FOREWORD

2011 was a year of celebration of Singapore’s aviation centennial. A hundred years ago, aviation began in Singapore when a British Bristol Boxkite biplane took off from the old racecourse (now known as Farrer Park) on 16 March 1911. Singapore aviation has changed dramatically since then, with Singapore becoming the thriving and vibrant global aviation hub that it is today.

Recognition is due to the many individuals and organisations who have contributed to this remarkable success story. Each of them has played a role in shaping civil aviation in Singapore and enhancing the quality of air travel over the years. This has been achieved in tandem with the safe, secure and sustainable development of international civil aviation; key attributes providing the focus of the 2011 edition of the Journal.

In the section devoted to aviation safety, the articles look at not only the technological efforts to improve the safety performance of the aviation industry, but also address the role and motivation of both management and professionals in the industry for a more holistic approach towards effective safety management. They also examine new paradigms for providing safety oversight over a rapidly growing aviation industry, and explore how accident investigators can overcome the multiple conflicting interests, biases and influences as they uncover the true causes of accidents and incidents.

The article in the security section highlights the importance of the human factor in having a proactive and positive aviation security culture balanced with the needs of the industry, airport community and passengers. The section on international aviation and the environment discusses the initiatives taken by the airport and air traffic management communities to mitigate aviation’s environmental impact. This edition also includes articles covering the interesting subject of hypersonic air transport, and the challenges faced by emergency responders in evacuations on multi-deck aircraft.

The Singapore Aviation Academy publishes this Journal annually, and we hope you find this issue an interesting and thought-provoking read. We also hope that the articles in this edition will contribute to the efforts of individuals and organisations to bring about the desired changes in the aviation landscape. To the authors and the members of the Editorial Advisory Board, I would like to extend my appreciation for their valuable contributions.

Yap Ong Heng
Director-General
Civil Aviation Authority of Singapore
EDITORIAL ADVISORY BOARD

Ms Jeri Alles
Director, Asia Pacific Office
Federal Aviation Administration, US

Mr Ken McLean
Director, Safety Operations and Infrastructure (Asia Pacific)
International Air Transport Association

Mr Bernard Lim
Director, International Relations & Security Division
Ministry of Transport, Singapore

Mr Cletus M J Packiam
Chief, Airport Emergency Service
Changi Airport Group, Singapore

Mr Chiang Hai Eng
Director, Asia Pacific Affairs
Civil Air Navigation Services Organisation

Prof Henry Fan
SAA Fellow

Dr Jarnail Singh
Chairman
Civil Aviation Medical Board, Singapore

Mr Goh Chin Ee
Senior Consultant
Singapore Aviation Academy

Mr Pok Cheng Chong
Director, Singapore Aviation Academy
Civil Aviation Authority of Singapore

EDITORIAL TEAM

Ms Chan Pin Pin
Ms Jasmin Ismail
Ms Addrienne Kang
Ms Zheng Wanting
Ms Jaime Koh
CONTENTS

Air Transport

1 Hypersonic Air Transport – A Global Perspective
   Dr Gabriel D Roy
   Office of Naval Research Global, Singapore

Airport Emergency Services

2 The Challenge to Airport Emergency Services for Evacuations on Multi-deck Aircraft
   Mr Jack Kreckie
   ARFF Professional Services LLC, US

Environment

3 Addressing Noisy Neighbours: Curfews at International Airports – A Study of Current Practice
   Ms Jana Schroeder
   Brisbane Airport Corporation Pty Ltd, Australia

4 Aviation and the Environment – An Airport Perspective
   Mr Xavier Oh
   Airports Council International

5 Mitigating Aviation's Impact on the Environment – The ATM Initiative
   Mr Saulo da Silva
   International Civil Aviation Organization
Safety

6 Conflicting Interests in Aircraft Accident Investigation 49
Prof Graham Braithwaite
Cranfield University, UK

7 Safety Culture and Safety Management Systems – Enhancing the Heartware of Managing Aviation Safety 59
Mr Kang Huei Wang
Civil Aviation Authority of Singapore

8 The Future of Safety Oversight – The Value of Industry Standards 71
Mr Donald Spruston
International Business Aviation Council

Security

9 Aviation Security – The Human Factors Supply Chain 79
Mr Bernard Lim
Ministry of Transport, Singapore
Abstract

There has been a great void in high speed commercial air transportation since the grounding of the iconic Concorde. Lessons learnt from the Concorde include the need for further understanding of the fluid dynamic, acoustic and engineering phenomena at high speeds, and assessment of the economics of the market. As science progresses, even faster transportation is feasible to get into the realm of hypersonic flights. Some of the challenges have been addressed and better propulsion systems have evolved. With the leaders in the aviation industry around the world, academia and government agencies working together, hypersonic air transport could become a reality in the next few decades.
Dr Gabriel D Roy is Associate Director at the Office of Naval Research Global at the US Embassy in Singapore. He is responsible for fostering international research in areas related to air transport, fuel, noise and emissions. Prior to this, Dr Roy served as a faculty member in India and the US and Programme Manager at the Office of Naval Research, US. He holds a Ph.D in Engineering Science from the University of Tennessee Space Institute, US, and is the author and editor of over 20 books with over 100 publications and several patents to his credit. A fellow of the American Institute of Aeronautics and Astronautics (AIAA), Dr Roy is also a recipient of the AIAA Energy Systems Award, American Society of Mechanical Engineers Energy Systems Award, Joint Army, Navy, National Aeronautics and Space Administration, Air Force (JANNAF) Combustion Award, and the TRW Roll of Honour Award.
Hypersonic Air Transport – A Global Perspective

Dr Gabriel D Roy
Office of Naval Research Global, Singapore

INTRODUCTION
Moving from place to place has been a human need from the primitive ages, with domesticated animals being the first mode of transportation. Early purposes for travel included the searching of land for cultivation, hunting for food, shelter to live or to find a bride. Travelling was later motivated by acquiring land and wealth, visiting places for pleasure, performing business and at times, conquest. One factor that increased as our motivations evolved has been the “speed of travel”. From the years of horseback to bicycles, ships, automobiles and airplanes, there has been a steady development of infrastructure such as roads and highways, airports, runways and control towers. Like roadways, the airways are also getting busy with myriads of aircraft and missiles flying at various altitudes and speeds. Some of the major developments that led to high speed air transport started from military demands – to be able to reach the target before the enemy. Subsonic speed air travel was considered a marvel when it first began in the 1950s where business people can travel across the world within 24 hours, parents are able to visit their children on the other side of the globe, or people can attend family functions that otherwise would not have been possible.

The push for speed continued and the military researchers developed suitable propulsion systems and airframes for fighter aircraft to fly at supersonic speeds. These developments, along with research pioneered by passenger aircraft manufacturers, made supersonic commercial air transport a reality with the advent of the Concorde. Though the Concorde may not have been a financial success from a business perspective, it was a huge success from scientific and prestige perspectives. Travel from London to New York was three hours and twenty minutes, less than half the time of conventional air travel. The cost per passenger mile increased substantially, and Concorde flight was not amenable to an average traveller. But it was indeed a “dream come true” for the business traveller.

Unfortunately the Concorde fleet has been grounded, and it is clear that doing the scientific and engineering homework before a successor product is put to use is key it is were to carry people in the skies. Now the focus is on hypersonic air transport – aircraft flying at Mach number\(^1\) 6 and above. This would mean that a flight from Singapore to New York would take less than 3 hours! But there are challenges and complications in achieving this.

---

\(^1\) The mach number is the speed of flight divided by the speed of sound. Mach numbers below 1 are categorised as subsonic, up to 5 as supersonic and above 5 as hypersonic.
CHALLENGES

Power Plant
At present, the power plant considered for hypersonic vehicles is fuel-based and is to be converted to
thrust by burning the fuel with air – probably a hydrocarbon fuel for now, depending on the speed.
Unlike a rocket motor, an air-breathing engine which sucks in ambient air from the atmosphere to
provide the oxygen needed for burning the fuel is the preferred choice. However, there are two major
problems associated with this. First, with the speeds at which these vehicles will travel, there is hardly
enough time for the incoming air to mix with the fuel that is injected, burn it completely and exit the
combustion chamber. A certain minimum time of contact known as residence time is required for the
fuel to completely burn and release all the chemical energy it has. The other issue is that, depending on
the altitudes these vehicles could be flying at, the ambient pressure could be too low to get sufficient
surrounding air into the combustion chamber. Hydrogen, with its much higher energy release (engine
specific impulse), may be a better choice when flying at high Mach numbers.

Materials
Even with a reliable energy conversion system from the chemistry perspective, materials required to meet
the high temperatures, fatigue environment of the combustion chamber, nozzles and exhaust, as well
as airframes to withstand the substantial friction have to be developed as well. The surface properties
of the airframe material should be such that the friction is minimal, as drag losses increase with speed.

Economics
Even if an aircraft is developed to fly at Mach 6 and above, infrastructure modifications and changes
are needed. For commercial aviation, we have seen a substantial investment in the modifications of
airport control towers, runway extensions and protection of surrounding areas as aircraft became larger
and faster. The hypersonic airplane does not have to be large, but would still demand extensive airport
related modifications. However, aircraft that operates in a short take-off and landing mode can alleviate
this problem. From the business perspective, investors have to consider the cost per passenger mile
that would make hypersonic aviation profitable for a particular market, whereas for the consumer, the
increased cost of travel would need to be compensated by the benefit of shorter travel time. So along
with the studies that are undertaken to develop the engine, airframe, control and integration, careful
attention must be given to the economics of hypersonic commercial air transport. Initially it would
probably appear in a similar market as the original Concorde.

Environment
Health hazards due to the noise produced by supersonic air vehicles have captured the attention of the
US Navy and other defence agencies from the US and other countries. Problems related to hearing, such
as hearing loss and other associated illnesses are taking their toll on young sailors on the decks of carrier
aircraft, and at airfields performing take-off and landing practices. In addition, the nuisance caused by
the noise generated by these aircraft, particularly during take-off and landing has led to civil law-suits against the US Navy. When the time comes, these hypersonic airplanes are most likely to operate from busy international airports where land will be a premium and extension of runways and preventing community noise will be a major challenge. On the other hand, sonic boom and its impact will require further study.

RECENT DEVELOPMENTS
When an innovative and risky solution in the technology of high speed propulsion and vehicles is called for, the military has always taken the lead in the industry. This is natural since the demands on the military are more competitive and based more often on performance than economics. However, as in the past, the commercial industry can reap the benefit of the investments in research and development made by the defence departments all over the world. With the advent of fast and reliable computing, simultaneous measurements of performance parameters with increased spatial and temporal resolutions, advanced test facilities, and high temperature, abrasion and erosion resistant materials and coatings, the realisation of a hypersonic commercial transport dream may not be too far away.

Propulsion System
Several propulsion systems are considered for flights at Mach numbers reaching 4. Conventional turbojets suffer performance penalty as the speed i.e. Mach number increases. Ramjets are suitable for Mach numbers up to 6 or 7; beyond that range, scramjets would be used. Of course, the rocket engine can propel the aircraft to very high Mach numbers with the same performance. But the disadvantage is that it has to carry its own oxidiser (in the propellant) throughout the flight. On the other hand, the engines mentioned above have the advantage of using external air (air breathing engines).

A novel type of engine known as the pulse detonation engine (PDE) is under research and development. It employs an explosive process (detonation) rather than the burning process (combustion) used in other engines. Substantial research has been done on PDE in the US with research sponsored by the Office of Naval Research, the Air Force Research Laboratory, National Aeronautics and Space Administration as well as by defence and research organisations in France, Italy, Japan, Germany and Russia. The advantages of this type of engine are the use of a single engine to propel up to the required speed with additional booster, probable fuel savings (uses a more efficient thermodynamic cycle) and simpler design.

Some test results of this engine are shown as circles (see Figure 1) where a comparison is made on the Engine Specific Impulse of various engines shown using hydrocarbon and hydrogen fuels. The current trend is towards continuous detonations rather than operation in a pulsed mode. In the case of the ramjets and scramjets, the vehicle has to be propelled to a certain speed (referred as ram speed by a booster) before the ramjet engine can take over. The superior performance of hydrogen-based engines is very clear, and for Mach numbers over 10, hydrogen seems the only fuel of choice.
Since it is relatively less challenging to build engines that are disposable and require a shorter life span, military investment has been in missiles, which need not be recovered once deployed. The BrahMos supersonic missile developed by a joint venture of India and Russia is an example (see Figure 2). BrahMos II flying at Mach 5 to 7 uses a scramjet engine, and hypersonic missiles with supersonic cruise are in the horizon. Production of a new weapon like this takes more than just focused research and development effort. To this end, a new research and development organisation – BrahMos Aerospace Thiruvananthapuram Ltd was established.
Some of the major efforts include the Unmanned Space Vehicle Programme (USV) led by Italy which started with a focus on transonic to re-entry and leading to USV 4 for a short duration Mach 8 flight, and Intermediate eXperimental Vehicle developing flight-quality re-entry systems and technologies; Sharp Edge Flight Experiment II led by Germany at Mach 11 using a sounding rocket for launch from Woomera in Australia; Sustained Hypersonic Flight Experiment led by the UK, a long range Mach 6 ramjet powered missile; Hypersonic Technology Demonstrator Vehicle programme led by India with Israel collaboration and a scramjet technology demonstrator at Mach 6.5.

Some of the major programmes are aimed at hypersonic airplanes for military and commercial applications. The Japanese Aerospace Exploration Agency at the Kakuda Space Centre is developing a technology for a silent supersonic technology demonstrator aimed at vehicles with low sonic boom and low noise levels with a fuel-efficient propulsion system. Their Hypersonic Turbojet Experiment uses a rocket booster or pre-cooled turbojet followed by a scramjet for intercontinental hypersonic commercial airplanes. The European Space Agency's Long Term Advanced Propulsion Concept and Technologies programme is focusing on an intercontinental hypersonic airplane that carries more than 200 passengers at Mach 4 and 8. Various airframe designs have emerged from the various projects, one of which is shown below (see Figure 3).

The European aerospace leader, European Aeronautic Defence and Space Company (EADS), plans to produce an environmentally acceptable fuel efficient hypersonic commercial aircraft. Their Zero Emission Hyper Sonic Transportation (ZEHST) envisions a package that will carry 50 to 100 passengers from Paris to Tokyo in two and a half hours. The proposed propulsion system and airframe can be seen in (Figure 4). The tri-engine propulsion system consists of two turbofans to climb to Mach 0.8, followed by
a rocket booster to pass transonic region bringing it to Mach 2.5, and finally ramjets to bring it to speeds above Mach 4. EADS plans on commercial production of this aircraft in 2040. It will cruise just above the atmosphere, glide during descent and use turbofan-power to land.

CONCLUSION
Though the grounding of Concorde left a gap in supersonic commercial aviation, high speed flight is well and alive in the military arena. The current trend is towards hypersonic transport with aircraft flying at or over Mach 5 speeds. Considerable progress has been made in the development of propulsion systems, airframes and controls, and in the basic research on aerothermodynamics, diagnostics and computations. Military focus in the recent years is towards hypersonic missiles, although there is substantial scientific attention given to hypersonic commercial aviation and access to space. As new engine technologies develop, materials emerge, and computational tools progress, one can foresee hypersonic commercial airplanes flying in the skies within the next three or four decades.
The Challenge to Airport Emergency Services for Evacuations on Multi-deck Aircraft

Abstract

Large multi-deck aircraft such as the Boeing 747 (B747) and the Airbus 380 (A380) are capable of carrying hundreds of passengers with differentiated travelling needs, and are designed to attract varying classes of travellers.

These mammoth aircraft raise the level of difficulty for emergency responders. With the aircraft occupancy exceeding 500, and the possibility of over 800, the challenges become daunting. The typical demographics of passengers are far different from those who were chosen to participate in aircraft certification evacuation tests. Reviews of actual evacuations from multi-deck aircraft offer interesting details on human behaviour during emergency evacuations.

This paper reviews past emergency evacuations of the B747 and A380 aircraft, as well as the effectiveness of typical airport emergency services equipment, plans and procedures, the harmonisation with flight crew experiences and the associated risks. Interesting characteristics that should be considered during emergency planning and response on these multi-deck aircraft will also be discussed.
Mr Edwin Lim is Head of Planning in the Airport Emergency Service (AES) division of Changi Airport Group, Singapore. He oversees the AES functions in operations, manpower and logistics planning, standards assurance, special projects as well as the planning, control and review of AES’ annual budget. Since January 2010, Mr Lim was appointed Singapore’s representative in ICAO’s Rescue and Fire-fighting Working Group which was responsible for the review and development of Standards and Recommended Practices. He holds a Bachelor of Science (Hons) in Fire Safety and Management and a Master of Science in Air Safety Management under the CAAS Overseas (Operations) Scholarship in 2005.

About the Author

Mr Jack Kreckie is Chief of Operations at ARFF Professional Services, LLC which provides consultation services relative to aircraft rescue and fire-fighting (ARFF), emergency planning, emergency response, and airport safety to a number of airports in the US and abroad. He was formerly Deputy Fire Chief at Logan International Airport, Boston, US. Mr Kreckie has over 30 years of experience in the fire service, and was co-founder of the Logan Airport Safety Alliance. He was also former Chairman of the ARFF Working Group and holds the distinction and title of ‘ARFF Legend’, a lifetime achievement award conferred by the ARFF Working Group.

The Challenge to Airport Emergency Services for Evacuations on Multi-deck Aircraft

Mr Jack Kreckie
ARFF Professional Services LLC, US

INTRODUCTION

The Airport Emergency Services (AES) unit in commercial airports worldwide are trained to respond to incidents involving large passenger aircraft. In 2007, prior to the entry of the A380, the only multi-deck commercial aircraft was the B747 which allowed limited seating capacity on the upper deck. With the introduction of the A380, the aircraft characteristics are designed to accommodate such a significant increase in passenger capacity on the full length upper deck. With that increased capacity comes a dramatic increase in the challenges presented to aircraft fire-fighters.

To benefit these operational personnel in the gruelling task of rescue and fire-fighting, prudent planning, as well as best practices in the usage of evacuation slides and interior access vehicles should be employed in this increasingly more demanding environment.

EVACUATION SLIDES

Figure 1 depicts the evacuation slides found on both aircraft model A380-800 and B747-400. It is to be observed that the escape slide on the A380 touches the ground one metre further on either side as compared to the B747. In order to ensure the safety of the rescue and escape path taken by fire-fighters and passengers, there must be enough foam coverage for a larger surface area. In fact, there is an additional area of more than 140 square metres to protect.
The priority in all significant incidents involving a commercial aircraft i.e. aircraft fire, is to deplane and evacuate all passengers and crew members. The emergency evacuation slides would be used when the evacuations take place on aircraft that are more than six feet (1.83 metres) above ground level. The Federal Aviation Administration (FAA) requires a full-scale demonstration to certify that the aircraft is safely designed, whereby all passengers and crew members onboard have to evacuate the aircraft using half the number of emergency exits in the dark, within 90 seconds. Taking into consideration that slides may fail to operate or become damaged due to the actual emergency conditions, it is a requirement for the demonstration to be performed with only half the number of working exits.

A study conducted by the National Transportation Safety Board (NTSB) reviewed 46 evacuations involving a total of 2,651 passengers from the period of 1 September 1997 to 1 June 1999. Six percent of these passengers suffered from minor injuries while evacuating, while 2 percent suffered from serious injuries. To minimise the injuries afflicted onto passengers while evacuating, manufacturers have improved slide technologies and at the same time are incorporating them onto newer aircraft. Certain slides onboard make use of the Tribrid inflation system, which is connected to a sensing system within the door. The system is activated only when the door is opened in an emergency situation at an abnormal attitude. The slide inflates normally and in addition, inflates several feet of additional slide to increase the chances of reaching the ground.

Figure 1: Comparison of Evacuation Slides on both Aircraft
The term ‘ramp slide’ describes an evacuation slide that has a small platform or landing between the exit and the slide itself. These ramp slides are installed on aircraft where the proximity of the exit to an aircraft engine is not safe and requires the slide to be angled away from the engine. Ramp slides are used for the over-wing exits on the A310, A340, A350, A360, A380 and B747 aircraft. The certification of the A380 required the use of dual lane slides, and these double slides can transport up to 70 passengers per minute.

Slides are typically constructed of urethane coated nylon sprayed with grey aluminised paint. The reflective paint is added to reflect heat from any nearby fire, extending its operation time when adjacent fires are present for at least the 90 seconds of required slide use. The slides must be deployed within six seconds in temperatures ranging from 65° to 160° F (18° to 71° C). They should be capable of being deployed and remain useable in winds up to 25 knots.

The escape slides certainly help to facilitate evacuation of the aircraft, despite known human factors and mechanical shortcomings that limit their effectiveness. However, the increased number of slides for new large aircraft (NLA) also adds a level of difficulty and increased tasking.

Escape Slide Assistance
Dedication of emergency personnel to man the base of escape slides to steady them in high winds or to assist passengers at the bottom of the slide is highly recommended. Aircraft cabin crew may assign passengers to provide assistance at the base of slides. In some scenarios, this is a practical solution. In other scenarios, particularly those involving pooled fuel or fire, it is not prudent to allow persons without personal protective equipment to remain in the hot zone. Taking note that a majority of the passengers evacuating an aircraft are doing so for the first time, the hazards of evacuation are complicated by a number of factors, as identified in the NTSB ‘Emergency Aircraft Evacuation Study1’ and the Airport Cooperative Research Program (ACRP) ‘Evaluation and Mitigation of Aircraft Slide Evacuation Injuries2’. According to the ACRP report:

“Wind had an adverse effect on slide use in 12.4 percent of the accidents. In these cases, the wind blew the inflatable slides up against the sides of the aircraft, hampering slide use. In the evacuation events where the slides were unusable, the mean wind speed varied from 13 to 20 knots.”

The report claims that “historical data show that when the wind’s mean speed does not exceed 25 knots and one individual holds down the slide, the inflatable evacuation slide remains stable”.

Human Factors
Several notable issues related to human behaviour during evacuations are as follow:

- Passengers commonly insist on retrieving luggage, briefcases, etc. Injuries have been documented from these carried items;
- There is a noted hesitation in passengers evacuating via upper deck escape slides versus main deck slides; and
- The most serious evacuation associated injuries occurred when occupants jumped out of exits and off wings.

1 Safety Study: Emergency Evacuation of Commercial Airplanes, NTSB, 2000
2 Evaluation and Mitigation of Aircraft Slide Evacuation Injuries, Airport Cooperative Research Program (ACRP), 2008
Mechanical Factors

The NTSB ‘Emergency Aircraft Evacuation Study’ indicates that 37 percent (7 out of 19) of the documented evacuations involving slide deployments had at least one slide failing to operate. Redundancy of exits is included in the safety margin in accordance to the requirement of evacuating 100 percent of the passengers using 50 percent of the exits in 90 seconds or less. A failed slide, however, certainly adds to passenger anxiety and will delay at least those passengers who were planning on evacuating through the exit with the failed slide. Slide failures occur for a variety of reasons. See Figure 2 extracted from the ACRP study.

<table>
<thead>
<tr>
<th>Identified Problem</th>
<th>Amount (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slide Did Not Inflate</td>
<td>28.1</td>
</tr>
<tr>
<td>Aircraft Altitude</td>
<td>15.7</td>
</tr>
<tr>
<td>Other</td>
<td>13.5</td>
</tr>
<tr>
<td>Wind</td>
<td>12.4</td>
</tr>
<tr>
<td>Slide Burnt</td>
<td>11.2</td>
</tr>
<tr>
<td>Incorrect Rigging</td>
<td>7.9</td>
</tr>
<tr>
<td>Slide Ripped</td>
<td>6.7</td>
</tr>
<tr>
<td>Unknown</td>
<td>4.5</td>
</tr>
</tbody>
</table>

The study looked at 142 emergency evacuation events for the period of 1 January 1996 through 30 June 2006. The data illustrated that during this time period, approximately 50 percent of emergency evacuations resulted in injuries, 90 percent of which were minor.

The ACRP study demonstrated that human reactions in situations requiring emergency evacuation include panic and confusion. Some interviews indicated competitive behaviour among passengers. The ACRP made recommendations for the first responders to:

- Practise the initial stabilisation and proper orientation of the slide, particularly during windy conditions; and
- Realise that continued stabilisation may be needed under such conditions.

Obstruction to Aircraft Rescue and Fire-fighting (ARFF) Operations

Escape slides are the primary conveyance for the egress of passengers from an aircraft. The protection of these slides is one of the primary initial actions of AES. During the critical period of evacuation and
until confirmation is received that all occupants are off the aircraft, these slides must be protected and preserved in usable condition. An attendant may be required at the base of the slide to maintain a connection with the ground, or to assist passengers to their feet and direct them to safety.

While deployed, the slides serve as obstructions to AES activities. The slides will thwart foam streams being used to control a spill fire or to cover a fuel spill. The 16 escape slides on an A380 create a web of obstructions; six are from the upper deck, and all slides have a width of two lanes. If the slides are intact, and the pool of fire is under control, hand lines will be necessary for application and re-application of a foam blanket.

Providing AES personnel to stabilise slides being used in emergency evacuation would likely reduce the number and severity of injuries. It would also likely reduce delays in passengers jumping onto the slides, as the anxiety of the event would be decreased at the sight of emergency responders at the bottom of the slides.

With 16 escape slides deployed, access is restricted for ARFF operations. The slides from the upper deck extend beyond the Practical Critical Area (PCA), the area by which foam quantity calculations are derived (see Figure 3).

---

**Figure 3: A380 Theoretical Critical Area (TCA) / Practical Critical Area (PCA) with Evacuation Slides Deployed**
The slides from a two-deck aircraft like an A380 block access to a majority of the occupiable portion of the fuselage. Winds can raise or twist slides. Ramp slides from the A380 wing actually route passengers under the mid-ship upper deck two-lane slide, putting that evacuation point out of sight from emergency personnel who are outboard of the slides.

![Diagram 1: Approach of ARFF Vehicles with Slides Deployed](image)

Each slide on the A380 is equipped with a re-entry line, installed to provide direct access for ARFF crew to both the main and upper deck. This may be a physically challenging method of access, but it is an available feature. Each escape slide is also equipped with three emergency lights – one each at the midpoint, the side, and the middle of the bottom of the slide.

**INTERIOR ACCESS VEHICLES (IAV)**

Mobile stair vehicles or air stairs, when correctly deployed, provide a safe stable platform designed for enplaning or deplaning passengers. Most airlines or fixed base operators (FBOs) have such vehicles in their fleet; however availability during emergency operations cannot be guaranteed. The majority of stair trucks are designed to accommodate the sill heights of aircraft ranging from a B727 to an A340, i.e. 66 to 228 inches (168 to 579 centimetres). The A380 upper deck sill height can be as high as 315 inches (800 centimetres) in a normal aircraft altitude.

The FAA ARFF research programme made use of the FAA’s Civil Aerospace Medical Institute evacuation simulation programmes to study how making closed exits available using an IAV could improve evacuation times, once emergency passenger evacuation had begun. The results of the study indicate that, in a total evacuation, an IAV could significantly impact evacuation times, especially in double aisle aircraft.

---

3 Approach of ARFF vehicles for the points aft of the wing is limited. The over wing ramp slide exit disappears from view behind the upper deck double lane slide.
Rapid access to the aircraft may be critical to successful mitigation of an onboard incident. Gaining access to emergencies onboard, whether the event is a medical emergency, fire, investigation or law enforcement incident, is the first step upon arrival at the aircraft. For airports serving multi-passenger deck aircraft, having equipment that can reach the sills of upper decks should be a primary consideration when planning a purchase. If the IAV can also be equipped with agent or equipment to better facilitate the mission of ARFF and satisfy the Index/Category agent requirements, it further justifies the staffing of the vehicle. The vehicle can be used in the initial response to the aircraft emergency rather than to be called out afterward.

**EVACUATIONS AT CHANGI AIRPORT**

Singapore Changi Airport was the first airport outside of Europe to host the A380. The aircraft arrived in November 2005 for airport compatibility verification tests. Changi AES conducted a needs analysis and developed plans to align with the International Civil Aviation Organization regulations and guidance, as well as to satisfy Changi Airport’s goals for emergency preparedness for NLA.

In 2006, Changi AES procured two Rosenbauer mobile air stairs. Each is equipped with fire-fighting capabilities, including 264 gallons (1,000 litres) of water and a hose connection at the top of the platform for rapid access to either deck of an NLA for interior fire-fighting. The standard response for an incident involving an A380 at Changi calls for a response of six ARFF appliances, including an emergency stairs (ES2).

The first A380 evacuation on record occurred at Singapore Changi Airport. On 10 January 2008, Singapore Airlines flight SQ 221 was disconnected prematurely from a push back tractor and the aircraft rolled off the pavement adjacent to Terminal 3. The aircraft was deplaned and recovered from the grass strip.
The second evacuation of an A380 also occurred at Singapore Changi Airport. The incident on 4 November 2010 unfolded as Qantas flight 32 left Singapore bound for Sydney. The A380 suffered an uncontained engine failure of its Number 2 engine just six minutes into the flight. The failure and flying shrapnel sliced electrical cables and hydraulic lines in the wings. The wings’ forward spar was damaged, and two wing fuel tanks were ruptured. As fuel leaked out, an imbalance was created between the wings. The electrical problems meant that the pilots were unable to transfer fuel forward and the aircraft became tail heavy. The pilots struggled to maintain balance and keep the A380 from losing lift, which would cause the aircraft to stall, while fielding 54 alarms of system failures or impending failures in the cockpit. The Number 2 engine was on fire, the flaps were inoperable, and so were the landing gear doors. The pilots were able to use gravity to lower the gear. During landing, the brake temperature exceeded 1,650°F or 900°C, causing four flat tires. The possibility of leaking fuel reaching the hot brakes also posed a significant threat. The pilots rolled out the plane the full length of the runway so that it would be close to ARFF vehicles to facilitate the application of foam under the aircraft. Upon landing, the crew was unable to shut down the Number 2 engine, and only managed to do so when Changi AES used foam to choke out the engine.

Forty-four minutes after declaring the emergency, Qantas flight 32 landed at Changi Airport. The events that had occurred during the previous 44 minutes would have certainly justified the Captain ordering evacuation by slides, but in spite of the combination of events, he elected to deplane the passengers over air stairs on site provided by Changi AES.

The following media statement was issued by Changi Airport Group (CAG):

"An A380 Qantas flight, QF 32, bound for Sydney, Australia, departed Singapore Changi Airport at 0956 hours today. For technical reasons, the aircraft turned back to Changi and landed safely at 1146 hours. Changi Airport Group’s Airport Emergency Service (AES) responded with six fire vehicles, in accordance with standard operating procedures for such incidents. In response to the pilot’s request, checks were conducted on the aircraft by AES. Once the checks were completed, passengers and crew began disembarking from the aircraft at Runway 2. Buses were arranged to ferry them to the airport terminal. Disembarkation of all 469 passengers and crew on board was completed by 1340 hours."

When the decision was made to disembark all passengers from the A380, AES 2 was positioned at the MR-2 door. An upper deck door was not chosen, as there were far fewer passengers on that deck (business class) and none that could not come down the interior stairs. The Captain instructed passengers to deplane using one side of the aircraft exits. The main deck had a number of elderly passengers and children. The evacuation of the 469 passengers and crew on the aircraft took approximately an hour, partly due to the Captain’s decision to use only one set of stairs to deplane. He wanted an orderly and systematic evacuation and on hindsight, this proved to be the right decision as none of the 469 passengers and crew sustained any injuries.
Singapore Airport Emergency Services (ES2), capable of reaching upper deck of A380. During this evacuation, a decision was made to deplane all passengers from the main deck. Had it been necessary, ES2 could have reached the upper deck just as easily. Take note of the diversity in age and physical characteristics of the sampling of passengers in the photo. An escape slide exit puts some passengers at risk more than other, it should therefore be used only if necessary.

A380 following an uncontained engine failure. Changi AES used foam to shut down Number 2 engine.
HISTORICAL REVIEW OF EVACUATIONS: B747 AND A380
The NTSB lists 271 incidents or accidents involving B747. Only eight of the incident narratives reported that an evacuation was conducted. None of the narratives indicated that passengers were evacuated directly from the upper deck. The ACRP emergency evacuation study identified four B747 emergency evacuations.

There have been two cases reporting a need to evacuate passengers as a result of an incident or accident involving an A380. Both of those previously cited incidents occurred at Singapore Changi Airport. Neither incident involved passengers being deplaned via slides or air stairs directly from the upper deck. In each case, the passengers came down the interior stairs from the upper deck to the main deck to exit the airplane.

Analysis of Evacuation Models and Trends
A number of evacuation studies have been completed. A great deal is known about the frequency of evacuations, percentage and types of injuries, effects of wind and passenger behaviour during evacuations.

The ACRP evacuation study “focused on slide emergency evacuations from upper decks of very large transport aircraft.” Several initial parameters were changed to see the effect they had on the velocity of an individual as a function of position on the slide. The study also shows and compares the results between sliding down from the upper deck of the A380 versus the B747.

Certification requirements are based on a single evacuation trial. The subjects used to conduct the evacuation test are prepared for the exercise, and are properly dressed for an evacuation. The European Aviation Safety Agency (EASA) and FAA regulations require that 35 percent of the participants must be over age 50, a minimum of 40 percent must be female, and 15 percent must be female and over 50.

Over 1,000 volunteers were assembled at Airbus’s Finkenwerker Plant in Hamburg, Germany on 26 March 2006 for the A380 evacuation test. About half of the volunteers were Airbus employees while the other half were members from a local gym. Prior to participating, an agility test was conducted, which was designed to cull out the very elderly or clinically infirm participants. Before boarding the aircraft for the evacuation test, warm up exercises were conducted with the group.

The passenger loading for the A380 maximum capacity simultaneous evacuation trial included 315 passengers and 7 crew on the upper deck, 538 passengers and 11 crew on the main deck, and 2 in the cockpit. For this test, the aircraft was not equipped with a main deck crew rest area.

Using a more diverse profile of age, condition and health would put the occupants at a higher risk for injuries. It is unlikely that all passengers on large aircraft would be fit enough to self-evacuate in 90 seconds or less using half of the exits. The demographics standardised by FAA and EASA set a standard for evacuation testing for aircraft certification, but they do not accurately describe the typical passenger load, which would nearly always include infants, small children, elderly, handicapped, and obese passengers. Some passengers or cabin crew members will almost certainly be occupied assisting
those unable to evacuate on their own. The delays caused by those who may block an aisle trying to self-evacuate or by those assisting others will contribute to some occupants spending longer periods of time in the aircraft. Multiple references in each of the studies showed that human factors impact evacuation in actual emergencies. The actions, reactions and decisions made by each passenger will have an effect on the overall process.

The height of the upper deck slide is likely to cause apprehension in some passengers, and may cause some to turn upon reaching the door, refusing to jump, particularly if the emergency condition prompting the evacuation is not visible to the passenger. Jumping onto the slide may seem like a greater danger than staying onboard. This may contribute to the migration of passengers from the upper deck to the main deck using the interior connecting stairway. This action would increase the time taken to evacuate the upper deck, and disrupt the evacuation process underway on the main deck. While the cabin crew is responsible to coordinate, communicate and direct passengers, the large number of passengers in an A380 or B747 may increase their anxiety and panic level.

Beyond the initial certification test, there is no way to predict how aircraft crew or passengers would react in an evacuation. Statistically, it is very common for aircraft doors or slides to malfunction during evacuations; this gauge prompted the requirement for completing the evacuation test in 90 seconds or less using half of the exits. However, there is no telling which door(s) would be safe for evacuation and whether or not those doors are operational when needed. Emergency responders must be prepared to face any combination of scenarios, taking these contingency plans into consideration during development of an incident action plan.

Quick entry to the interior of the aircraft is essential to the assessment of interior conditions, assisting with evacuation, treatment of the ill or injured, and mitigation of the emergency condition. Equally important is that the entry must never restrict the flow of passengers deplaning. In the case of the A380 or B747, additional decks mean additional access points.

AES teams need to quickly assess the aircraft to determine the best location to gain entry. By having an IAV capable of reaching every deck, the greatest number of opportunities is available. The IAV can be used to gain access, to assist passengers left onboard, and to launch interior fire attack.

The additional access points on these NLA also create obstructions for gaining access. Deployed escape slides block the approach to doors and must be deflated or removed prior to positioning an IAV at a door.

Positioning of the IAV should be done such that support for the greatest number of anticipated missions is provided. If passengers are evacuating through main deck doors only, then positioning the IAV on the upper deck would provide access for rescue or entry teams without obstructing an exit. If passengers are all evacuating through forward doors, positioning the IAV at an accessible rear door follows a similar strategy. Positioning an IAV at a door at which the slide failed to deploy creates an access point or exit not previously available.
CONCLUSION

In summary, the important points to note for emergency evacuations are:

• Clear and concise communications may avert unnecessary evacuations;
• Statistically, injuries will occur during emergency evacuation;
• Visibility from the ground or cab of an ARFF vehicle is obstructed by deployed escape slides. Monitoring under the aircraft or to the opposite side will not be possible from one position;
• Carry-on luggage may be thrown from exit doors;
• Passengers on the upper deck are more likely to move down interior stairs to the main deck slides rather than sliding from the upper deck. This will increase anxiety and evacuation time; and
• An analysis of the largest aircraft passenger load divided by the number of passengers on airport buses will determine the number of buses needed to transport passengers off the airfield.
Addressing Noisy Neighbours: Curfews at International Airports – A Study of Current Practice

Abstract

This paper provides an overview of the variety of operational night flight restrictions at international airports. It summarises existing curfew arrangements, the different reasons for their implementation, the various impacts at airports and their environments, and suggests methods to deal with aircraft noise and curfews.

The information presented in this paper is a summary of the main findings of the ‘Curfews at International Airports – a Study of Current Practice’ study conducted by an Aviation Management Masters student on behalf of Brisbane Airport Corporation Pty Ltd (BAC) in 2010.
Addressing Noisy Neighbours: Curfews at International Airports – A Study of Current Practice

About the Author

Ms Jana Schroeder (née Bulicke) is a Business Analyst with the Brisbane Airport Corporation Pty Ltd at Brisbane Airport, Australia since October 2010. Her key responsibilities include analysis of organisational performance data, particularly relating to noise metrics, night flight operations and noise complaint data.

Ms Schroeder has over 10 years’ experience in commercial aviation. She has previously worked at other airports such as Berlin Airports, Germany, and Zurich Airport, Switzerland. She holds a Master of Aviation Management degree from the Wildau Institute of Technology, affiliated to the Technical University of Applied Sciences in Wildau, Germany, and a Bachelor degree in Aeronautical Engineering/Aeronautical Logistics from the Technical University of Applied Sciences in Wildau, Germany.
Addressing Noisy Neighbours: Curfews at International Airports – A Study of Current Practice

Ms Jana Schroeder
Brisbane Airport Corporation Pty Ltd, Australia

INTRODUCTION

International airports today face limitations due to restrictions imposed on their operations, especially at night. Many of those restrictions have been implemented to counteract an undesired but inevitable by-product of aviation – aircraft noise.

According to the National Aviation Policy White Paper (2009, p. 206ff), the Federal Government of Australia oversees the regulation for 21 leased airports on Commonwealth land, four of which (Adelaide, Sydney, Gold Coast and Essendon Airports) are currently subject to an airport curfew. Though there is “no current intention to introduce additional airport curfews”, the Government is “committed to a formal review of the need for a curfew at Brisbane Airport” – a process scheduled to commence in 2012.

In order to prepare for the upcoming review, the airport’s operator, Brisbane Airport Corporation Pty Ltd (BAC), commenced a research study to gain broad knowledge on airport curfews. The main research topics were the identification of reasons for curfew imposition (or prevention), an overview of existing international regulations, the analysis of environmental and socio-economic impacts of curfew introductions and the analysis of current practice for effective community engagement regarding noise management efforts.

METHODOLOGY

A threefold approach to conduct the study was chosen in order to meet the main objectives. First of all, existing studies that were available in the public domain were included in the research. Secondly, relevant aviation industry stakeholders were interviewed on their views and experience with airport curfews.

The majority of information, however, was collected by carrying out a survey on international airports worldwide, where both airports with and without curfews were invited to participate. This survey had a response rate of nearly 40 percent, with 25 curfew airports and 17 non-curfew airports responding.

Although the survey was sent out to different geographic regions, most of the responses received were from European, US-American/Canadian and Australian/New Zealand airports.
EXAMPLES OF EXISTING CURFEW REGULATIONS AND EXEMPTIONS

It is important to understand that although it might be the general public perception of the term, an ‘airport curfew’ does not automatically represent a complete shutdown of airport operations. On the contrary, ‘curfews’ are usually partial restraints of an airport’s operation, applicable only during distinct time frames or for particular air traffic.

AIRPORT CURFEW – TERMINOLOGY

The term ‘curfew’ in the context of airport restrictions has been agreed by members of the International Civil Aviation Organization (ICAO) to be defined as “a global or aircraft-specific partial operating restriction that prohibits take-off and/or landing during an identified time period” (ICAO, 2008, p. vi).

This means that an airport curfew does not necessarily refer to a complete shutdown of all aircraft operations during certain hours of the day or night, but instead include a selection of well-defined and specific traffic limitations.

The study found that no airport curfew is like one another, but there is a wide variety of ‘curfew’ options. Even regulations that appear similar to each other usually differ in certain details, such as their individual severity.

One commonality however, is that if curfew arrangements have been implemented in a particular airport, the strictest rules are enforced during night hours, usually between 2200 hours to 0700 hours local time. That is when communities around an airport are most sensitive to noise.

Some of the most commonly applied restrictions are:

- **Total aircraft ban**, i.e. no air traffic is allowed during certain hours;
- **Partial shutdown**, e.g. arrivals are allowed but not departures, or closure of certain runways and/or flight paths at night;
- **Movement quotas**, i.e. only a defined number of flights are allowed during a specific time period;
- **Noise level limits**, e.g. annual noise quotas, prohibiting a certain noise accumulation during certain hours of the operating year, or a limitation on the maximum allowed noise level per individual operation;
- **Aircraft type restrictions**, e.g. ban of certain aircraft types only, often applied specifically to jet aircraft;
- **Approved operation only**, i.e. no operation without a slot;
• **Compulsory noise abating operating procedures**, e.g. low-noise approaches must be applied, and/or intersection departures are prohibited during night hours;

• **Noise reduction on ground**, e.g. engine run-up or reverse thrust restrictions; or

• **Combinations** of the above restrictions.

At some airports, only a single restriction is applicable, whereas a combination of more than one rule might be applicable at others.

Not only do curfew restrictions vary significantly from airport to airport, a potential ‘curfew breach’ can be defined differently as well. At various airports, selected restrictions allow for exemptions or dispensations, some of which might be more common and more frequently accepted than others, whereas at other airports any divergence from operational restrictions incurs severe penalties and flexibility is rare.

More commonly, exemptions from curfew regulations will be granted due to:

• Mid-air emergencies that require an immediate landing at the nearest airport;

• Meteorological requirements and resulting alternations, leading to diversions to curfew airports; or

• Search and rescue missions, medical, humanitarian or police flights.

Other identified exceptions from curfew restrictions are more seldom and rather airport specific. Some airports allow for delayed operation of scheduled services, or for aircraft arriving late for technical overhaul; other airports provide significant curfew advantages for aircraft operations of designated home carriers. This study even identified some airports that grant curfew dispensations due to big public sports events and festive occasions.

**REASONS TO IMPOSE AN AIRPORT CURFEW**

Ashford, Stanton and Moore (1996, p. 77) stated that “the nature of the curfew depends greatly on the local political atmosphere, the location, and physical climate of the city involved and the nature and volume of air transport through the airport”.

This statement is strongly supported by the findings of the curfew research study. When asked about the initial reasons that led to the imposition of their curfew regulations, 52 percent of the participating curfew airports stated ‘political motivation’ as the main contributing factor, followed by ‘expansion of airport facilities’ and ‘voluntary implementation’ (see Figure 1). This indicates that the local political atmosphere, influenced by several drivers, is definitely a crucial factor for such decisions.
Further, the year of curfew imposition was reviewed and showed a strong accumulation of curfew implementations between the 1960s and early 1970s, and then again in the pre- and post-millennial years of mid-1990s to early 2000.

Several reasons have been identified for these concentrations. First of all, the early 1960s saw the introduction of jet aircraft, involving a significant increase in aircraft noise. Furthermore, jet aircraft made air travel faster and cheaper, which led to growth in traffic movements and as a result noise nuisance; this was then offset by airport curfews.

The increased rate of curfew implementation during recent years can again be explained by increased traffic. A merging global world created a much greater need and interest in air travel, which requires today’s airports to expand their facilities in order to accommodate increased demand. Additionally, communities around airports grew larger and closer during the last decades and their political power increased too. All of those factors combined have led to community involvement and pressure, followed by voluntary or enforced curfews on airport operations.

**FACTORS SUPPORTING A CURFEW-FREE STATUS**

The curfew-free airports included in this study were asked what they thought were the main reasons contributing to their operations not being restricted. The majority of them referred to early, effective, and forward-looking land-use planning efforts, followed by the successful implementation of noise management measures as well as an appreciation of economic benefits for the region. Many of those arguments can be seen as good industry practices.
A local peculiarity, however, has been identified in the US, where the imposition of operational restrictions, especially on larger airports, is regulated by the ‘Airport Noise and Capacity Act (ANCA)’. The ANCA requires particularly large airports to undergo an extensive study if an airport or a local authority believes airport restrictions are needed (ANCA 1990). Such a study aims to prove the airport’s actual need to implement restrictions and their impact on the airport’s long-term sustainability. The ANCA therefore stands in stark contrast to common European or Australasian practices, where airports need to put great effort into proving a curfew is actually not needed.

ICAO’S BALANCED APPROACH TO AIRCRAFT NOISE MANAGEMENT

In 2004, ICAO published the first version of its ‘Guidance on the Balanced Approach to Aircraft Noise Management’. This material was the result of an initiative to harmonise the so far mostly individual approaches of airports and local authorities to regulate noise emissions from air traffic.

ICAO acknowledged that, up to that point, many airports around the world some kind of curfew imposed on their operations to counteract noise problems. These “uncoordinated policy developments”, however, were believed to “hinder the role of aviation in economic development” in the future (ICAO n.d., p. 3).

In order to address aircraft noise globally and consistently, ICAO’s member States made clear that operating restrictions should only be the last resort after fully assessing the benefits of an overall balanced approach to aircraft noise management. Such a ‘balanced approach’ should include the following key steps:

- **Reduction of noise at source**, e.g. by encouraging airlines to use quieter aircraft fleets;
- **Planning and managing land-use**, e.g. by appropriate noise-zoning around the airport premises, insulation schemes, easement acquisition or comprehensive future development planning;
- **Noise abatement operational procedures**, i.e. preferred runways and routes usage, noise mitigating approach and departure procedures; and
- **Implementation of operating restrictions**, i.e. noise quotas, movement caps or fully-banned aircraft operations. (ICAO n.d., p. 6)

It is noteworthy that ICAO, an organisation of national government representatives from all over the world, officially advances the view that operating restrictions are the least desirable option to manage aircraft noise at an airport. Even more remarkably, findings of this study showed that current practice often enough contradicts this approach. Examples showed that various airports had curfews imposed by exactly such government representatives to address local frictions, but without any ‘balanced approach’ assessments of pros and cons.

IMPACTS OF AIRPORT CURFEWS

The study also identified the different effects curfews can have on airports, their stakeholders and the overall environment. It is believed that curfews generally support the overall reduction of noise emissions to communities in the night time, with that being a relief for noise-affected communities.
For the aviation industry, however, curfews impose several risks. For airlines, the need to meet curfew requirements at airports within their network means a significant decrease of their overall scheduling flexibility, especially as they apply buffer times around curfew hours to cater for possible operational delays.

Such buffer times scheduled by the airlines reduce curfew airports’ overall operating hours even further. Additionally, airports might also face traffic loss because of curfew restrictions, if traffic cannot be arranged around curfew periods. Further, airports can face a shifted and intensified peak demand due to the effects of an implementation of curfew periods.

Unfortunately, the survey produced insignificant information on the effects curfews have on noise complaint development, but there were still indications that a curfew at an airport does not automatically lead to a decrease in noise complaint figures. On the contrary, airports with the strictest curfew regulations received the most noise-related complaints, which was a notable outcome considering the intention of airport curfews is to decrease noise nuisance. It was believed that perhaps knowing that there were stricter curfew regulations, the communities around the airport have a higher expectation of noise reduction and are thus less tolerant to noise exposure, hence the increased figure of complaints.

Another finding of the study is that curfews are likely to stay once it is implemented. No airport participating in the survey could confirm any operational restrictions ever being lifted again after their initial introduction. Moreover, research has shown that such restrictions are likely to only get stricter over time. Several triggers for intensification have been identified, including increasing community pressure, renewal of operating permissions or trade-off-agreements to gain approvals for airport expansion plans.

Also, curfews do not only impact the overall noise situation at a curfew airport itself but can shift the noise problem to another region. This is particularly the case for international long-haul flights that might need to operate earlier or later than necessary from one airport in order to meet curfew demands at another.

**SUGGESTED APPROACH TO AIRCRAFT NOISE MANAGEMENT AND CURFEW MATTERS**

Airports that are located in the vicinity of residential areas will soon face the challenge of communities opposing aircraft noise, often involving strong calls for operational restrictions such as curfews. These airports might find it difficult to counteract such movements, particularly once the general public pressure has changed into a political one. However, research shows that noise-related issues are best addressed by a proactive and open management of aviation noise.

A key supporter of that is ICAO’s ‘Balanced Approach to Aircraft Noise Management’. Airports, their industry partners and regulatory authorities should analyse any options they have to ease communities from aircraft noise by applying main elements from this approach. Apart from the overall reduction of noise at source, a significant part of that approach is an effective, future-oriented land-use planning around airport premises. In addition, the implementation of noise abatement procedures, such as changes to flight routes or approach and departure procedures can also help reduce the noise impact from an airport’s operation.
Besides a ‘balanced approach’, it is also considered important to provide easily accessible and understandable information on airports’ current operation and future development planning. In support of that, airports are advised to consider the creation of special community engagement programmes, designed to address community concerns and distribute noise information. Regular consultations also foster a closer relationship with residents around an airport, which often provide the basis for productive and sustainable interaction.

This study further identified that hardly any evaluation of noise management measures was made after their initial implementation. So it seems self-evident that there is a need to check on the effectiveness of individual approaches sometime after their initiation and also apply changes to them, if required.

Finally, a mutual approach involving all affected stakeholders is highly recommended, as joint efforts to minimise the effects of noise from aircraft operation can be sustainable and achieve mutual gains. Therefore, airport planning and development processes in particular should be discussed with business partners and communities as well as with legislating bodies, such as local, regional or federal governments.

CONCLUSION
Research shows that curfews are a reality for many of today’s international airports and their stakeholders such as airlines, passengers, business partners or surrounding communities. Although airport curfews were identified as a commonly applied means to address “noisy neighbours” their overall benefits must be re-examined. Curfew restrictions around the world can have severe effects in the longer term as they cause complicated network arrangements for airlines, which will make future operations in an even more globalised world much more challenging.

This study therefore suggests that the most effective way of managing aircraft noise is to adopt ICAO’s ‘Balanced Approach to Aircraft Noise Management’. Governing authorities should consider operational restrictions as a last resort and only after carefully assessing other noise management measures on a case-by-case basis. Additionally, this study recommends adopting an active and transparent way of communicating with all participating stakeholders. Airports are strongly advised to work together with business partners as well as surrounding communities in order to better manage airport noise and communicate their efforts in this regard.
References


Bulicke, J. (2010). Curfews at International Airports – A Study of Current Practice. Master Thesis, Wildau Institute of Technology at the University of Applied Sciences, Wildau. This thesis is available via the University’s library system


Aviation and the Environment – An Airport Perspective

Abstract

Environmental issues in aviation should be discussed in the context of sustainability and the needs of future generations, taking into consideration the impact and benefits to society, economy and the environment. The aviation industry can help societies in further development provided that in turn, societies allow aviation to expand. Through this, the aviation industry must demonstrate its ability to compensate for growth, notably through expanding its activities without escalating the adverse effects.

Together with the International Civil Aviation Organization (ICAO), the aviation industry has set out a roadmap to address the issue of carbon dioxide (CO₂) emissions based on aircraft technology, operational efficiency, market-based measures and sustainable biofuels.

In this, the airport operators must play an active role by mitigating their greenhouse gas (GHG) emissions, as well as working with other industry stakeholders to address aircraft, ground transportation and other related emissions. However, aircraft noise remains the most pressing local environmental issue for most airports.

Community outreach and communications are vital links to compensate for growth and the mitigation of environmental pressure, thereby obtaining society’s permission to grow based on mutual trust and partnership.
Mr Xavier Oh is Senior Manager, Environment and ICAO Liaison at Airports Council International (ACI) since September 2005. His responsibilities include participating in the triennial Committee on Aviation Environmental Protection meetings, including the Steering Group and the technical working groups on noise, emissions, operations and modelling.

Besides supporting and coordinating airport participation and input on these groups, Mr Oh is also the secretary of ACI’s World Environment Standing Committee (WESC) where he develops, coordinates and implements policy and positions on all issues relating to the environment and airports. Other WESC tasks include supporting environmental training for airports, sharing best practices between airports and working with other aviation industry organisations. Prior to this, Mr Oh was a consultant in machine vibration and structural dynamics in Australia and Malaysia, and an acoustical engineer in New Zealand.
Aviation and the Environment – An Airport Perspective

Mr Xavier Oh
Airports Council International

AVIATION SUSTAINABILITY

Origins
As it is with safety and security issues at airports, environmental stewardship is gaining importance at a rapid rate. Airport operators are usually viewed as the body responsible for the overall environmental performance of the airport and must answer to community as well as government scrutiny.

In the past decade or two, dialogue on environmental management is no longer just about basic consideration of limiting or reducing the environmental impact. In simplistic terms, the easiest way to eliminate airport environmental impacts would be to stop flying and close the airports.

The concepts associated with sustainability (or sustainable development) allow for a broader, more balanced consideration of issues. The Brundtland Commission (1987) of the United Nations provided a widely used definition, “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

This definition refers to environmental stewardship – the preservation or improvement of air, water and land quality, as well as the careful use of finite, non-renewable resources and the increased usage of renewable resources. Furthermore in the case of airports and aviation, meeting the needs of future generations implies the continued growth of the capacity of the global aviation system to meet the ever increasing demand.

Three Pillars
Sustainability requires the consideration of environmental, social and economic demands, also known as the “three pillars”. As virtually all of man’s activities (starting with breathing and eating can adversely impact Earth’s environment, sustainability is about minimising the adverse effects to the environment and its society while maximising its benefits to the society and economy. This broader approach to the activities of the aviation industry allows us insight beyond the potential adverse impacts and to also consider the benefits and finding an appropriate balance between the two.
Permission to Grow
If mankind chooses to continue developing our societies and pursue the alleviation of poverty, hunger and mortality, the best known avenues for these remain through modernisation, technology, education and prosperity. The ease of global mobility provided by aviation plays a vital role in modern society. Thus, the growth of civil aviation is integral with economic development and the sustainability approach provides a balanced consideration of environmental issues and the potential extent of the benefits to society and the economy.

To grow and expand as a whole, the aviation industry needs blessing from the society. By allowing the industry to attain growth, the society will stand to reap the economic and social benefits while stakeholders acknowledge the environmental consequences and mitigate these impacts.

Compensating for Growth
The focus of this sustainability approach is fostering the growth of the industry, while endeavouring to reduce the increasing rates of adverse impact. In the case of aviation’s CO₂ emissions, avenues such as technology, system efficiency developments and renewable sources of energy would help the industry to compensate for its growth. Eventually, this would enable the aviation industry to expand its activities without increasing the adverse effects. In the long run, the aviation industry plans to be able to continue growth while achieving absolute reductions in total CO₂ emissions.

Compensating for growth may also take the form of funding projects that mitigate adverse effects. In the case of CO₂ emissions, this could include the purchase of officially recognised offset certificates. To mitigate the impact of aircraft noise, funds could be used to upgrade the sound insulation and ventilation of homes and schools in affected areas. It should be noted that these examples are partial solutions and primary efforts should be directed at minimising the adverse effects.

ENVIRONMENTAL PRESSURE

Effects of Growth on Society
Economic growth and the development of society are among the major goals of good governance. Growth should bring prosperity to the whole population by increasing the standard of living, quality of life, education, health and life expectancy of the average citizen.

The combination of increasing economic activity and individual wealth invariably leads to increasing demand for all forms of transportation including aviation. Besides the transportation of freight, people travel for business and leisure, forming an interweb of economic dependency internationally through aviation. In regions with poorly developed infrastructure for land transport, or locales isolated by oceans or distance, aviation is a necessity rather than a luxury. Economic growth and demand for aviation are thus closely coupled.

At the local level, there are some additional important consequences of general economic growth for airport operators. Firstly, there is a growing demand for housing and the pressure to develop
residential areas. Invariably, the lands near airports are also subject to this pressure, and the employment opportunities near airports are an additional attraction to developers. Many airports built outside urban areas find that residential development, even in noise affected areas, is a tide difficult to turn back.

The second important local effect of wealth generation and increasing standards of living is that people have an increased expectation in the quality of life. For airports, this can mean an increasing sensitivity to issues such as noise and complaints coming from the local community, well outside traditional airport noise contours that indicate areas of high noise.

**Effects of Growth on Airport Operations**

The growing demand for air travel increases the activities in airports and can lead to a significant increase in environmental impacts, such as noise and emissions of aircraft and road vehicles, resource use and waste generation. In situations where a local regulator imposes limits, perhaps on noise levels or local air pollutant concentrations, continued growth in airport operations could lead to exceeding regulated environmental limits. The level of airport activity where environmental limits start to be infringed upon is sometimes called the ‘environmental capacity’.

Increased aircraft noise can also lead to increased levels of adverse community reaction. Individuals or community groups can exert pressure on local government to introduce new environmental limits or tighten existing ones. Such environmental pressure might encourage the government to expand regulations such as operational restrictions on certain aircraft or impose night time curfews. These are usually undesirable from an airport operator’s point of view as they can impose artificial limitations on the efficient use of cost-intensive infrastructure resources.

It can also be helpful for the airport operator to recognise that, in some cases, it may not be the physical effect alone for example the noise level causing the annoyance; perception issues and attitudes toward an airport or aviation can be the root of adverse reactions. Such perceived impacts are no less valid than physical ones, however the resulting environmental pressures can be much more difficult to address.

Finally, as airports get busier, throughput may approach the operational capacity limitation either of the runways, the terminals or any other infrastructure bottleneck. This can lead to congestion and delays to operations rendering the system inefficient and unreliable.

**Planning Permission**

An airport operator needs to monitor growth, anticipate traffic trends, plan the construction and commission appropriate infrastructure to meet the projected traffic growth. In most jurisdictions, airports need planning permission from the local government for large infrastructure projects, especially terminal buildings and runways. In many cases, a public consultation process is required and some form of public approval must be obtained. The lack of public approval could lead to legal action and projects can be delayed in review panels or courts for many years.
For an airport, permission to grow from communities and government is needed to obtain planning approval for infrastructure projects. A crucial part of the process requires that the airport authority address environmental pressure by establishing a track record on environmental stewardship and demonstrating plans to continue compensating for the environmental impacts of growth. By presenting a case for sustainability and the need to cater to future generations, the permission process can include consideration of the social and economic need and benefits of airport growth.

The remainder of this paper will focus on the efforts of the aviation industry and airports to address environmental issues and on-going efforts to operate within environmental capacity, compensating for the growth of the industry.

AVIATION AND CLIMATE CHANGE

Global Contribution
The change in the earth’s climate due to the long-term accumulation of GHG, especially CO₂, in the atmosphere is considered by many to be the most important environmental challenge mankind has ever faced.

Domestic and international civil aviation currently contributes approximately 2 percent of anthropogenic CO₂ emissions (ATAG website, 2011) and this proportion is predicted to increase as growth outpaces industry-wide efficiency gains and other industry sectors achieve absolute emissions reductions. Fossil fuel-based kerosene remains the most readily available and usable form of fuel for passenger aircraft.

UNFCCC and ICAO
The Kyoto Protocol (1997) excluded the emissions from international civil aviation from national GHG inventories and targets. The UN Framework Convention on Climate Change (UNFCCC) gave the responsibility of addressing these emissions (from “international bunker fuels”) to ICAO.

In 2010, ICAO’s General Assembly Resolution 37/19 approved a framework for addressing aviation’s contribution to climate change that included the following features:

- A basket of measures for States to implement to reduce aviation emissions;
- A global goal of an average annual efficiency improvement of 2 percent through to 2050, including fleet and operational improvements;
- A global aspirational goal of achieving carbon neutral growth from 2020 onwards;
- A set of principles for the design and implementation of market-based measures for international aviation;
- A target to implement a new CO₂ emission standard for aircraft by 2013; and
- A process for ICAO to collect data from States on their Action Plans for achieving these goals.
The agreement of these goals and principles by the ICAO member States represents an important achievement unparalleled by any other international industry and is a significant step towards incorporating international aviation into any post-Kyoto climate agreement.

Aviation Industry Goals

The aviation industry, represented by the Air Transport Action Group (ATAG), includes stakeholders such as Airports Council International (ACI), International Air Transport Association (IATA), Civil Air Navigation Services Organisation (CANSO) and leading individual aircraft airframe and engine manufacturers.

The joint aviation industry's position on addressing aviation CO₂ emissions is closely aligned with ICAO's goals. The industry's goal for average annual efficiency improvement is 1.5 percent (less than ICAO's 2 percent, but not including the portion that falls under the responsibility of governments such as releasing military airspace) and the industry has the same goal for carbon neutral growth from 2020.

ATAG has a further goal of achieving absolute CO₂ emissions reductions of 50 percent (relative to 2005 levels) by 2050. This is planned to be achieved by a combination of aircraft technology advances, fleet renewal, operational improvements and, crucially, aviation fuels produced from biomass sources.

Biofuels

Biofuels for aviation have moved from concept to reality in five years and are a potential game changer for the sustainability of aviation. By early 2011, there were a dozen test flights on large passenger aircraft with some of the fuel made from biomass sources. In mid-2011, fuel with 50 percent bio-derived synthetic content blended with conventional fuel, was officially certified for aviation. These fuels are "drop in" substitutes and will not require changes to aircraft or airport fuel delivery infrastructure.

The biomass sources include crops such as the jatropha nut, the camelina grain, algae and others such as municipal and forestry waste material and spent cooking oil. Great care is being taken by the aviation industry to identify and develop biomass sources that will not adversely affect food, water and land supply. Many challenges lie ahead, especially the massive scaling of biomass production and refining capabilities.

In summary, the medium and long-term sustainability of aviation is dependent on three main efforts. Firstly, aircraft technology must continue to make substantial improvements in fuel efficiency and new developments such as light-weight composite materials, geared turbofan engines and open rotor technology could provide step change improvements toward that goal. Secondly, the operation of aircraft at airports and enroute must continue to achieve efficiency improvements and avoid congestion and delays. Thirdly, aviation biofuel production needs to be streamlined and scaled to meet massive demand, while avoiding the pitfalls of displacing food production, land and water use.
AIRPORTS AND CLIMATE CHANGE

Aviation versus Airport Emissions

The discussion in the section above is confined to aviation emissions, specifically the emissions from the operation of aircraft. This stems from the fact that the Kyoto Protocol excluded the emissions from international aviation, while emissions from domestic aviation and all ground-based airport activities were included in national GHG inventories and targets.

As airports are the interface between aviation and ground transportation, the responsibility and management of emissions are less defined for airport operators. Activities and emissions sources need to be categorised according to ownership and influence. ACI provides recommendations to its airport members in the publication ‘Guidance Manual on Airport Greenhouse Gas Emissions Management’ (2009) which categorises emissions into three scopes:

- **Scope 1**: Emissions from sources that are owned or controlled by the airport operator, such as an airport power or heating plant, airport fleet vehicles, construction and fire-fighting;
- **Scope 2**: Emissions from the off-site generation of electricity purchased by the airport operator; and
- **Scope 3**: Emissions from airport-related activities from sources not owned or controlled by the airport operator, including aircraft, most ground support equipment and most ground access vehicles, such as private cars and public transport.

Airport GHG Emissions Management

Whether under local regulation or within a voluntary process, managing GHG at an airport may include the following steps:

- Conducting an inventory of GHG emissions (usually annually);
- Setting goals for the reduction of emissions such a carbon neutral growth, an emissions target or carbon neutrality for the airport operator;
- Implementing mitigation measures for an airport’s Scope 1 and 2 emissions;
- Engaging and assisting tenants and stakeholders to reduce their emissions (the airport’s Scope 3 emissions);
- Reviewing the inventory and progress towards goals and publishing the results; and
- Purchasing carbon offset credits of residual Scope 1 and 2 emissions to achieve carbon neutral status.

GHG Mitigation Measures

Some examples of measures for an airport operator’s Scope 1 and 2 emissions reductions include the following:
- Modernisation of the power, heating and cooling plants;
- The generation or purchase of electricity and heating from renewable sources such as wind, solar, hydroelectric, geothermal and biomass sources;
- Design, inclusion or retrofitting of energy efficient buildings and component technologies, including double glazing, window tinting, variable shading, natural lighting, light emitting diode lighting and heat recovery power generation;
- Modernisation of fleet vehicles especially using alternative fuels, such as compressed natural gas, hydrogen, electricity, compressed air and hybrid vehicles;
- Driver education on fuel-conserving driving techniques and eliminating vehicle idling;
- Solid waste management through recycling and composting that reduces volumes of waste going to landfills; and
- Reusing excavation and demolition material on-site to reduce transportation emissions.

Airports can help reduce aircraft emissions at airports, by doing the following:
- Providing fixed electrical ground power and pre-conditioned air to reduce fuel burn in aircraft auxiliary power units (APU);
- Improving aircraft taxiing efficiencies by providing appropriate airport and taxiway layout;
- Reducing aircraft queuing with options such as slot management, virtual queuing and delayed push-back; and
- Working with stakeholders to improve landing and take-off fuel burn efficiencies with procedures such as continuous descent operations.

Non-aircraft Scope 3 emissions are dominated by ground transportation and airports can work with stakeholders to achieve the following:
- Provision of public transport and rapid transit to and from the airport including buses, coaches, light rail and trains;
- Educational campaigns (or using by-laws) to reduce vehicle idling, taxi dead-heading (one-way trips), and individual passenger drop-off and pick-up;
- Hotel and rental car agency shuttle bus consolidation;
- Encouragement of alternative fuel or hybrid taxis, rental and other cars using incentives such as priority queuing, parking cost reduction and priority parking areas; and
- Providing infrastructure to fuel and power low emission vehicles including recharging stations.
Carbon Neutrality and Accreditation
ACI encourages its members to set goals on both GHG emissions sources within their control and those in the control of stakeholders which they can influence. For an airport’s Scope 1 and 2 emissions, the ultimate target is for the airport to become carbon neutral. Carbon neutral status can be achieved by reducing emissions as much as practicable, then purchasing carbon offset credits for the remaining emissions. Offset credits must comply with international standards and be fully verified.

Airports can attain recognition for their achievements in carbon management with ‘Airport Carbon Accreditation’ (2011) which recognises four levels of progress – inventory, emissions reduction, stakeholder optimisation and carbon neutrality. The project started in Europe in 2009 and is to be expanded from 2012 onwards. During the first and second year of operations, it contributed to reducing CO₂ emissions from airports by 411,000 tonnes, and 730,000 tonnes, respectively.

ENVIRONMENTAL MANAGEMENT AT AIRPORTS
Airport operators have been managing environmental issues for many years before climate change captured the world’s attention. Historically, aircraft noise has been the most pressing issue for local communities and this remains the situation despite massive reductions in individual aircraft noise emissions in recent decades. Other issues include local air quality, water, soil, waste water and solid waste.

Aircraft Noise
At most airports, noise remains the issue most likely to trigger environmental pressure and mobilise local residents against airport infrastructure or capacity expansion. Permission to grow may be conditional, often giving rise to operational restrictions and constraints on an airport.

An airport operator has three fundamental avenues for managing aircraft noise, although none is fully within the control of the airport operator. They are:

- Reducing the level of aircraft noise emissions;
- Reducing the number of people exposed to high noise levels; and
- Improving community acceptance of the airport and its activities.

Aircraft noise management includes using the best technology and flight procedures to reduce incident noise levels. The main measures include the following:

- Improving aircraft technology so that the new generation of aircraft are consistently quieter than previous models;
- Fleet modernisation will gradually reduce average noise levels as older aircraft are retired;
- Noise-related landing fees can incentivise the use of the best available aircraft;
- Flight operational procedures such as power limitations and flap management can reduce noise generation;
• Preferred runway and noise preferential routes can concentrate noise on the least populated areas; and

• Operational restrictions may be imposed on an airport due to high opposition to certain operations including specific aircraft or night time flights.

Land use planning is usually the responsibility of local government authorities, and airports need to work with them to introduce zoning and land use rules that prevent or minimise noise-sensitive activities in the areas of high aircraft noise. Actions can include:

• Land zoning to avoid new residential, hospital and school development in high noise areas;
• Sound insulation minimum requirements for new developments;
• Retrofitting of sound insulation upgrades and alternative ventilation to homes and schools; and
• Purchase of homes in very high noise areas.

Airports need to proactively foster community relations based on open and clear communications and social programme initiatives as discussed in the final section of this paper. Noise specific actions can include:

• Monitoring noise levels in the community and publishing the results in accessible, non-technical formats;
• Fielding and responding to individual noise complaints; and
• Establishing and maintaining community liaison groups for consulting and dealing with issues that arise.

Local Air Quality
Noise management primarily addresses the mitigation of adverse response from noise-affected communities. In contrast, the management of an airport’s local air quality (LAQ) and relevant emissions fundamentally targets achieving and maintaining compliance with local regulation on permissible levels of pollutant concentrations. An airport with a history of non-compliance with LAQ regulations can be subject to pressure from regulators and communities when planning permission for infrastructure expansion is required.

Starting with the relevant national and regional LAQ regulations, an airport operator should assess compliance for each pollutant species and determine which emissions sources are contributing to any non-compliance. This assessment can include the following:

• Monitoring LAQ pollutant concentrations at locations at and near the airport;
• Conducting an inventory of the emissions that affect LAQ pollutants including current and projected future activities; and
• Conducting dispersion modelling using computer calculations to predict LAQ from an emissions inventory, topographical, weather and other information.
Such an assessment should indicate the relative importance of various emissions sources and activities at airports including aircraft, ground support equipment, fleet vehicles, power and heating plants and local road traffic.

Addressing LAQ problems is fundamentally achieved by reducing emissions and virtually all of the GHG mitigation measures described earlier will also mitigate LAQ emissions. Given the strict Swiss LAQ regulations, Zurich Airport has one of the most comprehensive airport LAQ management programmes including monitoring, modelling, inventory, aircraft APU restrictions and landing fees with a nitrogen oxide emission component.

Resource Use and Waste Management
This section addresses most of the remaining environmental issues at airports. Resource use collectively addresses environmental policies aimed at reducing the use of resources such as water and land (or soil). Fuel, electricity and air are included and are addressed in the sections on LAQ and GHG management. Waste management addresses the consequences of resource usage. The waste hierarchy – reduce, reuse, recycle – provides a framework for these issues. The starting point should be reducing resource use, then where possible, reusing or recycling. Disposal is the last resort.

Water Use
Potable water use can be reduced by modern plumbing practices i.e. low flow taps and showers, detector-controlled toilet flushing, maintenance and leak detection. Much potable water use can be replaced with water from other sources including rain water from roofs and tarmac, treated waste water and recycled cooling water. Landscape planting should also make use of native or arid zone plants that need little watering. Brisbane Airport achieved a potable water use reduction of 72 percent in a four-year period, a reduction equivalent to that of 24,000 households.

Storm Water and Waste Water
Storm water can be collected from roofs, tarmac and landscaped areas. Depending on the collection, storage and possible contamination, the water may require treatment ranging from settling ponds to a proper water treatment plant. Usage of treated water will depend on water quality and could be used for landscaping, vehicle and building washing, and toilet flushing. A crucial task of storm water management includes keeping water with tarmac residues from contaminating surface water sources.

Soil and Land Management
Soil, surface and ground water can be contaminated by storm water run-off, fuel spills, de-icing fluids and other spill incidents. Spill prevention and reaction to incidents are operational and environmental responsibilities, and poorly planned land management can provide habitat that attracts bird or other wildlife, thus creating a hazard to aviation.

Solid Waste
There are many streams of solid waste at an airport, including municipal waste from concessions and passenger areas; waste from airfield operations and maintenance (i.e. derelict equipment, pallets and hazardous material like paint thinners); deplaned waste that might require incineration, and debris from
construction and demolition. Some streams are regulated, while some materials can be recycled and generate income.

COMMUNICATIONS AND COMMUNITY ENGAGEMENT

Community Relations
The perception of the environmental impact by neighbouring residents can be as important as the physical effects. Fostering positive community relations can make a vital contribution to the mitigation of adverse environmental pressure resulting from airport operations.

The goals of an airport's community engagement programme should include the following:

- Establish and maintain the trust of the community. If the public does not believe in the information provided, there is no foundation to achieve community engagement. This trust is built upon a long-term culture of honesty and transparency;
- A community that is well-informed and can respond to issues in a balanced manner; and
- Avoid government regulations or court decisions. If communities can grant the airport permission to operate and grow, and airports can undertake sufficient voluntary measures, then overly restrictive regulations and court actions can be avoided.

Components
Unlike engineering projects, communications campaigns are difficult to measure and successes are difficult to gauge. The following features should be included in most programmes:

- A policy declaration clearly supported by top management;
- Regular reporting on an airport's environmental management programmes and achievements, including on-line websites;
- Community consultation, keeping people informed and providing opportunities for community opinions and inputs. Community interaction on smaller projects would help build trust, form important relationships and provide valuable experience for larger projects; and
- Community projects, such as the sound insulation of homes and schools, may be required as part of planning approval on a large project. Other social projects can include providing recreational space, education and open days.

Principles
Community engagement will more likely succeed if built on a working relationship based on trust, when adhering to the following principles:

- Honesty – Public information that is not straightforward and truthful will eventually be revealed as such. Eventual discovery of deception will invariably have worse consequences than knowledge of the original facts in the beginning.
• Clarity – All information presented must be clearly understood; otherwise it is a wasted effort and probably counterproductive.

• Comprehensive – Summaries of data are useful to aid with initial presentation, but detailed data should be available so that individuals can examine the information should they wish.

• Technical versus non-technical – Data must be presented in both technical and non-technical formats. It cannot be assumed that any particular level of technicality would satisfy the range of people in a community. People do not want to be “blinded by science”, but those who understand do not want to be “kept in the dark” either.

CONCLUSION
The aviation industry recognises the significant effects brought to the environment and community. However, as a vital component in society and the economy, the aviation industry sets out to address the concerns and mitigates environmental issues while maintaining continual growth. In order to expand and operate sustainably for generations ahead, the airport operator must constantly communicate and engage its local community while addressing pressing environmental issues. Together with the blessings of both the government and community, airports will be able to play an active role in dealing with sustainability and emission-related concerns.

References


ICAO (2010) International Civil Aviation Organization, Assembly Resolution 37/19


Abstract
Since the early years of aviation, ongoing research has been done to find ways to improve the safety and efficiency of air operations. With the increase in aviation activity and growing concern on the impact of human activities on the climate, there have been several initiatives by the aviation community to address societal concerns.

The air traffic management (ATM) community has been actively reviewing flight paths for optimum trajectories and unrestricted operations. Operational improvement plans through the use of new technology are also helping the aviation community to reduce aviation’s impact on the environment.

This paper provides information on some of the improvement plans as well as ways to measure the benefits that may be accrued from operational improvements.
About the Author

Mr Saulo da Silva is a Technical Officer at the Air Traffic Management (ATM) Section of the International Civil Aviation Organization (ICAO) where he is also Secretary of the Air Traffic Management Requirements and Performance Panel (ATMRPP). Mr da Silva was involved in several projects geared towards the achievement of the vision established by the Global ATM Operational Concept of an interoperable ATM system. As an ICAO Secretariat, he also provides ATM support to the Committee on Aviation Environmental Protection (CAEP) and is one of the authors of the ICAO Fuel Savings Estimation Tool. He is an Air Traffic Controller and Engineer with a Master’s degree in Air Transport Engineering.
Mitigating Aviation’s Impact on the Environment – The ATM Initiative

Mr Saulo da Silva
International Civil Aviation Organization

INTRODUCTION
Aviation is an essential component of our global society. It is a driver of economic, social and cultural development. For landlocked countries and smaller island States, it is an economic lifeline, often the only available link to the global marketplace. It creates and supports millions of jobs, brings people together for leisure or business activities and, in many instances, ensures rapid and effective delivery of humanitarian aid where it is most urgently needed. As such, aviation contributes positively to the economic and social pillars of sustainable development.

ATM AND THE ENVIRONMENT
It is a generally accepted fact that climate change can pose threats to life on the planet. The aviation industry has long recognised this reality that underlies the benefits that air transportation brings to world development.

The aviation industry's need to grow in a sustainable manner, coupled with the global desire to reduce the impact of aviation on the environment, has triggered several actions by the ATM community. These include investing in new technologies and applying new concepts of operations to reduce emissions from aviation. This is also in line with the Convention on International Civil Aviation (i.e. Chicago Convention) which calls for support to ensure the safe and orderly growth of international civil aviation throughout the world while meeting global demand for safe, regular, efficient and economical air transport.

The experience of the ATM community in applying the International Civil Aviation Organization (ICAO)'s Standards and Recommended Practices (SARPs) as well as the Procedures for Air Navigation Services has already set in motion several plans to respond to the impact of aviation on climate change.

Bearing in mind that the aviation sector is responsible for the movement of billions of people and millions of tonnes of goods per year while providing employment for millions of people, it stands to reason that flight operations today are much more efficient than they were 40 years ago. However, such advancements have not stopped the ATM community from continuing to study and apply new concepts of operations and procedures to reduce
the impact of aviation greenhouse gas emissions on the environment. Clear progress is being achieved in the provision of well-structured services that improve efficiency as well as reduce fuel consumption and gas emissions. The ultimate goal is a seamless airspace and a globally harmonised ATM system that operates in an environment that is carbon-free.

As previously mentioned, international civil aviation is an important sector for the global economy. With the projected growth in air traffic demand and the industry’s contribution of approximately 2 percent of global emissions of greenhouse gases, action plans to combat climate change are already in place to ensure long-term sustainability and growth of the aviation industry.

All sectors of the ATM community are striving in this direction. Investments are being made to modernise ATM and improve infrastructure. New operational measures are being taken to reduce the impact on the environment. Projects aiming at a more efficient ATM system are being implemented in all regions of the world, by all States. The ultimate goal is to cut fuel burn through the use of an ATM system where aircraft can operate most efficiently, ideally with carbon-free emissions.

Concepts such as the use of reduced vertical separation minimum (RVSM), now implemented globally, has saved and continues to save billions of tonnes of greenhouse gas emissions. Regional monitoring agencies were established at the same time to monitor the operations and help achieve the RVSM safety objectives.

The use of area navigation (RNAV) systems since the first satellite constellation was made available for civil aviation use more than 15 years ago. It has reduced aircraft flying time tremendously and improved flying profiles, with a consequent reduction in emissions through the use of reduced lateral separation standards and more efficient routes.

Operational procedures like the use of Continuous Descend Operations and Continuous Climb Operations have been put in place and are being improved with a view to reduce emissions.

New concepts and processes in information sharing and exchange as well as flight planning are being implemented to meet the needs of aircraft with advanced capabilities and the evolving requirements of automated ATM systems. This has resulted in more efficient ATM, with a reduction in flying time and its related environmental benefits.

As a complement to and sometimes replacement of conventional voice communications, air traffic controllers are using communication via data-link not only between air traffic services facilities, but also with pilots. This increases the reliability of communications, which directly impacts the capacity of the airspace, and allows aircraft to fly at optimum flight levels which in turn reduces emissions.

The ATM community recognises that there are important trade-offs or interdependencies that may preclude complete efficiency in the ATM system. However, many projects are underway, and with the participation and collaboration of its members, a clear path is built in addressing the global impact of aviation on climate change.
AVIATION SYSTEM BLOCK UPGRADES
ICAO is expecting States to invest over US$120 billion on ATM performance improvements over the next 10 years. Global interoperability, or harmonisation, is an objective of most ATM improvement programmes, considering the benefits it brings to the aviation industry.

With this in mind, ICAO is providing the framework for the Aviation System Block Upgrades (ASBUs) to be developed with the active participation of the aviation community. The ASBUs aim to introduce improvements in the ATM system that would benefit, among other areas, the environment. The ASBUs are a comprehensive means of presenting a strategic direction. Specifically, the ASBUs require States to:

- Nominate the intended performance improvement including the metrics to determine its success;
- Recommend the necessary procedures, both air and ground;
- Identify the required technology if appropriate, both air and ground;
- Outline the business case;
- Propose a regulatory approval plan;
- Define any necessary transition strategies; and
- Nominate any global demonstration trials that relate to the intended operational improvement package.

As a follow-up to the Directive given at the 37th Session of the ICAO General Assembly (2011), ICAO launched the ABSUs initiative to facilitate interoperability, harmonisation and modernisation of air transportation worldwide that would benefit several different performance areas including environment. To that end, ICAO established a programmatic, collaborative approach to develop a set of ATM solutions to meet the global needs for an interoperable airspace that takes advantage of current equipment, establishes a transition plan that provides key performance improvements, and enables global interoperability.

ABSUs comprise a suite of capabilities, called modules, each offering a performance benefit related to a change in operations. The concept originated from existing near-term implementation plans and initiatives and are largely based on operational concepts extracted from the US Next Generation Air Transportation System (NextGen), Europe's Single European Sky ATM Research (SESAR) and Japan's Collaborative Actions for Renovation of Air Traffic Systems (CARATS) programmes. It is also aligned with the ICAO Global ATM Operational Concept. The intent is to apply key capabilities and performance improvements, drawn from these programmes, across other regional and local environments with the same level of performance and associated benefits on a global scale.

It is recognised that not all module solutions are required in all airspaces. The specific elements of the block upgrades are defined by a Technical Team comprising subject matter experts from ICAO and several other organisations. Additional expertise and perspectives are provided by the industry through the International Coordinating Council of Aerospace Industries Associations and the NextGen Institute.
The modules consider a broad number of factors, namely:

- Goals and plans in the ICAO Global ATM Operational Concept and Global Air Navigation Plan (GANP);
- Existing detailed plans for NextGen, SESAR, CARATS, and others as well as experience to date;
- The criticality of global interoperability and harmonisation in ATM modernisation;
- Current knowledge on the feasibility of the modules;
- The need for balance, clear operational rationale and measurable value in implementation;
- The notion of building upon existing advanced but underutilised capabilities;
- Recognition of the potential risks to implementation and risk identification considerations; and
- Challenges in moving forward with implementation.

ATM MODERNISATION

The availability of international standards with realistic lead times would enable regional regulations to be identified and allow States, operators and industry players to develop and implement adequate ATM modernisation action plans. These action plans would identify the regulations that States need to develop in order to facilitate and drive evolution and, if needed, investment in new facilities and/or infrastructure. This would also allow the industry players to perform business case and market assessments and update their long-term business plans in the design, development, production and delivery of products and services integral to the block upgrades’ modules.

Block upgrades define a way to progress from the general objectives contained in the ICAO Global Air Navigation Plan towards actual implementation of regional performance improvements. By identifying common targets and various components of operational improvements, block upgrades facilitate stakeholder commitment to efficient implementation along common timelines. Their descriptive material provides specificity and progression of various improvements leading to appropriate standards development and implementation. Interaction of the various modules and elements are described in a way that allows a level of flexibility in implementation. Thus, decisions on operational requirements can be made on the basis of regional needs, in a timely manner without jeopardising global interoperability.

At the same time, it also meets the expectations of the aviation community which include the reduction of greenhouse gas emissions.

STAKEHOLDER ROLES AND RESPONSIBILITIES

Stakeholders including service providers, regulators, airspace users and manufacturers will be facing increased levels of interaction as new, modernised ATM operations are implemented to address society expectations. The highly integrated nature of capabilities covered by the block upgrades require a significant level of coordination and cooperation among all stakeholders. Working together is essential
for achieving global harmonisation and interoperability, which are necessary in order to address, among others, the wishes of the society for a greener aviation system.

For ICAO and its governing bodies, the block upgrades would enable the development and delivery of necessary SARPs to States and industry players in a prompt and timely manner to facilitate regulation, technological improvement and ensure operational benefits worldwide.

States, operators and the industry would benefit from the availability of SARPs that have realistic lead times. These enable regional regulations to be identified, allowing for the development of adequate action plans for evolving, or if needed, investing in new facilities and/or infrastructure.

Different stakeholders worldwide should prepare ATM for the future. The block upgrades initiative should constitute the basis for future plans for ATM modernisation. Where plans are in existence, they should be revised in line with objectives defined in the block upgrades.

For the industry, this constitutes a basis for planning future development and delivering products on the market at the proper target time. For service providers or operators, block upgrades should serve as a planning tool for resource management, capital investment, training as well as potential reorganisation.

**ABSU MODULES**

An ABSU designates a set of improvements that can be implemented globally from a defined point in time to enhance the performance of the ATM system. A block is made up of modules, with each module representing a specific, well-bounded improvement. A module can be a grouping of several elements which can contain communications, navigation and surveillance (CNS) components in the airplane, a communication system, a ground component of the ATC automation or decision support tool for controllers etc.

The elements mutually make the module comprehensive and cohesive. A module is a deployable package (performance) or capability. A module will offer an understandable performance benefit, related to a change in operations, supported by procedures, technology, regulation or standards as necessary, and a business case. A module will be also be characterised by the operating environment within which it may be applied.

It is fairly important for each of the modules to be both flexible and scalable to the point where their application can be managed through any set of regional plans and realise the intended benefits. The preferential basis for the development of the modules rely on the applications being adjustable to fit the needs of different regions as opposed to being mandated as a one-size-fits-all application. Even so, it is clear that many of the modules developed in the block upgrades would not be necessary to manage the complexity of ATM in many parts of the world.

A series of dependent modules across the block upgrades represent a coherent transition thread in time from basic to advanced capability and associated performance. The date considered for allocating a module to a block is that of the initial operational capability.
Block upgrades have been defined as such:

- **Block 0**: Available now
- **Block 1**: Available to be deployed globally from 2018
- **Block 2**: Available to be deployed globally from 2023
- **Block 3**: Available to be deployed globally from 2028 and beyond

The dates refer to the availability or ability to use the module in an operational manner and generate operational benefits that would impact areas such as environmental protection. There are several activities (i.e. research, development and validation) which need to be properly planned and executed before reaching the initial operational capabilities dates and these (for example the necessary infrastructure to support a block upgrade capability) are an integral part of the plan.

The inclusion of a module in a block is dependent on the time at which the appropriate ICAO provisions are made available and the operational capability deployable.

The notion of blocks introduces a form of quantisation of the dates in five-year intervals. However, detailed descriptions would allow the setting of more accurate implementation dates, often not at the exact reference date of a block upgrade. The purpose is not to indicate when a module implementation must be completed, unless dependencies among modules logically suggest such a completion date.

For Block 0, no new airborne technologies are required, although modules may imply the deployment of existing technologies to a larger aircraft population depending on chosen modules respectively paired with tied benefits.

The modules have been grouped to support a transition in time, as follows:

- **Threads**: A thread describes the evolution of a given capability through the successive block upgrades, from basic to a more advanced capability and associated performance, and representing aspects of the Global ATM Operational Concept.
- **Performance Improvement Areas (PIA)**: Sets of threads that group operational and performance objectives in relation to the environment in which they apply, thus forming an executive view of the intended evolution. The PIAs facilitate comparison of ongoing programmes.

The four PIAs are as follows (see Figure 1):

- Greener airports;
- Globally interoperable systems and data – through globally interoperable system-wide information management;
- Optimum capacity and flexible flights – through global collaborative ATM; and
- Efficient flight path – through trajectory-based operations.
When identifying the capabilities, focus is given to global interoperability issues which give rise to a need for ICAO and/or industry standards. Interoperability concerns the interaction of aircraft with other aircraft and/or ground systems, as well as the interactions among ground ATM systems or elements and it is anticipated that the block upgrades will provide the basis for a revised Global Air Navigation Plan (GANP).

The block upgrades aim at delivering improved performance. The technical enablers, in particular CNS, will be derived from the modules and presented for convenience as individual but consistent roadmaps. A technical enabler may support several modules of the same block.

In effect, the roadmaps in the GANP will identify the longitudinal technology path over time whereas the block upgrades provide a vertical slice of those capabilities over defined five-year terms with all of the supporting information for their implementation included for completeness.

**ASSESSING GLOBAL EMISSIONS**

Despite all the programmes and investments for implementation of operational improvements through a modernised ATM system, one aspect that has been a challenge for the ATM community is the assessment of the emissions reduction using the operational initiatives to improve efficiency.

Recognising this difficulty faced by many States to assess the environmental benefits of their investments in operational measures to improve fuel efficiency, ICAO with the support of subject matter experts and other international organisations such as the International Air Transport Association (IATA), the Federal Aviation Administration (FAA), the European Organisation for the Safety of Air Navigation (EUROCONTROL) and the Civil Air Navigation Services Organisation (CANSO) developed the ICAO Fuel Savings Estimation Tool (IFSET). It is part of a project to assist States in assessing fuel savings in an easy and harmonised manner and be consistent with more advanced models already approved by the Committee on Aviation Environmental Protection (CAEP).
IFSET will estimate the difference in fuel mass consumed by comparing a pre-implementation (i.e. “baseline”) case against a post-implementation case (i.e. “after operational improvements”), as illustrated notionally in Figures 3 and 4.
The selection of the baseline case is an important step of the process. It is to be defined by the user and could correspond to:

- The published or planned procedure (i.e. Aeronautical Information Publication and flight plan) scenarios;
- The daily practices;
- A combination of the two; or
- Other criteria as appropriate.

In order to compute the amount fuel consumed in two different scenarios for comparison, information on the number of operations by aircraft category for both scenarios is required, together with a combination of the following:

- Average taxi time;
- Time spent or distance flown at a specific altitude;
- Top of descent altitude and bottom of descent altitude;
- Base of climb altitude and top of climb altitude; and
- Distance flown in a climb or descent procedure.
The IFSET has been rolled out to ICAO member States with the help of CANSO. A series of workshops was developed to provide assistance to those States without such facilities to estimate the benefits from operational improvements in an easy and harmonised way and not to replace the use of detailed measurement or modelling of fuel savings where those capabilities exist.

CONCLUSION
International civil aviation is an important sector for the global economy. To ensure the long-term sustainability and growth of the industry, all stakeholders must look towards investing in new technologies and applying new concepts of operations to reduce emissions from aviation. The ATM community recognises this and is working hard to support this. The ASBU initiative constitutes the framework for ATM system modernisation which would in turn facilitate interoperability and harmonisation of air transport worldwide, while the IFSET provides assistance to States to estimate and measure benefits from operational improvements. With these initiatives well underway, the ATM community is all set to support the global need for a continuously improving aviation system that is more safe, secure and environmentally friendly.

References
- ICAO (2005), Global Air Traffic Management Operational Concept (1st edn).
Conflicting Interests in Aircraft Accident Investigation

Abstract

Aircraft accidents are thankfully rare, but carry the potential for significant loss of life and property. Investigations into the causes of such events are likely to come from many different, and sometimes conflicting interest groups. Whilst the concept of “multiple causality” is well understood, are accident investigations able to beat the multiple conflicting interests, biases and influences that face them in their quest to uncover the true causes of accidents?

This paper considers fundamental challenges in accident investigations that go way beyond the initial technical challenges into practical, political and philosophical differences. As investigation capability increases, care must be taken to ensure that the increased threat of criminal litigation does not destroy the opportunities for learning created through good accident investigation.
About the Author

Professor Graham Braithwaite is Head of the Department of Air Transport and holds the Chair in Safety and Accident Investigation Centre at Cranfield University, UK. He is also Course Director for the world renowned Aircraft Accident Investigation course and in 2011, led the successful bid for a Queen’s Anniversary Prize for Higher and Further Education for the University’s contribution to aviation safety through research and training in accident investigation. Prof Braithwaite has served as a member of the SAA Advisory Board since 2007.
INTRODUCTION
The investigation of incidents and accidents is a vital component of safety management (ICAO, 2009) driven not just by legal obligations and the need to identify remedial actions to prevent recurrence, but also a strong moral obligation to explain why the tragedy occurred. The responsibility to conduct an investigation often lies with multiple organisations, each with their own priorities. This creates one of many major hurdles for investigations which are discussed below.

INTERESTED PARTIES
The initial response to an occurrence should rightfully be focused on the preservation of life and property. However, the emphasis soon shifts to the investigation of the causes and circumstances behind the event and at this stage, multiple and often competing interests will appear. Whilst some are focused on the allocation of responsibility or blame, others are more concerned with the prevention of recurrence. With a diverse range of interests and timescales, how effectively are the true causes of accidents being identified? A review of the various interested parties is needed to answer this question.

The Technical Audience
Following a significant accident, there may be a wide and varied technical audience who have a particular interest in the design or operational lessons learnt from the incident. Within air transport, the Standards and Recommended Practices of the International Civil Aviation Organization (ICAO) Annex 13 (Aircraft Accident Investigation) detail the parties who are entitled to participate in an investigation. When a serious incident or accident occurs, the State of occurrence is responsible for instituting a not-to-blame investigation. In addition, the State of the registry of the aircraft, the State of the operator, State of design and State of manufacture are all entitled to appoint ‘accredited representatives’ to the investigation. On top of this, the State conducting the investigation is entitled to appoint one or more technical advisers to assist with the investigation. This can quickly lead to a large investigation team from multiple countries with different and, at times, competing interests.
On 1 June 2009, Air France flight 447 crashed into the Atlantic Ocean with the loss of all onboard. As the accident occurred in international waters, France, the State of registry, commenced the technical investigation through the Bureau d’Enquêtes et d’Analyses pour la Sécurité de l’Aviation Civile (BEA). Accredited representatives were appointed from the technical investigation agencies of Brazil, Germany, UK and US and through them, technical advisers from manufacturers such as Airbus, CFM International and Thales. States which had citizens onboard were also granted observer status and hence introduced representatives from China, Croatia, Hungary, Ireland, Italy, Lebanon, Morocco, Norway, South Korea, Russia, South Africa and Switzerland. Immediately, the geographic spread of the larger investigation team can be seen and this is even before an investigation starts to work with States which may have experienced similar events. An example may be the Australian Transport Safety Bureau (ATSB), which had previously investigated an in-flight upset involving another Airbus 330 aircraft in 2008.

In compliance with Annex 13, the State leading the investigation needs to ensure independence so that evidence is not tampered with, findings are not leaked inappropriately and so on. This is a difficult “ringmaster” role, particularly if the occurrence is in a smaller or less affluent State that needs to rely on the input of a larger State. For example, Egypt handed over its investigation of Egyptair flight 990 (which crashed into the Atlantic Ocean with the loss of all onboard) in 1999 to the US. When the National Transportation Safety Board (NTSB) investigation focused on a deliberate act by the Relief First Officer of the flight, the Egyptian authorities tried to take back control and ended up running a parallel investigation that drew different conclusions to the State of Manufacture, US.

The Affected Parties
Those affected by a major catastrophe may include those injured by, or who witnessed the event, as well as the friends and families of victims. It could also include colleagues of those killed or injured, and staff who felt that their actions may have had some influence on the incident. For a major aircraft accident, the number of affected parties may run into the hundreds or even thousands and can be spread across the world. The needs of this audience have not always been well recognised or provided for. Problems encountered following a number of high profile aircraft accidents in the late 1980s and 1990s led the US Government to establish the Aviation Disaster Family Assistance Act of 1996. The Act, amongst other things, places a responsibility on the NTSB to work closely with victims and their families throughout an investigation, providing regular briefings (NTSB, 2005), but not making them part of the investigation as such. The latter distinction is important as families are often frustrated by the speed of an investigation or its non-punitive nature and may create problems for the scientific and investigative process.

This is not to say that victims and their families are not important – quite the opposite, in fact. They have the need for an accurate and timely investigation in the same way that the technical audience does. However, they are likely to be unfamiliar with the process or traumatised by what has occurred and in many cases wanting some sort of restitution, which may well be in conflict with the no-blame aspect of the technical investigation.
The General Public
The public interest following an accident can be substantial, especially if there are significant third-party losses to life or property or the event had caused real or perceived anxiety in the local community about the particular activity. For example, some residents became genuinely more concerned about third-party risk following the crash landing of a Boeing 777 (B777) short of the runway, at Heathrow Airport in January 2008. However, there were also those who saw this event as an opportunity and reason to object to the proposed third runway.

The public’s interest is also represented through a variety of legal and quasi-legal processes, which may run consecutively or concurrently with each other, depending on the circumstances or jurisdiction. For example, in England, Wales and Northern Ireland, an accidental death must be reported to the relevant Coroner who will chair an inquiry into the circumstances. This inquiry will often be suspended until the technical investigation is complete as factual information will be required from it. Where multiple deaths occur, a public inquiry may be called, either immediately or after a period of time. Such inquiries are ad hoc and infrequent. The last public inquiry into an aircraft accident in the UK followed the loss of a British European Airways Trident in 1972, whereas more recent inquiries followed the capsize of the ferry Herald of Free Enterprise in 1987; the Piper Alpha production platform explosion in 1988; and the Ladbrooke Grove and Southall rail accidents in 1999. Many accidents receive multiple calls for public inquiries without one ever being convened, such as following the Potters Bar and Grayrigg rail accidents in 2002 and 2007 respectively.

In the Thames Safety Inquiry (2000), Lord Justice Clarke remarked,

“The public interest is not of course the same as the interest of the public. The public may be interested in many things which it would not be in the public interest to investigate publicly.”

In many endeavours, processes exist whereby thorough investigation can take place without the time and cost of a public inquiry, which arguably has common objectives with transport accident investigation, “…namely ascertaining the facts and learning lessons for the future” (Clarke, 2000). This notwithstanding, public inquiries have led to substantial changes in the way that safety is managed and events investigated. The UK Marine Accident Investigation Branch was founded partly in response to the Sheen Inquiry (Herald of Free Enterprise) and the Rail Accident Investigation Branch following the Ladbrooke Grove Inquiry.

Both public inquiries and coronial hearings are inquisitorial in nature rather than adversarial. Whilst these processes may involve the need to criticise organisations or individuals, they cannot determine questions of civil or criminal liability (Cullen, 2007).

The Legal Process
A more concerning trend is towards the criminalisation of accident investigation. In 2006, the Flight Safety Foundation (FSF), the Civil Air Navigation Services Organisation (CANSO), the Royal Aeronautical
Society (RAeS) and the Academie Nationale de L’Air et de L’Espace (ANAE) issued a joint resolution,

“...decrying the increasing tendency of law enforcement and judicial authorities to attempt to
criminalise aviation accidents, to the detriment of aviation safety.”

This followed a range of high profile accidents in France, Greece, Brazil, Italy, US and Switzerland where criminal investigations had been instigated against crew, air traffic controllers, maintainers and senior staff. This statement was reissued in 2010 with further signatures from the International Federation of Air Traffic Controller’s Associations (IFATCA), the International Society of Air Safety Investigators (ISASI), the European Regions Airline Association (ERA) and the Professional Aviation Maintenance Association (PAMA).

Whilst criminal investigations are right and proper where a criminal act is suspected, the threat of such investigations can have a negative impact on the effectiveness of a safety investigation. Where witnesses believe that their testimonies could be used against them later, there is little incentive to cooperate with the investigators. Where States fail to provide protection against not-for-blame investigation reports being used as evidence for criminal proceedings, the quality of safety investigations will suffer.

Acknowledging this as a potential problem, the Crown Prosecution Service (CPS) of England and Wales, together with the Air Accidents, Marine Accident and Rail Accident Investigation Branch agreed on a Memorandum of Understanding (CPS, 2008) setting out the principles for liaison following an accident. One of the basic principles is as follows:

*The public interest requires that safety considerations are of paramount importance, the consequence of which may mean that the interests of an accident investigation branch (AIB) investigation have to take precedence over the criminal investigation.*

However, this does not mean that parallel investigation will not take place or that certain elements of evidence collected by the not-for-blame investigation process cannot be used by the CPS. A second principle of cooperation identifies that:

*All evidence and factual information, except where there are specific legislative bars, can be disclosed between the AIBs and the CPS. The AIBs will not share their own opinions or analysis.*

Striking the right balance is hard, particularly if the investigation process is overly protective of evidence sources such as data recorders. The legal investigation can argue that, without evidence, it is not possible to deliver justice, whereas misuse of evidence (such as witness interviews or voice recordings) may lead to unwillingness for people to assist. As Quinn (2007) notes,

“...when considering the chilling impact the threat of prosecution can and does have on safety investigations, it becomes clear that the future of aviation safety depends on unhindered communication between investigators, witnesses and those involved in accidents.”

The fear that evidence collected for not-for-blame purposes may subsequently be used for criminal litigation is of great significance. As Michaelides-Mateou and Mateou (2010) observed,
“This view undoubtedly results in the fear of prosecution which impedes safety and casts doubts upon the integrity of the technical investigation.”

SPEED OF INVESTIGATION
In addition to the multiple interests detailed above, the speed of investigation differs greatly. Public expectations can be unrealistic, no doubt influenced by news media clichés such as “24 hours on and investigators still don’t know the cause of yesterday’s accident…” when in reality an accident investigation may have barely begun.

Accident investigation is often complex, requiring detailed forensic analysis of evidence and careful cross-checking. Whilst ICAO targets to complete an aircraft accident investigation in one year, many take much longer, for example:

- The investigation into the loss of Swissair flight 111 near Peggy’s Cove, Nova Scotia took five years, involved over 350 investigators and cost approximately US$48.5 million to complete.
- The NTSB investigation into the explosion of Trans World Airlines flight 800 off Long Island took four years and was the most costly aircraft accident investigation in US history.
- The NTSB investigation into the loss of US Airways flight 427 near Pittsburg took four and a half years to complete.
- The NTSB investigation into the loss of United Airlines flight 585 near Colorado Springs took 3,677 days to complete.
- Whilst the investigation is ongoing (as of October 2011), the investigation following the loss of Air France flight 447 took 23 months before it was able to locate and recover the flight data recorders.

Investigators face the difficult trade-off between the need for an industry to continue to operate, versus the need to pursue systemic causes that may well be very deep. The resourcing available will make some difference to the ability of the investigation team to do its job, as well as the available evidence and the willingness of the agency to keep “digging”. This was clearly demonstrated following the loss of Air New Zealand flight 901 at Mount Erebus, Antarctica in November 1979. The official technical report was released in June 1980 and focused on the actions of the flight crew, who descended below the minimum safe altitude limit and continued at that height despite being unsure of their position. However, in response to public demand, a Royal Commission of Inquiry was formed under Justice Peter Mahon and in 1981 reported its findings (Mahon, 1981). The Commission concentrated on deeper, systemic issues within the airline and regulator as well as a tragic combination of factors which had induced at least some of the crew’s errors. The findings were controversial and the final report was not tabled in Parliament until 1999.

In transport accidents where a particular vehicle type may come under question, there is a critical need to assess whether it is suitable to continue in service. Similarly where a common fault may affect different vehicles, there may be a drop in confidence in components, technologies or even infrastructure.
For example, following the crash landing of British Airways flight 38 at Heathrow Airport in 2008, operators of both the B777 aircraft (around 60 airlines) and Rolls-Royce Trent 800 engines (i.e. Boeing and Airbus) were understandably concerned, as were those using fuel supplied at Beijing Airport, the origin of the flight. The potential effect would be dramatic if the aircraft type, engine or fuel were found to be at fault, especially if grounding was an option. Despite media rumours to the contrary, the fuel, for example, was found not to be relevant to the accident. Finding the right answer is critical, not just to the credibility of the investigation, but also to the financial health of many companies and even the global economy. The impact of grounding the entire fleet of B777 aircraft which in 2011 stood at nearly 1,000 aircraft would be unimaginable.

THE QUALITY OF THE INVESTIGATION

Accident investigation is a multidisciplinary pursuit that draws upon a wide range of technical skills and personal traits. Whilst investigators are frequently recruited based on their technical specialisation, it is their methodical, analytical approach that is most valuable and in particular, how they deal with the collection, preservation and interpretation of evidence.

First responders to accidents are generally motivated by the principle of preserving life. This is not necessarily the first priority of the safety investigator who is concerned with securing evidence. This is not to say that the two types of responders are incompatible. Indeed, investigators may well provide useful guidance on an accident site regarding hazards or advice for mounting rescue attempts. Once survivors are rescued and fires extinguished, the investigator must ensure that the site is safe for them to conduct their work. This involves striking a balance between the hazards on site and mitigations that destroy the least amount of evidence.

The crucial point is that from the moment an accident occurs, the investigation will be faced with challenges and compromises. Evidence may be tampered with due to priorities such as rescue work and gaining access to wreckage. Evidence such as ground marks, volatile memory, and witness testimony are perishable, and may never be available to the investigation at all. Any accident investigation is only as good as the quality of evidence it is able to draw upon and in some cases, there is just not sufficient evidence to draw a satisfactory level of proof. As former ATSB Executive Director, Kym Bills (Rosenkrans 2008) noted,

“Investigative bodies find the analysis aspect of their work among the most difficult tasks, with complex crash scenarios likely to involve missing, obscure or even deceptive data.”

The quality of the investigators is also a major influence on the outcome of an investigation. This can be affected by wilful factors such as politics and corruption, or natural biases and heuristics. An investigator may cause irreparable damage to the established safety culture if they employ unethical means to get hold of information. However frustrating or convinced an investigator may be that someone is not telling the truth, he must not lie or use deception to illicit further information. If witnesses are assured that their testimonies will not be used against them, the investigator must be confident that this is true and not use this guarantee as a technique to encourage cooperation.
Objectivity is a fundamental quality required of an investigator. The facts will indeed speak for themselves but by favouring one side more than the other, the investigator can fall foul of confirmation bias, which is seeing what they expect to see, or of inducing bias on the part of witnesses. Without evidence, an investigator merely becomes another individual with an opinion. Yet, over time, investigators get to see the same causal factors over and over again. It is often said that there are no new accidents; only people with short memories. Whilst this may hold true in many cases, it may well be the first time something has occurred, and may be completely different from what is first expected in any given investigation. While the news media has the right to speculate, an investigator must not do so as it introduces bias into an investigation. However, hypothesising forms part of the investigative process and is to be encouraged.

As with all forms of research, hypotheses are to be tested by considering all evidence that supports and refutes the hypothesis, before a conclusion is drawn based upon both sides of the argument. Accidents are almost never caused by a single factor. Indeed, an investigation that finds only one contributory factor is likely deficient. Therefore, whilst there may be a quick and apparently easy answer for the case, other avenues may also need exploration. Investigators need to determine how deep to go and which avenues to explore, recognising that resources for an investigation are likely to be finite, except for perhaps, major or multiple fatality disasters.

GETTING TO THE “RIGHT” ANSWER

Accident investigations, quasi-legal (i.e Coronial or Fatal Accident Inquiries) and legal proceedings may ultimately be looking for different answers. Whilst they are effectively investigating the same contributory events and factors, their purpose is likely to be satisfied by different levels of answer. For example, the aim of safety investigations is to develop recommendations to prevent recurrence; the Coronial process aims to establish the cause and circumstances of death while legal proceedings are concerned with allocating responsibility or liability.

Commensurate with this, different investigations often work to different levels of proof. This may cause problems and conflicts, such as the ATSB’s investigation into the aircraft accident in 2005, which occurred near Lockhard River in Queensland, where the regulator, Civil Aviation Safety Authority took exception to the Bureau’s analysis model and standard of proof. This in turn led the investigation agency to re-examine its approach. As Walker and Bills (2008) noted,

“Despite its importance, complexity, and reliance on investigators’ judgements, analysis has been a neglected area in terms of standards, guidance and training of investigators in most organisations that conduct safety investigations.”

There is an industry-wide acceptance of the need for investigations to consider what Reason (1990, 1997) describes as active failures, but also the latent conditions that may lie deep within an organisation or system, that could be in designs or decisions made months or years prior to an accident. This is evidenced through endorsement by ICAO and the International Maritime Organisation through successful application in a range of high profile investigations such as the overrun of Boeing 747 VH-
Safety
Conflicting Interests in Aircraft Accident Investigation

OJH at Bangkok, Thailand in September 1999 (ATSB, 2001). Such focus on the systemic causes of accidents rather than the immediate actions or technical failures lies at the heart of not-for-blame safety investigations. However, application across the global transport sector is far from universal for a variety of reasons, including:

- The competition for evidence between agencies;
- Different views regarding primacy in the investigation;
- Fundamental differences in philosophy regarding the accident causation;
- Standards of training for investigators;
- Resources available for the conduct of the investigation;
- The level of independence of the investigation agency;
- The political will to go deeper into systemic factors such as regulation;
- Reporting deadlines; and
- Concerns about the use of not-for-blame investigation reports in litigation

The various competing interests will inevitably lead to either real or perceived compromises. If the push towards a deeper, systemic understanding of causation is thwarted by fear, then organisations will lose great, and often expensive, opportunities to learn from the mistakes of others. It is with this in mind that FSF, RAeS, ANAE, CANSO, ERA, IFATCA, PAMA and ISASI, through their joint resolution regarding criminalisation of aviation accidents,

“...urge National aviation and accident investigating authorities to:

(i) assert strong control over accident investigations, free from undue interference from law enforcement authorities;
(ii) invite international cooperation in the accident investigation under Annex 13;
(iii) conduct professional investigations to identify probable cause and contributing factors and develop recommendations in a deliberative manner, avoiding any “rush to judgment”;
(iv) ensure the free and voluntary flow of essential safety information;
(v) provide victims’ loved ones and their families with full, accurate, and precise information at the earliest possible time; and
(vi) address swiftly any acts or omissions in violation of aviation standards” (Flight Safety Foundation et al. 2010).
CONCLUSION
Faced with the practical, political and philosophical challenges detailed in this paper, it is remarkable how much accident investigation has achieved. Beginning immediately after an occurrence, the rush to start an investigation and collect what may be vulnerable, perishable, incomplete or inaccurate evidence comes as multiple agencies compete for primacy and access. Faced with multiple pressures from the technical audience, such as manufacturers, regulators and operators, as well as those who may have been directly affected through the loss of loved ones, investigators need to find the right balance of timeliness and accuracy. Doing so requires strict professional ethics and a disciplined approach towards the analysis of evidence. The value of success is enormous. However, the loss of trust or damage to safety culture that can be sustained through failure is similarly far-reaching.

References


Safety Culture and Safety Management Systems – Enhancing the Heartware of Managing Aviation Safety

Abstract

Aviation is generally very safe – with serious accidents occurring rarely. However, as aviation continues to grow, there is a need to further improve its safety performance.

Accident rates are low and have reached a “plateau” whereby technological efforts to further improve the trend is limited. In order to continue improving safety performance, it is necessary to also address “the hearts and minds of the management and workers”.

The aviation community must continually learn from its own experiences and introduce new and innovative safety initiatives such as safety management systems and safety culture.

A safety management system (SMS) provides a structured mechanism for organisations to continuously improve safety to ensure safe operations. A strong safety culture is an essential element in a SMS. It fosters the necessary commitment, organisational attitudes, individual and group behaviours towards effective safety management.

Amidst the growing hardware and software that are used in safety management and the challenges confronting the aviation community to further improve safety performance, the test of how successful we are in achieving that goal will depend increasingly on the competency and commitment given to grooming, grounding and enhancing the heartware of managing safety in aviation organisations.
Mr Kang Huei Wang is Head (School of Aviation Safety and Security) at the Singapore Aviation Academy (SAA) and is responsible for the overall operation, administration and performance of the School. He is also a qualified ICAO trainer for the ICAO endorsed Government Safety Inspector (GSI) Airworthiness and Personnel Licensing courses.

Mr Kang’s 36 years of experience in the aviation industry includes working with Qantas Airways, Singapore Airlines and Northwest Airlines as a licensed aircraft engineer for more than 20 years. He joined the Civil Aviation Authority of Singapore in 1996 and was the Head (Airworthiness) in the Airworthiness/Flight Operations Division before joining SAA in 2009. Mr Kang’s extensive experience also includes involvement in several aircraft accident/incident investigations in Singapore and overseas. He holds a Master of Business Administration degree from the University of Leicester, UK and has been conferred the Public Administration Medal (Bronze) in the Singapore National Day Awards 2011 for his outstanding public service.
Safety Culture and Safety Management Systems – Enhancing the Heartware of Managing Aviation Safety

Mr Kang Huei Wang
Civil Aviation Authority of Singapore

INTRODUCTION
In the aviation industry, the focus and efforts to improve safety have traditionally been on the technical aspects. Human errors or technical failures are often identified as the immediate causes of accidents. Initially, it was quite appropriate to address these technical issues as technology was immature then and the cause of an accident could often be traced to the failure of a structural or system component that, once improved, would enhance safety.

Over time, aviation technology has matured – and with accident rates practically close to zero, greater effort is needed to reduce this trend further. Even with new advancements in aircraft materials, technologies and construction methods, there is little room left for further improvements. Moreover, it is natural for aviation professionals, who are predominantly technically-inclined to focus on the technical aspects of safety - the hardware - when accidents occur.

However, when embracing new technologies, issues such as the performance of people who must interface with and use this new equipment and its associated hazards tend to be overlooked. With growing awareness that available technical solutions to improving safety have almost reached its peak, other aspects such as human factors, organisational performance and quality assurance - the software - have also emerged.

Shift of Emphasis to Heartware
The shift in emphasis from hardware to software has generally been driven by:

- A change of focus from technical aspects to human factors;
- Broad systemic view of the environment in which aircraft operates, including its crew, ground staff, maintenance and air traffic service providers;
- A forward-looking and proactive approach to safety;
The involvement and assumption of safety responsibility by all in the organisation; and

Safety accountability by organisational management.

This shift in focus from an administrative to a more performance-based regulatory approach allows industry to assume more responsibility to actively manage the safety risks associated with its aviation activities. While maintaining and improving safety, this approach gives service providers more flexibility and efficiency to go beyond rigid administrative regulations, apply safety risk management principles based on the specific operating environment of their organisations. It can also result in competitive advantages.

This paradigm shift encompasses safety culture and safety management systems which can be viewed as the heartware of aviation organisations.

In aviation, hardware is important and is essential. More important than hardware is the software that will enable organisations to use their resources efficiently and effectively. However, the most critical element is the heartware of the organisation – its people, their attitudes and behaviours towards managing safety in their organisation.

Safety Culture and Safety Management Systems

The awareness, existence and importance of safety culture, has evolved over the years through lessons learnt from several major catastrophic accidents. The term ‘safety culture’ was first used in the accident investigation report published by the International Atomic Agency’s (AEA) Nuclear Advisory Group after the Chernobyl nuclear reactor disaster (meltdown and steam explosion) in Ukraine in April 1986. The AEA concluded that the nuclear power plant was poorly designed and the people operating the plant were not properly trained or supervised. The accident, said the World Nuclear Association, was a direct consequence of the lack of a safety culture. Safety culture was described as:

“[That assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance.”

This concept was introduced to help explain how the lack of knowledge and understanding of risk and safety by the employees and organisation contributed to the outcome of the disaster.

Recently, the International Civil Aviation Organization (ICAO) introduced the concept of safety management systems to the aviation industry. The purpose of a Safety Management System (SMS) is to identify safety risks associated with the delivery of services in an organisation and to systematically manage them. Traditionally, safety management and accident prevention have been reactionary, investigating incidents and accidents after they occur and then analysing them to determine how to prevent the recurrence of the same accidents. A SMS is proactive, actively looking for potential hazards and identifying errors before they turn into accident causal factors. ICAO has identified four components that make up a SMS:
• Safety policy and objectives;
• Safety risk management;
• Safety assurance; and
• Safety promotion.

Safety culture and safety management systems are two safety concepts commonly used and often discussed within the aviation community. But what do they really mean?

**Safety Culture and Aviation**

Since the Chernobyl nuclear reactor disaster in 1986, the concept of safety culture has spread to other industries such as medical, chemical, oil and gas, rail and aviation. In aviation, it has been used to help provide some insights into the Überlingen and Milan Linate accidents.

Over time, a number of definitions of safety culture have also emerged. The Advisory Committee on the Safety of Nuclear Installations (ACSNI) and the UK Health and Safety Commission, both describe safety culture as:

*The product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organisation’s health and safety management.*

Among the first to bring the term ‘safety culture’ to the aviation industry was Dr John K Lauber when he was a member of the US National Transportation Safety Board (NTSB).

On 11 September 1991, Continental Express Flight 2574, a scheduled domestic passenger flight operated by Britt Airways from Laredo International Airport in Laredo, Texas to Bush Intercontinental Airport in Houston, Texas crashed as it was approaching the runway for landing, killing all 14 people on board the Embraer EMB 120 Brasilia aircraft.

The NTSB investigation revealed that bolts had been removed from the horizontal stabiliser during maintenance the night before the accident and, after a shift change, the bolts were not reinstalled. NTSB cited the failure of airline maintenance and inspection personnel to follow proper maintenance and quality assurance procedures. Some months after, a similar incident happened on the same airline when a plane was forced to return to the airport after discovering that bolts had been removed from a wing panel.

Recognising that organisational factors can influence the root cause of some aviation accidents, Dr John Lauber suggested that the probable cause of this accident included:

*The failure of Continental Express management to establish a corporate culture which encouraged and enforced adherence to approved maintenance and quality assurance procedures* (NTSB/ AAR-92/04, 1992, pg. 54).
As a result of this and other similar aviation accidents, safety culture came to the forefront and has since gained prominence within the aviation community.

**Characteristics of a Safety Culture**

Various definitions have been used for *safety culture* but the concept is undoubtedly relevant and significant because safety culture creates the environment within which safety attitudes of individuals are developed and maintained and safety behaviours are promoted.

A positive *safety culture* implies that the whole is more than the sum of the parts. The different aspects interact to provide added effect in a collective commitment. In a negative safety culture the opposite is the case, with the commitment of some individuals strangled by the cynicism of others (IET, 2010).

Increasingly, safety culture is seen as fundamental for good safety performance in aviation. The importance of establishing and maintaining a positive safety culture in an aviation organisation is also recognised as an essential aspect of effective safety management. An organisation's safety culture is ultimately reflected in the way in which safety is managed in the workplace.

One implication of the concept of safety culture is that organisations, like individuals, can cause accidents. Safety culture represents the priority given to safety at all levels in the organisation, and reflects the real commitment to safety. It is the way that safety is perceived, valued and prioritised in an organisation.

It is important to note that safety culture is a sub-set of the overall culture of the organisation and that the safety performance of an organisation is greatly influenced by aspects of management that have not traditionally been seen as a “part of safety”.

Organisations therefore need to evolve a safety culture which enables their people to develop their attitudes and behaviours towards safety rather than telling them what these should be. If people in the organisation are enabled to perform their work activities safely and are proactively looking out for hazards, a new level of safety that is behaviour driven can be achieved.

Leadership is central to safety culture. All the elements of a safety culture must be actively promoted and demonstrated by organisational leaders on a regular basis to encourage participation from all staff if this level is to be achieved.

Dr James Reason (1997) has suggested that safety culture consists of five elements:

- An informed culture;
- A reporting culture;
- A learning culture;
- A just culture; and
- A flexible culture.
An informed culture collects and analyses relevant data, and actively disseminates safety information.

A reporting culture cultivates an atmosphere where people have confidence to report safety concerns without fear of blame. Employees must know that confidentiality will be maintained and that the information submitted will be acted upon, otherwise they will decide that there is no benefit in their reporting.

A learning culture learns from its mistakes and make changes.

A just culture does not punish errors and unsafe acts if the error was unintentional. However, those who act recklessly or take deliberate and unjustifiable risks will still be subject to disciplinary action.

A flexible culture is capable of adapting effectively to changing demands.

Taking a glance at safety culture through the lens of the healthcare industry, the Health and Safety Executive Research Report, UK suggested that:

‘…the commitment to and the style and proficiency of an organisation’s safety programmes matter as much as the formal definition of those programmes and that this commitment and style are the product of individual and group values, attitudes, competencies and patterns of behaviour’.

Therefore, safety culture is partly dependent on the attitudes, behaviours, beliefs, values and underlying assumptions of individuals and everyone who contributes to safety culture in their own way. A strong organisational and management commitment is also implied and therefore safety needs to be taken seriously at every level of the organisation.

How does the safety culture of an organisation influence and affect the way safety is being managed in the organisation? Too often, people design and implement safety management strategies without first evaluating if their organisation’s safety culture could be at risk.

One model often referred to as the Safety Maturity Model developed by Professor Patrick Hudson, describes continuous improvement of safety management in terms of an evolutionary journey with five stages. Each stage has distinct characteristics and is a progression on the one before. Organisations need to establish a path towards better practice, let its people understand the level of safety maturity they have achieved, which stage are they at, where were they before and where are they heading. From worst to best, organisations can be distinguished along a line from pathological to generative (see Figure 1).

It is necessary to develop organisational cultures that support higher processes such as “thinking the unthinkable” and being intrinsically motivated to be safe, even when there seems to be no obvious reason to do so. What is needed is a safety culture that supports the SMS and allows it to flourish (Hudson, 2002).
Safety Management Systems
ICAO defines SMS as “A systematic approach to managing safety, including the necessary organisational structures, accountabilities, policies and procedures.”

SMS provides an organisational framework to effectively manage safety and have shown effectiveness when adopted as part of business.

The ICAO SMS framework consists of four components and twelve elements, and its implementation should commensurate with the size of the organisation and the complexity of the services provided:

1. Safety Policy and Objectives
   1.1 Management commitment and responsibility
   1.2 Safety accountabilities
   1.3 Appointment of key safety personnel
   1.4 Coordination of emergency response planning
   1.5 SMS documentation

2. Safety Risk Management
   2.1 Hazard identification
   2.2 Safety risk assessment and mitigation

3. Safety Assurance
   3.1 Safety performance monitoring and measurement
   3.2 The management of change
   3.3 Continuous improvement of the SMS
4. Safety Promotion

4.1 Training and education

4.2 Safety communication

A SMS is like a toolbox. It contains the tools that an aviation organisation needs to be able to control the safety risks of the consequences of the hazards it faces when delivering its services. Among others, inside the SMS toolbox are the actual tools employed to conduct the two basic safety management processes – hazard identification and safety risk management. What a SMS does is to provide an organisation with a toolbox that is appropriate in size and complexity, to the size and complexity of the organisation.

As a toolbox, a SMS ensures that when specific tools are needed for hazard identification and safety risk management:

- The right tools for the task at hand are available for the organisation to use;
- The tools and tasks are properly related;
- The tools are commensurate with the needs and constraints of the organisation; and
- The tools can be easily found within the toolbox.

Basic Features of SMS

There are three features that characterise a SMS. They are:

- Systematic;
- Proactive; and
- Explicit.

Firstly, a SMS is systematic because safety management activities are conducted according to a pre-determined plan and applied in a consistent manner throughout the organisation. SMS activities aim at gradual but consistent improvement, as opposed to instant dramatic change. SMS also focus on processes rather than outcomes. Although outcomes (e.g. adverse events) provide useful conclusions that support the control of safety risks, the main focus of a SMS is to capture hazards, which are the precursors to outcomes, during the day-to-day activities (processes) that the organisation engages in during delivery of services.

Secondly, a SMS is proactive because it builds upon an approach that emphasises hazard identification and safety risk control and mitigation, before events that affect safety occur. It seeks to keep safety under the constant control of the organisation, instead of engaging in repair action (or damage control) when an adverse event occurs, and then going into “sleep mode” until the next adverse occurrence and damage control measures are re-activated. Being proactive allows safety data on hazards to be collected and organisational decisions to be made on safety risks and control that are data-driven, instead of making decisions on safety risks based on opinion, bias or prejudice.
Thirdly, a SMS is explicit because all safety management activities are documented, visible and therefore defensible. Safety management activities and know-how of the organisation are formally documented so that they are available for anyone to use. Thus, safety management activities are transparent, formalised and do not reside in the heads of individuals. An organisation that allows safety management activities and know-how to reside in the heads of individuals exposes itself to higher volatility and inconsistency in terms of safety management.

**Synergising Safety Culture and Safety Management Systems**

When considering how aviation organisations manage safety, how does one feel the pulse of the safety health of an organisation?

Generally, the safety health of an organisation relies on the outcome of two key factors:

- **Competence** – the quality and implementation of the organisation’s safety systems and processes (i.e. the SMS); and
- **Commitment** – how safety is valued and managed by people in the organisation, which includes people’s motivation, shared values, beliefs and attitudes about safety (i.e. the safety culture).

These two contributing factors (SMS and safety culture) linked together, characterise the way people behave within an organisation, the ‘behavioural norms’ (see Figure 2).

![Figure 2: Synergy between SMS and Safety Culture in an Organisation.](adapted from: Interdependence between safety culture and SMS in ATM (Skybrary, 2010))
The relationship and interdependence between SMS and safety culture provides a synergy whereby the SMS embodies the competence to managing safety, and safety culture represents the commitment to achieve safety performance levels that are acceptable. Together, this creates awareness and understanding of the hazards to an organisation’s operations, which in turn shapes an organisation’s approach to managing safety and personal behaviours towards safety.

An organisation’s SMS is more than just a set of policies and procedures on a bookshelf. The SMS is the manner in which safety is handled in the workplace and how those policies and procedures are implemented into the work processes. The nature by which safety is managed in the workplace (i.e. resources, policies, practices, procedures and monitoring etc.) will be influenced by the safety culture of the organisation (Kennedy and Kirwin, 1998).

Since a SMS represents an organisation’s competence in the area of safety, it is important to have people who are competent (with the right skills) to execute it. This includes people with the commitment (personal motivation), to apply the SMS as intended. Thus, an organisation that possesses both a well-developed SMS and a positive safety culture is better poised to achieve a level of safety that is “as low as reasonably practicable” (ALARP) and with “forward vision” in safety. SMS and safety culture are like body and soul and should reinforce each other. Together they form the heartware of aviation safety management.

An active safety culture can be considered as the heart that is vital to the continuing success of SMS – it gives the dynamic energy needed to ensure that the system will provide a continuous cycle of improvement as intended. This can only be developed by leadership, commitment and setting a good example.

To ensure that the heartbeat of an organisation’s competence and commitment to safety remains strong, organisational leaders must take the lead and show that safety is a priority. They must demonstrate their commitment, not just by saying they are committed, but be able to show their commitment in practice. It is also vital that all levels of the organisation are competent and committed towards making safety a priority.

**Safety Management as a Skill**

Another way to look at how both organisations and individuals manage safety is to regard safety management as a skill. For skills to develop, constant practise is required because skills cannot be achieved just by reading manuals. Similarly, for safety management to be effective and maintained, safety practitioners will have to use their skills frequently and stay current or they may soon become obsolete.

To acquire a skill requires practising individual elements and then combining these elements so that actions become natural and automatic (second nature). In this way, attention can be devoted to broader issues, and the skill can then be extended.
Highly skilled individuals or teams do difficult things well, particularly in time of an emergency or crisis. They are able to prioritise and respond appropriately and effectively. They would constantly review their shortfalls and practice in order to improve. This also applies to safety and safety management in particular. Individuals need to acquire skills to identify hazards, to know when to be careful, what to report and what to do with the hazards and reports.

When an organisation has acquired considerable skills in managing safety, both as an organisation and as a set of individuals, there is an advantage. They can operate in a more complex or hazardous environment, whereas less skilled organisations can only depend on luck or otherwise be subjected to close monitoring by their regulatory authorities.

With the proper heartware in place, an organisation can take the first step to promoting a safety culture in which the organisation and its people can gradually develop highly skilled performance in the management of safety.

CONCLUSION

Aviation is generally very safe – both in terms of quantitative measures such as accident and incident rates, and qualitative measures such as the perceptions of the travelling public – with serious accidents occurring rarely. However, as aviation continues to grow, there is a need to further improve its safety performance.

Accident rates are low and have reached a “plateau” whereby technological efforts (the hardware) to further improve the trend is limited. In order to go beyond this “low but (seemingly) unassailable” plateau and to continue improving safety performance, it is necessary to also address “the hearts and minds of the management and workers” (Lee, 1998).

The aviation community recognises that organisational factors and the operating environment (the software) can influence safety performance. However, the need for continuous improvement to maintain a high level of safety in today's fast growing and changing aviation environment demands even more from all stakeholders in the aviation system to challenge the processes, culture, and themselves to identify weaknesses and seek corrective solutions. To do this, the aviation community must continually learn from its own experiences and introduce new and innovative safety programmes and initiatives such as SMS and safety culture.

A SMS provides a structured mechanism for organisations to continuously improve safety. It sets the organisational structure, policies, procedures and processes, which gives the organisation the competence to ensure safe operations. A strong safety culture is an essential element in a SMS. It fosters the necessary commitment, organisational attitudes, mindsets, beliefs, shared values, individual and group behaviours towards safety management so that the processes can be effective.

A SMS without a strong commitment from all levels of the organisation will be a “mechanical” process that has no real benefits to safety performance except to make sure that the organisation is legally compliant. Similarly, without an effective SMS in place, it is impossible for even the most motivated and far-sighted leader or staff to have a significant impact on safety performance.
While SMS may increase competencies, a safety culture strengthens commitment and motivation. Therefore, safety culture and SMS, the heartware of an organisation, must coexist so that an organisation can instill a keen understanding and awareness of potential hazards, operational safety risks and threats. Together, they can then mould the correct way people behave within an organisation, the behavioural norms towards safety.

Looking forward, amidst the growing hardware and software that are used in safety management and the challenges confronting the aviation community to further improve safety performance, the test of how successful we are in achieving that goal will depend more and more on the competency (skill) and commitment (the quality of attention) given to grooming, grounding and enhancing the heartware of managing safety in aviation organisations.

References


Abstract

Since its birth over 100 years ago, aviation has become a critically important contributor to the global economy and enables us to routinely travel to every corner of the globe. The aviation industry has developed and matured at an incredible rate, with steady advances in operational efficiency, technology, procedures and safety systems. Constant improvements in aviation safety, such as jet engine technology and many important innovations like forward-looking terrain and airborne collision avoidance systems, have been key to aviation’s unprecedented growth. The aviation community’s status as a global leader in advanced safety concepts has also contributed to a high level of trust from the travelling public.

Commitment from the aviation community as a whole has resulted in constant improvements in safety results. Safety rules are part of this steady improvement as these are being modernised to keep current with advanced safety concepts. However, there is evidence to show that overall safety oversight is lagging behind new rules, procedures and technical advances. This paper discusses the need for the aviation community to collectively focus on new paradigms for providing safety oversight over a rapidly growing aviation industry.
About the Author

Mr Donald Spruston is Director General of the International Business Aviation Council (IBAC) since 1999. Prior to this, Mr Spruston held numerous positions in the field of aviation, including managing partner of the Canadian Aviation Safety Associates where he conducted evaluations of civil aviation authorities and was an advisor to ICAO in establishing the ICAO Universal Safety Oversight Audit Programme.

Before that, Mr Spruston was Director General of Civil Aviation in Canada for more than six years. He also held a number of air traffic management positions, including Regional Director of Air Navigation in Transport Canada’s Pacific region. Mr Spruston has written numerous articles on aviation safety and has won awards such as the Transport Canada Safety Award, Canadian Owners and Pilots President Award and the Canadian Aeronautics and Space Institute C D Howe Award.
The Future of Safety Oversight – The Value of Industry Standards

Mr Donald Spruston
International Business Aviation Council

INTRODUCTION
The term ‘safety oversight’ is applied to the role of safety regulators in “overseeing” all aviation activities, from establishing legislation and regulations to issuing documents, inspections, auditing, monitoring, surveillance and investigation. The Universal Safety Oversight Audit Programme (USOAP), introduced in 1999, is the means of tracking adherence to safety regulations. However, since safety rules are rapidly changing, the time has come to consider a change to outdated concepts for other safety oversight functions.

This paper looks at evolving safety oversight concepts and encourages broad acceptance of new thinking for promoting universal involvement by all participants. In essence, the proposals progress the objectives stated in the International Civil Aviation Organization (ICAO) Global Aviation Safety Plan (GASP) for an aviation safety partnership and shared responsibility, an objective that has not yet been realised.

To understand the future, it is usually best to look briefly at the past, so a quick review of aviation rulemaking and the evolution of safety oversight will be followed by some of the current constraints and an explanation of why past practices would not be effective in the rapidly evolving aviation system.

EVOLUTION OF AVIATION SAFETY RULES
Understandably, aviation safety rules in the 1920s and 1930s were very basic, consisting primarily of procedures for collision avoidance and personnel licensing. As aviation grew and became more complex, so did the rule structure. Many new safety rules grew from experience, often without adequate assessment or rationalisation. Unfortunately, a large number resulted from accidents where regulators were forced to be seen to be doing something in reaction to public tragedy. This is one reason for the discrepancy between rules of ICAO member States and the general haphazard organisation of national rules.

The most significant impact on the evolution of global aviation safety rulemaking was made in 1944 with the signing of the Convention on International Civil Aviation (often referred to as the Chicago Convention). The Convention incorporated a number of Annexes containing Standards and Recommended Practices (SARPs) that address various sectors and disciplines of the aviation system such as personnel licensing, aircraft operations,
airport operations, aircraft certification and many others. The responsible body for the Convention, ICAO, convened panels and committees of representatives from member States, with a goal of keeping the SARPs current and developing new Annexes where appropriate.

ICAO consists of 191 member States, of which 36 are represented on the ICAO Council. Overall governance is provided by an Assembly which serves as the sovereign body, meeting on a triennial basis to set policy and direct ongoing action of the Council. In turn, the Council entrusts most of the technical and operational development to an Air Navigation Commission (ANC) for activity required to amend and develop new SARPs. In principle, the intent of the Convention is for State aviation regulations to be harmonised with the internationally developed and accepted SARPs. This concept generally works well, albeit far from perfect. Not all States are conscientious about the need to harmonise, which has resulted in there being many differences. Thankfully, the differences are gradually diminishing, largely influenced by USOAP.

SARPs and State aviation rules remained very prescriptive for many years, essentially describing in detail how things must be done. The rules contained detailed specifications for licensing, marking, engineering, maintenance and operations – to a certain extent emulating a “how to” manual. Unfortunately, but understandably, this rather prescriptive “how to” approach could not keep pace with the rapid evolution of aviation technology, procedures and demand for efficiency.

Over the past 10 to 20 years, the international standards and State regulations have been gradually changing from the old prescriptive approach to a performance-based approach whereby results are the objective. This rather revolutionary change brings a myriad of challenges, placing a much greater and more complex responsibility on regulated organisations and greatly changing how State regulators must oversee the regulated organisations. This is a change that many States, regulatory personnel and industry users find very difficult, with evidence of resistance in all sectors.

Safety Management Systems (SMS) represent a good example of the new paradigm in rulemaking. Although SMS has logical steps for implementation, ultimately it is the operator or user organisation that must apply the principles to identify the hazards inherent in their operation and to manage the associated safety risks to as low a level as reasonably practical through activities integral to that organisation’s objectives, operations, equipment and its personnel. SMS should be developed based on the size of the organisation and the nature and complexity of its operations, taking into account the hazards and associated risks inherent in these activities rather than a prescriptive checklist. It is a performance-based concept for which users must demonstrate how they achieve each result. The concept is progressive and is strongly supported by aviation senior leaders. ICAO and member States have universally accepted SMS and many of the Annexes (SARPs) have SMS requirements incorporated in them. The ICAO Assembly has proposed a new SMS Annex, and a whole new industry providing SMS training and implementation assistance has now been developed. Yet, there is evidence of resistance, and many States and user organisations are not finding the transition easy. There is also evidence of operators’ lack of understanding of how to implement SMS. The strain this causes on the regulatory oversight infrastructure exacerbates the problem.
SAFETY OVERSIGHT PRESSURES
An effective safety oversight system is dependent on the quality of all the elements in the programme. In the early days, oversight was the sole domain of inspectors or surveyors employed by civil aviation authorities (CAAs). Inspectors issued documents and inspected aircraft, personnel or airports, either through programmed inspections or spot checks. Most authorities established additional capacity for enforcement by taking sanction action for regulatory transgressions. As the system grew, authorities increased use of delegation of authority for various functions such as aircraft certification and personnel proficiency. As aviation operating companies such as airlines, airports and corporate operators became very large entities, CAAs introduced audits as a more comprehensive way of coordinating a large number of specialised inspections. However, the ever-increasing scope and size of the aviation community has been straining the oversight system.

Availability of Qualified Inspectors
Aviation is a highly technical and complex industry. Training of qualified professionals is very expensive and expertise is usually gained over years of experience. In the early days of aviation, the civil aviation community benefitted from a flow of trained and experienced personnel from the world's armed forces. Highly trained pilots and technical engineers who had completed military duty would move to civil ranks, filling cockpits of aircraft and maintenance positions as a second career. Similarly, trained personnel were recruited by CAAs to provide regulatory oversight. However, over the past 20 years, availability of military expertise has been diminishing as governments reduce armed forces and change retirement practices. CAAs have found it increasingly difficult to fill critical safety oversight positions. The work of inspectors is highly specialised and more difficult than routine flying, often with pay inequity, making the search for highly qualified and willing personnel increasingly difficult. The resulting critical shortage is not likely to improve in the future as civil aviation continues its rapid growth.

Oversight Linked to the Size of the Industry
A safety oversight system that requires repetitive inspections of all elements of the system means that the number of inspections, audits and checks must grow with the industry size. Delegation of authority provides some relief for CAAs, but the design remains very workload intensive, resulting in increasing costs proportional to the growth of the industry.

Assessing Safety Indicators
A system designed to challenge each rule with blind adherence to checking implementation of the rule (i.e. manuals are up-to-date, proficiency checks completed, log books accurate etc) is based on a philosophy that if little things are done right, the operation must be alright. However, this is not always true. Modern aviation is complex and many operations have significant risks that are not obvious when assessing regulatory compliance. Design flaws can be significant and may not be obvious when looking at the small pieces. Operations can be legal but have a high level of risk, as we have seen from many past aviation accidents. Moreover, aviation will continue to increase in complexity.
Speed of Change
In the early days of aviation, technological change was reasonably gradual, allowing professional regulatory staff to remain current. Technology and system change is now so rapid that CAAs are finding it difficult to keep staff abreast. CAAs have also had considerable difficulty in keeping regulations current with an increasingly complex aviation system.

Safety Culture – The Missing Link
Arguably, safety culture is the most critically important organisational characteristic. There are no rules governing safety culture and indeed, systems for measuring culture are not prevalent or mature. Modern safety systems such as crew resource management training, flight data analysis systems, hazard identification programmes and others provide excellent indicators, but not assurances that all personnel, ranging from chief executive officer to the cleaning staff, are consistently committed to doing things the right way at all times. The current safety oversight system is not effective in measuring the cultural temperature of an organisation.

MODERNISING SAFETY OVERSIGHT
Problems created by the lack of trained professional staff, outdated inspection methods, changing rule paradigms, speed of change and the inability to assess safety culture, require a new way of thinking about safety oversight. Some States have promulgated regulations adhering to new performance-based concepts; however, most States are well behind and are trying to catch up. SMS is a good example of this. In some cases, States are meeting resistance from inspection staff as the new paradigm demands different skills – it takes inspectors out of their bubble of comfort and thrusts them into a new role that requires oversight of the forest rather than the trees. CAAs in general have not updated their skills sets to match new rule paradigms. A critical reality of modernised safety oversight is that all participants would have to agree that change is needed.

Another weakness in the current safety oversight structure is the lack of a robust system for collecting and analysing safety indicators. Many States do not have good statistical records of accidents or exposure data. Sophisticated CAA risk indicator assessment systems have been developed by some States, but are not globally available. Even relatively modern regulatory programmes do not effectively and routinely apply risk assessment principles to directing valuable oversight resources.

Although weak but growing in strength in many States is the recognition of the value of industry oversight as a contribution to State safety oversight programmes. ICAO’s GASP recognises the value of using industry standards and verification audits, and some rulebooks are starting to recognise these benefits, but the role of industry oversight has generally not been formally incorporated into State Safety Programmes (SSP). Under the ICAO concept, an SSP consists of an integrated set of regulations and specific activities aimed at improving safety and the establishment of a nationally acceptable level of safety.

Although delegation of authority for various oversight functions is a relatively common practice, there remains vast possibilities for CAAs to delegate additional activities to the private sector, thereby freeing
valuable government specialist resources that can then be applied to broad risk management activities. Modern thinking in safety oversight recognises that safety is everyone’s business and that, to be effective, safety oversight must be a partnership between the regulator and regulated communities. Regulators can no longer view themselves as the sole guardian of the system, to be governed by prescriptive “by-the-numbers” inspections. Safety oversight design should recognise the inherent commitment of the whole community to maximise safety.

CONTRIBUTION OF INDUSTRY SAFETY STANDARDS TO SAFETY OVERSIGHT

Industry representative bodies such as the International Business Aviation Council (IBAC), the International Air Transport Association (IATA) and many others, are as committed to aviation safety as governments. International bodies work in partnership with ICAO on international rules and national associations work with State CAAs on national regulations. Significantly, the representative bodies have also developed safety standards for their respective industry sectors that serve as safety codes of practice.

The benefit of industry safety standards is their currency, as it is easier for industry bodies to keep codes modernised. Many of the impediments to rapid change in regulations are avoided as industry bodies can readily adjust to new technologies with innovative thinking. Industry standards are best practices developed by good operators, hence more “saleable” to users in need of a culture change.

Industry standards for corporate operators and airlines have been in place for 10 years. The business aviation sector has an International Standard for Business Aircraft Operations (IS-BAO) while the airlines refer to the IATA Operational Safety Audit (IOSA) Standards and Recommended Practices. In both cases, the industry bodies, IBAC and IATA, have established oversight audit programmes that verify respective industry standards. In the case of IS-BAO, it is a voluntary programme, whereas the IOSA programme is mandatory for IATA member airlines. Industry safety standards and the industry’s oversight programme cannot replace State CAA accountability; however, in response to the ICAO objective of partnership and shared responsibility, industry safety standards should be recognised formally as a contributor to States’ oversight programmes.

MECHANISMS FOR RECOGNISING INDUSTRY STANDARDS

Integration of industry standards and oversight with State regulations and oversight should be based on safety indicators. Modernisation of aviation safety rules focuses increasingly on risk assessment with attention to risk indicators. For example, the modernisation of Annex 6, Part II (International General Aviation Operations) recognises that corporate aviation has low risk and hence validates the use of industry standards. Regulations in some States such as the British Overseas Territories Islands of Bermuda and Cayman Islands have applied this principle in accepting IS-BAO as one means of demonstrating compliance with their rules. Many States recognise IOSA by mandating airlines in their jurisdiction to undergo an IOSA audit. This is a valuable benefit to both regulator and user as registered aircraft are in all corners of the world and accredited auditors are similarly available in all areas.
Recognition of industry standards in States’ regulatory structure can be achieved in different ways. In non-commercial rules for example, ICAO’s SARPs, Annex 6, Part II, notes that:

“Some States accept and reference industry codes of practice in the development of regulations to meet the requirements of Annex 6, Part II, and make available, for the industry codes of practice, their sources and how they may be obtained...”.

The European Aviation Safety Agency’s draft rules for non-commercial complex (NCC) aircraft include a provision for operators to use an industry standard as a means of meeting the regulatory requirements by providing for a Declaration that “The operator has implemented and demonstrated conformance to an officially recognised industry standard.” In commercial oversight, IOSA programmes have been accepted as a regulatory requirement by some States.

Changing the philosophy towards a partnership approach is not easy given the prevalent mindset that operators often cut corners for competitive reasons. However, the success of the IS-BAO and IOSA programmes provide excellent examples of the significant change that industry oversight can achieve. Operators that implement an industry standard and undergo verification audits are highly likely to have a positive safety culture, particularly if the SMS programme is effective. Given that many States now recognise IBAC’s IS-BAO and IATA’s IOSA programme, this approach can also be considered for smaller on-demand commercial operators, airports and others. The business aviation IS-BAO programme is designed for small operators and can be an effective component of the State’s regulatory oversight for both non-commercial and on-demand commercial operations.

Global safety indicators demonstrate that safety is not globally balanced and that aviation systems in areas of the world mature at different rates. Safety practices are being accepted more rapidly in some areas than others. As a result, safety indicators show that more diligent oversight is needed in some States or continents. State safety oversight should recognise regional risk indicators, but at the same time international standards can be of benefit as the standards represent global best practices of the best operators. Less developed or mature systems can learn from the experience of good operators from around the world, just as regulators in developing aviation markets are gaining from the experience of more advanced regulations in the mature aviation systems of the world.

THE PARTNERSHIP SAFETY OVERSIGHT MODEL

Formal integration of industry safety standards and oversight should be established in SSPs. A model of a partnership approach is illustrated (see Figure 1).
The degree of reliance and implementation should be dependent on risk assessment. State regulatory bodies must retain overall accountability, but increasing formal delegation should be made to industry bodies to conduct routine document issuance, personnel licensing, certification, letters of authorisation and equipment approvals. It is important to keep the two streams distinct so that industry standards can remain dynamic and easily kept current. CAAs should recognise the industry standards for their value as a part of the oversight programme, rather than as another form of regulation.

The model considers the process for establishing the safety norms through two streams albeit with support and coordination provided between the two streams. The responsibility for establishing regulations rests with regulators and the industry can assume responsibility for establishing codes of practice and safety standards that can be used to assist in the process. Government authorities have overall responsibility for risk assessment leading to the development of SSPs. The SSP should establish a programme for a partnership in the verification and monitoring of activities. CAAs should assume increasing responsibilities over high-risk elements of the system and increased reliance should be given to industry bodies for lower risk activities. A structured policy is needed for when and how delegation can be given to the industry and how industry standards and verification audits can be applied within the State oversight programme. Valuable state resources should be directed towards overall risk management and attention to high risk elements of the aviation system.
CONCLUSION
Many elements of the partnership safety oversight model are now in place. Pieces of the puzzle that require improvements are an effective risk indicator and risk assessment programme, as well as formal integration of delegation of authority, industry standards and verification audits into SSPs. This concept will provide a model to realise objectives of ICAO’s GASP and allow the aviation industry to continue growth while maintaining or improving on an already exceptional safety record.
Aviation Security – The Human Factors Supply Chain

Abstract
The human factor is a critical aspect in aviation security as it determines the success of developing and implementing security measures. To nurture the human factor to deliver this effectiveness, all stakeholders from the top echelons of management to the operating personnel should develop a positive security culture which also recognises the need to balance the requirements of the industry, passengers and airport community.

A major challenge that needs to be addressed is the insider threat, where aviation personnel have intentions of conducting unlawful acts and may have access to sensitive areas of the airport and aircraft, and know enough to overcome the security systems in place. Through a proactive security culture in the airport community, human factors could well be the key to arrest or prevent the insiders from achieving their aims.
Mr Bernard Lim is Director for International Relations and Security with the Ministry of Transport, Singapore. His key responsibilities include formulating and managing policy matters concerning international relations as well as transport security and emergency preparedness in Singapore. Currently, he is also the Chairman of the International Civil Aviation Organization Aviation Security Panel and the Vice-Chairman of the Asia-Pacific Economic Co-operation Aviation Security Experts Sub-Group. Mr Lim holds a Master’s degree in Public Administration from the University of Liverpool, UK. He was trained in crisis management at the Emergency Planning College in York, UK, and in Leadership at the John F Kennedy School of Government, Harvard University, US. Mr Lim was conferred the Airport Police Commander’s Award in 2000, the Singapore Armed Forces National Service Medal in 2001, the Ministry of Home Affairs’ Emergency Preparedness Commendation Award in 2002 and the Minister’s Innovation Distinguished Award in 2007.
Aviation Security – The Human Factors Supply Chain

Mr Bernard Lim
Ministry of Transport, Singapore

INTRODUCTION

There are many challenges in enhancing the level of aviation security worldwide as they come in many forms and are posed at different areas of the global aviation system. For instance, terrorist groups have shown how security threats against airports could be carried out, such as the bomb attack at Moscow’s Domodevo Airport in January 2011. The devastating terrorist attacks on 11 September 2001 is also a prominent example. These incidents clearly demonstrated the increasing sophistication the terrorists have in planning and executing attacks on aircraft and turning civil airliners into weapons of mass destruction. More recently on 25 December 2009, a terrorist succeeded in bypassing passenger security checkpoints with explosives hidden in his undergarments. He had planned to detonate the explosive while flying from Amsterdam to Detroit. Further attempted attacks such as disguising explosives as printer cartridges proved that the layers of airport security measures can still be defeated.

Many States and other regional and international organisations such as the International Civil Aviation Organization, the International Air Transport Association and the Airports Council International have been implementing various security measures over the years to deal with the security threats to civil aviation operations. In response, stakeholders affected by the threats have devised several security solutions to address the gaps, and improvised challenges to prevent and deter these terrorists from exploiting any security vulnerabilities that undermine the global civil aviation system. These solutions include technological developments from security equipment manufacturers to enhance airport security checks. The combined efforts as well as investments by various stakeholders are geared towards the planning and implementation of more effective solutions, to reduce security threats and minimise the success of unlawful acts that would disrupt air travel, inflict human casualties and excessive damage to airports and aircraft.

THE FUNDAMENTAL FACTOR

Conceptually, it may appear easy for stakeholders to demand for newer and more effective measures against security threats to civil aviation. However, there are a number of factors to be considered in order for these security measures to be implemented effectively.
Human factor is one such critical factor. Experts and analysts have determined that it was critical for the personnel implementing the security measure to have a sound level of training. Any lapse at this level may prove to be catastrophic as the personnel manning the fort i.e. checkpoint holds the key between success and failure.

THE SECURITY HUMAN FACTORS SUPPLY CHAIN

To ensure that the security layers are complete, it is important not to rely heavily on the ability and alertness of the personnel at the end of the security process. Front-end security personnel are also crucial as they need to be supported by a host of other personnel who are also members in the ‘Security Human Factors Supply Chain’ (see Figure 1) before they can successfully deliver and implement the security measures entrusted to them.

To examine the ‘Security Human Factors Supply Chain’, a generic aviation security screening system may be used as an example. The aviation security screening system would typically comprise a number of stakeholders as follows:

**Top Management and the State’s Regulatory Authority for Civil Aviation and Civil Aviation Security**

The agency or agencies concerned are responsible for establishing the national civil aviation security legislation such as the following:

- State’s National Civil Aviation Security Programme;
- Airport Security Programme;
• Operator Security Programme;
• National Civil Aviation Security Quality Control Programme; and
• National Civil Aviation Security Training Programme.

These agencies set the standards and approve measures implemented by the stakeholders, which includes training standards of security personnel performing various civil aviation security functions. Ultimately aviation security laws, standards, programmes, requirements and measures are approved by the top management entrusted with such authority. These personnel include political leaders, senior government officials and chief executive officers of airport companies and airlines.

Airport Operators, Airlines and other Airport Agencies
Examples of these would be ground handling, catering, aircraft cleaning and fuel companies, as well as cargo agents. These are the entities that conduct business and operations at the airport, and are an integral part of the entire ambit of civil aviation operations. They are likely to have access to the restricted or sterile areas of the airport and the aircraft and are required to undertake security measures to ensure that their personnel items, goods or equipment have not been compromised.

Security Equipment Suppliers
These are companies which manufacture, supply and maintain security equipment used by airport operators and airlines. Such equipment include x-ray screening systems for baggage and cargo, explosive trace detectors, explosive vapour tracers, archway and hand-held metal detectors, advanced imaging technology (body scanners), security surveillance systems such as closed circuit televisions (CCTV), security turnstile doors, access control readers and many others.

Security Service Providers
These providers are often security companies engaged by airport operators, airlines, or other companies that provide security services at the airport. Such services include the passenger pre-board screening, hand-held baggage screening, staff checkpoint screening of vehicles entering into airside premises, access control into aircraft from the ramp area, security of premises such as airport catering centres, cargo terminals, fuel facilities and others.

The Airport Community at Large and Air Travellers
The airport community comprises different groups of personnel employed by the airport, airlines, ground-handling companies, retail outlets, restaurants, service providers such as banks, medical service providers, law enforcement and fire and rescue personnel. In addition, there are thousands of air travellers using airport facilities and onboard airlines across the world every day. Family members and meeters-greeters would also be at the airports to send off and receive their family members, friends or business associates.

Aviation Security Audit Teams
In a complete aviation security system, an audit and compliance mechanism is critical to ensure that there are structured verifications in place to check that civil aviation entities are implementing the required
security requirements, and measures as mandated by the State authorities. Such audits and compliance checks serve as very valuable tools to obtain an appreciation of the state of security and effectiveness of the measures in place, identify gaps that need to be filled and measures that need to be improved. The audits and compliance checks would then allow the top management of both the regulator and industry to obtain feedback on the state and effectiveness of the security measures that are in place. These in turn would have a direct influence on decision-making such as improvements needed or weaknesses to be addressed.

THE FOCUS ON HUMAN FACTORS
From the above illustration, it is clear that in every aspect of aviation security, it is the human factor that plays a crucial role in determining the direction and level of success that can be achieved. These are further elaborated as follows:

Top Management and the State’s Regulatory Authority for Civil Aviation and Civil Aviation Security
In all States and organisations, it is the top management who has the most influence in the final decisions to be made, including those concerning aviation security. They are empowered to make the final decisions on establishing security standard, measures or policies. Therefore, it is important that the top-level decision-makers are adequately informed of the various considerations and implications before a decision is made, especially where a new aviation security standard or measure could have a detrimental impact on civil aviation operations, facilitation, cost as well as the future development and growth of the industry.

In some cases, States unilaterally impose security requirements onto other States or airlines. If done without proper consultation or assessment, it could detrimentally impact international civil aviation operations. It would be worse if such directions taken by top policy-makers lead to major local, industry and international impact and it becomes difficult, politically or otherwise, to retract such decisions and directives. This could potentially impair the industry and cause chaos and economic dents to all stakeholders. Some valuable lessons could certainly be drawn from the restriction of hand-carried liquids, aerosols and gels imposed by some States, and more recently a series of unilateral security directives issued by States to airlines, to comply with certain specific measures at short notice. In many cases, these unilateral directives are issued in the absence of due consideration for security measures that are already in place and for others, or in recognition of the lack of adequate resources to meet those requirements.

Top management also sets the security culture in an organisation. In the case of aviation security, if the top leaders of an agency do not see the importance of implementing effective security measures and ensuring compliance with international standards, then all the employees of that agency would not pay attention or devote their time and effort towards enhancing aviation security. This is especially so if such efforts are viewed by their superiors as unimportant and not in support of the core business, objectives or key performance indicators (KPI) of the organisation. In such a situation, it can be expected that the organisation would allocate little attention and resources to aviation security needs, and the culture of the company will be one where aviation security is deemed as insignificant. This can be detrimental if the said organisation has a critical responsibility in establishing and maintaining a high level of aviation security.
The reverse however, can also hold true. If top management recognises and places importance on establishing and keeping up aviation security, and supports the efforts and initiatives of the personnel entrusted with such responsibilities, including investing in resources and training for them, the organisation would certainly be able to fulfil and meet its aviation security objectives and KPI adequately. The personnel would also be motivated to carry out their duties well.

In addition, the regulator will be the agency to develop and establish the State’s aviation security laws, national aviation security programmes, standards and other requirements, such as for audit compliance and training standards to be met. These are also dependent on the personal conviction, expert knowledge, experience and aptitude of the personnel entrusted to draft these laws, programmes and standards. If these personnel are competent experts who possess sound knowledge of both aviation security as well as the implications and effects on civil aviation operations, it would be likely that the laws, programmes and standards set would be sensible and practical.

However, if the personnel concerned lack expert knowledge and experience, and are unable to appreciate or understand the uniqueness and intricacies of aviation security and civil aviation operations, the quality of the laws, programmes and standards of that State would be questionable and challenging for the industry and stakeholders to comply with. Passengers would also question the practicalities and rationale of the measures imposed if these are inefficient and lead to confusion and inconvenience.

Airport Operators, Airlines and Other Airport Agencies
Airport operators, airlines and other airport agencies are required under national legislation to implement measures to comply with the State’s aviation security requirements. These again require decisions to be made and these are decided by the senior management of these companies, who are likely to base their decisions on the recommendations made by personnel entrusted to study and assess the various options that can be undertaken to implement the required measures. Often, these measures are based on considerations such as cost and efficiency, with the possibility of multiple trade-offs in the equation.

Ultimately, the airport operator, airlines and other relevant airport agencies will decide on the specific components of the security measures needed to meet the objectives laid down by the regulator. These would include the specific type of security equipment to acquire for usage. The companies will also select and decide on the security service providers to operate the equipment and carry out the security measures as needed. These security service providers could be an in-house personnel, or outsourced to a company that is licensed to provide security services to the airport or airline concerned.

Security Equipment Suppliers
The manufacturers and suppliers of security equipment have an important place in the overall aviation security system. In meeting the challenges of more sophisticated security threats to civil aviation operations and higher passenger expectations, the use of security technology is a logical way to try to achieve a sound level of security, meet the needs of facilitation, minimise redundancies in security processes and reduce costs wherever possible. It is also important to note that the design and manufacture of such security equipment, be it hardware or software, are carried out by people who are the end-users. It is imperative that the design and programming of the software used by the security personnel concerned are done accurately, and that the hardware are assembled properly. Otherwise, badly-assembled or improperly-calibrated equipment could allow security lapses to occur even with the most proficient and alert personnel.
In addition to proper manufacturing and programming, it would be advisable for airport operators who purchase such security equipment to have in place a means to counter-check the maintenance work carried out for these equipment. Poor maintenance can also lead to the security equipment not performing optimally and thus contributing to security compromises which could result in fatal consequences.

**Security Service Providers Engaged by Airport Operators**

Many airports, airlines and companies in the civil aviation business engage security service providers to undertake various security measures for them. These include passenger pre-board screening, access control, baggage and cargo screening, managing the issuance of airport visitor badges, security patrols, surveillance monitoring, guarding of aircraft and other critical installations. Usually, these security service providers would be licensed by the State aviation security regulator or another State authority to allow these companies to provide the said services. These companies would also be subjected to strict conditions to ensure that they meet the required security standards and that the personnel they employ to carry out these functions are adequately trained and certified.

This again highlights the critical element of the human factor. The security service providers are engaged to undertake many frontline security functions for airports, airlines and other stakeholders. Therefore, it is essential that they maintain a high standard and quality in carrying out these functions as it would be detrimental if any lapses were to occur. Moreover, it is critical that the personnel are provided with an adequate amount of training and recurrent training to keep their skills updated. The expertise level of these personnel must be compatible with the security equipment that they are assigned to operate, and these personnel must be able to undertake contingency actions should the security equipment break down, so as to maintain the level of security needed whilst minimising disruption to passenger facilitation and operations.

On a daily basis, these frontline security personnel would also be able to raise the awareness amongst airport staff, air crew and passengers, on the need for the various security measures implemented. For instance, the frontline security officers could help explain to passengers the security procedures being conducted, such as removing shoes for x-ray checks, removing items from pockets or taking their laptop computers out of hand-carry bags. Often, there are passengers who do not understand the need for such checks and may ask questions to understand the rationale behind the security measures.

In many cases especially for elderly air travellers, passengers who are physically challenged or travelling with young children, helping to explain the security procedures involved will remove a good deal of stress and anxiety from the passengers. This would help in the overall efficiency of the security screening checkpoints. However, these frontline security personnel must first be able to explain the security procedures coherently and logically, rather than blindly following instructions and implementing the security measures, which is an element pertaining to human factors.

There are some questions however, that need to be further addressed, especially in the area of security training. While security service providers can engage trainers and instructors to provide the necessary training for the personnel concerned, there are pertinent questions to be asked. For example, how competent is the trainer? Who trained and certified the trainer? How qualified and up-to-date is the trainer? The quality of security trainers is equally crucial as the proficiency level of security personnel is dependent on the competency of their trainers.
The Airport Community at Large and Air Travellers

Employees working in the airport and air travellers are an important part of the entire aviation security human factors supply chain. Arguably, the majority of passengers and airport staff do not have an intent to carry out unlawful acts. Most of the airport and airline workers go about their daily livelihood with minimal disruptions and hindrance, while the passengers simply want to travel from one point to another safely, securely and comfortably without much hassle.

However, over the last 10 years, there is an increasing number of security measures imposed on airports and airlines as a result of the increased threat from terrorism and by zealous regulators. Some of these measures can be onerous and impose great inconvenience and hassle to the passengers and airport community. These often lead to complaints and demand for an explanation for the inconvenience caused, especially from passengers who missed their flights, had short-shipped bags or had their hand-carried items, such as airport duty-free liquid purchases, confiscated at security checkpoints.

A number of air travellers would also compare the security measures taken at one airport with those taken at another, and would question the difference in the measures experienced for similar checks, especially if the checks were done in a more efficient manner in one airport versus another. It is therefore important that regulators, airlines and airport operators engage with the airport community and passengers to help them understand the rationale for the security measures imposed on them. This could go some way in helping them appreciate the effort and resources used in the situation. They should also be informed of the security procedures needed to ensure smooth operations at security checkpoints.

In some situations, airport operators and airlines should not shy away from informing the affected passengers that the additional security measures which they are subject to undergo prior to boarding their flight are requirements imposed by the destination. This could help eliminate misunderstandings and allow the passengers to direct any queries or complains that they might have to the appropriate agency for an explanation or for redress. Communication with passengers and the airport community is essential without compromising security.

Aviation Security Audit Teams

Audit teams comprise trained and qualified personnel who would diagnose and assess the effectiveness of the aviation security system. They also assess whether the airport agencies implementing these measures are doing so in compliance with the State’s national laws and aviation security programmes. There are various ways to look at audit teams – they could be seen as punitive instruments or helpful trouble-shooters. In either case, audit teams are useful in identifying security measures that are being carried out effectively, and those that are not. They identify gaps and weaknesses that are structural, systemic, procedural, and human that need to be addressed.

Therefore, aviation security auditors should be properly trained and be clear on the areas of weaknesses to look out for, so that the appropriate improvements can be recommended and effected. Auditors should also be empowered with the independent authority to surface these gaps objectively, with the purpose of seeking improvements to strengthen the aviation security system. If the auditors are not well trained or are hampered in carrying out their duties, the audit results would not be accurate and these could lead agencies to gloss over the critical weaknesses that need to be plugged. This can be detrimental as lapses will prevail and terrorists can exploit the weak links to attack civil aviation operations.
CONCLUSION
It is evident that human factors is a core area in every aspect of the aviation security system. Therefore, the ‘Aviation Security Human Factors Supply Chain’ can be said to be the critical centrepiece that determines how progressive, effective and successful all stakeholders can be in implementing, upholding and enhancing aviation security standards and measures worldwide. Ultimately, it all boils down to the issue of establishing a positive aviation security mindset and culture. If all stakeholders in the airport community, from the top level down to the line staff, hold a positive and proactive attitude towards upholding a high standard of aviation security, then the entire civil aviation system and operations will be better protected. The best security equipment, systems and processes can only be effectively and successfully implemented with the human factor positively in place.

But one threat continues to be of serious concern – the insider threat. This is a challenge that all stakeholders may find difficult to address. Insiders can be airport and airline workers, including security personnel, who are in cahoots with perpetrators. They could be persons aimed at carrying out an attack in airports or on aircraft because they are under duress, under the influence of bribery, or have become radicalised with extreme ideologies. They are likely to have access to the sensitive areas of an airport and aircraft, are familiar with the security measures in place and may even be well-acquainted with the security personnel on duty. They would thus be in a position to defeat the airport and/or the airline’s security measures or exploit any weak points to carry out acts of unlawful interference effectively.

In this respect, human factors continue to play a critical part in the security. The protection of our global aviation system and a positive security mindset instituted in the civil aviation community may well be able to help defeat this insider threat. Through the development of a positive security mindset and culture amongst all stakeholders, anyone who comes to know that a co-worker has untoward intentions to carry out a security breach or act of unlawful interference, would not hesitate to report on the perpetrator to the authorities quickly so that they can apprehend the would-be culprit and prevent any catastrophic incident from occurring. Achieving such an ideal level of positive security culture may be a long way ahead. However, if all stakeholders are willing to invest in building and enhancing a positive security mindset amongst themselves, from the top executive down to the line staff, it can provide yet another layer of security, complemented with other measures such as physical security screening, to protect the global civil aviation system from threats and breaches effectively.
JOURNAL OF AVIATION MANAGEMENT 2012
CONTRIBUTOR GUIDELINES

The Journal of Aviation Management is an annual publication by the Singapore Aviation Academy, the training arm of the Civil Aviation Authority of Singapore (CAAS). It aims to provide an intellectual forum for the sharing of views and experiences on new developments and topical management issues in civil aviation amongst leading experts from Singapore and around the world.

It is distributed to a worldwide audience of experts and professionals in the field of civil aviation. Journal papers are also made available to SAA alumni. We welcome contributions of papers and feedback from members of the aviation community.

Selection and Review of Contribution
The Editor and Editorial Advisory Board reserve the right to select, edit and publish papers according to the Journal’s editorial policy. Contributors may be asked to revise their paper before a final decision is made as to whether it is suitable for publication. Contributors will have an opportunity to review proofs before publication but no major changes can be included at proof stage, and corrections must be limited to typographical errors only.

Copyright, Proprietary Rights and Confidential Content
Authors submitting papers for publication must ensure that they have obtained all necessary consent for the use and publication of any information in the papers. By submitting any paper for publication, the author is deemed to warrant that no part of that paper infringes any copyright, proprietary or other rights of any person, or violate any confidentiality obligation on the author’s part, or contain any defamatory or offensive material.

Where a paper submitted by an author is published, the author is deemed to have agreed to indemnify CAAS against any loss, liability, action, proceeding, expenses or claim for damages made by any person arising from any alleged or actual infringement of any third party copyright, proprietary or other right, or from any alleged or actual breach of confidentiality on the author’s part, or from any alleged or actual defamatory or offensive material in the paper.

Authors must indicate if their paper has been presented/published elsewhere. If he/she does not do so, it will be assumed that the paper is an original contribution. The copyright in any papers published shall vest in CAAS unless otherwise agreed.

Preparation of Paper
Length: Preferred length is between 3,000 and 4,000 words.

Title: Should identify the subject matter as briefly and clearly as possible.

Abstract: Authors are requested to provide an abstract of about 150 words.

Figures and Tables: Should be typed separately from the text, and numbered and captioned clearly.

Illustrations: Where possible, provide high resolution jpeg or digital files. High quality black and white and colour transparencies, slides or prints are also acceptable.
Footnotes: To be used as sparingly as possible. Footnotes should be numbered consecutively (1, 2, 3) and appear on the page they are referred to.

Referencing
References to other works should be presented according to the APA Referencing Style as follows:

- References to articles
  Author (surname followed by initials). Year of publication in brackets. Title of article. Name of the publication in which it appears, volume, issue (in brackets), page reference, date of issue.

- References to books or reports

- References to websites or a WWW document
  Author (surname followed by initials). Year of publication in brackets. Document title (underlined). Format [WWW], URL including filename extension. Date accessed in brackets

- Please list references chronologically in alphabetical order.
- Where necessary, in-text referencing should be included.
  - When quoting, referencing should be reflected in brackets immediately after the quote, as (author's surname, year, page reference).
    Example: (Wallington, 1997, p. 84).
  - When paraphrasing, referencing should be reflected as author's surname (year, page reference).
    Example: Wallington (1997, p. 84) argued that…

Biography and Photograph
Authors are requested to submit a brief biography (50-100 words) outlining their current title/position, qualifications and relevant career highlights, as well as a photograph of themselves. The photograph should be in color with a resolution of at least 300 dpi.

Submission of Paper
Authors are requested to submit a softcopy via email, preferably in Microsoft Word format by 30 June 2012.
Papers should be submitted to:

The Editor
Journal of Aviation Management
Singapore Aviation Academy
1 Aviation Drive
Singapore 499867
Fax: (65) 6542 9890/6543 2778
Email: saa@caas.gov.sg
JOURNAL OF AVIATION MANAGEMENT 2011

An annual publication since 2000, the Journal serves to provide an intellectual forum for sharing of views and experiences on critical issues affecting international civil aviation among leading experts from Singapore and around the world.

I wish to purchase copies of the Journal of Aviation Management at S$36* (inclusive of postage per copy). Please send them to:

Name: _____________________________________________________________________________________________

Designation: _______________________________________________________________________________________

Organisation: _______________________________________________________________________________________

Mailing Address: ____________________________________________________________________________________

Postal Code: ___________________________ Country: ________________________________________________

Tel No: ____________________________________________________________________________________________

Email Address: ______________________________________________________________________________________

No. of copies: ______________________________________________________________________________________

Total amount payable: S$ ____________________________

*Alumni members are entitled to a 10% discount.

Payment Details (Please tick where applicable)

☐ Bank draft/ Money Order/ Cheque No._______________________________________________________________

☐ Telegraphic transfer to Citibank, Main Office, Singapore Account No.:0-70203-25

☐ Credit Card: Visa/ Mastercard/ Diners/ Amex Card No.: __________________________________________________

Expiry date: _____________________________________________________________________________________

Payment must be made in S$ to “Civil Aviation Authority of Singapore”. Cash-and-carry purchases are welcomed. Journals will not be dispatched until payment has been received. Please submit completed Journal Order Forms with payment to:

The Editor
Journal of Aviation Management
Singapore Aviation Academy
1 Aviation Drive, Singapore 499867
Fax: (65) 6542 9890/ 6543 2778

Orders for the Journal (including past issues) may also be made through the Singapore Aviation Academy website at http://www.saa.com.sg.