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).

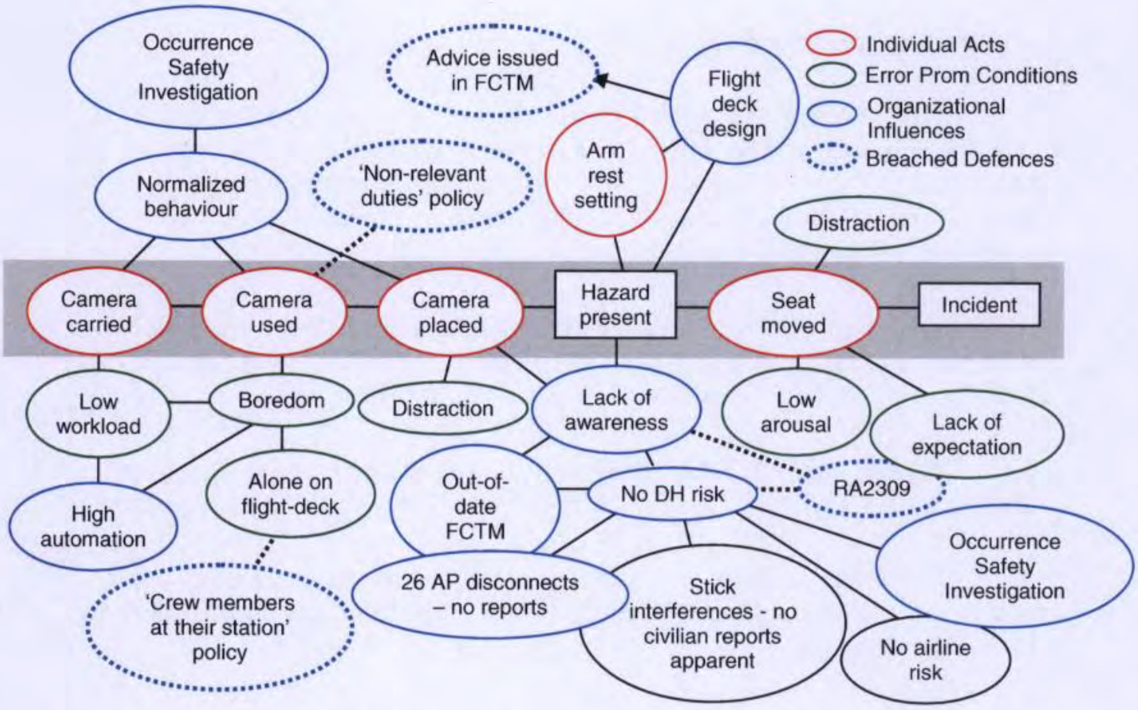

Figure 10 (Repeated): Diagram of key factors leading to pitch-down command.

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

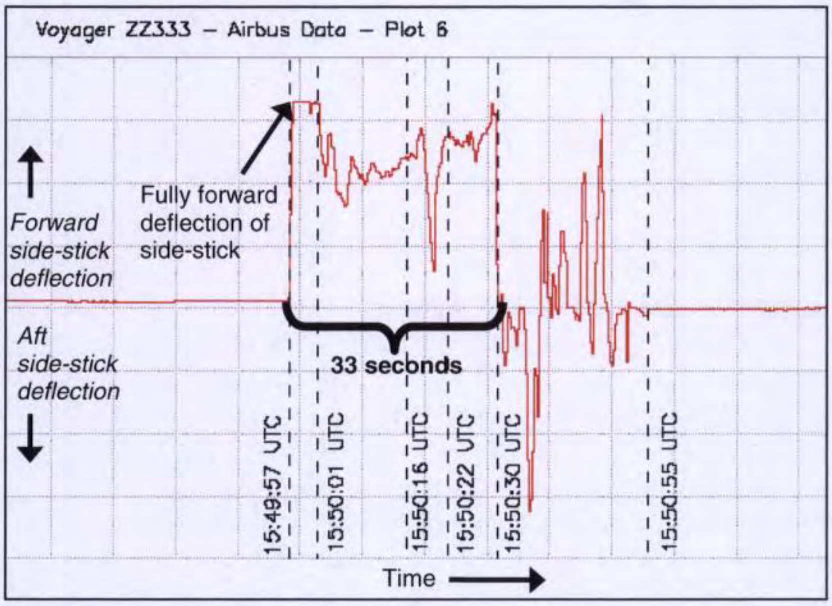

Figure 16: ZZ333 DFDR trace of Captain's side-stick in pitch.

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

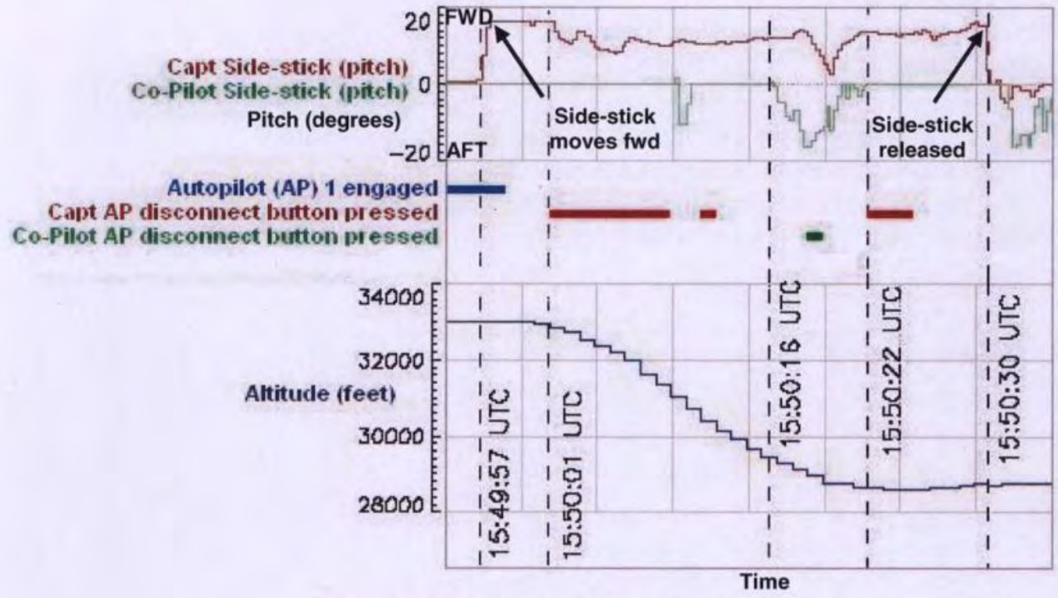

Figure 17: Composite DFDR trace.

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 over-ride 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

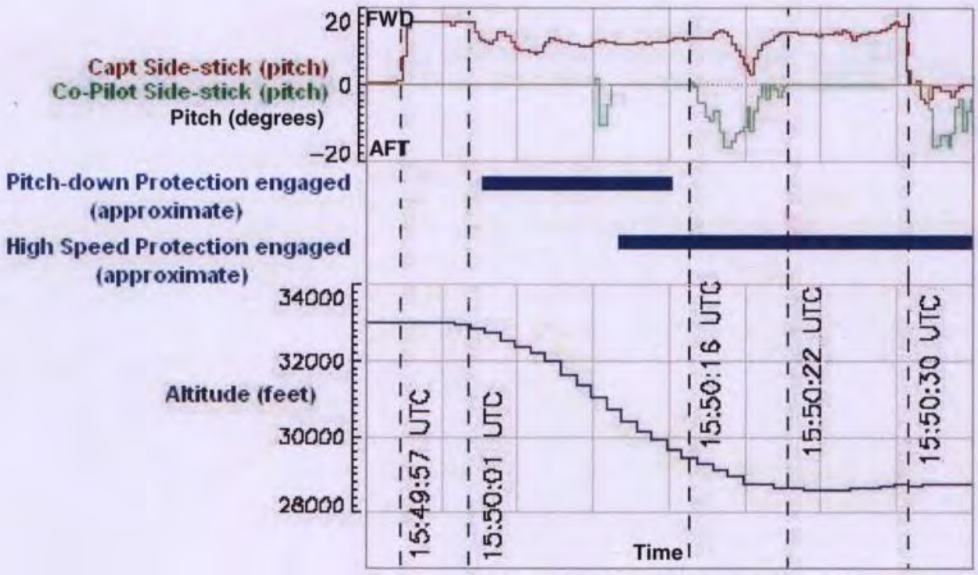

Figure 19: Composite DFDR trace.

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.

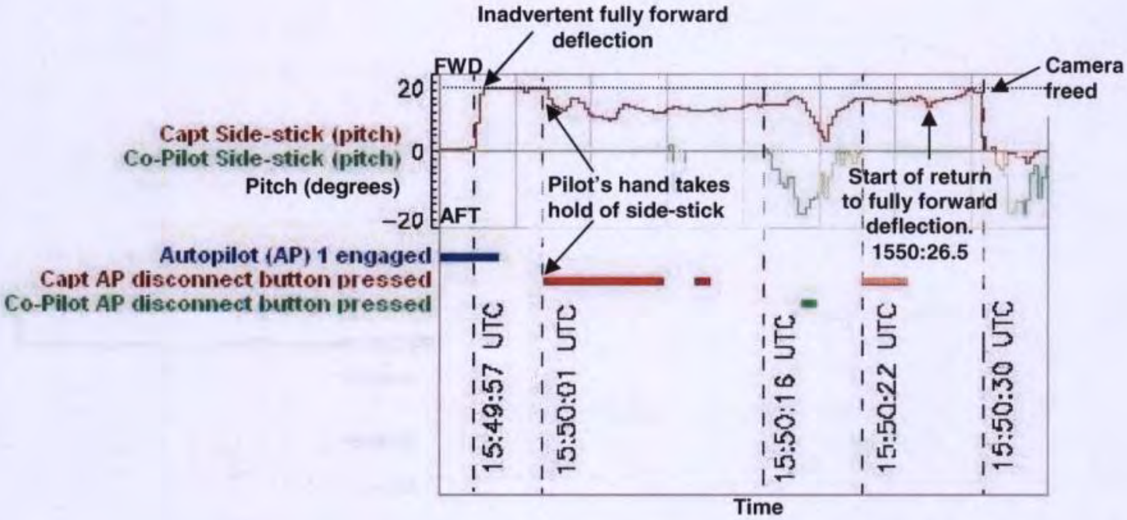

Figure 20: Composite DFDR trace.

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

Military Aviation Authority MAA

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

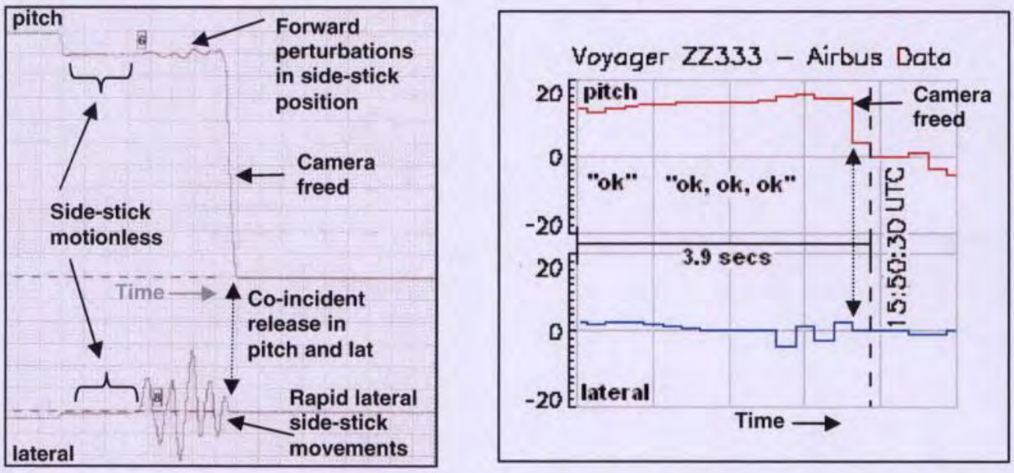

Figure 21: Simulator trace (left) and ZZ333 DFDR trace (right) showing side-stick in pitch and lateral axes.

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

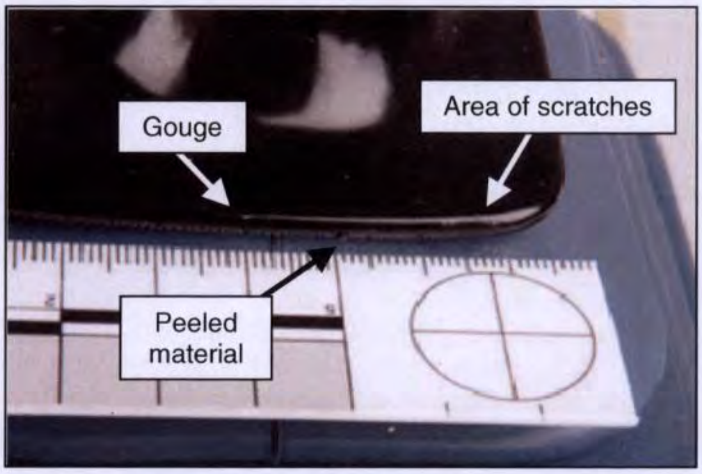

Figure 22: Witness marks on rear right-hand area of side-stick.

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

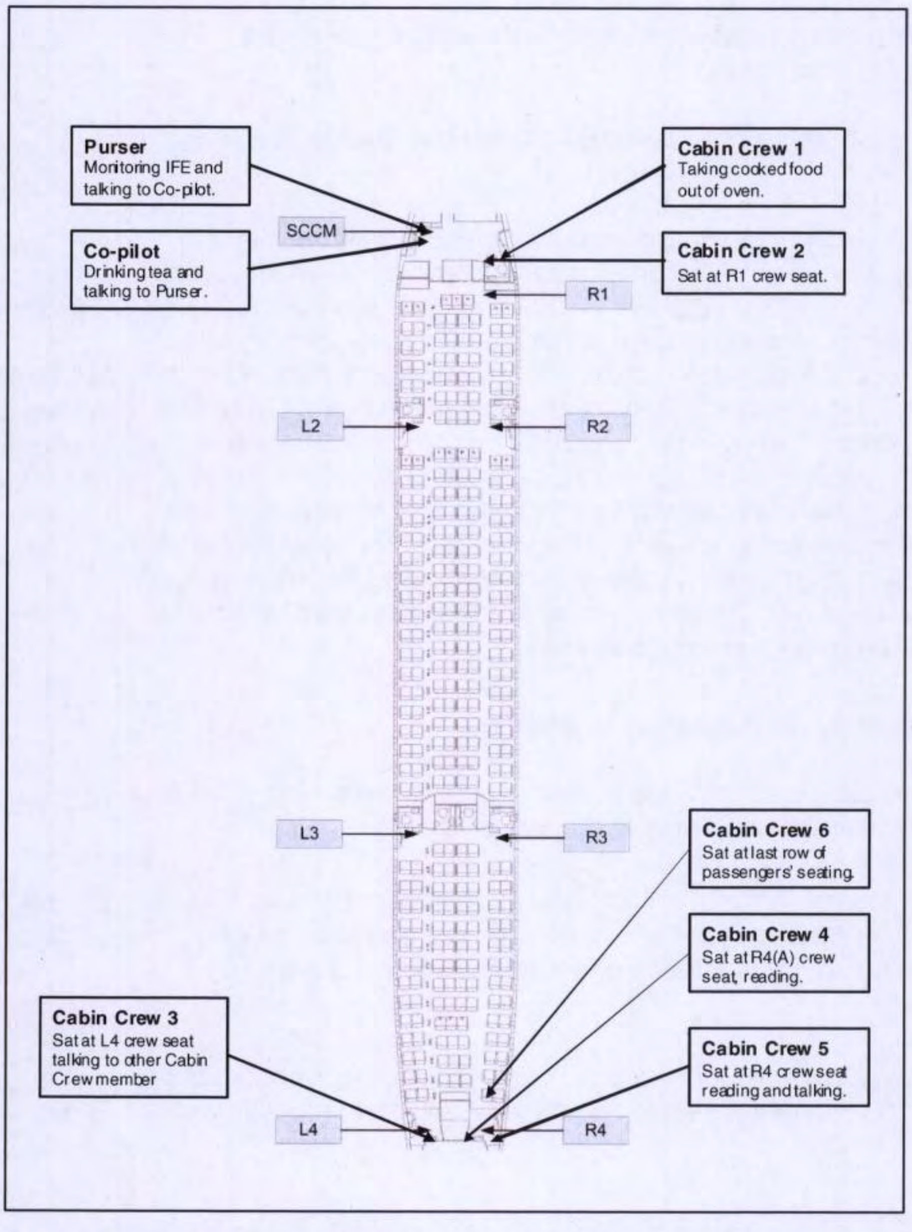

Figure 23: Cabin Crew positions at time of incident.

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, (Exhibit 21) 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 (Exhibit 28) 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**:

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. (Exhibit 13) 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 (Exhibit 75) cabin to be used for this purpose instead; this was the case on ZZ333. (Witness 3, Panel Interview 2) 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.**

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 (Exhibit 76, Exhibit 77) 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.

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 (Exhibit 46) by all passengers:

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.** 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

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).