focus

ON COMMERCIAL AVIATION SAFETY

SPRING 2005

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UNITED KINGDOM FLIGHT SAFETY COMMITTEE

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__FOCUS__ is a quarterly subscription journal devoted to the promotion of best practises in aviation safety. It includes articles, either original or reprinted from other sources, related to safety issues throughout all areas of air transport operations. Besides providing information on safety related matters, __FOCUS__ aims to promote debate and improve networking within the industry. It must be emphasised that __FOCUS__ is not intended as a substitute for regulatory information or company publications and procedures.

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Front Cover Picture: A Britten-Norman Defender off the South Coast of England

Picture courtesy of Flight Images

Complacency – Stamp it out

For many years operators in the United Kingdom have been operating what is believed to be the most open Mandatory Occurrence Reporting (MOR) system in the world.

The Civil Aviation Authority (UK CAA) to their credit, created a positive culture by encouraging the submission of these reports and not using them as a means of penalising pilots. They have also promoted the use of the MOR database and many operators have used information from the database in order to improve flight safety within their organisations.

As a result of the positive way that pilots in the United Kingdom have reported incident information and as a result of the sharing of this information between operators to prevent similar incidents from occurring, the UK MOR system is admired around the world.

For every MOR submitted to the CAA by an operator, about 30 Air Safety Reports (ASRs) are filed within that operator. All of these are scrutinised and action taken where necessary to fine tune the operation.

Presently about 1,000 MORs are filed with the UK CAA each year. Many of these are discussed in detail during the Safety Information Exchange session at the UK Flight Safety Committee meetings held every two months.

In an environment like that which currently exists in the UK, it may be easy to become complacent. Perhaps some incidents are not reported because they are thought trivial and perhaps some of us could put more effort into the quality of the reports submitted. Often one hears that fight safety officers are thinly stretched with too much to do and too little time in which to do it. Does this mean that their investigations are not as thorough as they should be? Probably not, but at times one can not help feeling a little uneasy about the effect of cost cutting and increasing commercial pressures.

The introduction of routine Flight Data Monitoring may be seen by some as a "spy in the sky" exercise. If used wisely it will assist operators to become aware of those safety events that are not being reported by some aircrew. It will also be an aid in the investigation of the reported events. More accurate data relating to safety events will become readily available to the investigating safety officer and result in a better understanding of the event and improve the recommendations that stem from such events.

Flight Data Monitoring is another tool for the operator to use in monitoring the safety of the operation. It is not a "Cure all".

Each member of staff needs to be on their guard for creeping complacency and must stamp it out at the earliest opportunity.

Man who is subject to repetitive tasks will with time become complacent. It is therefore necessary for each and every manager to see that there is sufficient variation in the task to ensure that their staff do not become complacent.

Nowhere is this more important than in the aviation industry.

UK FLIGHT SAFETY COMMITTEE OBJECTIVES

To pursue the highest standards of aviation safety.

- To constitute a body of experienced aviation flight safety personnel available for consultation.
- To facilitate the free exchange of aviation safety data.
- To maintain an appropriate liaison with other bodies concerned with aviation safety.
- To provide assistance to operators establishing and maintaining a flight safety organisation.

Safety and Security in Aviation

The events of 11th September 2001 changed the face of aviation permanently. Aircraft were no longer being hijacked to make a political point; they were now being used as missiles. The rush to produce counter-measures resulted in tighter security checks both on and off the aircraft, and the introduction of locked and armoured cockpit doors. Like all instant solutions - some were good and some were bad. Just over 3 years later and the aviation industry have settled into the routine of security measures at airports and aircraft.

One benefit that may be said to have come from all this is the relationship between safety and security departments. From government down through industry, they have been talking more to each other than perhaps they did in the past. Within airlines, both aircrew and ground crew have been made more aware of their security responsibilities and how they fit into the Flight Safety culture. Locked cockpit doors probably causing the greatest need for change for aircrew, and the need to secure aircraft for the groundcrew.

The days of allowing anyone on the flight deck, easy entry by cabin crew, and even flying with the door propped open have all gone. The armoured wall has meant that crews have to ensure that their CRM and communication skills must leave no room for doubt where the safety of flight is concerned.

So what affect does all this security have on the role of the company Flight Safety team?

Well certainly more contact with their security counterparts. The CAA, in conjunction with the Transport Security Section (TRANSEC) of the DfT has achieved some good agreements over the procedures for the use of hardened cockpit doors. These procedures have passed into Operation Manuals and have now become standard in UK aviation.

But how far does Flight Safety need to be involved in security? Well, there are no definitive lines to be drawn.

The locked cockpit door policy has the biggest effect on Flight Safety but it is only a very small part of the overall aviation security plan. Flight Safety managers (and us at UKFSC) must be careful not to be drawn into areas that are already well served by security experts. This does not mean that we should not be inquisitive, rather that we ensure that what we decide to do fits in with the overall security culture and that suitable advice is sought from those who are the 'experts' - but Flight Safety must always be the priority.

Passengers, those people who pay our way, have always taken it for granted that they will be transported in a safe manner. They never used to distinguish between a safe flight and a secure flight - the two were always integrated in their minds. It is interesting that more passengers are now taking note of the industry's security procedures and are not afraid to question them. The media have done a lot to raise the public awareness of aviation security and thus their expectations when they travel.

We must ensure that none of them are disappointed!

UK Flight Safety Committee Annual Seminar "Breaking the Barriers in Communication"

20th-21st September 2004
Radisson Edwardian Hotel, Heathrow Airport
Report by Ian Sheppard

An impressive array of speakers lined up at Heathrow to throw light on the critical issue of "enhancing aviation safety through better communication" – from a military man to a lawyer, an airline ceo, a leading academic, an industrialist, an air traffic controller and last, but by no means least, a regulator.

Colonel Arthur Gibson, who in July became Commandant of the UK's Defence Helicopter Flying School, said that while the military thinks itself good at communicating, the three branches of the armed services are perhaps "too compartmentalised". Much effort has been needed at DHFS to nurture mutual understanding in respect of "needs, desires and key functions" while "fostering the core values of all three."

Collectively, meanwhile, the essential military 'can-do' attitude is "very difficult to manage… at times the military has to push the envelope to get the job done [but] when do you allow crews to deviate?," he asks. "Are we different to civil or just being gung ho?" Leadership and communication have been central themes in the joint helicopter command's approach, with the aim of improving command and control. Gibson believes that pooling assets has worked in "enhancing communications" and he reflected that "it is remarkable that we were able to make it work at all before."

The Defence Aviation Safety Centre has been "leading the way" in defining new regulations since its formation in 2002. Gibson says that it is "unbelievable" that JSP318 (the military ANO equivalent used until mid-2003) worked at all and even more so that "CAA let us use it" – and says that the new joint regulations JSP550 is far better, also covering areas such as Joint Force Harrier and translating lessons learned in working together to avoid compartmentalisation at the front line.

Meanwhile looming on the horizon is the UK Flying Training System (MFTS) which is being developed for 2012 and will be outsourced under a £30 billion contract. "This will not have the compartmentalised management systems we still see today" says Gibson, who concludes that through all of these initiatives flight safety will "be the winner".

Barrister Charles Haddon-Cave QC, of Quadrant Chambers in London, said that in his experience management should be "not too rigid and not too flexible – both can lead to problems". Communications was an essential factor with the simplest words being easily misconstrued. "Trivial errors or omissions can be catastrophic", he said, while increasingly complex systems, crowded skies and greater awareness of 'rights', the risks were all too real.

Good communication is clear, concise and controlled – concise as busy people need to see the point "instantly" – although the discipline of brevity and good structure is very hard to achieve; controlled in three ways: between the relevant parties; timely; and with the right priority. "Poor communications usually lacks one of these factors, with causation can then lead to catastrophe".

There are also "inhibitors" (as opposed to barriers) to communication, he said, such as a poor safety procedure. With the Herald of Free Enterprise disaster in 1987, closing the bow doors was the job of the assistant boson who had fallen asleep on his bunk reading a Jeffrey Archer novel. There was no system for checking that the doors were closed and no light on the bridge to indicate that they were still open. Meanwhile, six months beforehand a senior director had vetoed a suggestion for a warning light – as there was a seaman watching the doors!

At the public inquiry in front of admiralty judge Sir Barry Sheen, counsel described the management as "sloppy, from top to bottom" – with the switch from a lifting door design to a clamshell design, so the bridge couldn't see if it was open or shut, not being acted upon. "There was a lack of appreciation of this change with some in the fleet – some masters of vessels put in place training while others did nothing," and there was no company forum to discuss safety issues, said Haddon-Cave. Thus the case is still a reminder that organisations need dedicated safety officers – but "not just superannuated pilots close to retirement with little clout." This mantra was reinforced following the Marchioness disaster on the River Thames. Lord Justice Clark reported that modern management needed trained risk managers.

A second inhibitor to good communication is "authority gradients", said Haddon-Cave, citing a midair collision where a pilot instructor had a bag on his head but the junior pilot didn't express his concerns. Similarly in the crash on the M1 motorway at Kegworth, UK, where a Boeing 737-400 failed to make the runway having shut down the wrong engine, the passengers and cabin crew had been "surprised" at the announcement by the pilot that he'd shut down the right hand engine when they could see that it was the left one that was on fire. 'Passive' passengers and 'mere' cabin crew failed to get up and bang on the cockpit door to highlight the possible mistake. "We fly the plane and you pour the drinks" was the prevalent attitude, says Haddon-Cave.

The third inhibitor of good communications is lawyers and the threat of litigation. "There has been a sea change in popular attitudes – give people rights and they exercise them, particularly where there are 'men in suits' as targets," he said. The European Convention on Human Rights has given people rights and they use them, with the assumption being that it must be someone's fault – the result being that the threat of lawyers obtaining e-mails etc "stultifying open debate".

The fourth inhibitor which Haddon-Cave highlighted was the tendency to make assumptions without asking or double-checking. People "often don't voice lingering doubts", which is why the SAS mantra is "assumptions are the mother of all cock-ups".

The fifth inhibitor he cited as language difficulties, where there is broad scope for misunderstanding non-native speakers, and the sixth is "technology itself" as it "completely changes" the way society thinks, operates and communicates. The first aspect of this is information overload, contrasting with the problem previously of too little information. "The temptation is to pour information and everyone disseminates it around – cut, paste and splurge". He added that e-mails have made us "sloppy" and that wading through them is "daunting". "It's a real problem in my view", Haddon-Cave concluded.

The second observation on new technology is the "toy" aspect, even in the cockpit, with the opportunity for old-fashioned communication often being lost. "Glass cockpits can be mesmerising and don't necessarily communicate [information] as well as dials," as was illustrated in the Kegworth crash where the first officer had been preoccupied with reprogramming the flight computer, while by conducting a proper conversation with the captain "he might have highlighted the mistake". As it happened the commander spooled up on approach causing the single operating engine to fail.

Finally Haddon-Cave said that post-accident communications were also essential. Both for damage limitation and to maintain confidence in the industry as a whole. Clarity and openness and finding out what happened to learn for the future should be the goal. It would also help the families of the victims and also the company, which also suffers trauma of

sorts. People in the companies involved often "clam up and become brittle" under the searchlight at a time when the company should be being more flexible. The legal ramifications of not handling the aftermath properly are also bad, leading to a more bitter battle; Haddon Cave said he would encourage discussions under Chatham House Rules (a confidentiality agreement.)

British Airways Chief Executive Rod Eddington said that safety is the heart and soul of "the industry we all love and serve" and most customers are happy to swap between airlines they think are completely safe. "We can't take safety, and security, for granted though", although the fact that they do is a tribute to the people involved and the way they work together. It is now not uncommon for a pilot to retire having never had an in-flight shutdown (other than in the simulator) and now people on the ground can monitor the aircraft and see a problem before the pilots.

The relationship between people and technology can pose both opportunities and threats, he said. As technology takes over there is a danger that people become "bored spectators [who] could miss things - too often the technology does and people monitor". With communications between people, that it has become less hierarchical and more open is good for a strong safety culture, where junior staff can talk openly to senior managers. A safety committee with "people from the business" is essential, said Eddington, as departments may work well within their own 'silo' but not together.

Eddington also highlighted the importance of a good relationship with regulators, in his case the UK CAA, and with key suppliers such as manufacturers and airports. We need to "bring together so nothing falls between the gaps", as well as managing change, such as new cockpit doors, which have their own implications for communications between the cockpit and cabin crew.

Meanwhile, with an increasing number of the accidents that do occur being due to people being in the loop, a no-blame culture is essential, including open sharing of safety information with competitors. "Take good ideas wherever you can find them [including] learning from other industries", he concluded.

James Reason, the former Professor of Psychology at Manchester University who is famous for his Swiss cheese analogy and who has written several books on managing maintenance error, said that safety relied on "timely and accurate communications". "I have never read an accident report where communications was not a factor somewhere, although it is more a 'condition' which gives rise to an accident rather than being the cause."

He cited the "horrors" of Tenerife as "where lots of this started", going on to discuss the SAS MD-87 accident at Linate Airport, Italy, which hit a Citation which had inadvertently strayed onto the runway in the fog. While the air traffic controller had a "mental model" that they were on the right path, the Citation's pilots, when confronted with two signs at a fork in the taxiway went for 'R6' as it had clearer lights and was nearer.

Thus the pilots and ATC shared a common misconception – a not uncommon theme, whether in the flight crew-cabin crew relationship, or that between shifts in ATC or maintenance, or between designer and user or airport and ATC. Uberlingen was a prime example, also bringing trust and procedures involving technology into the picture. There the supervisor failed to tell the ATCO of ongoing maintenance work to the short-term conflict alert system and the pilot of the Russian Bashkirian Tu-154 followed ATC instructions and ignored his Traffic Collision Avoidance System (TCAS), leading to the collision with the DHL 757.

The TCAS manual did say to follow ATC if there is a conflict, although ICAO Annex 10 says TCAS advisories have to be followed (although elsewhere ICAO says to look out if you do disobey!) "It's a crazy world", said Reason, who went on to say that the lengthy Dutch report on the accident focussed somewhat unfairly

on castigating the poor culture of the Swiss ATC provider. "We're in danger of missing the fact that it was an unlikely (but foreseeable) failure, and of missing the big picture, which is where communications is crucial."
Ian Linton, LATCC general manager, said that TCAS had become a "fundamental independent safety net" and that it was essential that everyone operating in controlled airspace should use it – even on military corridors. He added that "the jury is out on whether ATC should know about it" but he thought they should, because as soon as ATC knew that the pilots were responding to resolution advisories they would give only advisories and not instructions."

There are efforts to equip military aircraft in the UK with TCAS but there have been lots of problems trying to fit it into older aircraft. Alan Hudson, director of DASC, said that they had gained useful experience with the C130J Hercules but that it was harder for fast jets. It was trialled in the Tucano trainer last year, he said, and the Ministry of Defence has now cleared the whole Tucano fleet to be fitted.

Nearly half of pilot-controller errors are "readback-hearback" ones, says Reason, which is partly a workload issue. Also while en route controllers are typically relaying three bits of information, ground controllers give six. Academic studies have shown that as you get to over four bits of information, less than a third of the instructions get read back in full.

Reason cited various accidents, including that of an Air Ontario F28 in Dryden in 1989 which lead to a seven-volume investigation report drawing on 200 expert witnesses. After all that the report blamed the Canadian ATC system as a whole. "You get to a point where the statement becomes vacuous," said Reason. There had been snow on the wings which people noticed but nobody brought it to the attention of the pilots, leading the report to discuss the "culture of separation".

Another example was the Embraer 120 accident at Eagle Lake Texas where screws had been removed from the stabiliser but nobody relayed the information to the next shift. This led to the in-flight loss of the stabiliser ice-boot.

The Singapore Airlines 747 accident in Taipei during a typhoon was a classic example also, the pilots turning onto runway 05R rather than 05L and ploughing into a construction site. Reason described it as "an extraordinary sequence of miscommunication." The taxiway lighting was sparse but that onto 05R was bright. "It was bound to happen", says Prof Reason, who advised going back to basics to understand common failures.

GATCO deputy president John Levesley said that European communication is "a strange beast", with lots of voices on the future of ATM – centrally ECAC, Eurocontrol and the EU itself. There are too many languages and the European system is too fragmented, he said, which has resulted in no action over the past 30-40 years and now a serious problem with delays.

Communications is an issue in that many, such as airlines, are not clear on what is happening with the proposals, there are so many concepts and initiatives extant. The EU has adopted SESAME, originally proposed by Airbus as "Deploy", but "few people knew about it". With three times as many aircraft expected in the same airspace by 2025 "quite frankly current ATC methods can't do that", says Levesley. The EU Single Sky programme now has a voice "much louder than any of the others – because they have the power to legislate."

Industry consultation has not been straightforward. The EU was bound by the Maastricht treaty to consult and the Amsterdam Treaty said who was entitled to be consulted, but this excluded pilots as the European Transport Federation, which was selected as the industry's representative, represented no pilots. BALPA and IFALPA were thus excluded and has had to go through the European Cockpit Federation (which "has caused a few problems").

The rub is that only these "social or sector partners" have to be listened to. This is bureaucracy at its worst, said Levesley, which "may work for Brussels, but does exclude an awful lot of people." SES is driving convergence and Eurocontrol is trying to bring itself into line, he said, and with the EU legislation having been passed "it will happen", but there are "issues of considerable difficulty" to manage future airspace demand. Levesley concluded by saying: "Be warned, there are many plans afoot to change the way that we work and live."

Leading industry figure Stewart John OBE, of Thrust Logistics Company, focussed on engineering management and communication. He listed the many advances in aviation which have enhanced safety and reliability, in particular the fact that there were now around 5,000 ETOPS flights across the Atlantic a week compared with the 1970s. Then an engine going 1,000 hours incident free was a big achievement but now 15,000 is getting to be routine.

John believes, however, that manufacturers should communicate problems to get customer respect – "give us the bad news as well as the good (before we read it in Flight International) – and that the 'Working Together' mantra should be extended to continuing airworthiness. He added that communications were more important than ever in an industry which had been hit by so much, from the first Gulf War to Asian devaluation, SARS, 11 September and Asian Flu.

David King, Deputy Chief Inspector of Accidents at the AAIB, highlighted the need for good communications with industry "so we can conduct investigations efficiently". He compared aviation with other transport modes such as rail, which is under "tremendous pressure" to cope with "recommendation overload" after high-profile accidents, and maritime, which "struggles with a complex cultural mix to a far greater extent than aviation".

Aviation has a clearer appreciation of risk and probably a simpler regulatory structure, says King, although the European factor with EASA now presents "a serious challenge and quite a loss of clarity." ICAO has better communications and a better way of controlling international initiatives, he said. Meanwhile confidential reporting was good (the 'CHIRP' programme for example) but "could do better" – it has just been subject to a five-year review which concluded there was still a need for it.

The push with the UK Department for Transport is to encourage the investigation agencies under its auspices to work together and take a 'multimodal' approach, like the US NTSB although the three groups are "very discrete". Currently the three Chief Inspectors meet to share best practice and compare notes on various issues – from sharing of technical resources such as metallurgy to international co-operation and new EU Directives.

Another more recent development is improving family liaison, "giving out leaflets and briefing families throughout an investigation". Families used to be kept at arm's length but now they get advance copies of reports and with the recent Gerona investigation (Britannia 757), the families were taken down to Cardiff for a briefing ahead of the Spanish authorities publishing their report. This was "quite effective" said King, "and Britannia were happy with it".

Threats to efficient investigation include the "public thirst for blame and retribution" as well as new legislation – new proposed legislation on corporate killing, a new 'public inquiry' Act – and a lack of finding good people for the key jobs (partly because the "RAF sources are drying up").

EASA also represents a major challenge, as in late 2003 it became responsible for all airworthiness issues and the CAA handed over all type certificated. King said the challenge was knowing to whom it should send recommendations.

Bill Robinson, of the Rail Safety and Standards Board, said that for safety communications you have to be clear what everyone else is doing, and ensure that cultural issues are not swept aside. Rail has had the same difficulties as aviation in terms of blame culture, and keeping the health & safety inspectors and police off the scene of an accident – they are "quick to launch prosecutions", said Robinson. From 2005 a new rail investigatory agency will be up and running and will "help enormously".

Conclusion

The Conference was quite wide-ranging and various issues were explored in more detail than there is space for here, in particular the Single European Sky, which seems to be subject to much confusion, and TCAS. One vital issue which arose during the Q&A session was that of confidentiality of CVR material and the industry's need for a 'no-blame' approach. It was stated that prosecutors can go to court to try to obtain the material and the judge will balance confidentiality against the public interest. There is now an ICAO initiative to take CVRs out of the para of Annex 13 of the Chicago Convention where it currently resides and give it a discrete level of protection. Although IFALPA wants to see absolute protection for pilots, ICAO will be unable to achieve this as it has to leave scope for national legal processes.

Ian Sheppard, BEng MRAeS, is a freelance aviation journalist and edits his own monthly newsletter, Air Law News. A former Editor of Aerospace International and reporter with Flight International, he is currently studying law at Kingston University and specialises in writing on and researching air law issues.

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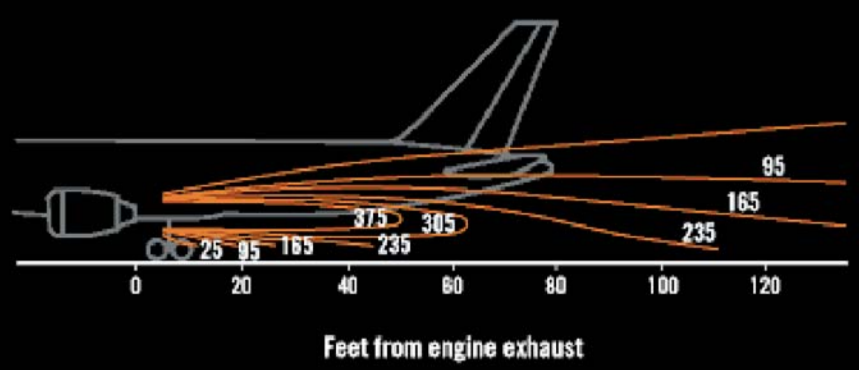
Engine Thrust Hazards in the Airport Environment

Boeing commercial airplanes are equipped with engines rated from 18,000 to nearly 100,000 lb of thrust. Such thrust levels provide for safe takeoff, flight, and landing over a wide range of temperatures, altitudes, gross weights, and payload conditions. However, the exhaust wake from these engines can pose hazards in commercial airport environments. Operators and airport authorities must carefully consider these hazards and the resulting potential for injury to people and damage to or caused by baggage carts, service vehicles, airport infrastructure, and other airplanes.

1. Power Hazard Areas

When modern jet engines are operated at rated thrust levels, the exhaust wake can exceed 375 mi/h (325 kn or 603 km/h) immediately aft of the engine exhaust nozzle. This exhaust flow field extends aft in a rapidly expanding cone, with portions of the flow field contacting and extending aft along the pavement surface (fig. 1).

FIGURE 1. MAXIMUM TAKEOFF THRUST ENGINE EXHAUST WAKE



The jet wake streamlines repesent velocities from 375 mi/h for the inside streamline to 25 mi/h for the outside streamline. Each successive streamline represents a velocity change of 70 mi/h.

Exhaust velocity components are attenuated with increasing distance from the engine exhaust nozzle. However, an airflow of 300 mi/h (260 kn or 483 km/h) can still be present at the empennage, and significant people and equipment hazards will persist hundreds of feet beyond this area. At full power, the exhaust wake speed can typically be 150 mi/h (130 kn or 240 km/h) at 200 ft (61 m) beyond the airplane and 50 to 100 mi/h (43 to 88 kn or 80 to 161 km/h) well beyond this point.

One approach to relating these values to airport operations is to consider the hurricane intensity scale used by the U.S. National Oceanic and Atmospheric Administration. A Category 1 hurricane has sustained winds of 74 to 95 mi/h (64 to 82 kn or 119 to 153 km/h). At these velocities, minimal damage to stationary building structures would be anticipated, but more damage to unanchored mobile homes and utility structures would be expected. An idling airplane can produce a compact version of a Category 3 hurricane, introducing an engine wake approaching 120 mi/h (104 kn or 192 km/h) with temperatures of 100˚F (38˚C). This wake velocity can increase two or three times as the throttles are advanced and the airplane begins to taxi.

At the extreme end of the intensity scale is a Category 5 hurricane, with winds greater than 155 mi/h (135 kn or 249 km/h). Residential and industrial structures would experience roof failure, with lower strength structures experiencing complete collapse. Mobile homes, utility buildings, and utilities would be extensively damaged or destroyed, as would trees, shrubs, and landscaping. At rated thrust levels, a jet engine wake can easily exceed the sustained winds associated with a Category 5 hurricane.

2. Maintenance Activity

High engine thrust during maintenance activity can cause considerable damage to airplanes and other elements in the airport environment. An example of this problem occurred after an airplane arrived at its final destination with a log entry indicating the flight crew had experienced anomalous engine operation. Subsequent evaluation resulted in replacement of an engine control component, followed by an engine test and trim run to verify proper engine operation. The airplane was positioned on an asphalt pad adjacent to a taxiway, with the paved surface extending from the wingtips aft to the empennage. During the high-power portion of the test run, a 20- by 20ft (6.1- by 6.1-m) piece of the asphalt immediately aft of the engine detached and was lifted from the pad surface. This 4-in (10.2-cm)-thick piece of asphalt drifted up and into the core area of the left engine exhaust wake, where it shattered into numerous smaller pieces. The pieces were driven aft at substantial velocity, striking the aft fuselage and left outboard portion of the horizontal tail. The maintenance crew was alerted to the ramp disintegration and terminated the engine run. Subsequent inspection found that the outboard 4 ft (1.2 m) of the left horizontal stabilizer was missing, as was the entire left elevator. Corrective action included replacing the stabilizer and left elevator and repairing holes in the fuselage.

3. Foreign Object Damage

Foreign object damage (FOD) caused by high engine thrust can affect airport operations as it relates to

- Airplane structure.
- Flight controls.
- Equipment and personnel.

Airplane structure

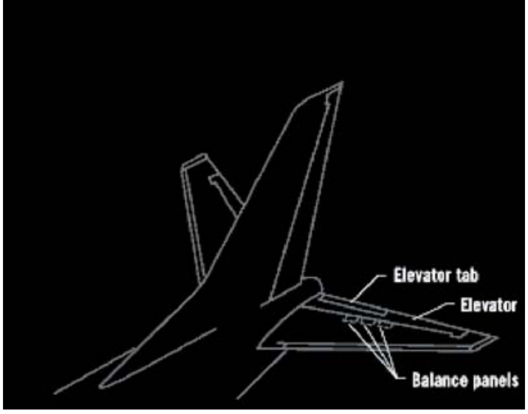
In an incident related to FOD caused by high engine thrust, Boeing was informed that a 737 had landed at a European airport and the flight crew had discovered significant damage during their walkaround inspection. Damaged areas included the right horizontal stabilizer leading edge and lower surface and elevator lower surface. Upon inspection, a piece of bricklike paving material was found embedded within the stabilizer structure. Shortly before the FOD was identified, the Boeing Field Service representative at the originating airport was notified of runway threshold damage. Subsequent correlation of these events matched the brick paving material extracted from the airplane with identical material formerly located along the runway threshold. The paving material was lifted and blown aft by the engine exhaust as the airplane turned onto the runway for takeoff. Repair included replacement of the stabilizer, elevator, elevator tab, and stabilizer-to-body closure panels.

Flight controls

FOD can also affect flight control system component interaction and system displacement force, which are intimately related to properly functioning primary control surfaces. In most airplanes, the elevator is powered by independent hydraulic systems through power control units. Some airplanes offer other modes that allow manual elevator operation. In an unpowered mode, aerodynamic balance panels, linkages, and hinges interact to assist in elevator deflection against air loads (fig. 2). These elements must work together to ensure that actual elevator displacement is proportional (and repeatable) with respect to the control column displacement, thereby providing a consistent pitch response. This interrelationship of proportional response is sufficiently important that aviation regulatory agencies impose certification requirements prohibiting airplane response reversal and requiring airplane pitch response to be proportional to control column displacement.

Even subtle FOD to the external portions of the elevator can change the surface balance and alter the airflow characteristics in a way which may induce surface flutter. This dynamic and uncommanded movement of the surface can grow in both amplitude and frequency, causing additional damage. Portions of the surface may be destroyed by the violence of the induced motion. If this motion is great enough, it can be coupled into nearby airplane structure and cause collateral damage. In exceptional cases, control surface flutter could lead to loss of airplane control.

FIGURE 2. ELEVATOR SYSTEM



Equipment and personnel

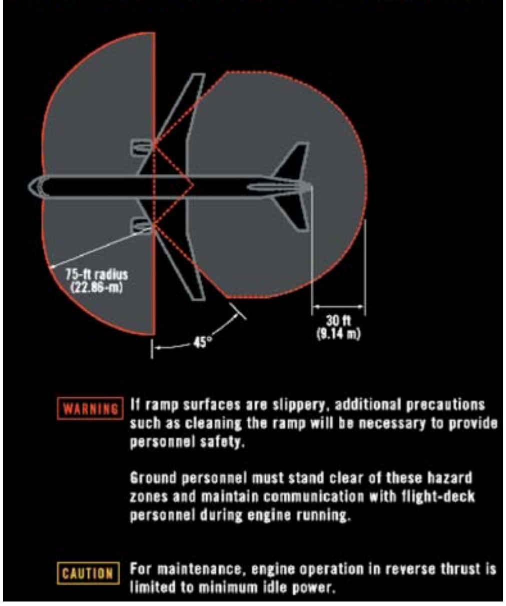
FOD also has the potential to affect the many aspects of ramp operations. These operations subject people, baggage carts, service vehicles, and airport infrastructure to injury and damage. For example, unsecured baggage carts can be displaced by the exhaust of passing airplanes, causing airplane damage or injury to personnel (see "Foreign Object Debris and Damage Prevention" in Aero no. 1, Jan. 1998). Engine inlets represent a potential personnel ingestion hazard (see "Engine Ingestion Hazards — Update" in the Jan.-Mar. 1991 Airliner magazine). Airplane reverse-thrust operations and the use of reverse thrust to move an airplane will increase the power hazard area and require particular care to ensure that people and equipment are adequately protected (fig. 3).

"Taxi Operations By Maintenance Personnel" (Apr.-June 1988 Airliner magazine) discusses the increased risk of injury and damage from inadequate clearance between the airplane and surrounding objects.

4. Precautionary Steps

Understanding an airplane's characteristics and capabilities is crucial to protecting the airplane, the personnel working around it, and the airport environment from the dangers of high-velocity exhaust. Operators should take precautions to prevent damage or injury

FIGURE 3. REVERSE IDLE THRUST POWER HAZARD AREAS



in the following hazardous areas or during hazardous activities:

- Power hazard areas.
- Maintenance activity.
- Airport environment.

Power hazard areas

These areas (fig. 4) are described extensively in the applicable Aircraft Maintenance Manual (AMM). Additional references can be found in the "Maintenance Facility and Equipment Planning" and "Airplane Characteristics for Airport Planning" documents provided to each operator. The documents include resources that describe engine exhaust velocity platform areas. These areas illustrate the horizontal extent of the engine wake hazard and representative exhaust velocity contours, providing invaluable information for service and support equipment location planning. The documents also contain auxiliary power unit (APU) exhaust wake data, engine and APU noise data, and engine inlet hazard areas.

Maintenance activity

The AMM for each model is a well-documented source of precautionary information on such topics as engine mainte-nance run-ups, taxi operations by maintenance personnel, and related engine activities. Operators should refer to the procedures, practices, and precautions in the applicable AMM when developing their operating specifications, operations, maintenance, and engineering practices.

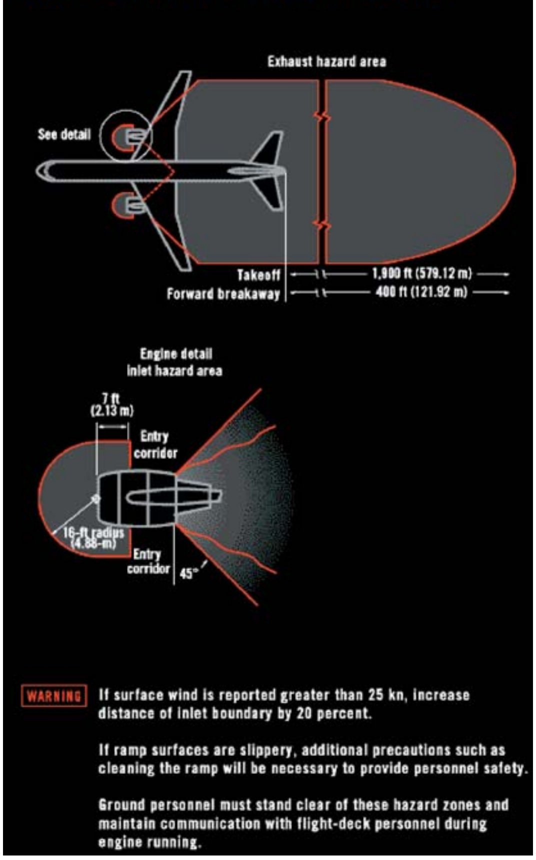
Airport environment

Operators should consult with the responsible airport authority to ensure that ramp areas, runway aprons, and engine run-up areas are compatible with the intended airplane operations. Further information about the design and maintenance of the airport infrastructure is available in the ICAO Aerodrome Design Manual and Airport Characteristics Data Bank. Other sources include the U.S. Federal Aviation Administration 150 Series Advisory Circulars (several of which are described in the accompanying chart).

Summary

Thousands of safe takeoffs and landings occur throughout the world every day. Each operation takes advantage of the benefits supplied by the high thrust levels of modern jet engines. However, during taxi and maintenance activity, this same thrust capability and its related exhaust wake can become a hazard, which can be intensified by lack of awareness about how the exhaust wake affects the surrounding environment. Techniques and precautions designed to help operators deal with high thrust exhaust wakes are available in Boeing publications and other document sources. Operators should use this information to develop the necessary operational procedures and should address the engine wake hazard issue in their safety awareness and training programs.

FIGURE 4. TAKEOFF THRUST POWER HAZARD AREAS



Jet Blast Damage and Injuries

The following examples reflect a sample of events from the past 30 years that reportedly involved jet blast and illustrate the range of potential damage and injuries.

Flying Object Damage

- An airplane was stopped 900 ft (274

m) from a parking area on the flight ramp for an engine performance run-up. During run-up of engine no. 3, large sections of asphalt overlay were broken loose and blown aft, with pieces striking both upper and lower surfaces of the stabilizer leading edge vertical fin and body in the area of the auxiliary power unit inlet.

Horizontal Stabilizer Damage

- The tower reported that an airplane took off using the restricted area of a runway. The engine thrust tore up approximately 197 to 328 ft (60 to 100 m) of asphalt, and several large chunks struck the upper surface of the right horizontal stabilizer and the lower surface of the right vertical stabilizer.
- During run-up, the left horizontal stabilizer on an airplane was damaged when a large piece of asphalt lifted and impacted the lower surface of the stabilizer. Approximately 20 in² (129 cm²) of the lower skin was destroyed, and four stringers were broken. The forward and aft spars were not damaged, nor were ribs 13 and 14. The skin was cut back from the front spar to the rear spar and approximately 7 in (17.8 cm) inboard of rib 13 and 7 in (17.8 cm) outboard of rib 14.
- An airplane experienced damage to the horizontal stabilizer during a maintenance engine run. The airplane was positioned for the run with asphalt extending from close to the wing trailing edges to beyond the empennage. During the high-power part of the run, asphalt lifted from behind the left engine and broke into pieces, sending large fragments into the aft fuselage and outboard horizontal stabilizer. The outboard 4 ft (1.2 m), including the elevator, was sheared off, and the entire stabilizer required replacing. The initial section of asphalt that lifted was a sheet about 20 ft² (1.9 m²) and 4 to 5 in (10.2 to 12.7 cm) thick before breaking into pieces. There were no injuries.

Jet Blast Damage

- After arrival and while taxiing into the gate, an airplane blew a nearby helicopter into a parked airplane.
- While taxiing for takeoff, an airplane reportedly made a sharp right turn onto a taxiway. Blast from engines no. 3 and no. 4 blew a maintenance stand into engine no. 2 of another airplane. The stand impacted the engine fan cowl, resulting in a 6- by 1-in (15.2- by 2.5-cm) puncture. In addition, the engine no. 1 cowl was laying under the engine and was blown across the ramp, causing damage to the latching mechanism.
- After aborting the takeoff, a flight returned to the gate because of overheated brakes. The two inboard engines were shut down for the taxi. However, the maximum allowable N1, 40 percent, was required for the airplane to maneuver into the gate. The engine thrust resulted in jet blast that threw two DC-8 containers into the windshield of a vehicle being driven by an airline employee.

Injuries and Fatalities

- After pushback from the gate at the start of taxi, jet blast from an airplane overturned several loaded baggage carts, and one cart fell on a baggage handler. Several coworkers lifted the cart to free the trapped worker. The individual was hospitalized with injuries that included a dislocation and multiple fractures.
- Maintenance personnel were performing high power run-ups at the engine run-up bay within the operator's technical area. Engines no. 1 and no. 2 were at 1.3 engine pressure ratio, with engines no. 3 and no. 4 at idle. The jet blast overturned and pushed a pickup truck for 165 ft (50 m). The truck was thrown over a steel guard rail and up a 33-ft (10-m) embankment. The operator of the truck was thrown clear but sustained a fractured femur and facial and chest injuries.
- According to preliminary investigation reports, an airplane departed from the gate and proceeded along the inner taxiway to a crossover, where it waited for clearance onto the runway. The airplane was stationary for some time before continuing on the taxiway. An airline operator's vehicle was reportedly traveling west on the outer service road between crossovers. After stopping to verify that the airplane was stationary, the vehicle allegedly passed behind the airplane. At the same time, the airplane was asked to expedite to the runway and began applying power. Whether the airplane began to move was not established. According to eyewitness accounts, the truck, occupied by two airline employees, was rolled over three times by the jet blast. The driver of the vehicle died two days later. The vehicle was a pickup truck with a low cap over the back end, which was even with the top of the cab. The truck had cleared the tail and was approximately 200 ft (61 m) behind the airplane. It started to roll when it was behind engine no. 3.

Structural Damage

- An airplane sustained heavy structural damage to the 46 section and empennage sections during a high-power engine run. The right engine propelled large pieces of the taxiway into these sections.

Turbulence Damage

- During an instrument landing system approach, turbulence damaged the roofs of three houses. Roof tiles fell, damaging a car and slightly injuring two people.

Exhaust Hazard Accident

The following is the abstract of Aircraft Accident Report NTSB-AAR-71-12 written by the U.S. National Transportation Safety Board. It summarizes a fatal commercial airplane accident near New York City that was later determined to be caused by exhaust hazard. The report concluded that the introduction of new large jet aircraft "...caused considerable erosion along most taxiways and runways. According to New York Port Authority personnel, the products of this erosion, pieces of asphaltic material, rocks, etc., were being blown onto taxiways, ramps, and runways, making it difficult to keep these areas clean."

A Trans International Airlines DC-8-63F, N4863T, Ferry Flight 863, crashed during takeoff at John F. Kennedy International Airport at 1606 e.s.t., September 8, 1970.

Approximately 1,500 ft after starting takeoff, the aircraft rotated to a nose-high attitude. After 2,800 ft of takeoff roll, the aircraft became airborne and continued to rotate slowly to an attitude of approximately 60° to 90° above the horizontal at an altitude estimated to have been between 300 and 500 ft above the ground. The aircraft rolled about 20° to the right, rolled back to the left to an approximate vertical angle of bank, and fell to the ground in that attitude. The aircraft was destroyed by impact and postimpact fire. Eleven crew members, the only occupants of the aircraft, died in the accident.

The (National Transportation Safety) Board determines that the probable cause of this accident was a loss of pitch control caused by the entrapment of a pointed, asphalt-covered object between the leading edge of the right elevator and the right horizontal spar web access door in the aft part of the stabilizer. The restriction to elevator movement, caused by a highly unusual and unknown condition, was not detected by the crew in time to reject the takeoff successfully. However, an apparent lack of crew responsiveness to a highly unusual emergency situation, coupled with the captain's failure to monitor adequately the takeoff, contributed to the failure to reject the takeoff.

Airport Planning, Design, and Operation References

Airplane operations in the airport environment are documented in multiple references from many sources, including industry organizations and airplane manufacturers. These references contain a broad range of relevant resources. Among the topics SQUARE used are airport development planning, airport marking, ground operations, service equipment, and terminal, ramp, taxiway, and runway design.

International Civil Aviation Organization (ICAO)
Annex 14, Aerodromes, volume I: Specifications on the physical characteristics of the airport movement area including runway, taxiway, and apron areas; firefighting equipment and safety measures associated with installed equipment.

Annex 15, Aeronautical Information Services: Notice to airmen (NOTAM) bulletins, which contain information on physical changes to the airport, airport service, or hazards.
Accident Prevention Manual: Development and maintenance of accident prevention programs.

Aerodrome Design Manual (five parts): Airport runways, taxiway, aprons, and holding areas designed to contribute to safe airplane operations.

Airport Services Manual (nine parts): Airport services, including maintenance of the airport physical condition to ensure safe operations.

International Air Transport Association (IATA)
Airport Handling Manual: Safety precautions in aircraft handling operations and aircraft pushback procedures and recommendations for ramp marking.

U.S. Federal Aviation Administration (FAA)
Advisory Circulars: The 150 series of FAA Advisory Circulars (AC) on multiple aspects of airport planning, airport design, construction, maintenance, airport safety equipment, and operational safety.

- AC 150/5300-13, Airport Design: FAA recommendations for airport design.
- AC 150/5320-6D, Airport Pavement Design and Evaluation: Design and evaluation of pavement at civil airports.
- AC 150/5335-5, Standardized Method of Reporting Airport Pavement Strength: Use of the standardized ICAO method to report pavement strength.

The Boeing Company
Airplane Characteristics for Airport Planning: Issued as individual documents applicable to a specific model or model family, such as the 757. Information to assist engineers in airport design, including airplane dimensional data, pavement loading information, condensed airplane performance, jet engine wake velocity, and temperature and noise data. Maintenance Facility and Equipment Planning: Issued as individual documents applicable to a specific model or model family, such as the 767. Information on such topics as noise hazard areas, power hazard areas, and engine exhaust wake velocity data.

Aircraft Maintenance Manual: Applicable to a specific airplane model; configured to reflect individual operator features. The aircraft general sections detail safe practices covering airplane ground operations, taxiing, engine power hazard areas, and precautionary practices to be observed during maintenance activities that require engine operation.

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- “Taxiing,” April-June 1988.

***Aero* magazine:**
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- “Airport Foreign Object Debris Prevention,” second issue, 1994.

Other
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With kind acknowledgement to The Boeing Company Aero Magazine.

Book Review

International Journal of Mass Emergencies and Disasters

August 2004, Vol. 22, No. 2, pp. 137–141

Airspaces. Pascoe, David. London: Reaktion. 2001. 303 pp. £17.95 (paperback). 1 86189 090 7 (Softcover).

Despite its technical, organizational and operational complexity commercial aviation is a remarkably safe mode of transport.

Innovations like primary and secondary radar, the turbojet engine and ground proximity warning systems have had an enormous impact on accident rates. Progress in the technical field has not been mirrored elsewhere, however. Perhaps because air travellers' demography has changed or perhaps because the amount of space allocated to most passengers has been reduced (to reduce unit costs) cabin crews' risk-exposure has increased. The level of abuse and violence (commonly known as "air rage") against cabin crew has increased.

According to a survey conducted by the UK's Transport and General Workers' Union (TGWU), 75% of cabin crew claimed to be suffering from an illness triggered by abusive passengers. Forty-nine percent of respondents said they had to deal with aggressive passengers "regularly." A TGWU official stated: "The survey clearly reflects the concerns of our members in respect of what is fast becoming an epidemic" (Ananova 2004). There have been several headline-grabbing incidents. In November 1998 a 33-year-old female cabin crew member was hit over the head with a vodka bottle by an inebriated passenger.
Having broken the bottle the passenger pushed it into the crewmember's face. There is violence elsewhere in the commercial aviation system, too. Aircraft have been hijacked and flown into symbolic targets (like the Pentagon and World Trade Center). Passengers waiting for flights have been bombed and strafed (as at Athens airport). Aircraft have been hijacked and flown to desert airstrips where they have been blown up in front of the world's media (as at Dawson's Field in Jordan).

Aircraft have been blown up in mid-air (as with Pan Am Flight 103 over Lockerbie in Scotland). Aircraft and airports have been burglarized. Massive sums have been stolen (as with the Brinks Mat bullion robbery at London's Heathrow Airport). Risk, then, has migrated from aviation's technical to its operational and social domain. (This migration brings to mind Adams's theories of risk compensation and risk homeostasis which suggest that the overall level of risk in any sociotechnical activity tends to remain constant (Adams in Faith, 1997: 140-3)). To understand why this has happened it is necessary to consider commercial aviation's social, economic and political context. *Airspaces* by David Pascoe talks about these tableaux in an engaging, innovatory and insightful way.

Airspaces is an extraordinary book—concurrently a book about the technics of commercial aviation, its social, economic and political context and the flying experience. Commercial aviation is the world's biggest industry and a stunning technical achievement: As Pascoe puts it, in the "vertical cities" of Positive Controlled Airspace "at any given moment hundreds of thousands of beings live" (page 12). Pascoe's discursive style mirrors that of Arthur Hailey, author of numerous aviation-centred novelettes. As with Hailey, Pascoe weaves prosaic (yet useful) factual description with illuminating discourse. But where Hailey explores human emotion (affairs of the heart, broken-down marriages, intimations of mortality and the like) Pascoe investigates air terminal design and decoration and its impact on passenger mood; the social, economic and political resonances of commercial aviation; the human dimensions of disaster; and aviation terrorism. Pascoe makes his points both directly and vicariously through aviation-inspired cultural products (that include novels, poems, paintings, photographs, sketches and blueprints). The effect is visceral. Consider, for example, Pascoe's discourse on the outcomes of the 1974 DC-10 crash at Ermenonville in France. After describing the facts of the crash and its aftermath (including the way in which victims' relatives and friends were received at Heathrow (a television set was wheeled in to the VIP lounge where it broadcast live images from the crash scene to the assembled throng)), Pascoe invokes Martin Amis's novel *London Fields* for illumination (page 250). In Amis's novel the daughter of one of the Ermenonville dead "drove reflexively to the airport [...] An airline official showed her into the VIP lounge [...] She drank the brandy pressed on her by the steward. ‘Free’, he confirmed. And then, incredibly … they showed live film of the scattered wreckage, and the bodybags lined up on the fields of France. In the VIP Lounge there were scenes of protest and violent rejection”. While literary accounts should of course be read with a degree of scepticism, Amis’s narrative does have the effect of bringing the episode to life. It *adds something.*

Pascoe is careful to situate commercial aviation. Commercial aviation is more than just a one-dimensional technical pursuit. Commercial aviation is an expression of the public will to promote the nation-state and its constituent ideologies (through the establishment and subsidized operation of national “flag carrier” airlines), to experience different cultures, to make money and to relax and “have fun.” Commercial aviation, alleges Pascoe, is “undertaken, above all, in the name of economy and commerce” (page 27). In Chapter IV, “Theatres of War” Pascoe deconstructs Berlin’s Tempelhof Airport. Tempelhof was much more than a mere air terminal. Tempelhof, according to Pascoe, was an expression of the Fuhrer’s desire to make Berlin the Capital of the World. As Pascoe explains: “On its completion, Hitler concluded, Tempelhof would undertake a crucial political role; through its size and appearance, it would ‘silence every dissenting critic of Germany’” (page 158).

Pascoe’s most interesting commentary concerns how departure-lounged passengers come to terms with the prospect of being suspended miles above the earth in a tube whose pressurized aluminium skin never exceeds 3 millimeters in thickness. It has been estimated that about one third of airline passengers are nervous flyers (Bor, 2003). This fact would seem to suggest that airports should be designed to be as welcoming and comforting as possible.

In Pascoe’s opinion, however, they alienate and intimidate more than they comfort. In Chapter V, “Cultures of the Terminal”, Pascoe reflects on the politics of the contemporary air terminal: “Despite the material diversions, the cultures of consumption [airports can make more money from on-site sales than from air operators], any freedom within such areas of containment is illusory [...] [T]he individual is assailed by the devices of circulation, process and containment” (page 202). Pascoe quotes photographer Martha Rosler: “Air terminals, more like each other than like anything else, tell us only of themselves. The airport is where you would rather not be, on the way to somewhere else” (page 203). The airport alienates and disorientates to the point, says Pascoe, where “the only version [passengers] have of themselves is a seat number in an aluminum tube” (page 223). Vicariously Pascoe seeks to explain how passengers’ physical and mental state might be affected by air travel. He quotes from Don DeLillo’s play Valparaiso (page 225): “I was intimidated by the systems [said the air traveller]. The enormous sense of power all around me [...] How could I impose myself against this force? [...] I felt submissive. I had to submit to the systems. They were all-powerful and all-knowing”. Airport designers’ and operators would do well to absorb this chapter.
Pascoe also explores the prevalence of violence within the air transport system. In Chapter IV he reviews several terrorist

attacks and dissects West Germany's Rote Armee Fraktion (RAF) terrorist group. As he explains "If Bomber Command had flattened Hitler's cities from the sky, the RAF [the name-irony is not highlighted] would destroy West Germany's post-War machinery from within" (page 183). In the 1970s and 1980s, claims Pascoe, the airport component of airspace provided the world's terrorists with the kind of platform they needed: "In order for the fate of the victims [...] to have the desired impact on such targets, there had to exist [...] a stage that would guarantee awe, outrage, anguish, or horror; that stage, inexorably, became the airport itself, whose anonymous public spaces seemed to be oddly complicit in random acts of terror" (page 191). Airports, then, constitute seductive targets for terrorists.

They are also useful for those attempting to maintain the peace and reassure the public. Witness, for example, the UK government's occasional (yet widely reported) deployment of tanks and troops at Heathrow. Airports' symbolism attracts both well- and evil-wishers.

Perhaps the most interesting aspect of the book, however, is its analysis of the design, dynamics and management of air terminals and the behaviour of ensconced passengers (in airline parlance, "PAX"). Given that one third of PAX are afraid of flying, Pascoe's analysis provides valuable insights into fears and phobias. The question of how passengers perceive and interact with air terminals and construct the act of flight is addressed at numerous points in the book, both directly, via Pascoe's own commentary, and vicariously through the artistic output of others. Warhol's thoughts on air travel are reproduced on page fifteen. The artist comments on the air terminal's authoritarian tendencies and bemoans his fear of flying: "Today my favourite kind of atmosphere is the airport atmosphere [...] I love the way you don't have to think about where you're going, someone else is doing that [...] The atmosphere is great, it's the idea of flying that I question. I guess I'm not an air person, but I'm on an air schedule, so I have to live an air life".

Pascoe summarizes: "[Air terminals] are often experienced as [...] edgy zones, places in which to experience oneiric moods, loss of agency and imprisonment within the confines of a technological system" (page 15). Later in the book he observes: "Without proper accreditation [a passport considered valid by the *locums*], the subject cannot move, but must remain inert [...] and await the decision of authority [...] It is in these acrid, fluorescently lit holding pens, alive with static electricity, sweat and polish that the traveller comes to understand what it means to have been furnished with the identity of a nation state; and it is here that the implications of statelessness on mental health are fully comprehended" (page 211). I suggest that whenever the issue of passenger anxiety, alcohol and drug abuse and misbehaviour is addressed analysts would do well to reprise Pascoe's observations.

Whatever one might think about the philosophical approach of Airspaces it cannot be denied that in presenting a compendium of insights, observations and constructs the book generates a textured and multi-dimensional understanding of passengers, terminals and the act of being propelled through the air in a fragile aluminium tube at close to the speed of sound some six miles above terra firma. Pascoe uses illustrations and literary representations as heuristics. The beautifully reproduced blueprints, photographs and sketches and carefully selected commentaries (from Warhol, Rosler, Amis, DeLillo, Woolf, Fleming and others) expand consciousness and promote comprehension. The book is not an easy read. But for anyone wishing to develop a more profound understanding of commercial aviation and its impact on humanity it is a valuable resource. Aviation has transformed our lives. It has transformed our sense of self and place. Airspaces helps one to understand how and why.

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Book reviewed by:
Simon Bennett
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Naval Ramp Operations Issue 57 Winter 2004

Dear Sir,
I read with interest the Editorial on Naval Ramp Operations in issue 57 WINTER 2004. As a former RAF Technician and having spent all my service career other than training on operational flying Squadrons I am totally familiar with the observations and conclusions that were made. Different service same culture. The main thing that strikes ex service Engineers is the apparent lack of control and professionalism within the ramp environment by all organisations involved with a/c operations be it ground handling or Engineering staff. This I must admit demoralised myself in the early days of my civil career as it often appeared as though we were not all "singing from the same Hymn sheet" and I was not alone in this. There was a lack of team spirit understandable if you are the only Engineer on duty. Everyone has a deadline to meet with little time to take pride in your work. This in time faded away as you became more familiar with your new world and realised that everyone was in fact trying their best in an often busy and difficult workday.

Of course the main differences are the commercial interest which even today the Armed Forces are not yet fully tied to. It is this one thing that I am convinced makes it very difficult to have the well greased mechanism the Editorial mentions. There is also the fact that the Armed Forces can cherry pick its personnel and by the process of training, education and doctrine the individual that emerges is ready to take their place within the mechanism with the old sweats keeping an eye on them until they become fully integrated. Compare this with the diversity of people required to turn around a large passenger transport aircraft, their different training environments, organisational structure and commercial interests.

Yes there is much that the commercial world can learn from the Armed Forces and this by no means is a one way street but the lessons are limited as both have a different raison détre. The main overriding thing that all have in common and all should strive for is Flight Safety along with the will to implement it. If this message is constantly pushed and never forgotten then surely it is this single unifying concept that makes it possible in the complex and hazardous world of the flight line for all the diversity of disciplines to achieve their roles.

If this could be achieved then I am confident a reduction in the 4 to 6 billion US Dollar cost can in time be reduced with a little more pride being felt by those involved.

Best Regards,
Jim Mowat
Maintenance Control Engineer

Avoiding Tailstrikes

Peter Simpson Manager Air Safety

Virgin Atlantic A340-600
Washington-Dulles, July 2004

The aircraft suffered tailstrike on touchdown at Dulles causing damage to the tailskid section.

Virgin A346 tailstrike

Air Canada A330-300
Frankfurt, June 2002
The ACARS provided the Flight Crew with the final load figures, indicating a take-off weight of 221 tonnes. The FO (PNF) reinserted the final load figures and take-off speeds in the MCDU. By mistake, the PNF typed a V1 speed of 126 knots instead of 156 knots. Neither pilot noted the incorrect VI speed. The Captain (PF) rotated at 133 knots, with a pitch rate of 2.8 deg/second. The tail strike occurred when the pitch attitude was about 10.4 degrees and lasted for about 2 seconds. The aircraft lifted off at a speed of 152 knots and a pitch attitude of 13.7 degrees. The strike was not detected by the pilots, but they were notified of the strike by ATC and Cabin Crew.

Emirates A340-300
Johannesburg, April 2004
The pilot used the sidestick position symbol displayed on the PFD when the aircraft was on the ground (the cross) to perform the rotation during takeoff. At VR, the pilot pulled on the sidestick to set the cross at a position corresponding to about 9 degrees on the moving pitch attitude scale. During the rotation, the pilot attempted to keep the cross on the same position of the moving reference. However, in this phase the aircraft pitch attitude increases and therefore the pitch attitude scale of the display moves down. Consequently maintaining the cross on the same mark of the moving scale led the pilot to progressively reduce the pitch-up sidestick command. The aircraft finally lifted off at the runway end, after hitting some lights. Three tires burst and the flap mechanism was damaged by tire debris. The crew landed with flaps jammed in config 1+F.

Singapore B747-400
Auckland March 2003
When the Captain rotated for lift off the tail struck the runway and scraped for some 490 metres until the aircraft became airborne. The rotation speed had been mistakenly calculated for an aircraft weighing 100 tonnes less (247t instead of 347t). The rotation speed of 130kts was 33kts less than that required for the weight. A take-off weight transcription error of 100 tonnes led to the miscalculation of the take-off data, which in turn resulted in a low thrust setting and excessively slow take-off reference speeds. During the take-off the pilots did not respond correctly to a stall warning.

Singapore B744 tailstrike

Malaysian B777-200
Zurich, July 2004
The crew had a last minute change of runway, with crosswinds resulting in a 2kt headwind on the new runway. There was a sudden 12kt increase in groundspeed with slow to nil increase in airspeed; indicating a burst of tailwind effect. The Captain (PF) stopped rotation at 9 degrees pitch as he felt the aircraft was not lifting off, but reassessed his judgment when he saw the positive speed trend indicated on the speed tape. He then continued his rotation and struck the tail. The EICAS "Tailstrike" was triggered. After circling and dumping fuel, a safe landing was completed.

Tailstrike Avoidance

Boeing have conducted an evaluation of the circumstances surrounding tail strikes (Boeing. 2004). They found several risk factors, one or more of which will precede a tailstrike event (these are listed below). The Boeing study also concluded that crew experience on type is a significant factor. Most tailstrikes occur to pilots who are transitioning from one type to another and have fewer than 100 hours of flight time on the new aircraft. Incidents are greatest among pilots during their first heavy-weight operation in the new model, especially when weather is marginal.

Take-off Risk Factors

1. **Mistrimmed stabiliser:** This is the case when the aircraft has been mistrimmed nose-up. Mistrimming can result from erroneous data, wrong weights or incorrect C of G.
2. **Rotation at improper speed:** Rotation is begun early because of some misinterpretation or at a Vr that has been incorrectly calculated as too slow.
3. **Excessive rotation rate:** Crew moving from unpowered flight controls to hydraulic controls are most susceptible to using excessive rotation rates, as are crew moving to side-stick configurations.

Malaysian B777 tailstrike

4. **Excessive initial pitch attitude:** Over-rotation often occurs due to misjudgment.
5. **Improper use of flight director:** The FD is designed to give pitch guidance only when airborne.
6. **Crosswinds:** Mishandling crosswinds and improper crosswind technique.

<u>Landing Risk Factors</u>

A tail strike on landing tends to cause more serious damage than that during take-off. In the worst case, the tail can strike the runway before the gear touches down, damaging the aft pressure bulkhead.

1. **Unstabilised approach:** An unstabilised approach is the largest cause of landing tailstrikes. An unstable approach can result in the aircraft flaring with either excessive or insufficient airspeed (insufficient airspeed is worse). These situations can result in large power and pitch changes in the flare, often culminating in a vigorous nose-up pull at touchdown. Boeing suggest that a firm landing on the main gear is often preferable to a soft touchdown with the nose rising rapidly.
2. **Holding off in the flare:** A long flare to a 'drop-in' touchdown can cause tailstrikes. Trimming the stabiliser in the flare may also contribute to a long flare.
3. **Mishandling of crosswinds:** Gusty conditions and wind changes with height can result in windshear. Crosswinds often result in minimal headwind component, so high ground speeds and descent rates can occur, often with idle thrust settings. Slipping manoeuvres further increase drag and reduce lift. Any increase in tailwind component now increases the risk of tailstrike. High crosswinds can often result in target fixation.
4. **Over-rotation during go-round:** Go-rounds initiated during flare or after a bounce can result in a tailstrike if the pilot has not allowed the engines to spool up before rotating to a go-round attitude. Also, pilots can over rotate if not using the instruments and flight director. Crew may try to avoid the wheels contacting the runway due to possible damage, however Boeing state the risk of damage is minimal.

United Airlines, who have had around 60 tailstrikes in the last ten years, analysed their data and came out with some specific information for their Airbus fleet (United Airlines 2004). United found that pitch attitudes above 10 degrees were present in all their landing tailstrikes. Many of these pitch commands were in anticipation of the nose coming down rapidly when autobrakes were set at MED.

Some aircraft are more vulnerable to tailstrikes, such as the B747 classic, which has around 12 tailstrikes per million flights, compared to the B777-200 which only has around 2 per million flights (the B777-300 has 0/million flights). Boeing state that it is a misconception that longer aircraft have higher risk of tailstrike, as longer aircraft usually have higher take-off speeds, and the same relative tail clearance as shorter aircraft (Boeing, 2004)

Boeing 747 tailstrike

How to avoid tailstrike at TAKE-OFF

Use normal takeoff rotation technique

Do not rotate early

Do not rotate at an excessive rate

Do not rotate to an excessive attitude

Ensure t/o V speeds are correct and adjusted for actual thrust used

Manage gusty winds and use proper technique during crosswind

(Boeing 2004)

How to avoid tailstrike at LANDING

Maintain an airspeed of at least Vref+5 until start of flare

Fly the approach at the 'specified target airspeed'

Aircraft should be in trim at the start of the flare - do not trim in the flare

Do not 'hold the aircraft off' in an attempt to make an excessively smooth landing

Immediately after the main landing gear touchdown, release back pressure on the control column and fly the nose wheel onto the runway

(Boeing 2004)

(1) Boeing (20N). Tailstrike avoidance. Boeing Aero Magazine.
(2) United Airlines (2004) Tailstrike on landing. United SafetyLiner.
(3) Boeing (2004). A Human Factor Approach to Prevention of Tailstrikes.

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Mandatory Occurence Reporting

By Simon Phippard - Barlow Lyde & Gilbert

The DfT is undertaking a consultation on the UK's proposed manner of implementation of European Parliament and Council Directive 2003/42/EC on Occurrence Reporting in Civil Aviation. That Directive was passed in June 2003 and required Member States to implement mandatory occurrence reporting schemes, or to amend their existing schemes to comply with Directive 2003/42, by 4 July 2005. The UK is to achieve this by amending Art 117 of the Air Navigation Order with effect from 3 July 2005.

It is encouraging to see that in many respects the European Directive closely reflects the existing UK scheme. The Directive does however, adopt "Euro-speak" in a number of ways and as a result the revised Article 117 lacks some of the precision of its predecessor. As an example, the basic test for reportable occurrences is those "which endanger or which, if not corrected, would endanger an aircraft, its occupants or any other person". What perhaps gives scope for more confusion is a compendious annex of events, omissions etc. which are "examples" of reportable occurrences. It appears however that the intent is not that each and every such occurrence is reportable, but only those where flight safety is endangered. On the other hand, it is equally clear that the absence of an event from the list does not necessarily mean it need not be reported. The general test of endangerment applies.

The ANO will contain a specific obligation upon the CAA to maintain databases of reported occurrences and, subject to certain disidentification provisions, to make that information available to other European Community aviation safety bodies. In general terms ordinary MORs are not disidentified; names and addresses are removed in relation to accidents and serious accidents; and voluntary occurrence reports are disidentified.

Under the old law, it may have been arguable that the obligation to report an occurrence would be subject to the right not to incriminate yourself if you felt that it may expose you to criminal charges. The new Directive makes it plain that where the authorities' only knowledge of an infringement is because of a mandatory report, that report may not be used as the basis for disciplinary proceedings or similar. There is however an exception in cases of gross negligence and the interaction with criminal enforcement generally is left vague. The moral, clearly, is not to be guilty of gross negligence when involved in a reportable occurrence!

I am grateful to John Thorpe for identifying one particular change to the scope of mandatory reports. The current regime is directed to public transport and turbine-powered aircraft. Hence pilots, manufacturers, engineers, ATCOs and so on are obliged to report occurrences which relate to such aircraft – but not, for instance, to many private aircraft.

The new scheme differs in two respects. First, an additional category of personnel, namely those involved in ground handling functions such as fuelling, loading, towing etc. at (broadly) licensed aerodromes, will have to make reports. The second change is that the obligation to report is not always restricted to public transport and turbine aircraft. Pilots, manufacturers and engineers still only need report occurrences on public transport and turbine aircraft. However managers of and ground handlers at licensed aerodromes, and ATCOs, are subject to the mandatory provisions, whatever the class of aircraft.

This obviously has the potential to bring a wider class of occurrences within the scope of mandatory reporting. If the effect is a deluge of additional reports on an already busy data reporting system will this really operate in the interest of flight safety?

If the DfT cannot be persuaded to revise the amendment to the ANO on the basis that the effect was unintended, the solution may be for the CAA to take a pragmatic approach to reports relating to non-public transport operations and to enforcement. For practical purposes the CAA has a degree of discretion in prosecuting instances of failure to report but it would be unsatisfactory if one were entirely dependent on their good sense in not enforcing what appears to be an unintended requirement.

The consultation process suggests that there is no substantive change to the reporting requirements. To the extent that this is a material change the failure to conduct a regulatory impact assessment may give grounds for challenging the manner of implementation in the UK. However, because the Directive is now a requirement of European law, the UK's room for manoeuvre, on both context and timing, is limited.

Air Accident Investigation: The Role of the Police

By Simon Phippard - Barlow Lyde & Gilbert

At the January meeting of the UKFSC we had a very helpful briefing from Chief Inspector (Retired) Brian McConnell on the responsibilities of the Police following aircraft accidents. He explained how in a fatal accident at least three organisations are likely to be involved. In very brief summary:

H M Coroner has to determine the cause of a sudden, violent or unnatural death;

The Police have to determine whether there is suspicion of a criminal offence and if so ensure that evidence is preserved so that the criminal standard of proof, namely that the offence be proved beyond reasonable doubt, is met; The Air Accidents Investigation Branch of the Department for Transport discharges the UK's obligations under Annex 13 to the Chicago Convention 1944 and EU Council Directive 94/56/EC on investigation of civil aviation accidents and incidents. In each case the purpose is to determine the cause of an accident and to make recommendations to prevent a recurrence, not to apportion blame or liability.

Others, such as the Health & Safety Executive or the Environment Agency may have additional functions.

Each body operates within its own statutory regime. The interrelationship of those regimes is not always clearly prescribed[1] and in many instances depends on the good sense of those involved for each not to impede the others. One of the ways the AAIB goes about ensuring that problems are minimised is by publishing guidance on its own role and training Police representatives and others on its own role and procedures.

The AAIB guidance is on their website[2] and contains a large amount of useful material both on the legal background and the practical issues which arise. As I understand it, it is not formally agreed with any other party nor is it a definitive statement of the law. However, since it is the basis on which AAIB educate others, it is undoubtedly a very useful point of reference if any misunderstandings arise between the Police, the accident investigator and any party which may be involved in the aftermath of an accident.

1. The Lord Chancellor's Department has issued a document entitled "Disasters and the Law – Deciding the form of Inquiry" but we have not been able to find a copy.

2. http://www.aaib.gov.uk/cms_resources/guidance%20for20police%20and%20the%emergency%20services.pdf

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- A variety of flight safety material from many sources covering aeroplanes, helicopters, gliders, balloons, general etc
- News of GASCo events, Flight Safety Seminars and Visits
- Weekly listing of all Aviation Documentaries on TV, with a surprising range of subjects including in-depth analysis of some major accidents
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