On arrival back in the UK, the passengers of ZZ333 were met by RAF Brize Norton staff. Based on the assessment of the Incirlik support team, a number of passengers (assessed to be less than ten, but no precise record was kept) had been earmarked for a return to their home unit, from where transport had been despatched to collect them (arranged through PJHQ J1). Meanwhile, the rest of the passengers were transferred to transit accommodation pending a re-scheduling of their flight to Afghanistan.

Witness 6

1.3.33 **Wed 12 Feb and Thu 13 Feb.**

a. **UK**. Ten passengers returned to their home unit because their chain-of-command stated there was no longer a requirement for them to deploy. Some passengers elected to spend a night at home before reporting for the re-scheduled flight. Over the next 48 hours, a programme of welfare activities was provided for the remaining passengers by staff at RAF Brize Norton, during which Stn personnel (ranging from padres and TRiM practitioners to medical staff) monitored the passengers to assess their continuing suitability to fly to Theatre. As a result, some personnel were classified as being unsuitable to fly and were sent back to their home unit. This included personnel who, owing to their physical or emotional state, were removed from the re-scheduled flight to Theatre on 13 Feb at the point of check-in (these were passengers willing to fly, but for whom RAF Brize Norton staff assessed that there was a risk these passengers might have a detrimental effect on cabin atmospherics). The remaining passengers deployed to Theatre. By 1600 UTC on 13 Feb, the ZZ333 Service Inquiry Panel had been convened. Witness 6 Exhibit 26 Witness 13

b. **Incirlik**. All crew members were offered a TRiM interview. OC PMS conducted three formal TRiM interventions with crew members, all of which resulted in a recommendation for a follow-up intervention after 28 days. The remainder of the crew were directed to the mental health nurses for individual consultations. On 13 Feb the support team, the mental health nurses and the crew returned to RAF Brize Norton by a specially scheduled TriStar. The medical team arranged for those passengers who they had concerns about to be seated at the front of the TriStar with the medical personnel. On arrival in the UK they were met by the Stn Cdr RAF Brize Norton and OC BSW. Exhibit 26 Witness 6

Witness 4 Witness 5 Witness 7

1.3.34 **Post occurrence safety decisions**. The RAF Brize Norton executive team included the Delivery Duty Holder (DDH) and the RAF Brize Norton Senior Operator (SO). On the evening of 9 Feb, as well as managing the situation in Incirlik, one of the team's primary considerations was to assess the extent of any safety decisions which should be made in response to the incident and to convey that assessment to the Operational Duty Holder (ODH). A civil registered Voyager was due to depart RAF Brize Norton later that evening carrying Service personnel to the Falkland Islands. The next military registered flight was scheduled for the following morning in support of the Afghanistan air-bridge. Amongst the factors for the DDH was the extent to which the military modified variant of the aircraft was different to the civilian version. On the basis of a discussion with the Brize Norton SO and information gleaned from AirTanker Services' Head of Flight Operations, it was assessed by the DDH that a cause relating to the specific modifications on the military variant could not be ruled out. Furthermore, given the available information at that time, the DDH could not guarantee that the incident would not happen again on the military registered aircraft. This was conveyed to the ODH, which informed a decision to pause flying on the military registered aircraft. Simultaneously, in the AirTanker Services Hub a meeting of key engineering and maintenance personnel had been convened which brought together the Voyager senior RAF engineering representative (OF3 rank), a number of AirTanker Services duty engineering staff and the AirTanker Services Engineering Post Holder, who had dialled in by telephone from a remote location. The aircraft's post-flight engineering report was Witness 22

clear of faults and the Captain's oral report alluded only to a possible fault with the autopilot. AirTanker Services lodged a request for technical advice with the Design Organisation (Airbus Defence and Space) in Madrid, but it would be several hours before a response was received. By the end of the meeting however, word was received that flying on the military registered aircraft had already been paused, pending the receipt of further information. A brief response received shortly after 2300 UTC from the Design Organisation recommended that the data from ZZ333 should be further analysed before an assessment on its airworthiness could be made, but stated also that they saw no evidence to recommend a restriction on the rest of the fleet (either civil or military). Flying on the civil registered aircraft continued. Exhibit 27

Injuries

1.3.35 On landing in Incirlik, the following injuries were identified (see Table 1): the Co-pilot and seven Cabin Crew received minor injuries but were able to conduct their duties; one crew member had suffered a stress reaction but recovered within a few minutes and was able to carry out their duties; 24 passengers received minor injuries and one passenger had suffered an acute stress reaction which resulted in his admission to hospital. Injury definitions are in accordance with JSP 375 Volume 2, Leaflet 14, Annex B; Accident/Incident Reporting and Investigation. Exhibit 3 Exhibit 28 Exhibit 21 Witness 3 Exhibit 24

Injury Level	Crew	Passengers	Total
Reported injuries	**8**	**25**	**33**
- Minor Physical	8	24	32
- Minor Mental	-	1	1
- Serious	-	-	-
- Major	-	-	-
Not injured or not reported as injured	1	164	165
Total occupants	9	189	198

Table 1: Injuries identified on landing at Incirlik.

1.3.36 Following the initial incident, 15 passengers required medication to board the aircraft that returned to the UK. On return to the UK, twelve passengers were returned to their home unit for either medical or pastoral reasons as well as an additional ten passengers who were no longer required for duty. A number of further injuries emerged after the incident, which are addressed in the analysis contained in Section 1.4. Exhibit 26 Exhibit 3

PART 1.4 – FINDINGS

Notes:

Extended references to Cabin Safety analysis in report AO-2008-070 (Dec 11) made with the kind permission of the Australian Transport Safety Bureau.

Illustrations of the Digital Flight Data Recorder are adapted from raw data traces provided by QinetiQ.

Illustration of aircraft route: Map data © 2014 Google, Basarsoft.

Photographs provided by the Military Air Accident Investigation Branch (MilAAIB) and by 1710 Naval Air Squadron.

In this section, organizational references to 'Airbus,' refer to Airbus SAS, based in Toulouse, France.

Executive Summary of Findings

1.4.1 The incident involving Voyager KC Mk 3 (ZZ333) on 9 Feb 14 occurred when the aircraft suddenly pitched down while in the cruise at FL330 (33,000 ft). The pitch-down command persisted for a total of 33 seconds, during which time the aircraft lost 4,400 ft in height. The aircraft's self-protection measures initiated a recovery from the dive.

1.4.2 Evidence gathered from the aircraft's Digital Flight Data Recorder (DFDR) showed that a full pitch-down command had been initiated from the Captain's side-stick, which caused the autopilot to disconnect and the aircraft to enter a dive. The evidence also showed that the pitch-down command was not the result of a technical malfunctioning of the side-stick, the control surfaces, the autopilot, the flight control computers, or the aircraft's weight and balance. Neither was the pitch-down command the result of turbulence. A detailed examination of the aircraft indicated that there were no pertinent technical faults throughout the flight.

1.4.3 The Inquiry established conclusive evidence that the pitch-down command was actually the result of an inadvertent physical input to the Captain's side-stick. Specifically:

a. Two or three minutes before the event, a Digital Single Lens Reflex (D-SLR) camera was placed directly behind the side-stick, in the space between the side-stick and the Captain's left armrest.

b. At one minute and 44 seconds before the event, the Captain's seat was moved forward, creating a slight physical jam of the camera between the front of the armrest and the rear base of the side-stick.

c. At the onset of the event, the Captain's seat was moved forward again, forcing the side-stick fully forward and initiating the pitch-down command.

d. With the Captain's side-stick jammed fully forward, the pitch-down command could not be counteracted initially, as the Captain was the only person present on the flight deck.

e. The resulting forces were sufficient for a considerable number of passengers and crew to be thrown to the ceiling, resulting in a number of injuries.

1.4.4 The Panel found that the factors which led to the pitch-down command were influenced principally by the prevailing safety culture with respect to loose articles on the flight deck of RAF air transport aircraft. The small amount of guidance regarding the treatment of loose articles on flight decks was overwhelmed by an organizational requirement to take large amounts of equipment and documentation onto the flight deck to support missions, and to store it in ad hoc locations. As a result, the carriage, use and ad hoc storage of a small number of personal items had become normal practice. The recovery from the pitch-down command was initiated by the aircraft's own protection laws which prevented the incident from being far worse. In the opinion of the Panel, the evidence suggests strongly that the clearing of the obstruction from behind the side-stick was achieved

by means of a physical manipulation of the camera itself.

1.4.5 The situation in the passenger cabin was managed effectively and had no adverse bearing on the injuries which were sustained by either the passengers or members of the Cabin Crew. The actions of the Purser were particularly noteworthy in bringing the situation under control. Physical injuries were mostly minor; however a number of personnel were admitted to hospital in the days or weeks following the incident suffering from acute stress.

1.4.6 The practical response in the immediate aftermath of the incident was fast, thorough and highly effective. There was a sense in some areas however, of command, control and support being conducted in an improvised fashion. A lack of continuity in information flow led to a lack of pre-preparedness in Theatre for the volume of medical cases which followed amongst those passengers who subsequently deployed. There Panel found no evidence that this had an adverse effect on the quality of individuals' treatment.

1.4.7 As of 25 Feb 14, it was estimated that out of 198 personnel on-board ZZ333, a minimum of 32 (16%) and a maximum of 48 (24%) were, for varying reasons and periods of time, rendered unfit for duty as a result of the incident. The overall medical outcome of the incident however, was not being tracked.

1.4.8 The Service Inquiry (SI) was convened officially on 13 Feb 14 to investigate the circumstances which led to the incident, to determine the cause and to make recommendations to enhance air safety. The following analysis examines the cause of the incident and its associated factors, and makes a number of other observations which the Panel has deemed pertinent.

Methodology

Definitions

1.4.9 The following definitions were used to classify the various factors which were pertinent to the incident:

a. **Cause**. An event which led directly to the incident.

b. **Contributory Factor**. A factor which made the incident more likely.

c. **Aggravating Factor**. A factor which made the outcome worse.

d. **Other Factor**. A factor which was none of the above, but was noteworthy in that it may cause or contribute to future incidents or accidents.

e. **Observations**. An issue that was not relevant to the incident but worthy of consideration to promote better working practices.

Incident modelling

1.4.10 In assessing the evidence, the Panel adopted an epidemiological model first proposed by Professor James Reason of Manchester University in 1990. The model broadens the scope of an investigation beyond individual acts, to include an examination of the latent conditions and organizational factors which may also lie behind an incident. As such, the following categories were used to inform the Panel's analysis:

a. **Unsafe acts**. Unsafe acts are those committed by those at the 'sharp end' of a system, in close proximity to the incident. Fact-based, non-judgemental statements are used to categorize the potentially unsafe acts of an individual or a group, whether those acts have been intentional or not:

(1) **Unintentional acts**.

(a) **Slips**. A slip is defined as an error by commission; where a well-practised skill, requiring little cognition, has been carried out incorrectly.

(b) **Lapses**. A lapse is defined as an error by omission; where a well-practised skill, requiring little cognition, has not been carried out.

(2) **Intentional acts**.

(a) **Mistakes**. A mistake is defined as a deficiency in judgement and/or a failure to formulate the right plan based on flawed knowledge, and/or an incorrect comprehension of rules.

(b) **Violations**. A violation is defined as a deliberate and conscious departure from established rules or procedures, even if there has been no intent to cause harm.

b. **Error promoting condition (EPC)**. Error promoting conditions refer to those psychological, physical/mental limitations and physiological factors that can influence human performance; for example, pressure, weather or fatigue.

c. **Organizational influences**. Organizational influences refer to the broader, and often latent, influences that an organization brings to bear on those involved in an incident. These will inevitably be beyond those individuals' control and could, for example, relate to equipment design, operational culture or organizational policy.

d. **Breached or failed defences**. Breached or failed defences refer to those rules, orders, practices and procedures which are designed to ensure the safe operation of aircraft, but which failed or were breached in the course of the incident.

Available evidence

1.4.11 The Panel had access to the following evidence:

a. Interviews with the crew of ZZ333 and other witnesses.

b. Written statements and correspondence from witnesses.

c. DFDR data from the flight.

d. A Cockpit Voice Recorder (CVR) from the flight.

e. Photography from various sources.

f. Relevant orders, terms of reference and documentation including flying logbooks, aircraft documentation, flight planning, briefing materials and engineering documentation.

g. Aircraft ZZ333 at Incirlik airbase.

h. An aircraft technical report by Military Air Accident Investigation Branch (MilAAIB).

i. Technical reports by 1710 Naval Air Squadron (NAS).

j. A Human Factors report provided by the RAF Centre for Aviation Medicine (RAFCAM).

k. Flight Simulator assistance from AirTanker Services Ltd and Airbus.

l. Flight safety-related material, including previous MOD accident and incident reports and Mandatory Occurrence Reports from the Civil Aviation Authority (CAA).

Services

1.4.12 The Panel was assisted by expertise within the following organizations:

a. Air Accident Investigation Branch (AAIB).

b. Airbus (including Airbus Defence and Space).

c. AirTanker Services Ltd.

d. Military Aviation Authority (MAA).

e. MilAAIB.

f. QinetiQ.

g. RAF Brize Norton.

h. RAFCAM.

i. Rolls Royce.

j. 1710 NAS.

k. 206(R) Squadron.

Factors considered by the Panel

1.4.13 With respect to the pitch-down command, the Panel analysed the following key factors:

a. Possible triggers.

b. The relevance of individual acts.

c. The prevailing conditions at the time of the event.

d. Regulations and safety culture.

e. Aircraft design.

1.4.14 The Panel also analysed the following areas:

a. The recovery from the pitch-down command.

b. Cabin safety, including the handling of injuries.

c. Post Occurrence Management, including the handling of injuries.

d. Other areas pertinent to the Panel's terms of reference.

Determining the cause of the pitch-down command

Context

1.4.15 Aware that flying on the Voyager fleet had been paused and that the incident was attracting considerable international interest, the Panel's initial efforts were focussed entirely on determining the cause of the pitch-down command. [redacted] Comprehensive interviews with the pilots conducted in Incirlik by MilAAIB had already established a strong theme that pointed towards a technical malfunction on the aircraft, specifically associated with the side-sticks and the autopilot. By contrast, initial analysis of the DFDR and CVR had revealed no evidence of any pertinent technical malfunctions, particularly in respect to the side-sticks and the autopilot.

Exhibit 20
Exhibit 2
Witnesses 1 & 2

1.4.16 [redacted], a number of concurrent lines of inquiry became necessary in order to rule out a variety of possible causes. Such was the [redacted] nature of interview evidence taken by MilAAIB and the Panel, these lines of inquiry were necessarily broad and time consuming. They included early engagement with Airbus, from whom the Panel would have lengthy and close co-operation over the course of the Inquiry. They also included extensive work carried out for the Panel by independent parties to help isolate the cause of the pitch-down command.

Possible causes

1.4.17 The range of possible causes considered by the Panel included:

a. A Human Factors related deliberate act.

b. A Human Factors related inadvertent act.

c. A side-stick malfunction, including:

(1) A mechanical or electrical failure of a side-stick transducer.

(2) A mechanical or electrical failure of a side-stick solenoid.

(3) A failure of side-stick damper rods & linkages.

(4) A mechanical failure of Artificial Feel Spring and Dampening System.

(5) A loose article blockage in the side-stick pitch rods.

(6) Cross-talk or electromagnetic interference inducing a pitch-down command.

d. A Single Event Effect (atmospheric particles from a solar flare event) causing a pitch-down command in the Flight Control Computers.

e. An autopilot fault.

f. Any other avionics hardware or software design fault or 'bug.'

g. A weight and balance related issue.

h. A control surface malfunction.

i. Turbulence.

Analysis

1.4.18 The DFDR showed no indication of system failures that could have led the aircraft to pitch down. Throughout the flight, there were no annunciations to the crew of pertinent faults, nor were any relevant fault codes generated that would help explain the incident. The Panel found no evidence of unresolved comparable incidents across any A330 aircraft variants. The Panel assessed this incident to be unique. Exhibit 20 Exhibit 17 Exhibit 29

1.4.19 At 1548:13 UTC, one minute and 44 seconds prior to the event, the DFDR (Figure 1) detected a low frequency fluctuating pitch-down command of 0.5 to 0.9 degrees from the Captain's side-stick. This input endured until the onset of the full pitch-down command. This initial forward input was pure in pitch with no discernible lateral input. The force and displacement of the side-stick during this command did not disengage the autopilot, because a five deca-Newton force and five degree displacement of the side-stick (in pitch) is required before the autopilot will disengage. All side-stick movements, including those below the threshold for autopilot disconnection are recorded by the DFDR. Therefore, the aircraft remained initially in level flight with the autopilot engaged. At 1549:57 UTC, a fully-forward input was made by the Captain's side-stick. This input was also pure in pitch and at constant rate. It had no discernible lateral input and was held initially for approximately four seconds at a fully forward deflection. It was this input which initiated the pitch-down event. Exhibit 30 Annex C Exhibit 30

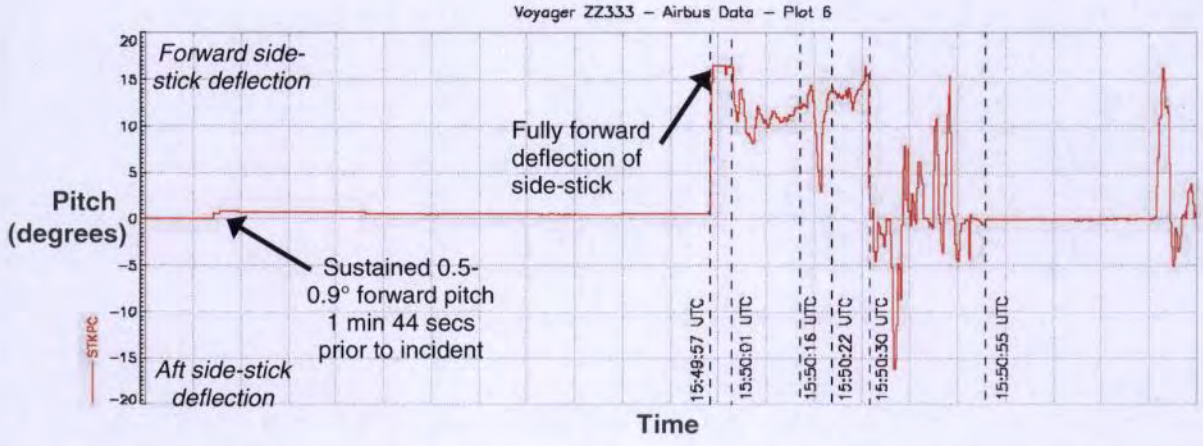

Figure 1: DFDR extract showing Captain's side-stick pitch commands.

1.4.20 The Panel examined the possibility that the input had been made deliberately. Neither the Captain's most recent training report, nor his flying Exhibit 7 Witness 4

records, nor his supervisory chain, nor his medical history, gave the Panel reason to suspect that the input was the result of a deliberate act. Furthermore, analysis of the CVR indicated that the Captain seemed genuinely surprised by the pitch-down event. The Captain did not press his autopilot disconnect button on the side-stick until four seconds after the pitch-down was initiated. UK Defence Standards indicated that a normal reaction time to an unexpected in-flight event would be in the region of three to five seconds[1]. Thus, the evidence indicated strongly that the pitch-down was unexpected and not deliberate.

Exhibit 31
Exhibit 2
Exhibit 20

1.4.21 Early analysis of the CVR identified a distinctive noise on the flight deck at one minute and 44 seconds prior to the event, and at the onset of the event itself. Spectral analysis of the noise identified it as the electrical motor used to adjust the flight deck crew seats (identified by its frequency of 1900-2000 Hz). The seats are adjustable by means of a switch which is located on the base of the seat itself. The Captain's seat is on the left-hand side of the flight deck and his adjustment switch is on the bottom right-hand side of the seat (Figure 2). In the two minutes leading up to the event the Captain was the only person present on the flight deck, indicating that the motor noise came from the Captain's seat. There was no evidence that the seat had malfunctioned in flight and functional tests carried out after the event showed that the seat was fully serviceable. It was quite normal for the seat to be adjusted several times during the flight, either for reasons of comfort or for the performing of a specific task. The Captain confirmed that his seat may have moved forward at this time, although he could not specifically recall it.

Exhibit 2
Exhibit 32
Witness 1, Panel Interview 1
Annex A, 1.2.6
Witness 1, Panel Interview 3
Witness 1, Panel Interview 2

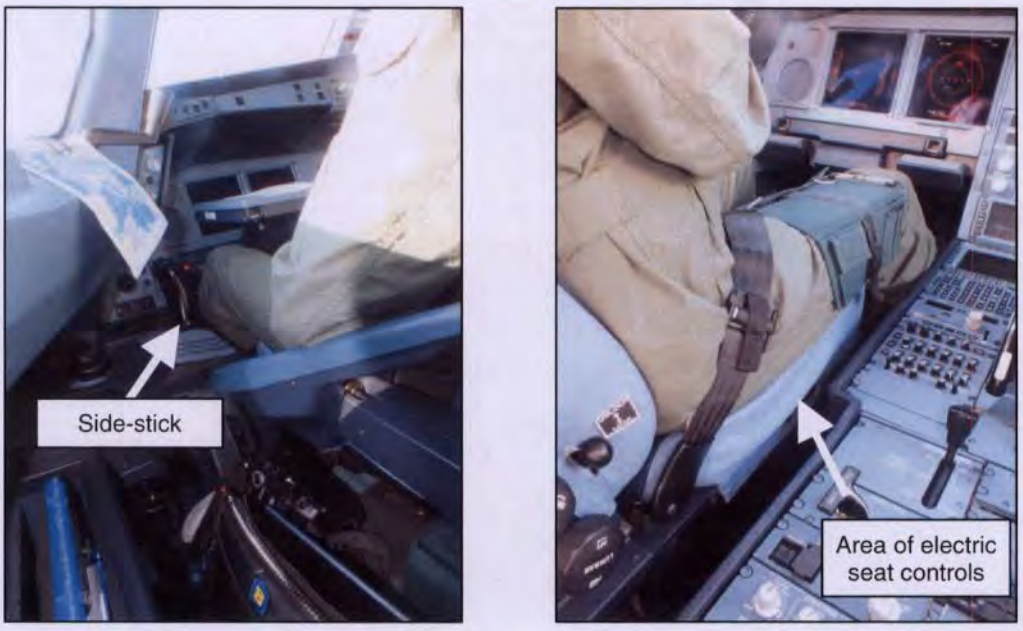

Figure 2: Captain's seat position.

1.4.22 There was an obvious and strong temporal and directional correlation between the seat motor movement and the side-stick movement. The Panel examined the possibility that the movement of the Captain's seat and the Captain's side-stick were connected. For there to have been a direct relationship, the seat and the stick would have to be physically connected, either by the occupant of the seat or by an object (other methods of interference are dealt with in a separate

[1] DEF-STAN 00-97- Part 1, Section 4, Leaflet 36.

paragraph). The pitch input from one minute and 44 seconds until the onset of the event remained around a datum of between 0.5 and 0.9 degrees, in a manner inconsistent with a human input. It would be extremely difficult for a pilot to hold and maintain the small forward elevator deflection manually on the side-stick for nearly two minutes. The side-stick would have a tendency to return to the neutral position under spring loading. Even extremely light atmospheric turbulence or airframe vibration would tend to move the pilot, which in turn would be expected to translate into movement of the side-stick. The movements of the pilot's body would be expected to create changes in side-stick pitch input that were not visible on the DFDR plot.

Annex A, 2.1 & Exhibit 30

Annex C Exhibit 30

1.4.23 The Captain was certain that he was not touching the controls prior to the event, and the persistence of the subsequent pitch-down command (lasting in total around 33 seconds) indicated that it was not the product of an inadvertent human input. Multiple attempts to recreate the pitch-down event were carried out in the simulator. Hand flying a fully forward deflection of the side-stick resulted on each occasion in some roll input inadvertently being applied. The lack of roll input on the DFDR trace during the initial pitch-down of the aircraft meant that a hand flown pitch-down command was unlikely. The Panel concluded that the Captain was not in physical contact with the side-stick either immediately prior to, or during the onset of the event.

Witness 1, Panel Interview 1 Annex C Exhibit 33

Exhibit 34 Annex C Exhibit 35

1.4.24 As a result, the Panel's focus turned to the possibility of an object connecting the seat and the side-stick. The Panel collected the official items and personal effects which had been on the flight deck at the time, in order to ascertain which of them could have interfered with the side-stick. In an interview with the Co-pilot, it became evident that a Nikon Digital Single Lens Reflex (D-SLR) D5300 Camera (Figure 3) belonging to the Captain had been present on the flight deck in the minutes leading up to the pitch-down event. Specifically, the camera had been seen by the Co-pilot on the surface area near the base of the Captain's side-stick shortly before the event. He had also seen the Captain using the camera during the flight.

Exhibit 18

Witness 2, Panel Interview 1

Figure 3: Nikon D5300 D-SLR camera as received.

1.4.25 [redacted]

Witness 1, MilAAIB interview & Panel interview 1

[redacted] Analysis of [redacted] photographs submitted subsequently by the Captain indicated that 28 photographs were taken during a period of darkness between around eight minutes and three minutes prior to the incident (Figure 4). It was established that, in all, 77 photographs were taken during the flight. In one photograph, the GPS digital clock on the flight deck could be seen, allowing a comparison to be made between the aircraft's internal time measurement and that of the camera.

Witness 1, Panel interview 2

Exhibit 36
Exhibit 123

Figure 4: Sample of 28 photographs taken on flight deck shortly before incident.

1.4.26 As such, the Panel established that the last photograph taken with the camera was at 15:46:38 UTC; one minute 35 seconds before the initial pitch event, and three minutes and 20 seconds before the full pitch-down event. Analysis of the CVR indicated that approximately four seconds after the last photograph was taken, the Purser came onto the flight deck to have a short conversation with the Captain, before returning to the passenger cabin (Figure 5).

Exhibit 18
Exhibit 2
Exhibit 18
Witness 3, Panel Interview 2

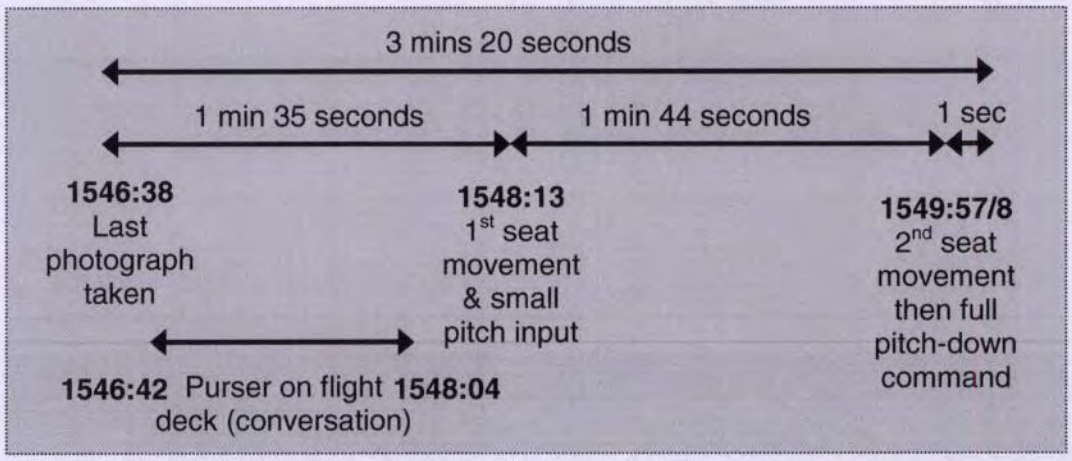

Figure 5: Timeline immediately prior to incident (all times UTC).

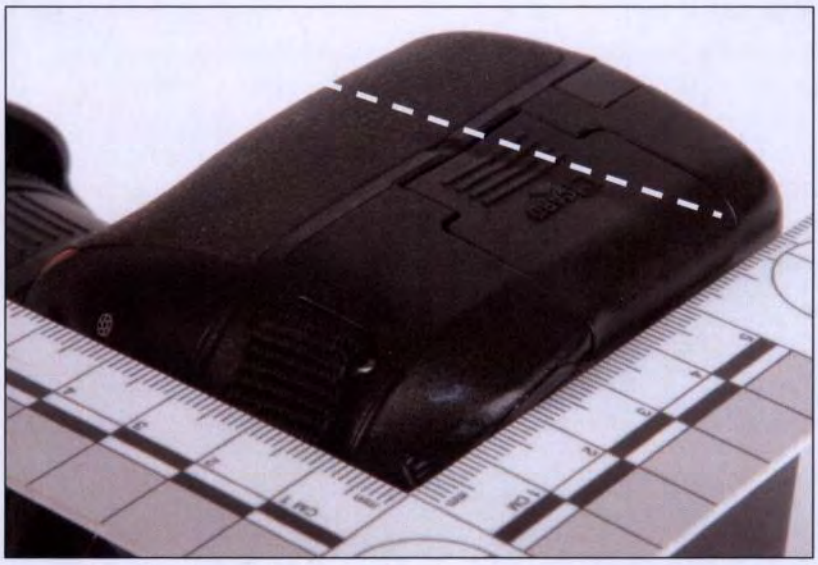

Figure 6: Location and orientation of large dent in camera (dotted line).

1.4.27 The camera was found to have a large linear dent on its right hand side (Figure 6). The dent extended from the softer hand grip region towards the front of the camera, across a thin part of the main body frame, and across the memory card flap. Annex A

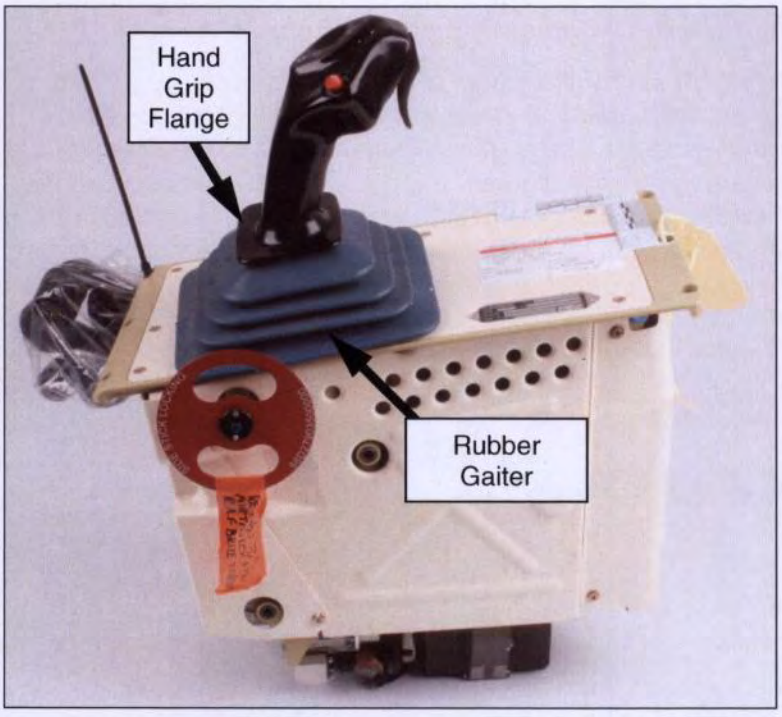

Figure 7: Side-stick unit as received by Panel.

1.4.28 The profile of the large dent was mapped forensically using surface profilometry and compared with the hand grip flange (Figure 7) at the base of the side-stick. The dent in the camera was found to be consistent with having been caused by the flange of the side-stick. Furthermore, chemical analysis indicated that trace amounts of materials present in a swab from the camera indentation were consistent with the material type of the side-stick. The rubber gaiter at the

base of the side-stick was examined using binocular microscopy, revealing two distinct perforations. The perforations were assessed to be the result of the gaiter material being pushed against the edges of the lower side-stick flange from the outside. When considered alongside other smaller witness marks on the camera, it was assessed as highly likely that the camera had experienced a significant compression against the base of the side-stick at some point during the flight. Specifically, it was assessed that the damage was consistent with the side-stick being pulled back forcefully against the body of the camera. Annex A, para 2.5

Figure 8: Re-construction of Captain's camera behind side-stick.

1.4.29 Using the Voyager simulator, the Panel reconstructed an arrangement of the armrest, the camera and the side-stick to assess the possibility of causing flight-control interference (Figure 8). The armrest was adjusted to the specific parameters used by the Captain on the flight in order to re-create the angle that was present during the event. Although the setting was within limits, it created an unusual angle, resulting in a particularly steep downward incline from back to front. The camera was placed in the gap between the armrest and the side-stick, with the damaged side presented towards the grip flange at the base of the side-stick. The seat motor was moved forward until the camera was gently flush against the base of the side-stick. Witness 1, Panel Interview 1

Figure 9: Side-stick locked in fully forward position (substitute camera).

1.4.30 The seat motor was operated in a forwards direction as heard at the onset of the pitch-down event. The effect was to push and hold the side-stick fully forward in a manner consistent with the pitch-down command seen on the DFDR (Figure 9). The motion resulted in the grip flange becoming aligned with a location exactly consistent with the dent in the camera. The re-construction took no more than a few seconds to set up. Exhibit 2 Exhibit 20

1.4.31 Using the calculated movement of the seat, the position of the armrest and the location of the camera, the analysis found that it was feasible for the seat movement recorded on the CVR to have caused the movement of the side-stick to the fully-forward position. Annex A

1.4.32 In the meantime, the Panel continued to pursue a standard of evidence that would allow a thorough range of other causes to be ruled out. A full examination of possible technical causes is in the MilAAIB Report at Annex A. In summary, the following were assessed by the Panel to have not caused the incident: Annex A

a. **Mechanical or electrical failure of a side-stick transducer.** Tests conducted with the side-stick manufacturer, UTC Aerospace Systems, established that the side-stick transducer unit was fully serviceable.

b. **Mechanical or electrical failure of a side-stick solenoid.** Tests conducted with the side-stick manufacturer, UTC Aerospace Systems, established that the side-stick solenoid was fully serviceable.

c. **Failure of the side-stick damper rods & linkages.** Tests conducted with the side-stick manufacturer, UTC Aerospace Systems, established that the side-stick damper rods and linkages were fully serviceable.

d. **Mechanical failure of artificial feel spring and dampening system.** Tests conducted with the side-stick manufacturer, UTC Aerospace Systems, established that the side-stick transducer unit was fully serviceable.

e. **FOD blockage in the side-stick pitch rods.** An X-ray computed tomography (CT) scan showed that there was no FOD blockage within the side-stick unit. This was confirmed by a subsequent visual inspection by the side-stick manufacturer.

f. **Cross-talk or electromagnetic interference inducing a false pitch-down signal**. Tests conducted with Airbus examining the effects of electromagnetic interference from the Captain's portable electronic devices established that their level of emissions were below the demonstrated immunity level of the equipment installed on aircraft.

g. **Single event effect (atmospheric particles from solar flare event).** Solar flare activity at the time of the incident was measured in the lowest range of emissions (class C), below that which could have caused interference with the aircraft systems. Exhibit 127

h. **Auto-pilot fault**. The autopilot behaved correctly in response to a

positive control input from the Captain's side-stick.

i. **Hardware or software design fault or bug.** Analysis found no evidence to doubt the integrity of the flight control system. No faults or spurious flight control inputs were recorded on the Flight Data Maintenance system and Built-in Test logs. It was confirmed that the auto-flight system and the five flight computers responded to an autopilot disconnection in accordance with the commands provided to them. The pitch-down command was correctly authorized in response to a positive control input from the Captain's side-stick.

j. **Weight and balance related malfunction**. Analysis of the aircraft's post-flight report showed no errors in the weight and balance calculation for the aircraft. The aircraft Load and Trim Sheet (Form AS.OGD.007) indicated that the aircraft trim was within normal limits for the duration of the flight. There was no shifting of the load on board the aircraft at any time during the flight.

Exhibit 124

k. **Control surface malfunction**. DFDR analysis showed that the flying controls responded correctly to positive control inputs from the Captain's side-stick. All control surfaces, including those mounted on the trim-able horizontal stabilizer, responded as expected to command input parameters and within design intent.

l. **Turbulence**. Although turbulence had been experienced earlier in the flight, no turbulence was reported at the time of the incident. Neither was any significant turbulence forecast for the area in which the incident took place.

Witness 2, Panel Interview 1
Exhibit 37

1.4.33 [redacted], the Captain agreed that a physical interference with the side-stick, in the manner suggested above, represented the most probable trigger for the pitch-down command. Given the weight of evidence therefore, the Panel concluded that **the cause of the pitch-down event was an inadvertent physical input to the Captain's side-stick, by means of a physical obstruction (a camera) that jammed between the left armrest and the side-stick unit when the Captain's seat was motored forward.**

Witness 1, Panel Interview 3

Factors leading to the pitch-down command

1.4.34 A series of individual acts took place in the moments before the pitch-down command which were assessed as having contributed to the incident itself. The individual acts however, were influenced by a combination of error promoting conditions, organizational influences and breached defences. The following paragraphs are drawn principally from Human Factors analysis conducted by RAFCAM. Figure 10 illustrates the key factors which were considered in determining how the pitch-down command happened, and forms the structure for the analysis in these paragraphs.

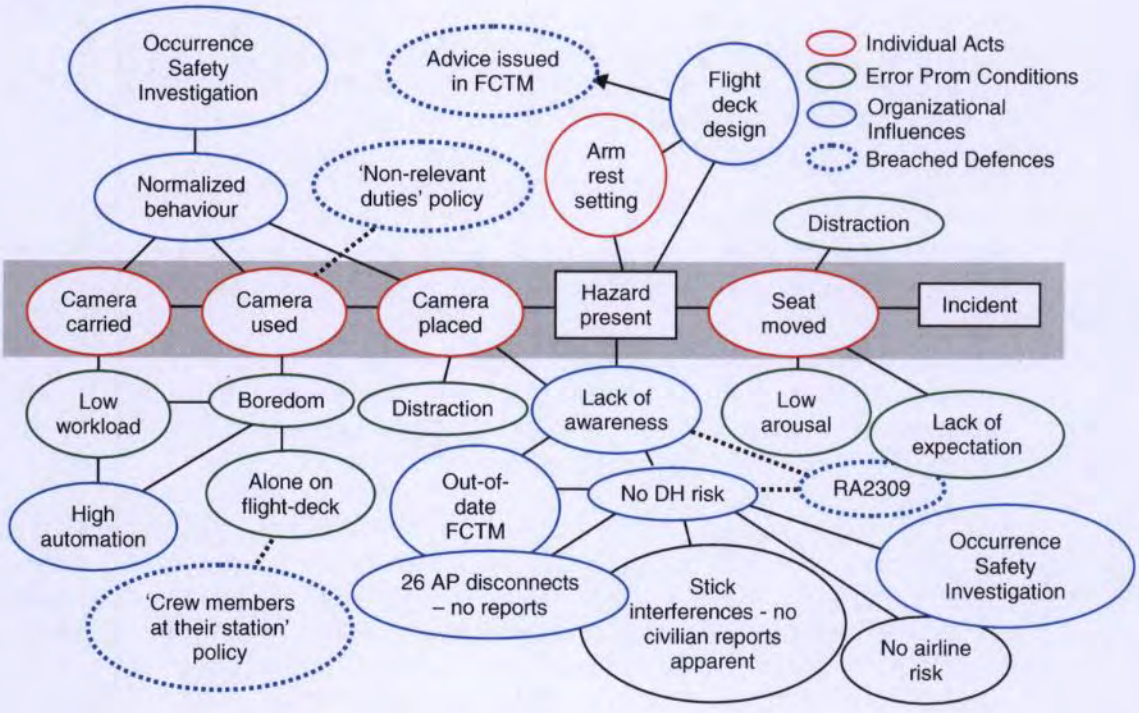

Figure 10: Diagram of key factors leading to pitch-down command.

1.4.35 **Carriage of the camera**. The carriage of the camera had a direct bearing on the incident, in as much as it was the object responsible for the side-stick interference. As such, the Panel concluded that **the carriage of the camera on the flight deck was a contributory factor**. This however, was influenced by a number of associated factors.

a. **Normalized behaviour**. The carriage of the camera was consistent with normalized behaviour regarding loose articles on RAF air transport aircraft. The Panel found evidence that the issue of loose articles on flight decks had been the source of considerable debate amongst junior Air Safety staff at RAF Brize Norton for several months leading up to the incident, but that it had not been resolved: Witnesses 10 & 11

(1) In Mar 13, 11 months before the incident, an Air Safety Occurrence Report (ASOR) was raised amongst Air Safety staff at RAF Brize Norton, who were concerned at the number of loose articles being found on board C-130 flight decks. A growing body of Exhibit 38

reports were being received from C-130 engineers describing how numerous aircrew items were being left on flight decks at the end of flights. In one three month period they included: five personal oxygen masks; one aircrew knife; three sets of spectacles plus cases; two NVG eyepiece covers; seven NVG helmet counter-weights, and six folders or notebooks. None of the items had been reported as missing by crews. By 12 Apr 13, RAF Brize Norton Air Safety staff began an Occurrence Safety Investigation (OSI) to examine whether the issue was limited to the C-130 fleet, and what measures should be taken to address it. The Occurrence Safety Investigators searched for reports on all of the fleets at RAF Brize Norton with the exception of Voyager, which was excluded because of perceived differences between their safety reporting system and that of the rest of the station. The investigators found no reports outside the C-130 fleet of loose articles on flight decks, leading to an assumption that the issue was limited to that fleet only. The issue was highlighted within the C-130 fleet over the next few months; however, loose articles continued to be reported. For the month of Oct 13 this included: two NVG batteries; one set of spectacles; one mobile phone; one finger-torch pouch; one NVG helmet counter-weight; one set of flight reference cards; two maps, and one jacket. None of the items found had been reported as missing by crews.

Witnesses 10 & 11

Exhibit 38

(2) By the time of the Voyager incident on 9 Feb 14, the OSI had still not published a formal report and an Occurrence Review Group had yet to convene to consider any findings (as required by AP 3207, Section 200.120 – Occurrence Safety Investigation).

Witnesses 10 & 11

(3) The Panel saw and heard evidence that the issue of loose articles was not, in fact, limited to the C-130 fleet. The C-130 was the only aircraft type at RAF Brize Norton whose engineers were constituted separately (and geographically remotely) from its flying squadrons. As such, some Air Safety staff believed that the issue of loose articles was simply being dealt with more directly on other squadrons where the engineers were embedded, rather than reported officially. Similarly to C-130 crews, Voyager aircrew were required to take a large number of items of equipment on board the aircraft for operational flights. These items included two sets of body armour for each crew member, combat survival waistcoats, crew weapons, aircraft documentation, two route bags, a set of worldwide navigation kit and charts and a bag of classified material. Only some of these items had designated storage, with the rest usually found space around the flight deck; for example, on the floor behind the pilots' seats (Figure 11 and Figure 12). This volume of items was a result of the nature of the tasking and the associated volume of paperwork necessary to support the mission. It is likely that the number of required items on the flight deck promoted an attitude that it was generally acceptable to have a large volume of items on the flight deck, such that the carriage of a small number of personal effects would not have seemed unreasonable. Accordingly, all pilots interviewed on 10 Squadron by RAFCAM reported having a personally acquired tablet computer that they would take with them on the flight to enable access to the large amount of aircraft documentation. It was also considered normal to carry a personal

Witness 1, Panel Interview 3

Annex B, para 25

Witness 10 & 11

Witness 10 & 11

Annex B, para 23

Exhibit 39

Annex B, para 24

navigation bag in which items such as clipboards, their tablet computer and additional paperwork would be carried. Annex B, para 24

Figure 11: Carriage of in-flight publications.

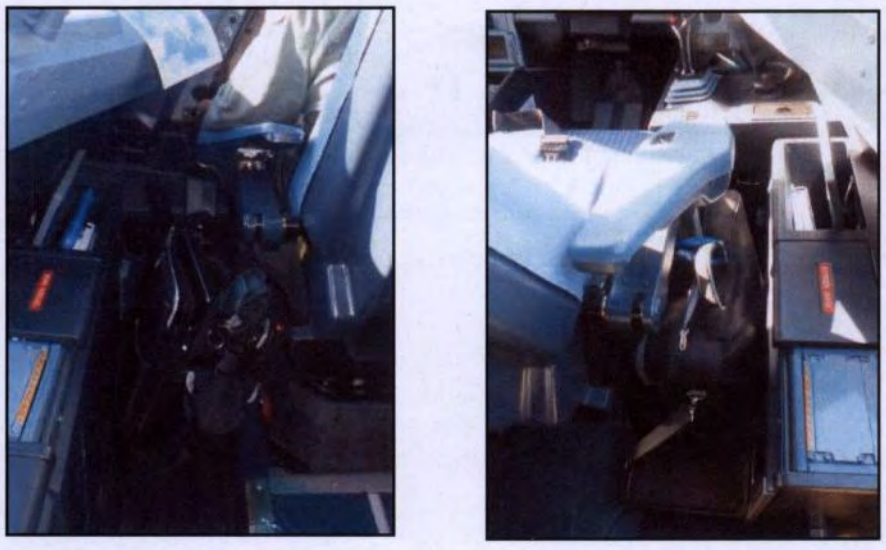

Figure 12: Floor area around Captain's and Co-pilot's seat.

(4) On the flight deck of any large aircraft a certain number of loose articles are inevitable if the aircraft is to operate effectively (pens, notebooks, spectacles etc). There was no evidence however, of official guidance or training within 2 Gp which related to the carriage and use of these items and how they should be stored and positioned on the flight deck, increasing the likelihood that personnel would develop their own norms and practices as a result of experience and advice of others. Photographs taken on the flight deck of ZZ333 shortly before the incident indicated that there were a number of loose articles placed in areas around the flight deck, some not officially designated for stowage (Figure 13). The selection of typical locations used to store items illustrates the challenge imposed by the imbalance between the available storage on the flight deck, the required volume of official equipment and documentation and the carriage of personal items. While the Voyager flight deck had adequate space for these items to be carried, there were not enough dedicated storage locations for the sheer volume of official items, resulting in items being stored on the floor and in ad hoc areas. In particular, the area around the side-stick appeared to be treated no differently to any other surface on the flight deck.

Annex B, para 21
Witness 1, Interview 3

Annex B, para 25

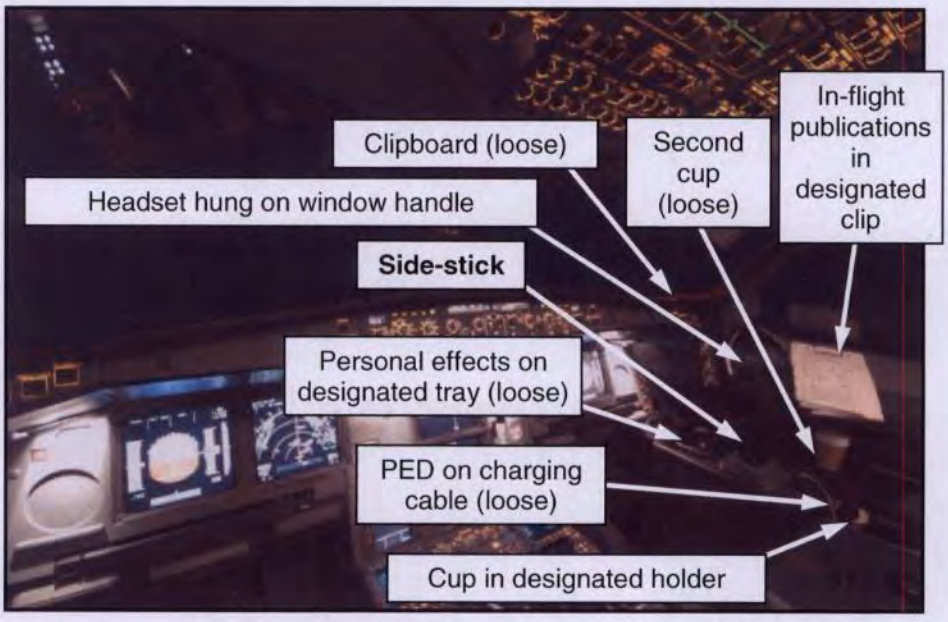

Figure 13: Photograph of Co-pilot's position 6 mins 15 seconds prior to incident.

(5) The carriage of personal items may also have been perceived as advantageous as it would provide access to items in flight which could be used to help maintain general mental alertness (see paragraph 1.4.36 (b) regarding **low workload** and **boredom**).

Annex B, para 24

(6) Reports of side-stick interference continued in the aftermath of the incident, even after safety advice had been issued by the MAA highlighting the risk of control interference. In Jun 14, four months after the incident, two reports emerged of inadvertent inputs to Voyager side-sticks resulting in one case from a loose article and in

another, from a pilot's leg knocking against the stick. In the case of the loose article, a documents folder had slipped from the pilots' tray table and made contact with the side-stick, disconnecting the autopilot and causing a master warning. In the other case, the pilot had been resting his foot on the raised foot-rest in the centre of the foot well, when his leg inadvertently knocked against the side-stick. He had been unable to feel the pressure of the side-stick against his leg because of the flight publication which was in his flying suit leg pocket. On both occasions, the autopilot was immediately re-engaged without the aircraft deviating from its flight path. Exhibit 40 Exhibit 41

(7) It was concluded that the carriage of a camera on the flight deck and its subsequent treatment in terms of stowage was consistent with wide-spread normalized behaviour at RAF Brize Norton regarding loose articles. The Panel assessed that **normalized behaviour regarding the carriage and treatment of loose articles was a contributory factor**. Furthermore, by excluding the Voyager fleet from its scope and not issuing a report by the time of the incident, the OSI was not sufficient in its thoroughness or timeliness to identify the extent of normalized behaviour with respect to loose articles. As such, Panel assessed that **the incomplete RAF Brize Norton OSI was a contributory factor**.

b. **Rules and regulations.** The carriage of the camera on the flight deck was not prohibited by any rules or regulations. Guidance in the Voyager Operations Manual, the aircraft Release to Service and Military Regulatory Publications, stated that portable electronic devices could be carried. Restrictions on the use of such items were only in regard to their transmitting properties during different phases of flight. Exhibit 42 Exhibit 43 Exhibit 44

1.4.36 **Use of the camera in flight.** The use of the camera on the flight deck during the flight had a direct bearing on the incident, in as much as it had just been used at the time it became lodged behind the side-stick. As such, **the use of the camera in flight was a contributory factor;** however, this was influenced by a number of associated factors:

a. **Rules and regulations.** The use of a camera on the flight deck during flight was not explicitly prohibited by any rules or regulations. As described in paragraph 1.4.35 (b), specific restrictions in the Voyager Operations Manual on the use of personal electronic devices related only to their transmitting properties during different phases of flight. However, in more general terms, the Voyager Operations Manual Part B, Section 2.1.2.6 stated that: Exhibit 45

- *Flight crew must refrain from non-relevant duties (e.g. paperwork, casual conversation), in circumstances such as (but not limited to): while the other pilot is away from the active Air Traffic Control (ATC) frequency.*

While on his own, the Captain took 28 photographs of the flight deck between approximately eight minutes and three minutes prior to the Exhibit 36

incident, which were not related to the duties he was carrying out at the time. In the judgement of the Panel, this was probably not a deliberate and conscious contravention of the rules. However, the use of the camera on the flight deck represented a lack of compliance with **the policy regarding non-relevant duties**, thus rendering the policy **a breached defence.**

b. **Low workload and boredom.** Voyager has a high level of automation. Of particular relevance to the ZZ333 incident is the impact of automation on workload. During a phase of flight (the cruise) when the workload on a pilot is low, a high level of automation can make it even lower, resulting in boredom and complacency. Individuals who are more susceptible to boredom are those with a high level of knowledge, education and ability, people who are keen for a demanding job, or people who are fatigued or not-adapted to night work. The cruise phase was described as a very quiet phase of the flight. The Captain and Co-pilot described the level of arousal, demands, and task difficulty during the cruise as between 'low' and 'very low'. The CVR provided some evidence of a low level of arousal, with yawns being audible in the 30 minutes prior to the incident, audible sighs and whistling while the Captain was alone on the flight deck and comments which indicated that it was perceived as a long and boring phase of flight. In the period immediately preceding the incident, the Captain reported that there were no aircraft indicated on the Traffic Collision Avoidance System (TCAS) and few ATC communications. The required tasks related to the flying of the aircraft at this stage were described by the crew in RAFCAM interviews as system monitoring, including checking fuel times and waypoints, checking the navigation display, running through the electronic system pages, monitoring the ATC frequency and obtaining the latest weather information. These tasks contained characteristics that give rise to boredom, in that the tasks demanded prolonged supervisory work, requiring vigilance, but with few cues to capture the crew's attention. Given the operating conditions, it was highly likely that the crew would take actions to raise their level of alertness and alleviate boredom. The crew described performing many of the actions considered by Human Factors experts as typical for Voyager air transport operations to maintain alertness during the flight. Specifically, they described having regular visitors to the flight deck, taking comfort breaks, reviewing in-flight paperwork and using personal items. In the Captain's case, this also included taking a considerable number of photographs. Notwithstanding the Voyager Operations Manual policy on non-relevant duties, undertaking actions such as these would have the perceived benefit of maintaining alertness and alleviating boredom. The Panel assessed that **low workload and boredom were contributory factors.**

Annex B, paras 17-19
Witness 1, Panel Interview 1
Exhibit 19
Witness 1, Panel Interview 1, A2
Annex B, paras 17-19
Exhibit 36
Exhibit 45
Annex B, para 18

c. **Single person on flight deck.** The Co-pilot left the flight deck approximately 18 minutes before the incident. As a result, and for most of this period, the Captain was alone on the flight deck and strapped into his seat. Approximately two and a half minutes after the Co-pilot left the flight deck, he returned briefly to bring the Captain a cup of tea. Approximately twelve minutes later the Purser came on to the flight deck and had a brief conversation with the Captain, departing approximately two minutes before the incident. While alone on the flight deck, there were a number of ATC communications between other aircraft, and one ATC communication

Exhibit 19
Exhibit 19

to which the Captain responded. Although the Captain had some interaction with other people while the Co-pilot was outside the flight deck, there was a much reduced level of personal interaction during this time and, due to being strapped into the seat, there were few opportunities for physical movement. Addressing the requirements for, 'crewmembers at their station,' the Voyager Operations Manual Part A, Section 8.3.10 stated that during the cruise: Exhibit 19 Exhibit 46

> • *...each pilot required to be on flight deck duty shall remain at his station unless his absence is necessary for the performance of his duties, or for physiological needs...*

There was no time limit associated with this guidance, although the Panel was told by a senior training officer that a pilot would not normally be expected to be absent from the flight deck for more than around five minutes. On the RAF C130J fleet, another two-pilot flight deck, standard operating procedures stated that no pilot was to be left alone on the flight deck for any amount of time. In the event that one pilot left a C-130J flight deck, a third crew member was to be present on the flight deck to monitor the remaining pilot. The presence on ZZ333 of only a single person in the flight deck for an extended period of time increased the risk of boredom and under-arousal, thus increasing the likelihood that the Captain would take actions to maintain his general alertness. The Panel assessed that **the presence of only a single person on the flight deck for an extended period of time was a contributory factor.** This represented a potential lack of compliance with the policy regarding crew members at their station, although it was possible to apply a wide interpretation to the rule. Nevertheless, as it did not prevent the extended absence of a pilot from the flight deck, **the policy regarding crew members at their station was assessed by the Panel to be a failed defence.** Witness 14 Exhibit 47

1.4.37 **Placing of the camera.** The placing of the camera between the armrest and the side-stick created a hazard. This went unrecognized initially, leading directly to the interference with the side-stick and the subsequent pitch-down. As such, the Panel assessed that **the placing of the camera was a contributory factor.** The reason why this act created a hazard, and the fact that it went unrecognized, was influenced by a number of associated factors.

a. **Distraction.** Immediately after the camera was last used, the CVR indicated that the Purser entered the flight deck and began a conversation with the Captain. This conversation could have drawn the Captain's attention and so reduced his focus on the task of stowing the camera. It cannot be positively determined that the camera was put down at this time, but if the point at which the camera was put down coincided with the Purser entering the flight deck, then it is possible that a distraction occurred. Without this distraction, it is possible that the camera may not have been placed behind the side-stick. The Panel assessed that **distraction of the Captain while using the camera was a possible contributory factor.** Exhibit 18 Exhibit 19

b. **Design of the side-stick area.** The side-stick is located on the outside of the Captain and Co-pilot seats.

(1) **Layout.** The seat can be positioned so that the side-stick is within the reach of the pilot. An armrest provides support to the pilot's elbow while using the side-stick, which is in line with good ergonomic practice to enable continuous adjustments and extended periods of use[2]. The armrest is adjustable to enable the pilot to achieve a comfortable working posture. A combination of the setting of the armrest and the seat position brings the armrest into the vicinity of the side-stick. The minimum distance the armrest can achieve relative to the side-stick when the seat is moved is 50mm. There is a minimum of 140mm clearance between the side-stick and the nearest fixed obstruction (Figure 14). Annex B, para 27

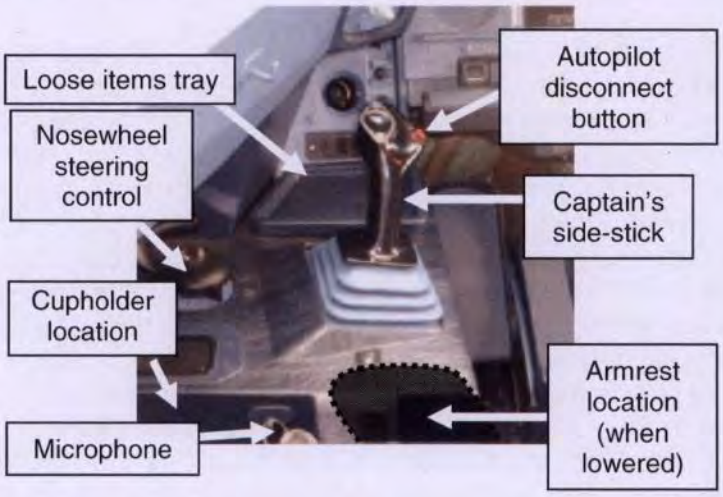

Figure 14: Layout of Captain's side-stick area.

(2) **Design to prevent accidental operation of the side-stick.** Joystick controls, such as the Voyager side-stick have a high likelihood of inadvertent operation[3]. Spurious or accidental operation of controls has been identified as an issue in safety critical systems[4], so it is good practice to include design features to reduce the likelihood of such accidental operation. For instance, British Standard (BS) 894 Part 3, though not specific to aviation, offers guidance on how equipment design can mitigate the likelihood of accidental operation such as recessing the control, shrouding the control, placing a collar around the control, using a lock out system, or requiring two-handed controls. European aviation regulations (specifically European Air Safety Agency (EASA) regulation CS25.777) state that controls must be designed 'to prevent inadvertent movement'. The nature of the protection against spurious operation that is appropriate will depend entirely on the context in which the control is operated. The certification of Voyager when it was brought into military service was conducted in Annex B, para 28 Exhibit 48

[2] Kroemer, K.H.E. and Grandjean, E. "Fitting the Task to the Human", Fifth Edition (1997) London: Taylor and Francis, and DEF-STAN 00-250, Part 3, Section 15.
[3] DEF-STAN 00-250, Part 3, Section 15.
[4] UK Health and Safety Executive, David Fox, "Inadvertent operation of controls in excavator plant - insight, analysis and recommendations for prevention by design." (Jan 14), http://www.hse.gov.uk/research/rrpdf/rr1000.pdf (accessed 2 Jun 14); and Australian Transport Safety, "Safety Bulletin 3 – Lifeboat Accidents," (1 Dec 03), http://www.atsb.gov.au/media/43401/lifeboat_accidents.pdf (accessed 2 Jun 14).

accordance with Joint Aviation Requirements 25 (civil two-crew cockpit certification) and Military Certification Review Items F11 and F16. Human factors assessments were conducted by the Design Organization, independently verified by INTA (the Spanish National Institute of Aerospace Technology) and witnessed by the UK Aircraft Test and Evaluation Centre. The Voyager side-stick is protected against accidental movement principally by its position being remote from other controls. In addition, when the autopilot is engaged, additional force is required to move the control from the neutral (central) position (see paragraph 1.4.19), reducing the likelihood that a low force impact against the side-stick by a person or an item would cause the aircraft to change trajectory. Furthermore, when inadvertent operation occurs, a specific audio and visual warning is triggered to alert the pilot. In respect to the seat controls, switches are designed to ensure that movement can only occur while the switch is held in position by the pilot.

Exhibit 49

Exhibit 126

Exhibit 48

Annex B, para 28

(3) **Potential for accidental operation of the side-stick.** Interviews with the ZZ333 crew indicated that there was a known issue that inadvertent contact with the side-stick (most commonly by a knee) could result in the autopilot being disconnected. Such incidents had been resolved immediately by re-engaging the autopilot and had not been reported formally. Data from AirTanker Services indicated that there may have been up to 26 incidents since the start of Voyager flying when the autopilot had been disconnected in the cruise by moving the side-stick against the increased force, although it is not clear how many of these were accidental. The layout of the side-stick means that there are few other controls in the vicinity that could interfere directly with it. The closest items to the side-stick are the nose-wheel steering control, microphone, and armrest. Of particular interest to the ZZ333 incident was the proximity of the armrest to the side-stick. The armrest moves with the seat and is never less than 50mm from the base of the side-stick. As a result it is not possible for the armrest itself to interfere directly with the side-stick, but the operation of the seat when an item of appropriate size is located between the armrest and the side-stick could create a situation in which movement of the seat causes the side-stick to be moved out of the central position while the autopilot is engaged. As such, **the design of the side-stick area was a contributory factor**.

Annex B, para 29

c. **Armrest setting.** Both the Co-pilot and Captain had tall upper bodies, with a sitting height that placed them between the 80th to 85th percentiles of the population. As a result, their required seat setting for operating the flying controls was lower than that of the majority of pilots. This seating position would cause the armrest to have no vertical separation from the side-stick. Vertical separation from the side-stick would reduce the scope for an item to become jammed between the armrest and the side-stick, because a wheel located on the underside of the armrest would enable it to simply roll over the top of any obstruction. The Captain's settings for the armrest are shown in Figure 15. Reconstruction of the incident in the Voyager simulator indicated that the configuration of the armrest, when combined with the nature of the camera obstruction and the lack of vertical separation of the armrest from the side-

stick, increased the risk of the item becoming jammed. Moving the seat forward against a camera of a similar size to the Captain's with the armrest at different settings (to those in Figure 15) did not result in the side-stick being held forward. **The armrest setting was a contributory factor.** Annex B, para 36

Figure 15: Captain's seat and armrest configuration.

d. **Awareness of the hazard.** The hazard presented by the loose article behind the side-stick was not recognized. Had it been so, either by the individual or the wider organization, it is possible that the camera might have been removed before it caused the side-stick interference, or that it might not have been placed behind the side-stick at all. As such, **a widespread lack of awareness regarding the risk of side-stick interference was a contributory factor.** The extent to which this was the case however, was influenced by a number of associated factors.

(1) The Flight Crew Training Manual (FCTM) is a generic publication produced by Airbus for all A330/340 operators. It is a supplementary document which sits outside the Voyager document set in order to provide pilots with useful information on how to operate the aircraft. The document included advice on 'clean cockpit' procedures in which it stated: Exhibit 50 Exhibit 51

- *Objects not stored in their dedicated area in the cockpit may fall and cause hazards such as damage the equipment [sic] or accidentally operate controls or pushbuttons.*

The document went on to recommend that any personal equipment should be, 'properly secured in the various stowage area [sic].' This advice was published in Dec 13, however the version of the FCTM which was available to Voyager crews on 9 Feb 14 reflected a previous edition which did not include this information. Owing to its supplementary nature, the Manual was not treated by users as a flight safety critical document and there was no regulatory obligation for operators to have the Manual available on the aircraft. Therefore, whilst Airbus recommended the document as a source of useful information, it was normal for the version in circulation amongst Voyager crews to not include the very latest amendments Exhibit 52 Exhibit 53

from the Company. Even had the latest version been in circulation, it is quite likely that its guidance would have been overwhelmed by the continuing demand for large amounts of equipment and documentation on the flight deck and the culture that this had fostered. Nevertheless, **the 'clean cockpit concept' represented a breached defence.**

(2) MAA Regulatory Article 2309 directed that: Exhibit 54

- *The aircraft commander should ensure that all loose articles and stores carried in the aircraft are properly stowed such that there is no possibility of fouling the flying controls.*

Voyager aircrew are not required to sign for Military Regulatory Publications, because the Voyager Operations Manual is designed to be a 'one-stop shop' covering the content of all relevant orders and regulations. There was no reference in the Voyager Operations Manual to RA 2309. Even had there been, the combined organizational guidance discouraging loose articles and the use of the camera on the flight deck represented only a few paragraphs in several thousands of pages of procedures and orders for which Voyager crews were required to sign. Human Factors analysis by RAFCAM highlighted that limited recall of procedures and difficulties in finding information within large numbers of documents increases the risk of unintentional procedural violations when flying. Nevertheless, the Panel assessed that **the lack of promulgation rendered Regulatory Article 2309 (carriage of loose articles) a breached defence.** Exhibit 55 Annex B, para 20

(3) Amongst a number of airlines which were canvassed by the Panel, none had identified the inadvertent operation of the side-stick to be a significant flight safety risk. The only reports of inadvertent side-stick operation had been associated with momentary movements of the side-stick by one or other of the pilots during autopilot operations, which had invariably been corrected quickly. One response highlighted that in over two decades of Airbus operations, no instance of side-stick interference as per the ZZ333 incident had been recorded within the Company. Loose article policy varied between airlines, with some requiring all portable electronic devices to be stowed away unless they did not represent a loose article hazard, while others had no formal loose article policy at all. No evidence was found to indicate that this risk had ever warranted significant attention within the airline industry as a whole. While the Captain had conducted his original A330 training within the civilian sector therefore, it is unlikely that this experience would have increased his chances of recognising the risk posed by the camera behind the side-stick. Exhibit 56, Exhibit 57 Exhibit 58 Exhibit 59

(4) Airbus were aware of two reports where side-stick interference had occurred in the past on Airbus aircraft; one, a loose cover stuck between a side-panel and the side-stick, impairing the side-stick movement, and another in which an incorrectly stowed hand microphone had impaired side-stick movement. Most notably Exhibit 29

however, the Panel found 26 incidents of inadvertent autopilot disconnections on Voyager between Apr 12 and Mar 14. Of these, none had been reported via the flight safety reporting system. MAA Regulatory Article 1410 stipulated the type of safety occurrences which must be reported officially, which included 'uncommanded flying control movements, no matter how momentary.' Involuntary disconnections of the autopilot were not explicitly included within this definition. Though RAFCAM interviews with the crew suggested these occurrences were a known issue, the Panel found little evidence that this was recognized at an organizational level. Had these occurrences been the subject of regular reporting within the Voyager Force, there would have been greater organizational awareness of the susceptibility of side-sticks to inadvertent interference. The Panel assessed that **a lack of reporting regarding inadvertent operations of the side-stick was a contributory factor.** Exhibit 60 Exhibit 61

(5) HQ 2 Gp held a risk register for Voyager operations. The risk register did not include a specific risk related to items becoming jammed between the armrest and the side-stick, nor did it contain any entry relating to the potential for inadvertent interference with flight deck controls. There was no evidence to indicate that the MAA Regulatory Article regarding loose articles had influenced the risk management processes for Voyager. That such a risk did not feature would have been influenced by: the lack of 'clean cockpit' advice in the FCTM in circulation at RAF Brize Norton; the absence of any similar identifiable risk within the airline industry; the apparent absence of any previous side-stick interference incidents on A330s; the general lack of reporting regarding inadvertent disconnections of the Voyager autopilot, and the inconclusive OSI regarding loose articles. The Duty Holder system is the only place where these various strands might feasibly have been brought together to inform a suitably articulated risk. That this potential hazard did not surface in the risk management process reduced the likelihood that suitable mitigations would be in place, and also made it unlikely that Voyager aircrew would have been any more cognisant of the specific hazard than the organization around them. The Panel assessed that **the lack of an identified Duty Holder risk regarding flight deck control interference was a contributory factor.** Exhibit 62

1.4.38 **Movement of the seat**. The movement of the Captain's seat without the interference with the side-stick being noticed represented an attentional lapse which led directly to the incident. As such, the Panel assessed that **the movement of the Captain's seat was a contributory factor**. The likelihood of this attentional lapse however, was influenced by a number of error promoting conditions:

a. **Low arousal**. The CVR provided evidence of a low level of arousal, with yawns being audible in the 30 minutes prior to the incident, audible sighs and whistling while the Captain was alone on the flight deck and comments that indicated that it was perceived as a long and boring phase of flight. The Captain may have been experiencing low arousal and underload as a result of the in-flight conditions which would have reduced his alertness and available attentional resources. Exhibit 2 Annex B, para 43

b. **Distraction**. There was a time delay between the Captain putting down the camera and the incident occurring of at least 104 seconds (as the camera would need to be in position from the first seat movement to enable the initial deflection of the side-stick to occur). Therefore, even if the Captain was initially aware that the camera had been placed in this position, he may have forgotten its location by the second time the seat was moved. Furthermore, the seat controls are located on the opposite side of the seat at some distance from the location of the camera. Therefore, while moving the seat it is unlikely that the Captain's attention would have been focussed on the location of the camera. Exhibit 2

c. **Cognitive lack of expectation**. The seat movement mechanism and the aircraft attitude controls are completely separate systems with no designed interface between them. The seat had been moved on many occasions in the past with no impact on the aircraft pitch, including 104 seconds prior to the incident (after the camera had been put down). Therefore, for movement of the seat to result in a change in aircraft pitch would be extremely unexpected. Annex B, para 50 (e)

1.4.39 **Mitigation of the risk**. Safety advice was issued by DG MAA on 28 Feb 14 highlighting the potential for foreign objects to interfere with side-stick controllers in such a way as to significantly endanger the safety of flight. Subsequent to the publishing of its Interim Report on 23 Mar 14, the Panel canvassed opinions from the aircraft manufacturer, from a number of civilian A330 airlines, and from EASA regarding the mitigating measures, design changes or technology which could be used to prevent the inadvertent operation of the side-stick. Exhibit 63

a. **Airbus**. According to Airbus, the primary mitigation for side-stick interference was the 'clean cockpit' concept, described in the FCTM. The Company explained that the side-stick design is the same between the A330/A340 and A320 families and that between all of these aircraft variants, a total of approximately 190 million flight hours and 86 million flight cycles had been accumulated. The incident involving ZZ333 was the first of its type ever to be reported to Airbus. Accordingly, the manufacturer regarded the 'clean cockpit' concept to be an appropriate mitigation. Airbus planned to issue a communication to all operators in order to remind them of the importance of the clean cockpit concept, using the ZZ333 incident as an illustration of the possible consequences of not complying with it. Exhibit 64 Exhibit 53

b. **Airline operators**. None of the airlines who were questioned regarded a change to the design of the flight deck to be necessary or practical. Some pointed out that mitigation already existed in the form of the audio and visual warnings for inadvertent autopilot disconnection. As well as highlighting the risk to crews through recurrent training and flight safety publications, suggestions for more practical mitigations included the use of a warning placard between the armrest and the side-stick, and a formal policy of not placing any items on the side-stick console. Exhibit 56 Exhibit 57 Exhibit 58

c. **EASA**. To the knowledge of EASA, the ZZ333 incident was the first of its type ever recorded in over 25 years of side-stick operations. They found it difficult to see how designs could be improved to reduce susceptibility to the type of incident seen on ZZ333. Exhibit 48

1.4.40 **Summary of factors**. The key factors which made the pitch-down command more likely were summarised as follows:

a. **Individual acts**. The following factors were classified under individual or unsafe acts:

(1) The carriage of the camera on the flight deck.

(2) The use of the camera in flight.

(3) The armrest setting.

(4) The placing of the camera behind the side-stick.

(5) The movement of the Captain's seat.

b. **Error promoting conditions**. The following factors were classified under error promoting (or local) conditions:

(1) Low workload.

(2) Boredom and low arousal.

(3) The presence of only a single person on the flight deck for an extended period of time.

(4) Distraction.

(5) Cognitive lack of expectation.

c. **Organizational influences**. The following factors were classified under organizational influences:

(1) Normalized behaviour regarding the carriage and treatment of lose articles.

(2) The RAF Brize Norton OSI into loose articles.

(3) The design of the side-stick area.

(4) A widespread lack of awareness regarding the risk of side-stick interference.

(5) The lack of reporting regarding inadvertent operations of the side-stick.

(6) The lack of and identified Duty Holder risk regarding flight deck control interference.

d. **Breached or failed defences**. The following factors were classified under breached or failed defences:

(1) The Voyager policy regarding non-relevant duties.

(2) The Voyager Operations Manual policy regarding crew members at their station.

(3) The Airbus FCTM advice on the 'clean cockpit' concept.

(4) MAA Regulatory Article 2309 (carriage of loose articles).

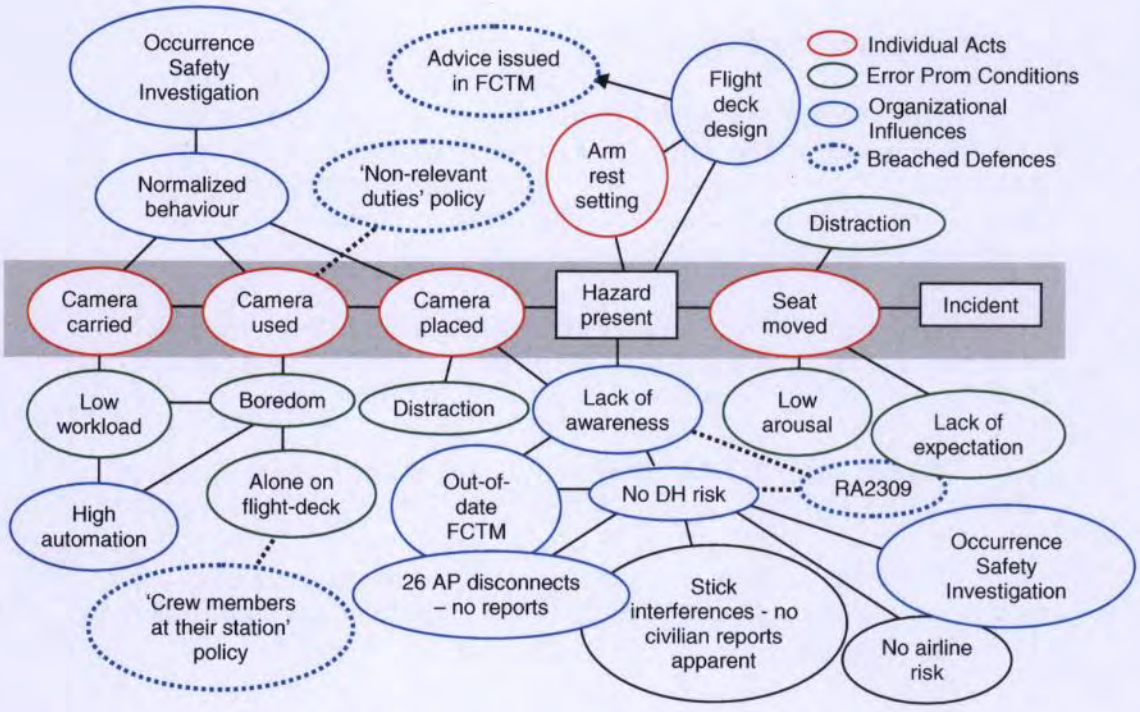

Figure 10 (Repeated): Diagram of key factors leading to pitch-down command.

Summary

1.4.41 The factors which led to the pitch-down command were influenced principally by the safety culture with respect to loose articles on the flight deck. Behaviour with respect to the carriage and treatment of loose articles on RAF air transport flight decks had become normalized. While a number of loose articles on flight decks were inevitable and necessary, the sheer volume of items that was required to be taken on board the flight deck undermined the possibility of complying with the little guidance that existed on how loose articles should be treated and stored. Accordingly, a culture developed in which it was generally acceptable to have a large number of items on the flight deck stored in ad hoc areas, such that the carriage of a small number of personal effects would not have seemed unreasonable. There was evidence in some areas of a general lack of control and accountability regarding such items, with numerous and persistent reports of unclaimed articles being found on flight decks by engineers. An Occurrence Safety Investigation into the loose article issue was artificially constrained and did not get to the heart of the matter. As such, there was a widespread lack of awareness regarding the risk posed by loose article interference, exacerbated by the apparent lack of any associated reporting. It was

known that the design of the flight deck could make it susceptible to interference from loose articles, but the manufacturer's advice featured in a supplementary publication which was not part of the Voyager core documentation. Even had the advice been available to crews, it is likely that it would have simply been overwhelmed by the continuing demand for large amounts of equipment and documentation on the flight deck and the culture that this had fostered. Accordingly, an individual act arising from normalized behaviour on a highly automated flight deck resulted in significant safety consequences.

Recommendations

1.4.42 **The Panel recommended that:**

a. **AOC 2 Gp implements a comprehensive strategy to effect a positive change in the safety culture with respect to loose articles on the flight decks of 2 Gp aircraft. The strategy should promote awareness of the risks loose articles pose to flight safety, and improve behaviours and accountability.**

b. **AOC 2 Gp conducts a review of the items carried by crews on all 2 Gp aircraft types, and take steps to minimize what is carried on the flight deck and maximize the use of designated stowage areas.**

c. **DACOS AvMed, RAFCAM examines ways of managing low in-flight pilot workload to minimize the risk of boredom and underload.**

d. **AOC 2 Gp reviews the rules governing crew members at their station to minimize the risks associated with having a single pilot on the flight deck.**

e. **Director Air Support, DE&S examines and, if possible, implements measures that could help prevent the placing of loose articles in close proximity to the side-stick of aircraft so equipped.**

f. **Stn Cdr, RAF Brize Norton takes measures to further strengthen the reporting culture and OSI process at RAF Brize Norton to ensure that risks are being adequately captured.**

g. **AOC 2 Gp, in consultation with AirTanker Services Ltd and Airbus, ensures that the Voyager Document Set is configured to capture all the manufacturer's safety advice, including that contained within supplementary documents.**

The recovery from the pitch-down command

1.4.43 The interference with the side-stick persisted for a total of 33 seconds before the camera became free (illustrated by the bracket in Figure 16). The recovery from the pitch-down command was analysed in three phases: first, the initial response on the flight deck; second, the response of the aircraft; and third, the clearing of the side-stick obstruction.

Exhibit 30

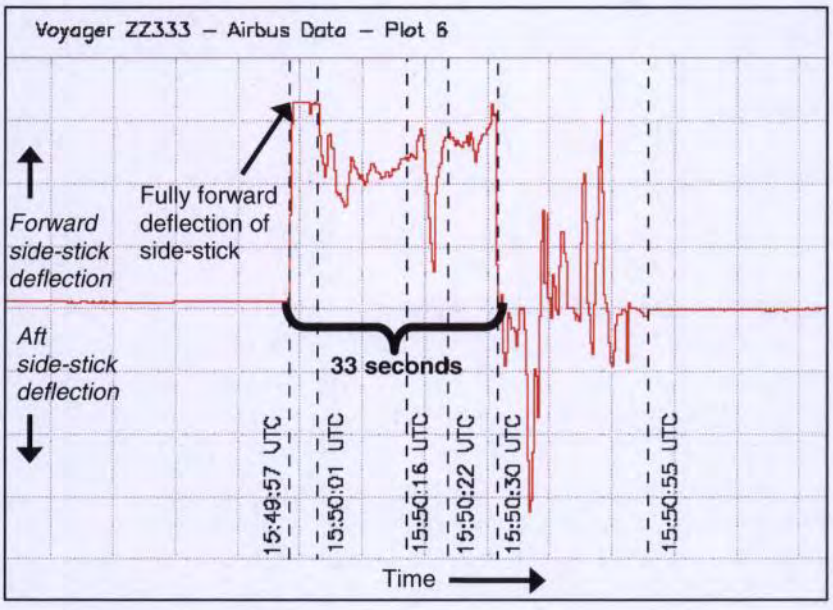

Figure 16: ZZ333 DFDR trace of Captain's side-stick in pitch.

The initial response on the flight deck

1.4.44 The Captain described his initial actions on identifying that the aircraft was descending and accelerating as being instinctive; to pull back on the side-stick. The aim of this action was to bring the aircraft nose up and so arrest the descent. Two seconds after the autopilot disconnected, there was a slight sideways (right) input on the side-stick which was probably the result of the Captain reaching forward and taking hold of it.

Witness 1, Interview 1, & Interview 3
Exhibit 20

Annex B, para 57 (a)

1.4.45 Approximately three seconds after the initial pitch-down (**1550:01 UTC**), the DFDR showed the Captain's side-stick moving rearwards by approximately five degrees from the fully forward position. It was assessed that this movement occurred as a result of the Captain pulling back on the side-stick. The rearward movement achieved, however, was not enough to fully regain control of the aircraft (Figure 17). It was assessed that the side-stick could not be moved fully because, at this stage, the camera and armrest restricted rearward movement. The Captain reported that he interpreted this lack of movement as the side-stick being stuck, thus leading him to believe that the autopilot was engaged.

Exhibit 20

Witness 1, Panel Interview 1
Annex B, para 57 (b)
Annex C

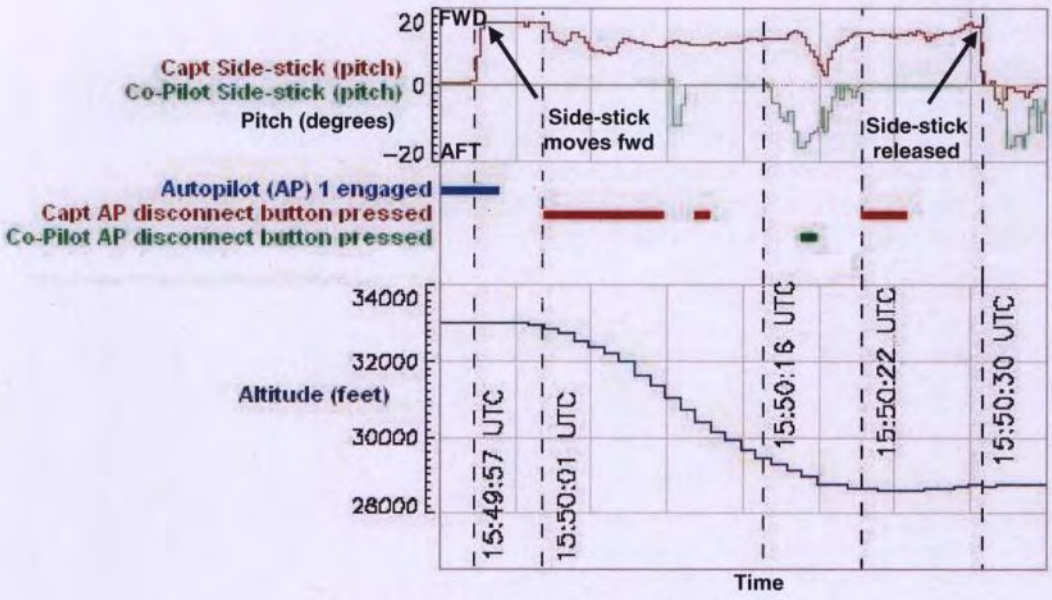

Figure 17: Composite DFDR trace.

1.4.46 The normal method of disconnecting the autopilot is via the side-stick autopilot disconnect button (also known as the instinctive cut-out button), which is located next to the thumb's natural position on each pilot's side-stick (Figure 18). Disconnecting the autopilot using this button triggers an audio warning known as the 'cavalry charge' (because of its distinctive warble); the warning lasts for 1.5 seconds. Disconnecting the autopilot by any other means (for example, by a physical push on the side-stick of at least five deca-Newtons) is classed as an inadvertent disconnection. Such an action also triggers the 'cavalry charge', but as a *continuous* warning, and is accompanied by a flashing red 'master warning' caption in front of the pilot. As the pitch-down command began, a *continuous* 'cavalry charge' sounded and the red 'master warning' caption illuminated to indicate that the autopilot had been disconnected inadvertently.

Exhibit 20
Exhibit 2
Annex C

Figure 18: Captain's autopilot disconnect button (indicated by arrow).

1.4.47 Pressing the autopilot disconnect button also allows a pilot to take priority over the other pilot's side-stick for the inputting of flying commands. This feature is activated when an autopilot disconnect button is pressed on one of the side-sticks when the autopilot is *not* engaged, and triggers a 'priority left' or 'priority right' audio warning. One second after the Captain pulled back on his side-stick, a 'priority left' audio alert sounded, indicating that he had pressed his autopilot disconnect button, but that the autopilot was *not* engaged. The Captain repeatedly pressed his autopilot disconnect button (Figure 17) in order to disengage the autopilot, based on his belief that the autopilot was still engaged. At the same time, the DFDR showed that the Captain's side-stick was moving further rearward, but still not reaching the neutral (central) position. It is assessed that this occurred as a result of the Captain applying additional force in an attempt to free the restriction on the side-stick.

Exhibit 2

Witness 1, Panel Interview 1

Exhibit 20

1.4.48 **Initial hazard identification by Captain**. Taken together, the above actions represented an instinctive but unsuccessful initial response to counter the pitch-down command by moving the side-stick rearwards and pressing the autopilot disconnect button. In the process of doing so, the Captain did not register the audio or visual cues indicating that the autopilot was already disconnected. The Captain described his inability to move the side-stick as leading to his belief that the autopilot would not disengage, rather than indicating there was an obstruction next to the side-stick. His initial actions reflected his attempts to solve a perceived problem by trying alternative ways of disconnecting the autopilot. In the view of the Panel, had the Captain realised immediately that there was an obstruction next to the side-stick, it is unlikely that he would have persisted with his attempts to disengage the autopilot. It is likely that, in addition to the error promoting conditions surrounding the initial seat movement, the following factors initially undermined the Captain's ability to detect the presence of the side-stick obstruction:

Annex B, para 58

a. **Workload.** The Captain described the demands and difficulty associated with the initial response to the incident as very high, and that there was a very high level of arousal during this phase of the response. Where task demands are very high, attentional resources are reduced and become focussed on a small set of cues. The Captain described only seeing the colours on the flight displays rather than the full detail, and did not recall the auditory alerts taking place, possibly reflecting this narrowed attentional focus. The Captain was, therefore, unlikely to have had a full appreciation of the cues to the autopilot status, such as the display indications and warnings and so focussed on a smaller subset of cues; the side-stick being unable to move.

Annex B, para 58 (a)

b. **Distraction.** The situation of a negative 'g' pitch-down generated a very unusual environment. A number of auditory alerts also commenced in quick succession at the onset of the incident, and these would have been accompanied by visual warnings on the flight deck. The Captain was simultaneously calling for the assistance of the Co-pilot who was aft of the flight deck in the galley area. The temporary negative 'g' would also have had the effect of

altering the normal position of the Captain's forearm behind the side-stick. These occurrences would have competed for the Captain's attentional resources, further reducing those available to gather further information on autopilot status and consider alternative explanations of why the side-stick was not achieving its expected range of movement. Annex B, para 58 (b)

c. **Fixation.** The Captain was likely to have been focussing all his available attentional resources on interpreting the situation and trying to move the side-stick. When undertaking problem solving, it is not unusual for individuals to become fixated on a particular solution set and require a shift in focus to a new set of possible solutions to enable the problem to be solved. The problem solving undertaken in the first ten seconds after the pitch-down command reflects a cycle of pursuing different ways to disconnect the autopilot (applying more force and pressing the disconnect button) rather than considering that an obstruction was preventing movement. This is consistent with typical styles of problem solving. Annex B, para 58 (c)

d. **Out of the loop performance issues.** A common issue cited with the use of automation is that crews may have a reduced level of performance when required to step in, particularly during the initial phases of response[5]. Such deficits may be as a result of reduced situational awareness or due to the need to have a sudden increase in alertness to reflect the revised demands of the situation. It is possible that these factors may have negatively influenced decision making during the initial response phase. Annex B, para 58 (d)

1.4.49 **Initial actions of Co-pilot.** The Co-pilot described his initial focus at the onset of the incident as being to access the flight deck. He reported pushing off from the galley ceiling, entering the flight deck, and travelling across the ceiling to his seating position. While moving onto the flight deck, the Co-pilot described how the Captain was looking at him and instructing him to get into his seat. The first movement of the Co-pilot's side-stick occurred 13 seconds after the full deflection of the Captain's side-stick, and consisted of a movement rearward. The initial movement was of a very brief duration and so it is not clear if this was a positive action by the Co-pilot or part of his movements to get to his flight deck position. Six seconds later the Co-pilot's side-stick was pulled rearward again and, for the following five seconds, made varying rearward movements. At the same time, a 'priority right' alert sounded, indicating that the Co-pilot was also pressing his autopilot disconnect button (Figure 17). The Co-pilot described seeing and hearing alarms on the flight deck and hearing the Captain's instruction to try and get the autopilot out. The Co-pilot described his initial aim as being to disengage the autopilot and the recorded actions of pulling the side-stick and pressing the side-stick button were consistent with this aim. Had the Co-pilot been able to respond immediately to the onset of the pitch-down command, the pitch-down command would have been neither as severe, nor as sustained, as it eventually was. As such, the Panel assessed that **the presence of only** Witness 2 Panel Interview 2; Exhibit 20; Exhibit 2 Witness 2, Panel Interview 2; Annex B, para 60

[5] Inagaki, T., Takae, Y., & Moray, N. (1999). Automation and human interface for takeoff safety. *In R.S. Jensen, B. Cox, J.D. Callister, & R. Lavis (Eds.), Proceedings of the 10th International Symposium on Aviation Psychology*, 402-407. Columbus, OH: The Ohio State University.

a single pilot on the flight deck was an aggravating factor.

1.4.50 **Initial hazard identification by Co-pilot.** The initial actions undertaken by the Co-pilot were consistent with those undertaken by the Captain; to disengage the autopilot and to pitch the aircraft up by moving the side-stick rearward. The actions undertaken by the Co-pilot were perceived on the flight deck as being successful as his moving of his own side-stick co-incided with the aircraft levelling off. The Co-pilot did not appear to consider whether the autopilot had already disengaged. It is assessed that this was likely to have been influenced by: Annex B, para 61

a. **Instructions from Captain.** The Co-pilot was outside the flight deck at the time the incident began. On arriving on the flight deck he would have sought input from the Captain, who had already started to respond to the incident, to advise on the actions required to deal with the incident. The Captain gave a very clear instruction that he could not disengage the autopilot and that the Co-pilot should attempt to do so. Witness 2, Panel Interview 2 Annex B, para 61 (a)

b. **Alerts.** At the time the Co-pilot entered the flight deck the auditory alert to the autopilot disengagement was no longer sounding, so the cues to the disengagement of the autopilot were limited to the text on the visual displays. Annex B, para 61 (b)

c. **Workload.** The Co-pilot described the arousal and demands associated with the initial response to the incident as very high. Where task demands are very high, attentional resources are reduced and become focussed on a small set of cues. As a result, the Co-pilot may have had limited resources to conduct a full diagnosis of the aircraft systems, at least at the initial stages of the response. Annex B, para 61 (c)

d. **Distraction.** The situation of a negative 'g' descent meant that the Co-pilot entered the flight deck on the ceiling and reached his workstation at a very unusual angle. This was a highly unusual and unexpected situation which would have competed for attentional resources, further reducing those available to him to undertake full diagnosis of the aircraft systems. Annex B, para 61 (d)

The response of the aircraft

1.4.51 Airbus aircraft are designed with self-protection features which engage automatically to prevent certain in-flight limits being exceeded. As with any type of aircraft, flying beyond maximum design speeds brings a risk that control difficulties will be experienced and that damage to the aircraft's structure will occur. As a result, Airbus aircraft are designed with high-speed protection which is triggered when an excessive build-up of speed is detected. The feature acts to increase the positive load factor on the aircraft (within 'g' limits) in order to protect the aircraft in the event of a dive. The feature is enhanced by pitch-down protection, which acts to progressively limit pitch-down commands from 10 degrees nose-down, until they are locked out Exhibit 65

altogether at 15 degrees nose-down. The pilots have the authority to override these features by a small margin, but once the protection measures are active both pilots' inputs are limited until parameters fall back within limits. The protection features do not require the autopilot to be engaged. Analysis of the pilots' actions and the aircraft's response during the incident established the following points (Figure 19 refers): Exhibit 66

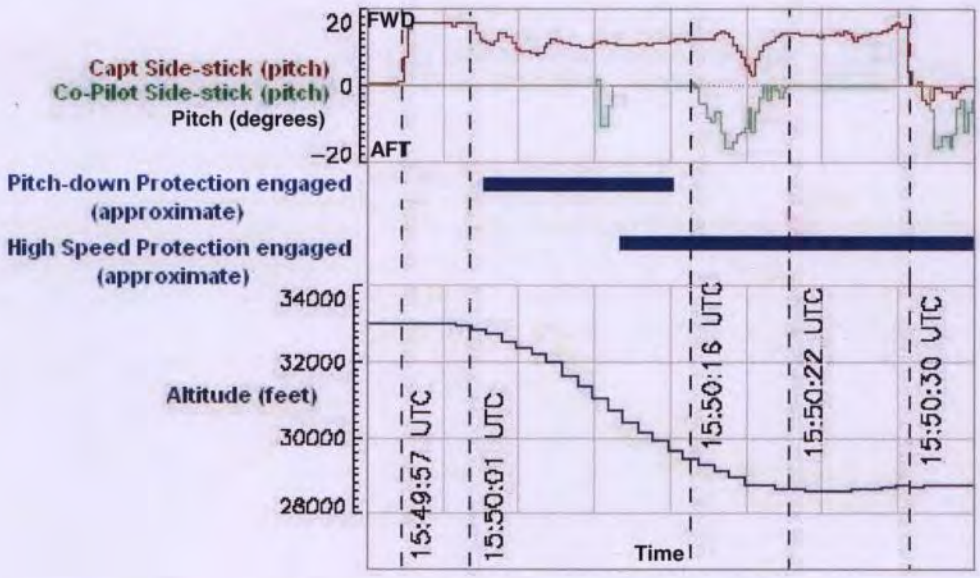

Figure 19: Composite DFDR trace.

a. Pitch-down protection was triggered approximately three seconds after the pitch-down command. A pitch limit of approximately 17 degrees nose-down was achieved as a result of the Captain's side-stick remaining significantly forward of the neutral position for over 30 seconds. As the 17 degree attitude was approached, the position of the elevators was automatically reduced towards zero. Annex C

b. High-speed protection was triggered approximately 13 seconds after the pitch-down command. An overspeed warning commenced at **1550:11 UTC** as the aircraft's speed passed 330 Knots Indicated Airspeed (KIAS)/Mach 0.86 and persisted for 24 seconds. The aircraft automatically pitched upwards under a sustained positive 'g' force of approximately 1.75 'g'. The DFDR recorded a peak speed of 358 KIAS/Mach 0.9. Although the thrust levers were moved to idle by a pilot input, the engine thrust had already been automatically reduced to near idle prior to this action. By the time the aircraft had begun to recover from the dive, no sustained or meaningful pitch-up commands had been successfully made by either the Captain or the Co-pilot. As such, the initial recovery from the dive was the result of the aircraft's own protection measures and not the product of pilot inputs. Annex C Exhibit 20 Annex C

c. The DFDR showed that at **1550:19 UTC**, the Co-pilot's side-stick pitch-up inputs were negated by the pitch-down inputs from the

Captain's side-stick (the aircraft summing the combined inputs from both side-sticks). As high-speed protection was in force at the time, the pilots' inputs were being severely limited. Nevertheless, where the Co-pilot inputs did have an impact was in biasing the mean input from both side-sticks in the correct sense, so as to assist the high-speed protection in reducing the airspeed. Had control of the aircraft been formally handed to the Co-pilot however, his inputs could have locked out the inputs from the Captain's side-stick altogether. This would have required the Co-pilot to press and hold his disconnect button whilst maintaining back-pressure on his own side-stick, thus locking-out the pitch-down command from the Captain's side-stick. Regulatory Article 2309(5) stated the requirement that, 'control in aircraft with dual controls shall be formally handed over.' The ability for the Co-pilot to take control priority was undermined because no formal handover of control took place, and because the Captain's disconnect button was being continually pressed throughout the dive (thus denying control priority being given to the Co-pilot's side-stick for long enough to be effective). The lack of a formal handover was undoubtedly influenced by the factors discussed in paragraph 1.4.48-50. Nevertheless, because both pilots were making competing control inputs to the aircraft, the recovery did not begin sooner. The Panel assessed that **competing control inputs on the flight deck represented an aggravating factor.**

Exhibit 20
Annex C
Exhibit 2
Exhibit 67
Exhibit 20

d. The Voyager Flight Crew Operations Manual and the Voyager Quick Reference Handbook state that pilots should apply the overspeed recovery procedure in the event that the overspeed warning is triggered. The drill requires the speed brake to be extended to the full position in order to counter the build-up of speed. This is the only positive action that the overspeed recovery demands, but it was not carried out. The Panel established that the Captain and Co-pilot had been trained in overspeed recoveries, including the use of speedbrakes. Had the drill been carried out, the extent and severity of the incident would have been mitigated and a more prompt recovery would have been possible. The lack of an overspeed drill was undoubtedly influenced by the factors discussed in paragraph 1.4.48-50. Nevertheless, the Panel assessed that **the absence of flight deck inputs in accordance with the overspeed drill was an aggravating factor.**

Exhibit 68
Exhibit 69
Exhibit 59
Exhibit 70
Exhibit 71
Exhibit 72

e. As the aircraft first began pitching-down, and believing he had an autopilot malfunction, the Captain had considered initially switching off the Air Data and Inertial Reference Units (ADIRU) in order to place the aircraft into 'direct law', and thus help wrest back control. The ADIRUs supply data on airspeed, angle of attack and aircraft altitude to various on-board systems, including the engines, the autopilot and the flying controls. Had they been switched off, the aircraft's self-protection measures for overspeed and pitch would have been disabled. Without pitch-down protection and high-speed protection, the Panel assessed that the certified limit of 365 KIAS would have been exceeded by a significant margin, potentially leading to significant damage to the aircraft.

Witness 1, MilAAIB interview
Exhibit 73
Annex C

Clearing the side-stick obstruction

1.4.52 **Methods of clearing the side-stick obstruction**. The side-stick became free at **1550:30 UTC**, some 33 seconds after the initial interference from the camera, with the aircraft under positive 'g' and in an approximately straight-and-level attitude. Repeated analysis was undertaken to examine how the obstruction may have been released by examining a number of ways in which the camera could have become free from its jammed position between the side-stick and the armrest. The analysis was conducted in several stages, including two practical sessions; one in an A330 simulator at Airbus HQ, Toulouse, and one in the Voyager simulator at RAF Brize Norton. Present at one or both of the practical sessions were two test pilots (including the Airbus Chief Test Pilot), a Human Factors Psychologist, members of the SI Panel and Investigators from MilAAIB. The simulator analysis was undertaken with a substitute camera of a size representative of the Captain's. Exhibit 20 Annex B, para 62

a. **Rearward movement of the side-stick.** Moving the side-stick backwards was not able to release the camera, as this movement exacerbated the jamming of the obstruction between the side-stick and the armrest. Annex B

b. **Sideways movement of the side-stick.** Repeated lateral movements of the side-stick resulted in the camera being released. Between eight and ten full-scale deflection lateral movements were required for the camera to be released by this method alone however, and such side-stick movements were not observed on the DFDR of ZZ333. Annex B

c. **Movement of the seat.** Rearward movement of the seat resulted in the camera being released. Annex B

d. **Movement of the armrest.** Movement of the armrest upward resulted in the camera being released. Annex B

e. **Movement of the camera.** Movement of the camera, using one or both hands, resulted in the camera being released. The force required to move the camera varied depending on the direction in which the camera was pushed or pulled and the way in which the camera was gripped. Movement of the camera was easier when a twist was added to the movement. Annex B

f. **A combination of movement types.** Combining one or more of the movements described in (a) to (e) would result in the camera being released, with a smaller degree of movement being required on each movement type. Annex B

1.4.53 On its own, the simulator analysis could not be used to conclusively determine how the camera was freed from behind the side-stick. It is unlikely however, that the camera could have become free without a positive movement of the armrest, the seat or the camera itself (or some combination of the three). [redacted] Annex B, para 62 Witnesses 1 and 2

[redacted] As such, the only way the Panel could assess how the incident was resolved was by means of a detailed examination of the DFDR and a forensic analysis of the side-stick.

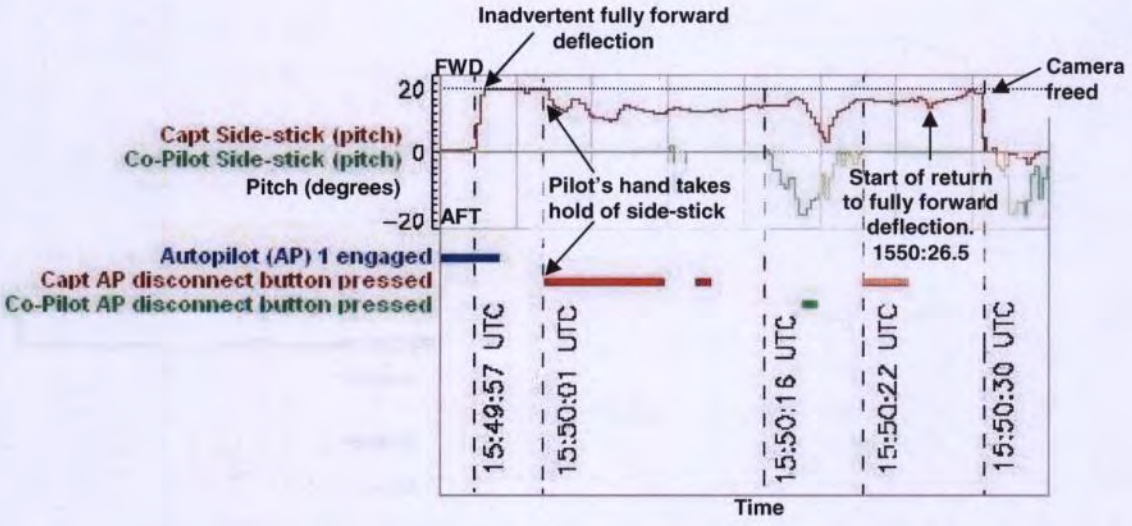

Figure 20: Composite DFDR trace.

1.4.54 Examination of the DFDR/CVR at the point the camera became free produced the following analysis:

a. Between **1550:26.5 UTC and 1550:29 UTC**, the side-stick began moving towards a fully forward deflection, the first such deflection of the side-stick since the initial pitch-down at **1549:59 UTC** (Figure 20). At the point of this second fully forward deflection, the aircraft was still experiencing an overspeed and was in a relatively level attitude. The movement of the side-stick to a fully forward deflection, therefore, was unlikely to have been made in an attempt to control the aircraft as such an input would only serve to exacerbate the overspeed and recreate the dive.

Annex C

Exhibit 20

Annex C

b. Small rapid lateral inputs on the side-stick occurred in the one second immediately prior to the camera becoming free (Figure 21, right-hand trace). The inputs were too rapid to have constituted an attempt to roll the aircraft, since the aircraft would not have had time to react to the roll inputs before they were reversed. Nor did there appear to be an obvious requirement to apply roll at this point, since the aircraft was in an approximately wings-level position.

Annex C

c. [redacted]

Witness 1, MilAAIB interview, & Panel interview 1, answers 4,27,31,32,37,171

[redacted] The DFDR suggests that, [redacted], the side-stick moved backwards under its own spring-loading to the neutral (central) position. Annex C

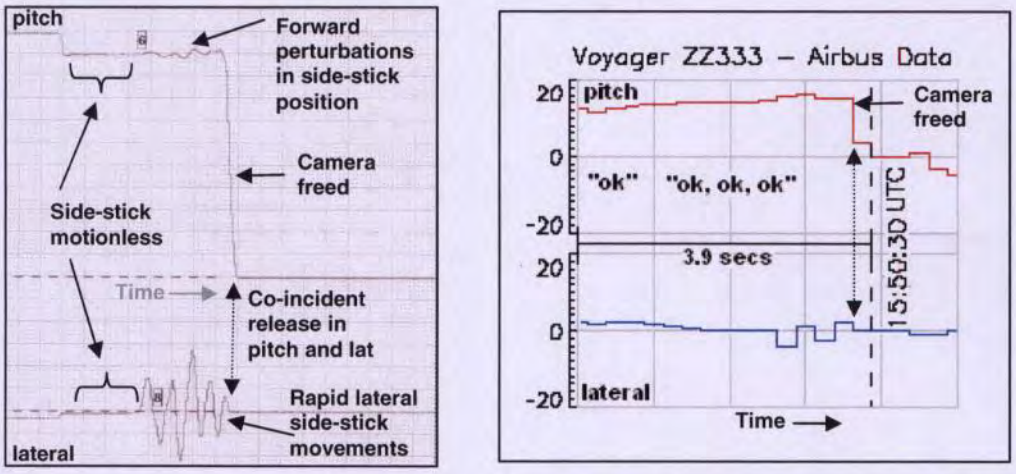

Figure 21: Simulator trace (left) and ZZ333 DFDR trace (right) showing side-stick in pitch and lateral axes.

1.4.55 In reconstructions of the incident in the simulator, a DFDR-type trace recorded attempts to remove a representative camera in a situation where the armrest and seat position were left unaltered. The simulator trace recorded the following key features (Figure 21, left-hand trace): Exhibit 34 Exhibit 35

a. A motionless side-stick as the simulator pilot's left hand moved to locate the camera.

b. Small and rapid lateral movements of the side-stick caused by the physical manipulation of the camera whilst jammed behind the side-stick.

c. Small forward perturbations in the side-stick position, co-incident with the lateral movement, caused by the movement of the camera whilst jammed against the side-stick.

d. A release of the camera co-incident with the last lateral movement of the side-stick. On the release of the camera (by a physical manipulation of the object itself), the trace recorded the uniform movement of the side-stick under spring loading to the neutral position.

1.4.56 In all respects, the simulator trace showed striking similarities with the DFDR trace from ZZ333 (Figure 21, right-hand trace). Exhibit 20

1.4.57 Forensic analysis of the ZZ333 side-stick identified several marks on the rear right-hand edge of the flange at the base of the side-stick. These marks included one large and several smaller gouges which suggested that a

hard edge had been pressed into the flange and dragged sideways, peeling away small chunks of material (Figure 22). Annex A

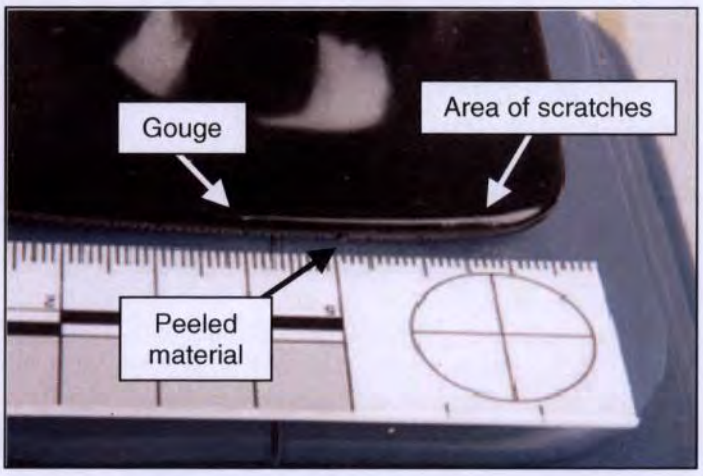

Figure 22: Witness marks on rear right-hand area of side-stick.

1.4.58 Further analysis found that:

a. Between **1550:26.5 UTC** and **1550:28 UTC**, immediately prior to the camera becoming free, the Captain said, "ok ….. ok, ok, ok," (superimposed on Figure 21, right-hand trace). It was not possible to confirm what this referred to. The Panel noted that there were no obvious changes in either the flight deck indications or the aircraft attitude at this point. Exhibit 19

b. At **1550:30 UTC**, there was the last of a succession of rapid lateral movements of the side-stick. The Panel assessed that this was the moment the camera became free (Figure 21).

c. At **1550:30.5 UTC**, there was a slight forward and sideways (right) input on the side-stick (Figure 21), similar to that seen when the Captain's left hand had first reached forward to take hold of the side-stick at the onset of the incident. Exhibit 20

d. At **1550:31 UTC**, a distinctive thud could be heard on the flight deck, over and above the general background noise. The source of the noise was unexplained. However, the aircraft had been under positive 'g' for some 22 seconds by this point, thus excluding the possibility that the noise was the result of a floating object falling to the floor. Exhibit 19

1.4.59 The camera was eventually retrieved from the back of the flight deck. In the opinion of the Panel, the evidence suggested strongly that the camera was removed from behind the side-stick by means of a physical manipulation, and possibly ejected to an area aft of the Captain's seat. [redacted] Witness 2, Panel Interview 1

Witness 1, Panel Interview 4

Summary

1.4.60 The attempted recovery from the pitch-down command was influenced initially by the belief that the autopilot was malfunctioning. As a result, the actions taken by the crew focussed on attempts to solve a perceived problem by trying alternative ways of disconnecting the autopilot. Had the Captain realised immediately that there was an obstruction next to the side-stick, it is unlikely that he would have persisted with his attempts to disengage the autopilot. A number of local conditions affected the extent to which the crew could identify the cause of the pitch-down command, and thus select the correct actions for recovery. While the inputs of the Co-pilot aided the recovery in a limited sense, some of the control inputs on the flight deck aggravated the outcome of the incident and delayed the recovery. The recovery from the dive was initiated by the aircraft's own self-protection measures. Had the self-protection measures not been in place, the dive would have been substantially worse, and it is possible that the aircraft would have suffered considerable damage. In repeated simulations, in the absence of full-scale side-stick inputs, it was impossible to remove the jammed camera without a physical manipulation of the camera, the arm-rest or the seat position. When taken together with key elements of the DFDR, the most probable evidence-based explanation that the Panel could identify for the releasing of the control restriction, was that the camera was removed from behind the side-stick by means of a physical manipulation. [redacted]

Recommendations

1.4.61 **The Panel recommended that:**

a. **Stn Cdr (DDH), RAF Brize Norton takes steps to ensure that Voyager crews are fully conversant with the overspeed recovery drill, as stipulated in the Voyager Flight Crew Operations Manual.**

b. **Stn Cdr (DDH), RAF Brize Norton ensures that the critical importance of a clear handover of control (in accordance with Regulatory Article 2309(5)) in side-stick equipped aircraft is emphasised throughout type-specific training.**

Cabin safety

Injuries

1.4.62 Amongst the 24 passengers who sustained physical injuries, there was a half-and-half split between those wearing a seatbelt, and those not wearing a seatbelt. All seven Cabin Crew reported physical injuries, of whom five were occupying seated positions, but not wearing a seatbelt. Of the remaining two Cabin Crew, one was standing in the forward galley area adjacent to the forward left door (position L1) along with the Co-pilot, while the other was in the forward galley adjacent to position R1 (Figure 23).

Exhibit 3
Exhibit 28
Exhibit 21

Exhibit 74

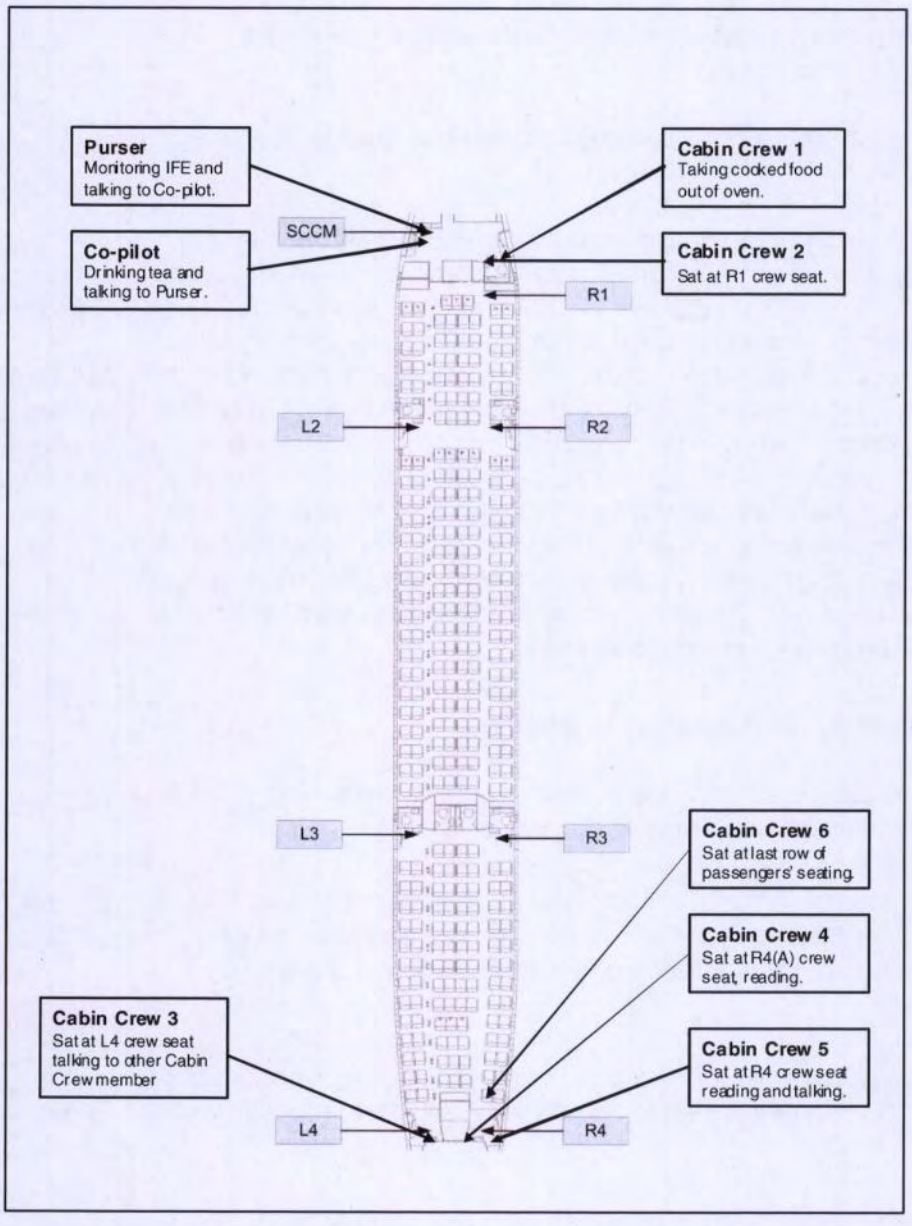

Figure 23: Cabin Crew positions at time of incident.

1.4.63 According to eyewitness accounts, most injuries were sustained as a result of impacts with the ceiling or overhead fittings. Some Cabin Crew injuries were the result of being struck by flying loose articles in the galley or burned by hot liquids. The primary physical injury types were bruising, cuts, neck or back injuries, and head injuries, with all of these being pertinent to those not wearing a seatbelt. Reported injuries amongst those wearing a seatbelt included whiplash and minor bruising, particularly where a seatbelt was fastened only loosely. Since Voyager flights do not operate allocated seating, and since the number of reported physical injuries was relatively low, it was not possible to conduct an accurate or meaningful analysis of passengers' injuries by location on the aircraft. The Panel assessed however, that **the following were aggravating factors**: Exhibit 21 Exhibit 28

a. **The lack of seatbelt restraint amongst some of the passengers and crew.**

b. **The presence of loose articles and hot liquids in the galley.**

1.4.64 With a few exceptions, passengers on Op HERRICK flights were not permitted to take hand baggage on board the aircraft; passengers were required to carry on board their personal helmet and body armour. Although the Voyager Operations Manual stipulated that crew baggage should be stored in the cargo hold, it was common for the various wardrobes within the cabin to be used for this purpose instead; this was the case on ZZ333. The Panel found no evidence however that any body armour, helmets or crew baggage had been responsible for injuries to cabin occupants. As a result of the baggage policy there was generally little in the way of large baggage that could become loose during the incident and thus cause injury to aircraft occupants. The Panel assessed that **the policy regarding cabin baggage was not a factor.** The Panel however, **observed that the rules on the stowage of crew baggage were not followed.** Exhibit 13 Exhibit 75 Witness 3, Panel Interview 2

Regulations and policy on the use of seatbelts

1.4.65 The Panel examined the regulations and policy pertaining to cabin safety, and in particular those relating to the use of seatbelts.

1.4.66 MAA Regulatory Articles 2130(4) and 2340 stated that passengers and troops should be strapped in at all times when the aircraft is moving except to facilitate cabin management, or on the direction of the aircraft commander. Exhibit 76 Exhibit 77

1.4.67 Further direction was contained in the Voyager Operations Manual, which stated that the seatbelt sign must be switched on and seatbelts worn by all passengers: Exhibit 46

a. Whilst taxiing, during take-off and for all phases of flight below 20,000 ft during the climb.

b. From top of descent.

c. At the commander's discretion or as required by abnormal or emergency procedures.

1.4.68 Civilian regulations regarding seatbelt use were held principally in EASA publications. Though not applicable to military operations, they were almost identical in their scope to military rules, and in particular to the Voyager Operations Manual. There was no evidence that any differences between military and civilian regulations had any bearing on the number of passengers who were using their seatbelt on board ZZ333, and thus the number of injuries. Exhibit 78 Exhibit 79

1.4.69 In respect to the briefing of passengers, a video safety brief was delivered prior to departure from RAF Brize Norton. An extant Voyager Crew Notice directed that as a means of maintaining crew currency a manual cabin safety brief, rather than a video brief, should be given to passengers on flights departing from RAF Brize Norton. There was, however, no substantive difference between the content of the video brief and the manual brief. The video was followed by a second brief, given shortly after take-off by the Purser via the PA system. The content of the briefs covered all necessary aspects of aircraft safety procedures, including the use of seatbelts. During an instance of turbulence in the cruise, the seatbelt signs were illuminated and passengers were instructed to fasten their seatbelts. When questioned, the Cabin Crew reported that passengers were attentive during the safety briefings. With the exception of the video brief on departure, the regulations and procedures regarding the use of seatbelts and the briefing of passengers were followed correctly. The overall application of the rules had no adverse bearing on the outcome of the incident. **The Panel observed that the Voyager Crew Notice regarding manual safety briefings was not followed, although it did not affect the standard of safety briefing given to the passengers.** Overall, the Panel assessed that **the application of regulations and procedures regarding the use of seatbelts was not a factor.** Exhibit 80 Exhibit 81 Exhibit 80 Exhibit 82 Exhibit 21

1.4.70 Other than the stipulations described above, there was no requirement for the Cabin Crew to routinely have their seatbelts fitted whilst seated in a crew position. In order to manage the cabin effectively, Cabin Crew must be free to move around the cabin as required. As noted by a Federal Aviation Administration Advisory Circular published in 2007, this invariably means that:

- *Flight Attendant injuries occur at a disproportionately high rate compared to other crewmembers and other cabin occupants because Flight Attendants spend more time in the passenger cabin unseated and, therefore, unbelted*[6].

1.4.71 The Panel assessed that it would be impractical to mandate the wearing of seatbelts every time a member of the Cabin Crew sat down, but noted that amongst the injured Cabin Crew on ZZ333 some had been on a Exhibit 21

[6] Federal Aviation Administration, "Preventing Injuries Caused by Turbulence," AC 120-88A Change 1 (19 Nov 07) http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/99831 (accessed 28 May 14).

break. Since the incident, Cabin Crew policy had been introduced which legislated for controlled rest, but this did not include guidance on the use of a seatbelt. A controlled rest period would normally involve being seated for an extended period of time and would thus lend itself more practically to the use of a seatbelt. Given the importance of the role played by Cabin Crew in the recovery from the incident, the Panel assessed that the wearing of a seatbelt by Cabin Crew during a controlled rest period could offer mitigation against potential injuries resulting from in-flight upsets. Exhibit 83

Cabin Crew requirements

1.4.72 Although eight Cabin Crew members were scheduled to fly on board ZZ333, only seven were fit to report for duty. The Voyager Operations Manual Part A, Section 4, paragraph 4.1.4.1 stated that the minimum permitted number of Cabin Crew was eight, however this could be reduced to seven in, 'unforeseen circumstances.' The Voyager Cabin Services Procedure Manual expanded on this direction, outlining various cabin restrictions that applied in the event that an aircraft was operated with only seven Cabin Crew (reduced numbers of passengers, manning of exits etc). The Purser reported that these procedures were duly followed. This supplementary guidance, however, also introduced an important caveat not found in the main Operating Manual, namely that operating with seven Cabin Crew applied only to flights returning 'back to base.' Interviews with key Voyager personnel did not resolve this apparent ambiguity. Notwithstanding the ambiguity however, the Panel found no evidence that the decision to operate with seven Cabin Crew members had any adverse bearing on the crew's ability to deal with the incident in the cabin. The Panel assessed that **the decision to operate with seven Cabin Crew was not a factor.** Exhibit 84 Exhibit 85 Exhibit 86 Exhibit 85 Exhibit 87 Exhibit 88

The response in the cabin

1.4.73 As well as the prompt reactions of the Cabin Crew, the response of the Purser was critical in recovering control of the situation in the cabin. The Purser was himself lifted to the ceiling before falling to the floor after the momentary negative 'g' force subsided. Despite this, he quickly took charge of the situation in the cabin, checking the state of each of his Cabin Crew, assessing any immediate damage to the aircraft and providing clear instructions and re-assurance to passengers via the PA system. Realising that one of the passengers had suffered an acute stress reaction, he alerted the pilots and summoned help from an on-board doctor. He oversaw the Cabin Crew as they attended to injured and distressed passengers and restored a sense of normality to the cabin by organizing the distribution of drinks and the playing of in-flight entertainment. Throughout the incident and subsequent diversion he kept the pilots regularly updated with the status of the passengers, particularly the affected individual who was by now in the care of the doctor. On arrival at Incirlik, the Purser's regular updates and instructions to the passengers, with the assistance of the Cabin Crew, ensured that the disembarkation of all 189 passengers was conducted in a calm and controlled fashion. The Panel assessed that **the response by the Cabin Crew was not a factor.** Witness 3, Panel Interview 1 Exhibit 2 Exhibit 89 Witness 8

1.4.74 There are two medicals kits used on Voyager aircraft; a First Aid Kit and an Emergency Medical Kit. The Emergency Medical Kit is designed to be used by a medical professional, and was used in this way during the ZZ333 incident. It contains instructions written in German but with an English translation. **The Panel observed that although the bilingual instructions did not prevent the effective use of the first aid kit, they were judged by the medical professional in attendance to be a potential source of confusion.** Exhibit 89 It was also noted by the medical professional that the lack of a pulse oximeter in the kit made it difficult to establish the oxygen saturation and monitor the pulse of a casualty under treatment, due to the individual's state of health at the time. Although a manual recording was eventually made, the inclusion of a pulse oximeter would have allowed this to be conducted more quickly. **The Panel observed that the lack of a pulse oximeter did not affect the overall standard of the casualty's treatment, but would have improved the speed and efficiency with which it was delivered.** Exhibit 89

Cabin damage

1.4.75 In the course of the incident, one of the ceiling-mounted emergency exit signs suffered impact damage. The lens containing the word, 'exit' fell out of the frame, but was subsequently re-mounted for landing. Exhibit 23

1.4.76 For aircraft registered in Europe, the regulations governing the design and crash worthiness of emergency exit signs are published by EASA. While the regulations do not cover the specific scenario on ZZ333, regulation CS25.561[7] stipulated that, in the event of a crash landing, the strength of an exit sign should be enough to withstand forward inertial forces of up to 9 'g'. Furthermore, if equipment breaks loose, it should do so in a way that makes it unlikely to cause direct injury to the aircraft's occupants. Exit signs are therefore made as light as possible, limiting possible injuries and saving on aircraft weight. This means they are not designed to withstand the sort of impact generated by a person or object, as occurred on ZZ333. Exhibit 48

1.4.77 The Panel found no evidence that the sign had itself caused injury to the aircraft occupants. Even had it not been possible to replace the 'exit' lens, alternative means of identifying the emergency exit would have been available in the event of a subsequent evacuation. While **the Panel observed that an emergency exit sign was damaged during the incident**, it did not consider it an issue worthy of a recommendation.

Previous investigations into cabin safety

1.4.78 In Dec 11, the Australian Transport Safety Bureau (ATSB) published its final report into an in-flight upset which took place on board an

[7] EASA, "Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes CS-25," http://easa.europa.eu/document-library/certification-specifications/cs-25-amendment-14 (accessed 28 May 14).

A330 in Oct 08[8]. Though the cause of the incident was unrelated to that of ZZ333, it also led to a significant and sudden pitching-down of the aircraft resulting in a number of injuries amongst the aircraft's occupants. The ATSB's report contained extensive analysis of the use of seatbelts on board the aircraft, and more widely across the airline industry. It was not necessary to repeat the depth of analysis contained within the ATSB report, since a number of areas within it were directly pertinent to the ZZ333 incident. With the permission of ATSB, the relevant areas are discussed below.

a. **The use of seatbelts.** The ATSB report considered the factors influencing the use of seatbelts amongst passengers. The Panel considered that this was pertinent, because the lack of seatbelt use was an aggravating factor in the ZZ333 incident. Whether a simple strengthening of the regulations on passenger seatbelt use would be effective however, was a matter that would require consideration of the factors known to be associated with seatbelt use:

(1) The ATSB report assessed factors affecting seatbelt use including age, gender and nationality. In a 2007 study by Girasek and Olsen[9], it was found that there was no significant difference in the use of seatbelts between men and women, but that younger adults (a demographic group occupied by a large proportion of Service personnel) were less likely to wear seatbelts than other age groups. Other factors influencing the use of seatbelts included the frequency of air travel, with more frequent travellers more likely to wear their seatbelt. According to the ATSB report, many passengers when questioned stated that it should be compulsory to wear a seatbelt when seated. The report said that there had been proposals in the past to mandate that passengers wear seatbelts when seated, or to require that the seatbelt sign is illuminated at all times. Citing an article written by the Flight Safety Foundation in 2001[10] however, it said that regulatory authorities had expressed the view that such measures would be impractical to enforce, and would reduce the effectiveness of the seatbelt sign when it is most useful. Cabin Crew had also advised that there were significant difficulties for them associated with attempting to enforce seatbelt requirements when the seat-belt sign is not illuminated.

---

[8] Australian Transport Safety Bureau, " In-flight upset 154 km west of Learmonth, WA 7 October 2008 VH-QPA Airbus A330-303," Aviation Occurrence Investigation AO-2008-070 (Dec 2011) http://www.atsb.gov.au/publications/investigation_reports/2008/aair/ao-2008-070.aspx (accessed 28 May 14).

[9] Girasek DC, Olsen CH, "Usual seat belt practices reported by airline passengers surveyed in gate areas of a U.S. airport." *Aviation Space & Environmental Medicine* (2007); 78:1050-4.

[10] Flight Safety Foundation, "Strategies Target Turbulence-related Injuries to Flight Attendants and Passengers," *Cabin Crew Safety* (Jan-Feb 2001) 36:1. http://flightsafety.org/ccs/ccs_jan_feb01.pdf (accessed 28 May 14).

(2) The ATSB report also examined the *way* in which seatbelts are worn, and the relationship this has with injuries sustained during in-flight upsets. On ZZ333, at least one passenger reported that his injuries were sustained as a result of his seatbelt being fastened only loosely across his lap. As highlighted in the ATSB report:

- *Loose seat belts also do not effectively limit the body's motion during vertical forces, and also increase the likelihood of a person being injured due to being thrown against armrests or other fixtures.*

(3) The ATSB report recommended that more frequent reminders regarding seatbelt use should be given during flights, employing a greater variety of communications. More detailed guidance for passengers on the *way* seatbelts should be worn throughout a flight would be useful. These measures, it argued, had the potential to increase compliance on the use of seatbelts. More fundamentally, the ATSB report pointed out that there was a general lack of research into the factors affecting the use of seatbelts.

b. **Safety measures in the cabin**. The ATSB Report also considered whether handholds in an aircraft cabin might assist occupants to secure themselves in the event of an in-flight upset (e.g. unexpected turbulence). A Federal Aviation Administration circular in 2007[11] had recommended the placing of handholds in a variety of locations around aircraft, including in the galley, the lavatories (both inside and outside), and under the overhead baggage compartments. The Voyager cabin has handholds in the galleys, underneath the baggage compartments and inside the lavatories. As with the 2008 incident however, the pitch-down event on ZZ333 happened so quickly that it is unlikely the presence of additional handholds in the cabin would have made a significant difference to the numbers of injuries sustained (unless occupants were already holding on to them). As also noted by the ATSB in their report, poorly placed handholds could themselves represent a hazard if they were 'hit by an occupant during an upset'. The Panel did not consider that a change in the design of the cabin area was warranted. Exhibit 90

Summary

1.4.79 The Panel concluded that, while there were some aggravating factors applicable in the cabin of ZZ333, none was the result of the way cabin safety regulations were applied during the flight. The rules relating to operations with only seven Cabin Crew members were ambiguous; however, neither the number of Cabin Crew, nor the manner in which they managed the situation had any adverse bearing on the outcome. The actions of the Purser were particularly noteworthy in bringing the situation

[11] Federal Aviation Administration, "Preventing Injuries Caused by Turbulence."

under control. A minor change to the policy regarding Cabin Crew seatbelt use could help in mitigating future in-flight upsets. Though a simple strengthening of the rules regarding passenger seatbelt use could seem attractive, the Panel considered that more effective measures to increase seatbelt use might be possible, as alluded to in the ATSB report of 2011. More research was needed in this area. Changes in the design of the cabin were not considered to be necessary.

Recommendations

1.4.80 **The Panel recommended that:**

a. **AOC 2 Gp examines methods of enhancing seatbelt use amongst air transport passengers, including (but not limited to) policy, the content and frequency of briefings, and publicity.**

b. **AOC 2 Gp amends the policy on Cabin Crew restraint to reduce the risk of injury during in-flight upsets. Specifically, Cabin Crew should wear a seatbelt during controlled rest periods.**

Post Occurrence Management

Command and control

1.4.81 Command and control responsibilities during the post-occurrence phase of the incident were not widely understood. The task fell within the Strategic Coupling Bridge, which describes the logistical link by air, land and sea between the UK and the Op HERRICK Joint Operations Area (JOA). In respect to the air component of the Coupling Bridge, command and control is subject to the following directives and instructions: Witness 13 Witness 18

a. **Chief of the Defence Staff (CDS) directive.** The Joint Command is responsible for the Coupling Bridge conveying personnel, equipment and materiel between the Strategic Base and the JOA. This remit includes methodology, strategic assets, infrastructure, facilities, routes, force protection, command and control arrangements and transport assets by which the capability is moved. Witness 18

b. **Chief of Joint Operations (CJO) directive.** CJO retains Operational Command (OPCOM) of all UK assigned naval, land and air forces. Witness 18

c. **Joint Mounting Order and Strategic Movements Instruction.** CJO retains OPCOM of all Force Elements throughout the deployment until they are dismounted from their home base Air Point of Disembarkation (APOD). Front Line Commands are responsible for dismounting their own forces. Exhibit 91

d. **Defence Instruction and Notice (2012DIN03-010).** Assistant Chief of Defence Staff, Logistics Operations (ACDS (Log Ops) sponsors 2012DIN030-010 which addresses the process and priorities for the allocation of fixed wing air mobility support across Defence. The Instruction states that Air Officer Commanding (AOC) 2 Gp has OPCOM of the Air Mobility Force (which includes Voyager aircraft and crews) for non-deployed operations. In the event of assets being assigned to a Theatre of operations, OPCOM of those particular assets is delegated to CJO. Exhibit 92

1.4.82 In practise, for the ZZ333 task:

a. Permanent Joint Headquarters (PJHQ) (CJO) had OPCOM of the passengers from the point that they departed RAF Brize Norton. Witness 18

b. HQ 2 Gp (AOC 2 Gp) had OPCOM of the aircraft and its crew throughout the task. Exhibit 92

c. Defence Supply Chain & Operational Movements (DSCOM) (for the Jt Command) was the tasking authority for the flight. In effect, DSCOM supplied the passenger movement to PJHQ, which Witness 18

was the 'customer'.

d. ASCOT Operations (for DSCOM) had Operational Control (OPCON) of the task, but was itself under the OPCOM of RAF Brize Norton (HQ 2 Gp). Witness 20 Exhibit 93

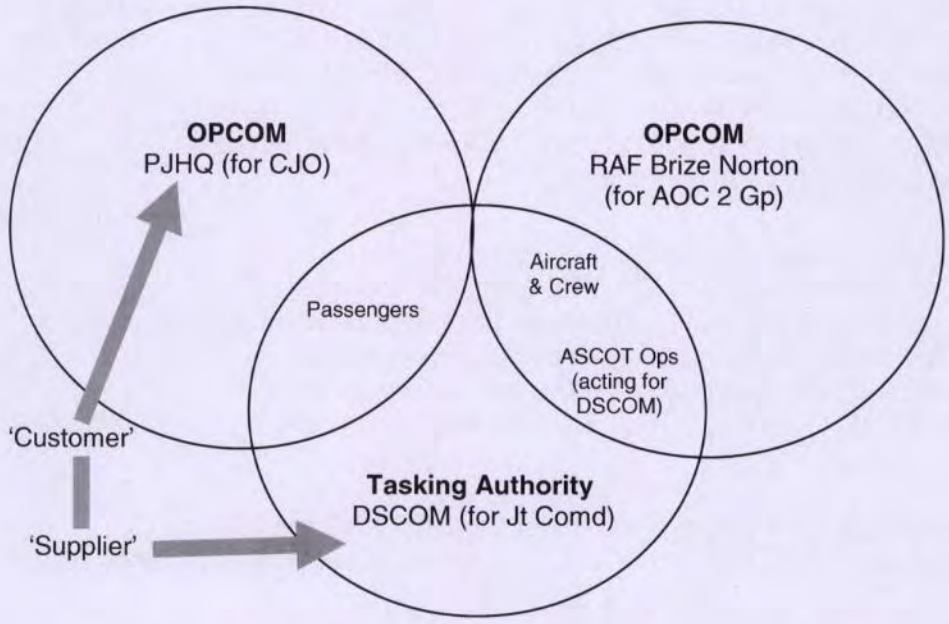

Figure 24: Command and Control relationships.

1.4.83 Following the diversion of ZZ333, RAF Brize Norton took control of the Post Occurrence Management of all force elements in Incirlik. This was not the result of a formal arrangement between HQ 2 Gp, PJHQ or DSCOM, but came about in the absence of general clarity regarding where command and control responsibilities should ultimately sit for a diverted aircraft and its passengers. By the time representatives from RAF Brize Norton and PJHQ spoke to discuss the incident on the evening of 9 Feb, the Station had already established lines of communication with the crew, the RAFLO at Incirlik, the Joint Compassionate and Casualty Centre (JCCC) at Innsworth, and the Directorate of Media and Communications (DMC) in Head Office. They had also begun arrangements to deploy a team to Turkey to support the crew and passengers. As a result, the Station took the default lead in most aspects of Post Occurrence Management, with PJHQ and DSCOM assuming a supporting role. Witnesses 5, 6, 13,16 & 18 Witness 5, 6 & 13

Decision making

1.4.84 The following key decisions and actions were taken at RAF Brize Norton:

a. The decision to deploy a support team to Incirlik, consisting of RAF Brize Norton staff and Trauma Risk Management (TRiM) practitioners (and subsequently mental health nurses from the Department of Community Mental Health, following input from PJHQ). Witness 5, 6 & 21

b. The decision that passengers would return to the UK and not proceed to Theatre. — Witness 20

c. The recording of passenger triage interviews conducted in Incirlik, including a note of physical injuries and any consequent referrals to mental health nurses. — Witness 13

d. The decision as to how and when the passengers would return to the UK. — Witness 20

e. The decision as to which passengers would re-mount the airbridge to Theatre, and which passengers would return to their home unit. — Witnesses 6 &13

1.4.85 Other key decisions and actions were as follows:

a. PJHQ J4 Medical, through HQ Air Command A4 Medical Ops, directed that mental health nurses from the Department of Community Mental Health should accompany the RAF Brize Norton support team which deployed to Incirlik. — Witness 21

b. PJHQ J4 Movements & Mounting led on contingency planning for the possibility of passengers returning to the UK by surface lines of communication. — Witness 18

The practical response

1.4.86 The response of the RAF Brize Norton executive team on 9 Feb was fast, thorough and effective. Notwithstanding that events were developing quickly however, the Panel found it difficult to establish an accurate timeline of key discussions that occurred on the evening of the incident. While records kept by the AirTanker Services Emergency Response Centre and JCCC were helpful in extrapolating a timeline, the lack of a written log for the Brize Norton executive team introduced an element of uncertainty about how and when key decisions were made. — Exhibit 16

1.4.87 The small SO2-led support team deployed by RAF Brize Norton (including the subsequent mental health and medical staff) performed a vital and highly effective role in Incirlik. Given the nature of the incident, the crew members were neither qualified, nor fit to deal with the scale and scope of activity required on the ground during the aftermath of the event. The RAFLO had a limited remit and she had not received any Post Occurrence Management training. Although she was able to deliver highly effective general support, the combination of her rank (OR-9), background (musician) and time accumulated in Theatre (two days) inevitably restricted the extent to which she could generate specialist support or provide liaison with the appropriate parties in the UK. The USAF support was also highly effective, but came with limitations and only from within its own spare capacity. As such the role of the support team became one of tactical control and J1-9 support. That this was possible, however, rested on the fact that suitably qualified and experienced personnel happened to be available to deploy at — Witness 9; Witness 9; Witness 13

the point of need. Excluding lodger units, RAF Brize Norton holds no stand-by commitment for such a task, nor is it resourced to fulfil it. A failure to deploy a support team would have left the 198 crew and passengers in the hands of the host-nation authorities and responsible for overseeing their own J1-9 requirements; without the support of the mental health team and the multi-disciplinary medics who followed from RAF Brize Norton, it is likely that many of the passengers would not have been fit to board the flight back to the UK at all. Chance appeared to have been an important factor in the successful and timely constitution of the support team, who were fortunate to be able to exploit the support of the RAFLO and the USAF in Incirlik. Had the aircraft had a full passenger load, or diverted to where there was no RAFLO or USAF support, it is questionable whether the support team would have had the necessary resources to deal with the situation on the ground. Witness 5

1.4.88 Passengers experienced border control difficulties at Incirlik that could have been avoided had they all been in possession of a NATO Travel Order, or if the crew had held a cash imprest for the payment of visas. The extant Op HERRICK Strategic Mounting Instruction mandated that passengers should carry a NATO Travel Order for scheduled C17 flights through Turkey, but did not include this stipulation for flights overflying Turkey. While the crew of ZZ333 carried a Government Procurement Card, they had no flight sub-imprest. Witnesses 9 & 23 Exhibit 13 Witness 3

Injuries

1.4.89 In determining the extent of injuries sustained during the incident, the following sources were available to the Panel: a report produced by RAF Brize Norton; crew medical records compiled in Incirlik; crew interviews; questionnaires completed by the crew and some of the passengers; a report compiled by one of the support team mental health nurses, and a report compiled by the Op HERRICK Visiting Consultant Psychiatrist. Exhibit 3 Exhibit 21 Exhibit 28 Exhibit 94 Exhibit 26

1.4.90 There were significant discrepancies between the sources, and the Panel could not track injuries that might have been reported at home units after the incident took place. The Panel found that, while diligent attempts had been made by various parties to produce J1/J4 records, there was no co-ordination of the information in such a way as to guarantee the continuity or oversight of J1/J4 action (especially medical treatment), and the accurate notification of that action to home/in-Theatre units. For example, the small support team in Incirlik was able to keep only basic records of the passengers' injuries and their onward disposal. This meant that on return to the UK, a number of passengers were sent back to their home unit without any accompanying paperwork explaining either the reason for their return or the extent of any J1 action that had already been taken. As a result, it was not clear whether home units ever offered TRiM interviews to their returning personnel. Witness 16 Exhibit 3 Witness 13 Witness 13

1.4.91 Elsewhere, some in-Theatre units only learned of individuals' involvement in the incident when they presented with mental health symptoms. On Sun 16 Feb, the PJHQ J4 Medical Duty Officer received a phone call from the Defence Consultant Advisor in Psychiatry (DCA Psych), relaying a message from the Field Mental Health Team (FMHT) at Camp Exhibit 26 Witness 21

Bastion that a large number of personnel from the ZZ333 flight had presented in Theatre with adverse mental health symptoms. The resources of FMHT, the Role 3 hospital and the mental health aero-medical team were insufficient to deal with the quantity and severity of symptoms, or the ongoing referrals which were expected to follow. As a result, PJHQ deployed the Op HERRICK Visiting Consultant Psychiatrist to Camp Bastion on Tue 18 Feb, along with two aero-medical mental health nurses. Exhibit 26

1.4.92 In a report compiled by the Visiting Consultant Psychiatrist, it was stated that within 48 hours of the passengers arriving at Camp Bastion (ie, by Sun 16 Feb), seven personnel had been referred to the FMHT. At this point, the FMHT had received a brief e-mail from the mental health cell at Tactical Medical Wing (TMW) alerting them to the fact that an incident had occurred; however the e-mail could only indicate that a Voyager had an in-flight problem. No further details about the flight or the initial triage process were available. Four of these patients presented with severe distress and significant psychological symptoms, of whom three were admitted to the Role 3 hospital. The other three patients required follow up, of whom two were unable to complete the in-Theatre flights to their final destination. In addition, the following reports were received by the FMHT: Exhibit 26

a. From the Emergency Department at Camp Bastion of patients who had reported in a distressed state overnight.

b. From the physiotherapy department at Camp Bastion of Voyager passengers who had sustained muscoloskeletal injuries who appeared also to be psychologically distressed and in need of mental health care.

c. From the primary care doctors at the outlying locations of soldiers in an anxious and agitated state, or who were not sleeping, and had been prescribed sedating medication.

1.4.93 By Wed 19 Feb, the first contact took place between the FMHT and the mental health staff who had attended the passengers in Incirlik. This provided FMHT with the first quantifiable measure of the number of personnel who had appeared acutely distressed in the immediate aftermath of the original incident. On Fri 21 Feb, orders were issued to all Theatre units (JFSp(A)_FRAGO_013_OPO 001/14) tasking them to identify any personnel who had been on board the Voyager flight and to ensure that they received 'appropriate TRiM support'. By Mon 24 Feb, a further seven passengers from ZZ333 were referred to FMHT. Two of these were patients based at a Forward Operating Base (FOB) only reachable by helicopter. One of these patients was the individual who had the acute stress reaction in the immediate aftermath of the incident and who was assessed at the hospital near Incirlik. By Tue 25 Feb, two more patients from the original seven referrals were returned to the UK by aero-medical evacuation. By now, news had reached Theatre that Voyager had returned to flying and would be resuming Op HERRICK flights. FMHT received several contacts from in-Theatre commanders who had identified that some of their soldiers, who up until this point had appeared to been fine and not presented to healthcare, were now nervous at the prospect of end-touring and returning to the UK on board a Exhibit 26

Voyager aircraft.

1.4.94 From the variety of records obtained by the Panel it was estimated that, as of 25 Feb 14, out of the original 198 personnel on-board ZZ333, a minimum of 32 (16%) and a maximum of 48 (24%) were, for varying reasons and periods of time, rendered unfit for duty. At the point of publishing this report however, **the Panel observed that the overall medical outcome of the incident was not being tracked.** It is possible therefore, that the true figure was higher.

Summary

1.4.95 As a whole, the practical response in the immediate aftermath of the incident was fast, thorough and highly effective. Given the unusual circumstances however, there was a sense in some areas of command, control and support being conducted in an improvised fashion, with chance playing a significant role in the composition of the support team and with key decisions and information being handled at the tactical level (including those with operational consequences). It was not clear how responsibilities in such a situation should be divided between the operating and operational areas of responsibility. Despite some individual diligence, the lack of overall co-ordination of information undermined the continuity and oversight of J1/J4 action, particularly with respect to medical cases. As a result, it is not clear whether initial TRiM was conducted for many of the passengers, and in-Theatre units were not fully pre-prepared for the volume of medical cases which followed (the Panel found no evidence that the quality of individuals' treatment was adversely affected). Up to 24% of the aircraft's occupants were rendered unfit for duty following the incident. At the point of publishing this report, there was no evidence that the overall medical outcome of the incident was being tracked. A properly formulated contingency plan, owned by an appropriate HQ, would ensure that for diversions of large aircraft (especially those involving a large number of passengers), sufficient support was always available from suitably qualified and experienced personnel, and with appropriate HQ oversight.

Recommendations

1.4.96 **The Panel recommended that:**

a. **COS Ops, PJHQ and COS Ops Air Command, in consultation with AOC 2 Gp, produce a contingency plan for unplanned diversions of strategic air transport aircraft. The plan should be held by an appropriate operational level HQ, should clarify command and control responsibilities between operational and operating areas of responsibility and, where necessary, have stand-by resources attributed.**

b. **AOC 2 Gp ensures that crews on all strategic air transport flights carry a flight sub-imprest.**

c. **PJHQ ACOS J1/J4 stipulates the carriage of NATO Travel Orders by all UK military passengers on strategic air transport flights.**

d. **Stn Cdr, RAF Brize Norton, reinforces in Stn Post Occurrence Management Procedures the requirement for key decisions to be recorded in a written log.**

Other areas of analysis

The selection and planning of the diversion

1.4.97 In the 38 minutes of available CVR recorded prior the incident, there was no discussion between the pilots regarding aircraft position, possible en-route diversions or their associated weather. This included the point at which the Co-pilot left his seat, some 18 minutes prior to the incident, although at this point a handover of the radio did take place. The Captain had spent some time in the cruise calculating a point-of-no-return for a theoretical return to RAF Brize Norton. The Voyager Operations Manual, Part B, Section 2.1.15.9 stated a requirement for pilots to continually monitor and discuss possible diversions and their associated weather. When interviewed, the Captain stated that although he and the Co-pilot would have had discussions of a general nature regarding the route, no specific en-route diversions were discussed during the flight. When asked about the scoping of specific en-route diversions prior to the flight, the Captain said that there was not enough time to do so. At the point of the incident the pilots did not have a specific diversion location in mind. As such, there was no scope for a planned diversion location to be used as part of the decision-making process.

Exhibit 19
Witness 1, Panel Interview 1
Exhibit 95
Witness 1, Panel Interview 4
Annex B, para 70 (e)

1.4.98 As the incident developed, the Captain elected to divert and land the aircraft as soon as possible. The Co-pilot asked Turkish ATC for, 'an immediate diversion to a suitable airfield of our choice.' ATC suggested Trabzon (LTCG), some 60nm south of the aircraft's position. The flight-deck route bag, compiled by AirTanker Services, contained Terminal Approach Plates for the following recommended en-route diversion airfields: Trabzon (60 nm range); Samsun (142 nm range); Tbilisi; (242 nm range); Ankara (331 nm range), and Istanbul (486 nm range) (Figure 25). In discussing Trabzon, the pilots were uncertain regarding its suitability and instead tried to recall, 'the name of the major airfield in Turkey.' The crew then asked ATC for a diversion to Istanbul Airport, approximately 500nm from their position. Initially, ATC agreed to this request and instructed the crew to set course to Istanbul. After a few minutes however, ATC relayed a message from the Turkish Military Authorities that it would better if the aircraft diverted to Incirlik (LTAG) where the USAF was based, at a range of some 340nm. This was accepted by the Captain, who turned the aircraft towards Incirlik. **The Panel observed that despite a number of suggested en-route diversions being within safe range of the aircraft, no pre-planned diversion formed part of the crew's decision-making process.** In addition to the lack of a pre-nominated diversion, Human Factors analysis indicated that it was likely the following factors influenced the diversion decision:

Exhibit 19
Exhibit 96

Figure 25: Illustration of diversion route (map data © 2014 Google, Basarsoft.)

a. **Familiarity**. There is a tendency to judge unfamiliar items more negatively than items with which an individual is familiar. The crew had a negative response to the diversion location that they were least familiar with (Trabzon), seeking a less unfamiliar option (Istanbul), and reporting being most happy when presented with a familiar location (Incirlik). Annex B, para 70 (a)

b. **Suitability**. The runway length and distance from current location were primary considerations for the pilots as they evaluated the suitability of any possible diversion airfield. The pilots indicated that they wanted to land the aircraft as soon as possible, but they also wanted enough flying time for preparations to be made for landing. In interviews, the pilots said that time would be required to make the cabin safe and to enable a low rate of descent to be used. The pilots had also perceived that there would be a requirement to cope with medical issues on board, although at the time of selecting a diversion location the nature of any passenger injuries was not known and had not yet been discussed. Exhibit 2; Witness 1 Panel Interview 1; Annex B, para 70 (b)

c. **Workload**. Eleven minutes elapsed between the initial decision to divert the aircraft and the selection of Incirlik. This period corresponded to the immediate aftermath of the incident and was characterised by shock, high workload and high arousal. It is likely that the capacity of the pilots to undertake complex decision making and to evaluate options from scratch would have been reduced.

Exhibit 2

Annex B, para 70 (c)

d. **Decision-making aids**. Owing to the negative 'g' experienced during the incident the flight deck was in considerable disarray and both pilots were strapped into their seats, therefore they did not have immediate access to the list of approach plates which were in the route bag. Although the nearest suitable airfield could have been obtained from the Multipurpose Control and Display Unit, this did not appear to influence crew decision-making regarding a suitable diversion location. The difficulty of access to Terminal Approach Plates was mitigated by the availability of ATC primary radar, the favourable weather conditions and the lack of extensive terrain around Incirlik.

Exhibit 2

Witnesses 1, 2 & 3

Annex B, para 70 (d)
Exhibit 2
Exhibit 119

1.4.99 The Voyager Operations Manual stated that the choice of nearest suitable airport should not be influenced by consideration of passenger ground handling or convenient technical support. The suitability of an airfield was determined by factors such as runway length, opening hours, air traffic services, lighting, navigation aids and emergency services. The guidance reflected the fact that in an emergency, aircraft Captains should not be unduly limited in their choice of available diversion airfields lest it compromise their ability to land the aircraft safely and as soon as possible. In the case of ZZ333, rather than choice being limited, there were numerous 'suitable' airfields within adequate range of the aircraft. That Incirlik was chosen (at the suggestion of the Turkish authorities) did not compromise flight safety but did allow important operational factors, such as medical care and security, to be managed with minimal risk. The Panel did not consider that advice for emergency diversions should change, but noted that none of the suggested en-route diversions in the route bag had been subjected to any form of operational risk assessment (assessed against Foreign and Commonwealth Office travel advice or checked with Embassy Defence Sections, for example). Whilst not directly pertinent to flight safety, factors such as security could have an important bearing on the management of a situation once on the ground, especially where large numbers of operational passengers, weapons and classified material were involved. Even a basic assessment of a regularly flown route would allow the operational risks associated with selected en-route diversions to be understood in advance. Such an assessment could also reveal where *preferred* airfields were in the event of *non-emergency* diversions.

Exhibit 97

Exhibit 98

1.4.100 **Summary.** The pilots did not have a specific diversion location in mind at the time of the incident. No pre-planned diversion formed part of the crew's decision-making process. The accessibility of in-flight publications was insufficient to enable the crew to find the appropriate Terminal Approach Plates prior to landing. None of the suggested en-route

diversions had been subjected to an operational risk assessment.

1.4.101 **Recommendation. The Panel recommended that the Air Mobility Force Commander ensures that the list of suggested en-route diversions for operational strategic air transport tasks is informed by an operational risk assessment of the consequences of diverting into each location.**

Cost of damage to aircraft and civilian property

1.4.102 At the time of publishing this report, the cost of damage to the aircraft resulting from the incident could not be accurately assessed, owing to the way costs are dealt with through the Voyager contract. The final figure would be subject to the outcome of an ongoing commercial process. Early estimates put the possible cost in the region of £0.5M, however confidence in the accuracy of this figure was low. There was no reported damage to civilian property as a result of the incident. Exhibit 99

Authorization, crew qualifications and currency

1.4.103 MAA Regulatory Article 2498 (1) detailed the duties of an authorizing officer. They included ensuring that the crew was qualified, in current flying practice and capable of executing the mission. The duties of aircraft commanders were detailed in MAA Regulatory Article 2115 (1) which stated that they should ensure their crew was properly constituted, qualified and capable of performing its duties. Exhibit 100 Exhibit 101

1.4.104 The authorization policy for Voyager flights stated that: Exhibit 102

- *Before departing Brize Norton and during normal working hours, all Captains should be authorized face-to-face by the Authorizing Officer after the crew brief, regardless of self-authorizing status. For flights departing outside of normal working hours, authorization should take place the working day prior unless this would impact on crew rest, in which case authorization should take place 2 working days prior.*

1.4.105 Powers of authorization for specific personnel on 10 Squadron were listed in a Voyager authorization matrix (covering both 10 and 101 Squadrons). Normally, authorization was carried out by a Wing Duty Exec, known as the DEX. The DEX duty was detailed in a Voyager Crew Notice, but it existed principally to provide 24/7 military oversight of Voyager tasking. The duty began at 1000hrs on a Tuesday and ran for seven days, during which time the DEX was required to be contactable at all times and to be able to return to work outside normal hours. Exhibit 102 Exhibit 103

1.4.106 On Fri 7 Feb, the authorization of the flight was conducted by the DEX in the presence of the Captain. The brief covered only an outline of the sortie plan, as the flight was not due to depart until Sun 9 Feb, meaning that a significant number of the items on the authorization brief (as detailed Witness 12 Exhibit 104

in Voyager Operations Manual, Part A, Section 2) were not known; they included considerations of weather, aircraft status, load, crew rest and the status of the in-flight documents. During authorization, the DEX checked to ensure that a properly constituted and Combat Ready crew was assigned to the task, but neither the Captain nor the DEX checked crew currencies. The authorization sheet (F1575B) was signed by both the DEX and the aircraft Captain.

Witness 12
Exhibit 108
Witness 12
Exhibit 15

1.4.107 On Sat 8 Feb, Voyager Crew Control produced a Recency Expiry Sheet for each crew member, as required by the Voyager Ground Operations Procedures Manual. The Sheet detailed crew expiry dates for both essential and non-essential currencies. The reports showed that, of the ten planned crew members, eight had out-of-date currencies of some description. Of these, three individuals had entries which were significant enough to prevent them from flying on the planned flight without a further clarification of their currencies.

Exhibit 105
Exhibit 106
Exhibit 107
Exhibit 108

1.4.108 On Sun 9 Feb, the day of the flight, the Captain required two changes to his authorization. The first was a change to the Cabin Crew composition, as one of the Cabin Crew had reported sick some ten minutes prior to the crewing-in time of 0925 UTC. The second change was to the nominated destination alternate airfield, from Minhad to Kandahar. The duty ops staff attempted to reach the DEX at 0920 UTC by phone to consult him initially regarding the Cabin Crew situation, but he could not be contacted. By 0950 UTC, still unable to reach the DEX, the Squadron Commander was contacted instead. The Squadron Commander approved the change to seven Cabin Crew members and directed that ASCOT Ops be contacted to check on the possibility of changing the booked destination alternate airfield. The DEX phoned Voyager Operations at 1035 UTC and received an update on the changes to the task. The sick crew member was crossed out on the authorization sheet by the Captain, but no annotation was made of how the revised authorization was given, who gave it, or when it was given (such an annotation was a requirement of the Voyager Operations Manual Part A).

Exhibit 16
Exhibit 16
Exhibit 104

1.4.109 The Captain could not recall whether or not he had seen the Recency Expiry Sheet on the morning of the flight. He stated that at the time of the flight it was normal for captains to rely on the Voyager Ground Operations staff to have ensured that the crew members were current, rather than to check themselves. Had he become aware of expired currencies amongst the crew he would normally check with the individual concerned to clarify whether or not they were current, and consult the DEX if there was an unresolved issue. In respect to fatigue, a risk matrix was reported to be available to assist the Captain in assessing the likelihood of crew fatigue before take-off, but use of the matrix was not a requirement.

Witness 1, Panel Interview 4
Annex B, para 16

1.4.110 The on-duty DEX stated that it was generally considered to be the responsibility of Voyager Ground Operations staff (specifically, 'Crew Scheduling') to ensure that crew members were current to complete a flight. The Voyager Operations Manual (Part A, Section 2.3.1) stated that before each flight, Voyager Ground Operations was to check that a Commander had been designated, the required crew complement had been allocated

Witness 12
Exhibit 104

and that they met all the required competency and recency requirements. As such, the DEX had not checked the currencies of the crew before the flight.

1.4.111 A Recency Expiry Sheet printed on Wed 12 Feb showed that, in fact, none of the previously reported expired currencies were out-of-date on the day of the flight. In an e-mail to Squadron staff some four months before the incident, a Voyager Flight Commander had directed a 100% check of currencies to be carried out on Voyager aircrew owing to the discovery of discrepancies in the records. According to the e-mail, the matter of currency oversight had, over several months, given cause for 'grave concern,' and needed to be addressed. Following the ZZ333 incident, the Squadron Commander directed improvements to currency monitoring, including the use of regularly updated quick reference tables in the pilot briefing room. Exhibit 109 Exhibit 110 Exhibit 111

1.4.112 **Summary.** The Panel found that the crew members were sufficiently trained, competent, qualified and current to complete the flight as briefed. However, the Panel also found that:

a. The currencies of crew members were not properly checked prior to the flight on 9 Feb. Poor currency oversight had been an issue on the Squadron for several months.

b. The DEX was not contactable at all times, specifically at the point the crew reported for duty on 9 Feb.

c. A significant variation to the task authorization was not correctly annotated in the authorization sheet.

d. The practise of authorizing flights two working days in advance did not allow for all of the items on the authorization brief to be covered. On the day of the flight there was no positive confirmation made between the DEX and the aircraft Captain of the outstanding items on the authorization brief.

1.4.113 **Recommendation. The Panel recommended that the Hd of Oversights and Approvals, MAA conducts an audit of the authorization process on the Voyager force to ensure that local procedures and practices are satisfactory and in compliance with Military Regulatory Publications.**

Regulations

1.4.114 The Voyager Operations Manual is based on the CAA approved AirTanker Services Operations Manual and amended to reflect Military Regulatory Publications (MRPs), 2 Gp Air Staff Orders and Brize Norton Air Orders (BZAOs). Exhibit 112

1.4.115 The Voyager Operations Manual, Part A, Section 0.1.2 stated:

- *The Operations Manual is to be used in place of HQ 2 Gp Air Staff Orders and RAF Brize Norton Air Orders unless otherwise stated within the Operations Manual.* Exhibit 113

Accordingly, Voyager crews did not sign for BZAOs. However, BZAOs stated:

- *All personnel who fly in RAF Brize Norton aircraft are to comply with the regulations in BZAOs and all other pertinent orders and instructions. Voyager crews are to comply, in the first instance, with the Voyager Operations Manual. In the event of a conflict between orders or instructions the most stringent is to apply. All RAF Brize Norton personnel in flying appointments are to sign as having read BZAOs.* Exhibit 114

1.4.116 Voyager crews did not sign for MRPs because of the Voyager Operations Manual's remit to capture the totality of relevant MRPs. However, the Manual did not contain a reference to Regulatory Article 2309 (3) (carriage of loose articles), and did not fully articulate Regulatory Article 2115 (1) (responsibilities of an aircraft captain). These discrepancies were small, but pertinent to the incident. Exhibit 112

1.4.117 The Cabin Safety Procedures Manual implied that it was not permissible to depart RAF Brize Norton with fewer than eight Cabin Crew members. This stipulation did not appear in the main Voyager Operations Manual, although it had appeared in a previous version of that document. Successive editions of the Operations Manual had seen this rule changed, apparently inadvertently and without recourse to a formal Duty Holder review. As such, there were conflicting views as to whether the limitation on reduced Cabin Crew applied or not on 9 Feb. Evidence submitted to the Panel by AirTanker Services and RAF Brize Norton Standards staff did not resolve this ambiguity. Exhibit 85 Exhibit 87 Exhibit 88

1.4.118 **Summary.** There was conflicting guidance regarding the requirement for Voyager crews to read and sign for BZAOs. There were small but pertinent discrepancies between the Voyager Operations Manual and Regulatory Publications. Within the Operations Manual, there was ambiguous guidance on when the carriage of reduced Cabin Crew numbers was permitted.

1.4.119 **Recommendations. The Panel recommended that:**

a. **AOC 2 Gp clarifies and re-promulgates the hierarchical status of the Voyager Operations Manual in relation to MRPs, 2 Gp Air Staff Orders and BZAOs.**

b. **AOC 2 Gp ensures that the Voyager Operations Manual is compliant with MRPs, is coherent with 2 Gp Air Staff Orders**

and BZAOs, and that this is supported by a timely and robust amendment process.

c. **AOC 2 Gp clarifies the circumstances in which the Voyager Operations Manual policy on reduced cabin crew operations may be applied.**

Charging of portable electronic devices

1.4.120 The aircraft had a number of on-board electrical sockets which were capable of being used to charge portable electronic devices. The Panel heard evidence that the practice of using the on-board sockets for this purpose was widespread, despite it being prohibited by the aircraft Release to Service. Witness 3, Panel Interview 1 Exhibit 43 Witness 2, Panel Interview 1

1.4.121 **The Panel recommended that the Stn Cdr (DDH), RAF Brize Norton, takes steps to ensure that Voyager crews are fully conversant with the Release to Service stipulation prohibiting the on-board charging of portable electronic devices.**

Cockpit voice recorder

1.4.122 That an extensive CVR record of the flight was available, was ensured by the pulling of the CVR Circuit Breaker (CB) after the aircraft had arrived at Incirlik. This was carried out on the prompt of one of the AGEs, who happened to recall that doing so would preserve the record of the flight. A failure to pull the CB would have caused the CVR to run-on under ground power until such time as the recording of the incident itself was lost. Given the importance of the CVR to the Inquiry, there is little doubt this would have hampered the investigation significantly. The Panel identified a need for type-specific instructions to be issued on the preservation of CVR/DFDR data post incident. Witness 22

1.4.123 **The Panel recommended that MAA Certification and Regulation issues advice for Duty Holders on the preservation of CVR data post-incident.**

Cockpit video recorder

1.4.124 The Panel relied on DFDR and CVR evidence to identify the cause of the pitch-down command. In the absence of accurate eye witness evidence, a significant amount of time passed before the aircraft was returned to flight and before the Panel could ascribe a level of confidence to its findings to rule out a technical cause. It is likely that a cockpit video recorder would have enabled the cause of the pitch-down to be established quickly, significantly curtailing the impact of the cease flight decision and preventing unfounded doubts regarding the technical airworthiness of the aircraft from perpetuating. On a subject that has attracted considerable debate across the airline industry, the Panel was not able to conduct enough research to support a generic recommendation.

1.4.125 However, **the Panel observed that the availability of cockpit**

video evidence would have allowed the cause of the ZZ333 pitch-down to be established more quickly than was the case, significantly curtailing the impact of the incident; such technology may be of use in future safety investigations.

Flight data monitoring

1.4.126 Voyager uses a system of Flight Data Monitoring (FDM) which is employed widely across the airline industry. The system allows for the routine downloading of an extensive range of in-flight parameters which can be used for a variety of purposes, including improving operational performance and identifying exceedances. In respect to the Inquiry, FDM data was critical in aiding early analysis of the incident, well ahead of the DFDR and CVR which could not be accessed immediately due to the requirement to physically remove the base units from the aircraft. Furthermore, FDM was able to identify 26 inadvertent disconnections of the Voyager autopilot which had occurred over several months, but which had not been reported.

1.4.127 As such, **the Panel observed that the availability of FDM was a significant aid to the Inquiry, and could represent a valuable source of information for future investigations.**

Fuel dumping

1.4.128 During the diversion, 20 Tonnes of fuel was dumped in order to reduce the landing mass of the aircraft. Fuel dumping was conducted in accordance with the in-flight Quick Reference Handbook, except that the Captain elected to not inform ATC. There was a requirement to record fuel dumping by means of a post-flight Captain's report, however this was not completed.

Exhibit 2
Exhibit 87
Exhibit 115
Exhibit 122

1.4.129 **The Panel observed that a post-flight fuel dumping report was not submitted.**

Logbooks

1.4.130 With respect to pilot logbooks, the Voyager Operations Manual Part A, Section 2.1.6.5 stated that, 'one supervisory signature is required each month.' As at 9 Feb 14, the last supervisory signature in the Captain's logbook was Sep 13; for the Co-pilot this was Oct 13.

Exhibit 116
Exhibit 8
Exhibit 10

1.4.131 **The Panel recommended that STANEVAL, RAF Brize Norton conducts a 100% check of logbooks on 10 Squadron to ensure they have been completed in accordance with the Voyager Operations Manual.**

The Incirlik RAFLO post

1.4.132 In examining whether the Incirlik RAFLO had been suitably trained, qualified and experienced to conduct her role, the Panel was not able to find any terms of reference for the post. The post had been transferred from the

Op HERRICK Operational Establishment Table to HQ Air as a 'below the line' fill. Subsequently, the chain of command for the post and thus the terms of reference appeared to have become ill-defined, with various parties claiming only partial knowledge or responsibility for the post. Exhibit 117

1.4.133 **The Panel recommended that HQ Air A1 Ops reviews the post of Incirlik RAFLO to establish terms of reference, a clear chain of command and appropriate training requirements.**

Summary of findings

The cause

1.4.134 The cause of the incident was an inadvertent physical input to the Captain's side-stick, by means of a physical obstruction (a camera) that jammed between the left armrest and the side-stick unit when the Captain's seat was motored forward.

Contributory factors

1.4.135 The following contributory factors were assessed to make the incident more likely:

a. Normalized behaviour regarding the carriage and treatment of loose articles.	Para 1.4.35
b. The carriage of the camera on the flight deck.	Para 1.4.35
c. The use of the camera in flight.	Para 1.4.36
d. Low workload.	Para 1.4.36
e. Boredom and low arousal.	Paras 1.4.36 and 1.4.38
f. The presence of only a single person on the flight deck for an extended period of time.	Para 1.4.36
g. The armrest setting.	Para 1.4.37
h. The design of the side-stick area.	Para 1.4.37
i. The placing of the camera behind the side-stick.	Para 1.4.37
j. A widespread lack of awareness regarding the risk of side-stick interference.	Para 1.4.37
k. A lack of reporting regarding inadvertent operations of the side-stick.	Para 1.4.37
l. The RAF Brize Norton Occurrence Safety Investigation into loose articles.	Para 1.4.35
m. The lack of an identified Duty Holder risk regarding flight deck control interference.	Para 1.4.37
n. Distraction and a cognitive lack of expectation.	Para 1.4.38
o. The movement of the Captain's seat.	Para 1.4.38

Aggravating factors

1.4.136 The following aggravating factors were assessed to have made the outcome worse:

a.	The presence of only a single person on the flight deck.	Para 1.4.49
b.	Competing control inputs on the flight deck.	Para 1.4.51
c.	The absence of flight deck inputs in accordance with the overspeed drill.	Para 1.4.51
d.	The lack of seatbelt restraint amongst some of the passengers and crew.	Para 1.4.63
e.	The presence of loose articles and hot liquids in the galley.	Para 1.4.63

Observations

1.4.137 The Panel made the following observations:

a.	The rules on the stowage of crew baggage were not followed.	Para 1.4.64
b.	The Voyager Crew Notice regarding manual safety briefings was not followed.	Para 1.4.69
c.	Although the bilingual instructions did not prevent the effective use of the aircraft first aid kit, they were judged by the medical professional in attendance to be a potential source of confusion.	Para 1.4.74
d.	The lack of a pulse oximeter in the aircraft first aid kit did not affect the overall standard of a casualty's treatment, but it would have improved the speed and efficiency with which it was delivered.	Para 1.4.74
e.	A cabin emergency exit sign was damaged during the incident.	Para 1.4.77
f.	The overall medical outcome of the incident was not being tracked.	Para 1.4.94
g.	Despite a number of suggested en-route diversions being within safe range of the aircraft, no pre-planned diversion formed part of the crew's decision-making process.	Para 1.4.98
h.	The availability of cockpit video evidence would have allowed the cause of the ZZ333 pitch-down to be established more quickly	Para 1.4.125

than was the case, significantly curtailing the impact of the incident; such technology may be of use in future safety investigations.

i. The availability of FDM was a significant aid to the Inquiry, and could represent a valuable source of information for future investigations.	Para 1.4.127
j. A post-flight fuel dumping report was not submitted.	Para 1.4.129

PART 1.5 – RECOMMENDATIONS

Recommendation		Analysis Reference
1.5.1.	**Introduction**. The following recommendations are made in order to enhance Defence Air Safety:	
1.5.2.	**AOC 2 Gp (ODH) should:**	
	a. Implement a comprehensive strategy to affect a positive change in the safety culture with respect to loose articles on the flight decks of 2 Gp aircraft. The strategy should promote awareness of the risks loose articles pose to flight safety, and improve behaviours and accountability.	1.4.35-36, 37d, 39, 40-41
	b. Conduct a review of the items carried by crews on all 2 Gp aircraft types, and take steps to minimize what is carried on the flight deck and maximize the use of designated stowage areas.	1.4.35
	c. Review the rules governing crew members at their station to minimize the risks associated with having a single pilot on the flight deck.	1.4.36c
	d. In consultation with AirTanker Services Ltd and Airbus, ensure that the Voyager Document Set is configured to capture all the manufacturer's safety advice, including that contained within supplementary documents.	1.4 37d
	e. Examine methods of enhancing seatbelt use amongst air transport passengers, including (but not limited to) policy, the content and frequency of briefings, and publicity.	1.4.62-63, 65-71, 78
	f. Amend the policy on Cabin Crew restraint to reduce the risk of Cabin Crew injury during in-flight upsets. Specifically, Cabin Crew should wear a seatbelt during controlled rest periods.	1.4.71
	g. Ensure that crews on all strategic air transport flights carry a flight sub-imprest.	1.4.88
	h. Clarify and re-promulgate the hierarchical status of the Voyager Operations Manual in relation to MRPs, 2 Gp Air Staff Orders and BZAOs.	1.4.114-118
	i. Ensure that the Voyager Operations Manual is compliant with MRPs, is coherent with 2 Gp Air Staff Orders and BZAOs, and that this is supported by a timely and robust amendment process.	1.4.114-118
	j. Clarify the circumstances in which the Voyager Operations Manual policy on reduced cabin crew operations may be applied.	1.4.117
1.5.3.	**Director Air Support DE&S should:**	
	a. Examine and, if possible, implement measures that could help prevent the placing of loose articles in close proximity to the side-stick of aircraft so equipped.	1.4.39b

1.5.4.	**COS Ops PJHQ and COS Ops Air Command should:**	
	a. In consultation with AOC 2 Gp, produce a contingency plan for unplanned diversions of strategic air transport aircraft. The plan should be held by an appropriate operational level HQ, should clarify command and control responsibilities and, where necessary, have stand-by resources attributed.	1.4.81-95
1.5.5.	**ACOS J1/J4 PJHQ should:**	
	a. Stipulate the carriage of NATO Travel Orders by all UK military passengers on strategic air transport flights.	1.4.88
1.5.6.	**MAA Oversight & Analysis Hd should:**	
	a. Conduct an audit of the authorization process on the Voyager Force to ensure that local procedures and practices are satisfactory and in compliance with Military Regulatory Publications.	1.4.112
1.5.7.	**MAA Certification & Regulation Hd should:**	
	a. Issue advice for Duty Holders on the preservation and handling of CVRs post-incident.	1.4.122
1.5.8.	**Air Mobility Force Commander should:**	
	a. Ensure that the list of suggested en-route diversions for operational strategic air transport tasks is informed by an operational risk assessment of the consequences of diverting into each location.	1.4 99
1.5.9.	**DACOS AvMed, RAFCAM should:**	
	a. Examine ways of managing low in-flight pilot workload to minimize boredom and underload.	1.4.36b
1.5.10.	**Stn Cdr RAF Brize Norton (DDH) should:**	
	a. Take measures to further strengthen the reporting culture and OSI process at RAF Brize Norton to ensure that risks are being adequately captured.	1.4.35
	b. Take steps to ensure that Voyager crews are fully conversant with the overspeed recovery drill, as stipulated in the Voyager Flight Crew Operations Manual.	1.4.51d
	c. Ensure that the critical importance of a clear handover of control (in accordance with Regulatory Article 2309(5)) in side-stick equipped aircraft is emphasised throughout type-specific training.	1.4.51c
	d. Reinforce in Stn Post Occurrence Management Procedures, the requirement for key decisions to be recorded in a written log.	1.4.86

	e. Take steps to ensure that Voyager crews are fully conversant with the Release to Service stipulation prohibiting the on-board charging of portable electronic devices.	1.4.120
1.5.11.	**A1 Ops HQ AIR should:**	
	a. Review the post of Incirlik RAFLO to establish terms of reference, a clear chain of command and appropriate training requirements.	1.4.132
1.5.12.	**STANEVAL, RAF Brize Norton should:**	
	a. Conduct a 100% check of logbooks on 10 Squadron to ensure they have been completed in accordance with the Voyager Operations Manual.	1.4.130

CONVENING AUTHORITY COMMENTS

1. On Sunday 9 Feb 14, 189 passengers and 9 crew were 5 hours into their flight from RAF Brize Norton to Camp Bastion on board Voyager ZZ 333. The aircraft was cruising at FL 330 when the Captain's personal D-SLR camera was placed between his seat-arm rest and his side-stick controller. Shortly afterwards, when he adjusted the position of his seat, the side-stick was deflected fully forward which resulted in the aircraft rapidly entering into a steep descent. The Captain, who was alone on the flight deck while the Co-pilot took a break, was unaware that his camera had caused the pitch down. The Co-pilot, now weightless due to the negative 'g' forces and just outside the cockpit door, managed to traverse the cockpit ceiling to get back to his seat where he was able to pull his side stick fully aft. In the ensuing dive the aircraft achieved a maximum rate of descent of 15,800 feet per minute and lost 4,400 feet in just 27 seconds while reaching a speed of Mach 0.9. From the onset of the pitch-down until the removal of the camera 33 seconds later neither pilot had control of the aircraft; however, the aircraft's automatic high-speed protection system triggered after 13 seconds, reducing the engines to idle before commencing a sustained positive 'g' recovery. Once the obstruction had been cleared, the crew were able to regain control of the aircraft and divert to Turkish Air Force Base Incirlik.

2. I classify this incident as a near-miss for very good reason; frankly, without the excellent technology of the Airbus A330 flight control laws, the outcome could have been very different, with the realistic potential for the loss of the aircraft and 198 of our people. It is important to reiterate that the purpose of the Service Inquiry (SI) is to investigate the circumstances surrounding an incident in order to prevent a reoccurrence and not to apportion blame. The Panel has been careful to respect this separation. [redacted] Without this thorough SI, and the full support of Airbus and AirTanker, we might never have known what exactly happened that night, potentially leaving low passenger confidence in the RAF Voyager and wider A330 fleets. I commend the SI Panel for an exceptional job and I agree with the findings of the report and support all of their recommendations. I also commend interested parties to read the full report as there are many lessons but I will limit my comments to 3 key areas; flight administration, loose articles on the flight deck and post-incident handling including Command and Control.

3. The authorisation system employed was weak. The flight was pre-authorised 2 days in advance. On the day of the flight the Duty Authoriser could not be reached by phone and the Squadron Commander had to be contacted to give approval for a reduced cabin crew complement after one member reported in sick. Following the pitch-down event, it became clear the crew had little if any situational awareness of en-route diversion possibilities. After issuing a Mayday call they elected not to use the nearest suitable option suggested to them by Turkish Air Traffic Control at Trabzon 60nm away and instead requested a diversion to Istanbul, 500 nm away. Air Traffic Control eventually offered the option of diverting to Incirlik, at a range of 340 nm, which the crew accepted. It is clear that a lack of preparation and understanding with regard to en-route diversion options had the potential to exacerbate what was a potentially serious situation by inhibiting the crew from landing as soon as possible. Following a highly unusual emergency and with a potentially damaged airframe I consider this lack of situational awareness and the subsequent decision making in relation to selecting a suitable diversion to be below

the standard that I would expect from such an experienced crew. Further, I would question why the crew did not make more use of the electronic data available to them from the aircraft's navigation systems to assist them in the process of selecting a suitable diversion. From a broader perspective I am concerned that no form of operational risk assessment (of military, security and diplomatic factors) was available to the crew, either prior to flight or on board, to inform their choice of potential diversions en-route. Given that the aircraft was minutes from Georgian and Armenian airspace when the incident occurred, the task of dealing with the aftermath could have had challenging diplomatic and security implications.

4. The event took place during a period of exceptionally low workload for the crew. [redacted] The Panel found that the Captain had used his camera as recently as 3 minutes and 20 seconds prior to the incident. The sequence of events involving the D-SLR camera was established following the detailed analysis of the data from the Cockpit Voice Recorder (CVR), the Flight Data Recorder, the D-SLR camera and its image data, and the forensic examination of the damaged camera body and side-stick unit. The analysis was supported by subsequent simulator trials that were readily able to replicate the chain of events. I am entirely satisfied that at some point in the 3 minutes and 20 seconds prior to the event, the Captain placed his camera on the flat surface between the side-stick controller and his seat arm-rest. At one minute and 44 seconds prior to the event, the CVR detected the noise signature of the seat electric motor as the Captain moved his seat slightly forward[1]. Coincident with this movement, a small pressure on the side-stick was detected, moving it forward by between 0.5 to 0.9 degrees, caused by the initial interaction between the arm-rest, camera and the side-stick. The autopilot remained engaged as the pressure applied remained below the threshold required for automatic disengagement and the aircraft attitude was unchanged. The Captain again moved his seat forward (motor noise signature audible), this time causing a geometrical lock to form between the camera, the arm-rest and the side-stick base, resulting in the fully forward deflection of the side-stick, the disengagement of the autopilot and the aircraft's steep descent. During the event, the Captain pulled hard back on the stick, but was unable to move it as it was locked by the obstruction. He struggled to disengage the autopilot, not realising it had already disengaged, while calling for the co-pilot to do the same. Concurrently, the crew manually placed the throttles to idle, despite the automatic high speed protection system having already reduced engine power, but failed to deploy the speed brakes in accordance with the high-speed recovery technique. At 29 seconds into the event, the Captain said "ok……ok, ok, ok" which was followed by a succession of rapid small lateral (left, right) movements of his side-stick which the SI Panel assesses is the moment when the camera became free. There then followed a distinctive thud on the flight deck, beyond the general background noise, which the Panel believes could be attributable to the camera falling to the back of the cockpit.

5. The operation of the camera on the flight deck was of pivotal significance in the chain of events. Whilst the *carriage* of the camera was not specifically prohibited by any rule or regulation, the Voyager Operations Manual states that lone flight crew must refrain from non-relevant duties. This would clearly include taking photographs. This incident also highlights that the side-stick is vulnerable to accidental operation by a foreign object. However, industry employed mitigations have proven effective for over 190 million flight hours on this family of Airbus aircraft and this was the first

[1] Prior to movement of the seat, it was assessed by the SI Panel to be in a correct and safe flying position as required when alone on the flight deck. It was quite normal to adjust the seat position at points during the flight.

flight control/object/armrest interaction of this nature to be reported to Airbus. Investigation by the Panel has shown that across the 2 Gp fleets the carriage of loose articles into cockpits and the storing of items around the flight deck has become normalised behaviour. While the hazards posed by loose articles had been previously identified, attempts at remedial action, including a previous Occurrence Safety Investigation (OSI), failed to adequately address the issue. To prevent future reoccurrence, AOC 2 Gp has now instigated a strategy to promote awareness of this issue and improve behaviours and accountability for the items that are necessarily taken into cockpits.

6. The post incident handling of this event also highlights several important lessons. The diversion into Turkey caused immigration problems as passengers did not have visas or NATO travel orders and no imprest was available to satisfy the demands of the Turkish Authorities. Overall, the Brize Norton Executive staff gripped the situation quickly, providing leadership of a whole range of activity beyond their Duty Holder (DH) responsibilities. The Panel considered their actions to be fast, thorough and effective but their lead was not through formal arrangement with the PJHQ or DSCOM, both of whom adopted a supporting role. Many decisions made by Brize Norton, with the best of intentions, including which passengers would return to the UK, remount to Theatre or return to their home unit, should have been taken by the operational chain of command. It is likely that this resulted in issues regarding medical support, Trauma Risk Management and mental health being carried forward into the operational theatre without clarity, documentation or accountability. Up to 24% of the aircraft occupants were rendered temporarily unfit for duties following the incident. At the point of writing this report the Panel had found no evidence that the overall medical outcome of this incident was being tracked. I have now taken this up with the Surgeon General as the long-term psychological impact of this incident on those passengers involved needs to be understood. It is also clear that there is currently no contingency plan to deal with the unplanned en-route diversion of a large strategic aircraft. I recommend that such a plan is now developed (including the Command and Control aspects) and held by a suitable Operational-level headquarters.

7. In summary, I consider this extraordinary and unnecessary incident, caused by the unfortunate placing of a camera close to the aircraft side-stick, to be an extremely serious near-miss. The culture and behaviours with regard to taking non-essential loose articles onto the flight deck is a major concern and needs to change. While this incident has highlighted lapses within the Air Transport community in relation to the carriage of loose articles, which I know the DH will resolve, it also serves as a timely reminder to all aviation platform operators of the dangers that loose articles pose. Clearly, certain equipment and articles need to be taken into cockpits for the flight to be conducted effectively but they should be stowed safely and in an accountable manner. There were a number of disappointing flight administration issues and an unacceptable lack of situational awareness was shown by the crew with regard to unplanned diversions. There were also some weaknesses in post occurrence Command and Control. Conversely, the calm and professional actions of the aircraft Purser and Cabin Crew should be commended during their handling of a confused and alarming scene in the immediate aftermath of the incident, as should the Brize Norton Executive team for their fast and effective response. On this occasion, the A330 automatic self protection systems likely prevented a disaster of significant scale. The loss of the aircraft was not an unrealistic possibility. While at its heart this incident was caused by the simple and unthinking act of placing a loose article close to the aircraft controls, there are broader lessons to learn here. Modern technology may be capable of reducing crew

workload to historic lows and aircraft can now protect themselves as never before, but the requirement for crews to understand and interact with the aircraft and its systems when things deviate from the norm remains as challenging as ever.

DG MAA