Managing Safety In and Around Airports

Edited by John Van Oudenaren and Erik Frinking

European-American Center for Policy Analysis
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Edited by John Van Oudenaren and Erik Frinking
Preface

The international air transport industry is undergoing major changes on all fronts: privatization and deregulation, globalization, increasing competition, cross-national mergers, and the entrance of new carriers to international markets. These trends, coupled with the continuing growth in freight and passenger traffic, are translating into increased cost pressures for companies in the industry, and to added strain on already limited air and ground capacity. Experts generally agree that the international air transport industry remains "safe" by almost any definition of the term, but pressures on safety can be expected to rise in the coming years.

These factors call for additional attention by those in the industry to the safety of air transport, and in particular to safety in and around airports, where most aviation accidents occur. Governments, parliaments, and public opinion will only support needed improvements in airport and related infrastructure if concerns about the safety of airports, along with concerns about noise and other environmental factors, are addressed by the relevant authorities.

Against this background, the Commission of the European Communities (Directorate-General for Transport) and the Amsterdam Airport Schiphol took the initiative to sponsor an international conference on the theme of managing safety in and around airports. Based on its earlier work on airport safety for the Netherlands Ministry of Transport, Public Works and Water Management, the RAND European-American Center for Policy Analysis was asked to organize the event.

The objective of the conference, which took place in Amsterdam on November 17-18, 1994, was to contribute to improved policymaking with regard to airport safety at both the national and the international levels by bringing together experts and stakeholders from different countries to identify the key policy challenges facing the aviation community and to discuss possible solutions. Conference speakers and participants were drawn from among the air transport stakeholders: airport authorities, carriers, manufacturers, regulators, and governmental and non-governmental international organizations. A major goal of the conference was to facilitate broad, inter-disciplinary discussion of the relevant issues.

The conference consisted of ten sessions over two days. The opening session took a broad look at the role of airports in modern transportation systems and the importance of the safety issue in the current operation environment. Session 2 addressed the question of safety in a broader context: how it is defined and measured, how it is perceived by the public, and what safety means and how it is addressed in other industries. Session 3 looked at the current state of air and transport safety from the perspective of key regulators in Europe and the United States. Session 4 looked at specific issues in the analysis of the safety of airports, as seen by airport operators and outside experts.

Sessions 5, 6 and 7 looked at safety developments and challenges in aircraft design and manufacture, flight operations, and air traffic control. Session 8 was devoted to an in-depth study of safety at one major airport, Amsterdam Schiphol, from the perspectives of the airport operator and the flag carrier. Session 9 dealt with new institutional mechanisms and requirements at the national and international level. Finally, in Session 10 a panel of outside experts and representatives of key stakeholders discussed airport safety in the broadest sense, and made concrete suggestions for possible action on the part of regulators, operators, and other stakeholders.
These proceedings document the results of the conference. They include the opening statements in each of the ten sessions, along with summaries of the discussion and the major points made from the floor. They have been produced in the hope that they will contribute to the ongoing discussion of airport safety in Europe, North America, and other countries.

The European-American Center for Policy Analysis is located in Delft, the Netherlands, and is dedicated to research and education on important policy issues facing Europe and North America in the post-Cold War era. Those wishing to obtain more information about the EAC are urged to contact Loes Romeijn at the Delft location, or Lory Arghavan at RAND’s Santa Monica office.

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Special thanks go to Loes Romeijn, who was responsible for the organizational aspects of the conference, and to Mathilde van’t Hoog and Chantal Groenendijk of the EAC staff, who helped to prepare the proceedings.
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<td>Area Control Centers</td>
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<td>Airports Council International</td>
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<td>ANC</td>
<td>Air Navigation Commission</td>
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<td>APATSIA</td>
<td>Airports/Air Traffic System Interface Program</td>
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<td>ARAC</td>
<td>Aviation Requirements Advisory Committee</td>
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<td>ASRS</td>
<td>Aviation Safety Reporting System</td>
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<td>ATC</td>
<td>Air Traffic Control</td>
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<td>ATCC</td>
<td>ATC Centers</td>
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<td>ATFM</td>
<td>Air Traffic Flow Management</td>
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<td>ATM</td>
<td>Air Traffic Management</td>
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<td>BAA</td>
<td>British Airports Authority</td>
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<td>CAA</td>
<td>Civil Aviation Authority</td>
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<td>CAS</td>
<td>Collision Avoidance Systems</td>
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<td>CFIT</td>
<td>Controlled Flight Into Terrain</td>
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<td>CFMU</td>
<td>Central Flow Management Unit</td>
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<td>CNS</td>
<td>Communication Navigation Surveillance</td>
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<td>CRDA</td>
<td>Converging Runway Display Aid</td>
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<td>CRM</td>
<td>Crew/Cockpit Resource Management</td>
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<td>CTP</td>
<td>Common Transport Policy</td>
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<td>DCB</td>
<td>Demand Capacity Balancing</td>
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<td>EATCHIP</td>
<td>European ATC Harmonization and Integration Program</td>
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<td>EATMS</td>
<td>European Air Traffic Management System</td>
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<td>ECAC</td>
<td>European Civil Aviation Conference</td>
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<td>ECARDA</td>
<td>European Coordinated Approach to Research and Development for ATM</td>
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<td>ETOPS</td>
<td>Extended Twin-Engine Operations</td>
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<td>ETSC</td>
<td>European Transport Safety Council</td>
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<td>EU</td>
<td>European Union</td>
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<td>FAA</td>
<td>Federal Aviation Administration</td>
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<td>FANS</td>
<td>Future Air Navigation System</td>
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<td>FAR</td>
<td>Federal Aviation Regulation</td>
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<td>FEATS</td>
<td>Future European Air Transport Safety Systems</td>
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<td>FSF</td>
<td>Flight Safety Foundation</td>
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<td>GNSS</td>
<td>Global Navigation Satellite System</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<td>GPWS</td>
<td>Ground Proximity Warning System</td>
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<td>IATA</td>
<td>International Air Transport Association</td>
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<td>ICAO</td>
<td>International Civil Aviation Organization</td>
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<td>ICPTF</td>
<td>International Certification Procedures Task Force</td>
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<td>ILS</td>
<td>Instrument Landing System</td>
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<td>IMT</td>
<td>Industrial and Materials Technologies</td>
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<tr>
<td>INSTAR</td>
<td>Institutional Arrangement for Air Traffic Control/Management System</td>
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<td>ISMS</td>
<td>Integrated Safety Management System</td>
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<td>ISO</td>
<td>International Standardization Organization</td>
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<td>ITSA</td>
<td>International Transport Safety Association</td>
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<td>JAA</td>
<td>Joint Aviation Authorities</td>
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<td>JAR</td>
<td>Joint Aviation Regulations</td>
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<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
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<td>NASDAC</td>
<td>National Aviation Safety Data Analyzing Center</td>
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<td>NLS</td>
<td>Natural Levels of Safety</td>
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<td>NTSB</td>
<td>National Transportation Safety Board</td>
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<td>PRM</td>
<td>Precision Runway Monitoring</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>SARPS</td>
<td>Standards and Recommendation Practices</td>
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<td>SATCOM</td>
<td>Satellite Communication</td>
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<td>SATNAV</td>
<td>Satellite Navigation</td>
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<td>SID</td>
<td>Standard Instrument Departure</td>
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<td>SIMOPS</td>
<td>Simultaneous Operation on Intersecting or Converging Runways</td>
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<td>SOP</td>
<td>Standard Operating Procedure</td>
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<tr>
<td>STAR</td>
<td>Standard Terminal Arrival Route</td>
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<td>SUATMS</td>
<td>Single Unified Air Traffic Management Systems</td>
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<tr>
<td>TEN</td>
<td>Trans-European Network</td>
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<td>TETN</td>
<td>Trans-European Transport Network</td>
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<tr>
<td>TCAS</td>
<td>Traffic Collision Avoidance Systems</td>
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<tr>
<td>TLS</td>
<td>Targeted Levels of Safety</td>
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<td>TMA</td>
<td>Traffic Control Area</td>
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<td>TSG</td>
<td>Target Safety Gain</td>
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<td>VHF</td>
<td>Very High Frequency</td>
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<tr>
<td>VOR/DME</td>
<td>VHF Omnidirectional Range/Distance Measuring Equipment</td>
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Welcome Address
Hans Smits

It is indeed a great honor for me to be able, jointly with Robert Coleman, the Director General for Transport of the European Commission, to welcome you to this conference on an essential subject.

The subject of lectures and discussions in these two days will be “Managing Safety In and Around Airports”. The objective is to stimulate the process of international policymaking in this essential field. As an airport operator we are not always convinced of the necessity of international policymaking. There are numerous examples in which it might be argued the aviation industry would probably be far better off if international policymaking would be either nonexistent or far less regulatory. If I just say half the word “Schengen” most of you will understand exactly what I mean.

But today Amsterdam Airport Schiphol has joined forces with the European Commission. We have done so because we strongly feel that the subject of external safety, or third-party risk, is an area that should be given the highest priority in international policymaking. There is a necessity to do our utmost in this respect. We feel that without increasing safety even further, without enhanced reliability, there can be no growth in aviation. There should be a continuous improvement of safety conditions. That is why we wholeheartedly support this conference on “Managing Safety In and Around Airports”.

Today’s and tomorrow’s discussions will focus on that part of aviation safety, or flight safety, that is concentrated in airport areas. We will certainly hear many views and see many statistics. A word of caution seems appropriate here.

Statistics can be used to prove anything or nothing. They can be interpreted or misinterpreted; they can be used or misused. Statistics show that, of those who contract the habit of eating, very few survive. They also show that in the very first year of aviation, around 1700 BC, the chance of an accident happening was 50 percent. Icarus fell, and statistics from that year show the cause was 100 percent “pilot error”. Let’s just be cautious with safety statistics. They operate just like computers: “rubbish in” will lead to “rubbish out”.

In 1992, Amsterdam Airport Schiphol took the initiative of a study on the subject of third-party risk. In view of our corporate strategy to become one of Europe’s mainports, we wanted to know if our airport operations could be considered safe. The Dutch government took over this initiative and commissioned this study to the RAND Corporation. This study was of course given high priority by the tragic accident in the Bijlmer-suburb of Amsterdam, involving a Boeing 747 freighter of El Al two years ago. It was one of the first major accidents of a large jet transport aircraft in a suburban area and it therefore raised a lot of questions. Most of these questions were answered in the subsequent study.

* Hans Smits is President of Amsterdam Airport Schiphol.
But the RAND Corporation also had to rely on safety statistics. Most of those statistics available were very reliable but some could lead to misinterpretation. For instance, in the case of aircraft crashes, the mass of information is broken down into “cause or probable cause”: pilot conditions (such as age and training, aircraft conditions) involving light aircraft or passenger/cargo transport aircraft and the state of technical maintenance of the aircraft. It is broken down into weather conditions and into location of the accident (in flight or near airports). But there is no mention whatsoever of general airport conditions. And those of you who have flown, will, I feel, agree that conditions on airports and traffic characteristics of airports vary greatly all over the world.

George Orwell could easily have written a book under the title “Airport Farm”. Because all airports are equal, but some airports really are more equal than others. We must have the common sense to admit that. Admit that there is a difference in airports, comparing them in their mix of operations, in the mix of operators, in the degree of congestion and in the management level and the degree of safety awareness at different airports. But no matter what category we are in, we still have to improve our efforts in enhancing safety. Not just at airports, but also around airports, decreasing the risk for third parties. There simply is no room for complacency.

At Amsterdam Airport Schiphol, our future plans are subject to a democratic process—a process that saw a fine-tuning with regard to third-party risk immediately after the El Al crash that I mentioned earlier.

This fine-tuning consisted of a number of proposals (partly based on the findings of the RAND study that we initiated). These proposals are now an integral part of both our Corporate Strategy and the government’s White Paper on the future of Schiphol and Environs. If and when these proposals are accepted by parliament, Amsterdam Airport Schiphol shall be the first airport in the world with dedicated contours for third-party risk. These contours are determined on the basis of what is called “individual risk”. That is the chance of a person, who stays constantly in one place for a whole year, dying as a result of an aircraft accident.

The area within the limit of this safety zone indicates that the chance is one per 100,000 years at any given place in that area. Along with the establishment of the safety zone, we will be introducing at the same time a new set of safety measures. These include the prohibition of new dwellings within the zone. And, at the extremities of the runways, all present dwellings will have to be removed by the year 2015.

However, the most important of the twenty-five recommendations of the RAND report is, at least in my view, the introduction of an Integral Safety Management System (ISMS), with the emphasis on “management”.

<table>
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<tr>
<th>Schiphol: Integral Safety Management System</th>
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<tr>
<td>* exchange of information</td>
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<td>* partnership</td>
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<td>* commitment</td>
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At Amsterdam Airport Schiphol, the introduction of the ISMS is probably the most important step we can take on the road towards increased safety. This new system differs from present systems in that it is not dealing with history or collection of statistical information. The ISMS, on the contrary, is firmly focused at the future. It will lead to creation of a safety management culture that really works among all parties involved.

The airport operator, airlines, handling agents, air traffic controllers and so forth, work together in an entirely new set-up that finds its roots directly in the highly developed and proven safety management system of, for instance, the petrochemical industry. Schiphol is “leading the airport pack” in this respect, making a safe airport safer by promoting a “Partnership for Safety”.

I come to a conclusion. There is a long history between the acclaimed first flight of Icarus in the 17th century BC and aviation in the 21st century AD. But civil aviation as we know it, only has a history of seventy-five years. This year we commemorate the birth of IATA. That was seventy-five years ago, here in the Netherlands.

I hope that we, here in the Netherlands, during today’s and tomorrow’s conference, will find ways to further enhance the “management of safety in and around airports” for the next twenty-five years. Because the challenge of safely accommodating the expected increase in air transport can only be met by combining the forces of all parties concerned. Meeting this challenge hinges on three key elements: exchange of information, commitment and partnership.

In this respect we do not want to stick to the saying: “United we stand, divided we fall”. Because that is far too passive. We do not want to choose between standing and falling. We want to move. To proceed. But if we just proceed divided we shall have no guarantee for success. The only way to succeed is to act united. United we’ll succeed. Only with combined efforts shall we gain momentum in the management of safety in and around airports in particular. We must make safety even more a common goal, and thus help to make civil aviation safer yet by the turn of its first century in the year 2019.

I close by wishing all of you very fruitful discussions—discussions that, I hope, will contribute to improved safety. I am convinced that today’s and tomorrow’s lectures, discussions and conclusions will be rewarding in this respect. I believe that. Because some conferences just are more equal than others.
Introduction to the Conference
Robert Coleman.

I am delighted to open the conference on “Managing Safety In and Around Airports” which, given the importance of the subject, has received the support, moral and material, of the European Commission.

By way of introduction to your discussions, I will try to present briefly the Community’s current approach to transport policy, and air transport and air safety in particular.

Shift in Objectives of CTP

For over twenty-five years, indeed into the early 90s, the main, almost exclusive objective of the Common Transport Policy (CTP) has been the completion of a single market in transport services.

With the completion of the 1992 program, and the adoption in 1992 of the White Paper on a framework for sustainable mobility, the CTP is now developing as a more global policy addressing not only the internal market but also the efficient functioning of the Community’s transport system as well as integrating necessary safety and environmental requirements.

This shift in emphasis is reflected in the Maastricht Treaty on the European Union, now in force. In addition to developing the internal market, the Community has to address other strategic goals. It must

- develop Trans-European Networks (TENs) for transport, telecommunications and energy
- integrate environmental protection requirements into other policies, including the CTP
- adopt necessary measures to improve transport safety
- strengthen economic and social cohesion by reducing disparities between regions, and linking remote regions with the Community’s core.

In other words, the internal market is still the alpha but not the omega of the CTP.

This shift in emphasis, or rather this broadening of our objectives, applies also to civil aviation. The internal market is complete and now being implemented. As we come out of the recession, its full potential will be increasingly realized in practice, as confirmed by the latest traffic figures.

But the aviation industry and its users will only be able to derive full benefit from the single market if a number of additional conditions are fulfilled. The availability of sufficient infrastructure, of appropriate quality, is essential. It will also be necessary to ensure that these facilities are used under the best possible conditions as regards efficiency, safety and the environment. The charges for their use will have to be in line with market principles.

* Robert Coleman is Director General for Transport of the European Commission.
These issues have recently been addressed in both *Expanding Horizons*, the Wise Men’s report of last January and the Commission’s subsequent action program of June, *The Way Forward for Civil Aviation in Europe*. In brief, key elements for the proper functioning of the air transport system in the EU will include

- the development of airport capacity and the Air Traffic Management (ATM) system as an integral part of the Trans-European Transport Network (TETN)
- the right degree of liberalization of ground handling
- the basis for airport charges
- measures on air safety and the protection of the environment.

Let me say something about those issues most relevant to this conference.

**Infrastructure**

The establishment of the Trans-European Networks, based on Article 129b to d of the Treaty, will help to further develop Community infrastructure by fully interconnecting national networks and ensuring interoperability of the various modes. It will also address problems faced by the peripheral regions of the Community.


This proposal sets out the guidelines for the development of the TETN between now and the year 2010 by providing for the integration of the land, sea and air transport infrastructure networks in the Union. With the establishment of such a single trans-European network, its users will be able to benefit from high quality services offered on the network in a space without internal borders under acceptable economic, social and environmental conditions.

With regard to air transport, the guidelines have identified the key role of airports and the means to ensure their interconnection with other long distance transport modes as well as with urban transport systems. The guidelines also highlight the specific function of airports as the gateways to the rest of the world and identify the trans-European air traffic management system as a vital component in the network.

The guidelines for the development of the airport component of the network seek first and foremost to ensure that airport capacity is able to meet existing and future demand.

The establishment of a quality transport network is of the highest priority. In this task the Union faces enormous challenges, not the least of which concerns financing. The Christophersen Group, which was set up in order to further the ideas of the Commission White Paper on *Growth, Competitiveness, Employment—The Challenges and Ways Forward into the 21st Century*, has succeeded in addressing some of the issues and is continuing its work so as to be able to present detailed recommendations on financing at the Essen Summit in a couple of weeks time. It is
already recognized that private/public partnerships should be pursued wherever possible whilst accepting that many transport networks have limited scope for mobilizing the requisite private funding, given long construction periods and the difficulty for many transport projects to meet strict targets for financial viability.

The eleven projects identified as priorities include the Malpensa airport project. Three issues were isolated as possible obstacles to the rapid completion of this project: the completion of the landside access to the airport, in particular a rapid rail link to the city center and the financial set-up. The workshops organized to address these issues produced a number of recommendations which were then followed by political commitment from the relevant authorities.

The work on financing in the context of the Christophersen group and elsewhere does permit a note of guarded optimism as regards development. By their nature, as increasingly commercial operations, airports seem to offer more scope for private financing than many other types of transport infrastructure.

Turning to the European ATM system, its development is clearly vital to the efficient and safe aviation in the EU. The problem is vast and complex, embracing the air space structure and the integration of the disparate control, surveillance and communications facilities that we have at the moment. A serious start has been made within ECAC, through activities of EUROCONTROL and at Community level with the 1993 directive on harmonizing specifications for the ATC equipment. But the Union must now decide and derive maximum benefit from the Maastricht Treaty. This is a priority issue for the new Commission.

Let us now turn to the environment and safety, two closely related policy areas.

Safety and Environment

In the area of safety we do not intend to rest upon our laurels. In its Communication to the Council on Community initiatives concerning air transport incidents and accidents of September 1991, the Commission described a number of initiatives to improve our knowledge of the causal factors leading to civil aviation accidents. These initiatives will be discussed at greater length in the course of this conference.

In The Way Forward, the Commission has expressed its intention to work actively towards a single regulatory authority on air safety. It will remain alert to the opportunity of making further proposals, as safety of transport—for the paying consumer, for the provider as well as for third parties—remains a key objective. The human cost alone justifies this, but the economic cost too should concentrate the minds of all of us here today.

I have also mentioned environmental protection. The Commission is greatly aware of the issue of the protection of the population living around airports against an increase in noise volume due to growth in air transport. The benefits for the noise climate around airports resulting from Council Directive 92/14 of 2 March 1992 on the gradual phase out between 1995 and 2002 of the noisiest aircraft, the so-called Charter Two aircraft, will be considerable. This opens a unique opportunity
for preventive action, which should ensure that no new noise-sensitive activities are allowed around airports. Such action should cover measures in the area of noise measurement, noise monitoring, noise zoning and land use rules around airports. The characteristics of individual airports will be a key issue when setting up this global framework.

The Commission is also convinced of the necessity of improving the environmental performance of individual aircraft, when such improvements are technically feasible and economically acceptable. It is obvious that Community action will have to take account of the work of the relevant international organizations such as ECAC and ICAO.

Conclusion

As I approach the end of these opening remarks, I am conscious that I have failed to do something important, namely, address the subject of our conference: “Managing Safety In and Around Airports”. You may feel that this is not unusual. But this time it is not oversight.

Neither the EU nor the Commission “manage” airport safety, nor are likely to do so. Personally, I also doubt whether it is our role to presume to advise those who do. Subsidiarity allocates that responsibility elsewhere.

What I have tried to do is outline the policy framework at Community level within which those responsible will be operating. That policy framework will clearly be relevant to their task. If this conference helps to identify ways in which the framework could be used to make a useful contribution, even limited, to managing airport safety, we will be delighted to follow it up. We will be studying the proceedings of the conference carefully to see what conclusions can be drawn.
Session 1: Introduction
Richard Everitt

Introduction

It is a considerable honor and a great responsibility to be asked to introduce this conference which aims to study in depth the challenge that we face in managing safety in and around our airports. Before developing some thoughts on how our approach to the management of safety might develop in response to the changing demands of the aviation industry, I would like to spend a little time examining some of the current trends in our business and their implications for the way we approach the whole subject of safety. The aviation sector has an enviable safety record. Flying is the safest form of transport. This record has been achieved through the adoption of an international system of safety regulation developed through ICAO and implemented through the national regulatory systems of each signatory state. This system is necessarily prescriptive in nature but in general it has served us well. However, it is now showing signs of some strain. Recently, the United States published the results of its determinations into whether 31 states whose aircraft operate into the United States had safety standards which complied with ICAO. They found that nine did not and that four others were marginal. This report has led ICAO to undertake its own assessments and ECAC, in Europe, has set up a working group on the issue. The report of the FAA has now led to a call for the setting up of Regional Civil Aviation Authorities (RCAAs) under which states would pool resources to provide the necessary resources to provide an adequate system of safety regulation.

Industry Trends

This development illustrates one aspect of the changing scene in civil aviation. That is the relentless growth in the number of airlines and operators as the cost of entry into the business falls ever lower. Similarly, as the number of countries in the world continues to increase with the changing world order many of them establish airlines as a symbol of national identity but do not have the systems in place or the resources to ensure that the aviation sector is properly regulated. This is a considerable challenge if we are to maintain the safety record of the industry and the public confidence in the safety of civil aviation that goes with it. Hence the importance of the recent initiatives by the intergovernmental bodies on this subject.

A second and more positive challenge and opportunity for civil aviation is that of the potential growth in passengers and freight over the next twenty years. For London we are forecasting a doubling of passenger traffic from 80 million passengers per annum (mppa) to 160 mppa by 2016. Similarly, for the European Union passenger numbers at the main airports are forecast to grow from 512 million in 1992 to 1180 million in 2010. About 75 percent of the passengers in 1992 used the thirty biggest airports or airport systems and while those airports may lose some market share over the next twenty years the growth will be concentrated on them. There are many reasons

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for this, the main ones being that these airports serve the principal markets and because their size enables them to offer considerable economies of scale for the airline operator.

What the European figures are not showing is how the total number of aircraft movements will increase in response to the forecast growth in passenger demand. This is more difficult to forecast as much will depend on the degree to which markets are liberalized and runway slots are available to enable airlines to compete in liberalized markets. The experience of liberalization to date in Europe has, at least initially, led to movements growing faster than passengers. In the five years to 1987, at the six main airport systems and airports in the EU passengers grew by 32 percent and movements by 19 percent. In the five years to 1992 which saw the introduction of the third package of liberalizing measures passengers again grew 32 percent and movements by 36 percent. The runway constraints at the main European airports will in all probability mean that in future passenger numbers will grow faster than movements overall but that trend will be reversed in the early stages of the liberalization of markets. This could well happen with the opening of domestic markets to competition from any EU airline in 1997.

The greatest challenge to the industry is to realize the opportunity that growth offers in a climate which is increasingly hostile to airport development. There are many reasons for this hostility and much of it is irrational. However, it does mean that we will have to use our existing airports and airspace resources more and more intensively. New terminals will be difficult to build and new runways almost impossible. It is perhaps one of the ironies that as we enter the 21st century our expectations are that we will have increasing opportunities to fly but at the same time we are becoming increasingly resistant to the development of the infrastructure that will enable us to do so.

All of these matters bear on the way in which we approach the issue of safety in each area of civil aviation. And in addition, it is against a background in which the losses in the airline business have reached staggering proportions over the last three years. Only last year did we see the IATA airlines collectively earn a modest profit and certainly not enough to remunerate the capital employed. This lack of profitability inevitably puts pressure on costs in all areas including safety. That is not a bad thing as long as safety standards are not compromised but the temptation to do so is one that must watched with great vigilance by regulators and those responsible for the quality control systems in each operating company.

The Safety Challenge

So what do these trends mean for all of the organizations engaged in our industry and our approach to the subject of managing safety in and around our airports? In addressing this issue we must not lose sight of the fact that a number of organizations and regulators have a role in this issue of which the airport is but one. Our governments issue operating permits for foreign airlines to fly into our airports. They also to a greater or lesser extent have some direct responsibilities for safety-related issues such as land use planning. The airworthiness authorities certificate aircraft and within Europe this is increasingly being done through the Joint Aviation Authorities based in the Netherlands. There are the respective civil aviation authorities or government departments of each state whose aircraft use our airports who are responsible for ensuring that the airlines operate to
ICAO standards. There are the air traffic control organizations who increasingly are answerable to independent safety regulators. For airports, in the case of the United Kingdom, and I believe other European airports, we operate under a licensing system and are answerable for safety issues to the Civil Aviation Authority. The effective management of safety at our airports will require the involvement of each of these organizations to a greater or lesser degree.

The fundamental challenge that our industry faces is to meet the challenge of growth in an environment that is increasingly hostile to new development while at the same time improving still further our safety record. This, I believe, requires us to develop the way we approach the management of safety and to learn and apply the experience of other industries who have faced similar issues. In relation to airports I firmly believe that it is the airports themselves who should take the lead in this as we are answerable to the communities around us for the activities at our airports. I would like to spend a little time describing a possible approach to this matter that we are currently considering within the BAA and which will involve our safety regulators and other key organizations that operate at each of our airports.

In order to find a simple way of describing what we are doing I have followed the time-honored practice in the aviation industry and invented an acronym. That acronym is PACE; this stands for Proactive, Analytical, Coordinated and Effective safety management. I would like to examine each element of this initiative in turn.

**PACE: Proactive Safety Management**

The regulation of safety in our industry is necessarily prescriptive but it contains within it a danger that the rules are slavishly followed and dangers are overlooked. We see in several other industries a new set of skills developing in the area of safety management which ensure that a proposed development or new procedure is examined at an early stage to identify risks and to determine measures to reduce those risks as far as possible. Examples of where such techniques are in common use are the nuclear and chemical industries and in recent years the offshore oil industry in the United Kingdom.

I believe that we need to adopt the established techniques of risk assessment to operations at our airports as the intensity of operations increases. The need to use our assets ever more intensively may mean that yesterday’s safety solution may well require re-examination in the light of today’s new circumstances. Let me give one example from our experience. We have public safety zones at the end of each runway at our major airports. Development is restricted in these zones in order to minimize the number of people in them at any time. The shape and area of these zones was set over twenty years ago during which time there have been significant increases in the number of movements on these runways. The types of aircraft using them are also significantly different from those in use twenty years ago. It is only now that the shape and area of these zones is likely to be re-examined. This is far too long and highlights the need to have systems in place to regularly review such issues.

The nature of our airport businesses demands that a consistent and coherent examination of the risks forms a central part of our management systems. But you may ask: How is this to be done? Well I am sure that this is one of the topics that will be discussed at length during this conference.
over the next two days. I would add that we have not yet settled on our own approach but there are one or two interesting examples that we are considering following. For all our major construction projects we are now required, as the client, to ensure that a safety plan is developed and agreed with the contractor prior to the construction commencing. We must also appoint a planning supervisor to ensure that the contractor proceeds with the project in accordance with the safety plan. A proper plan will identify the risks associated with the project and the measures to be taken to minimize those risks. One possibility is to prepare similar types of plans for all the main operational parts of our business which identify risks, plan how they are to be minimized and provide for performance monitoring. A second alternative, which is being used by National Air Traffic Services in the United Kingdom, is to prepare safety cases for new developments and new operating procedures. These cases are scrutinized by safety regulators before new procedure or development is brought into use. As this procedure becomes established it can be extended to the preparation of safety cases which consider the operation of each existing function or location within the organization.

If we establish a process for assessing the risks and determining measures to mitigate that risk on a systematic basis the next question is who should do the work? There can be no doubt in my mind that if we are to continuously improve the safety of our operations this work must be done by line managers and staff with the support, where necessary, of the professional safety team. It is only in this way that the risks will be fully understood and it should ensure that the relevant people own the measures that are identified to minimize the risks. The professional safety team can fulfill a valuable role in facilitating the development of the risk assessment, reviewing and challenging the conclusions and monitoring the implementation of the mitigation measures that may be identified.

**PACE: Analytical Safety Management**

If it is that we should take a systematic proactive approach to safety issues I believe that this can only be done effectively if an appropriate degree of analysis is applied to the work. We all know the adage that “if you can’t measure it you can’t improve it”. This is as true for safety as it is for any other aspect of business activity. Good analysis should also help us to prioritize the use of resources. I am not a safety professional and I am sure we will be hearing more on this important subject over the next two days. However, the quality of any analysis will depend on the quality of the inputs that go into it. This in turn depends on the quality of the systems that we have in place to collect that data. We have some very good data sources in our industry particularly for major incidents which are the subject of extensive investigation. Also in the United Kingdom and in other countries, we have a Mandatory Occurrence Reporting system as well as a Human Factors Reporting Procedure (CHIRP) run independently of the safety regulators, under which the anonymity of the people and organizations involved in potentially serious incidents is maintained.

What is surprising is the lack of information in the industry on ramp incidents. I read recently that incidents on the ramp cost the airline industry over one billion pounds each year either in direct costs of repair or through loss of utilization of aircraft. This is a staggering sum for an industry which has reported record losses over the last three years. I could spend a lot of time on this issue but to do so would lose the main points of these opening remarks. Suffice it to say that we are now
systematically collecting data on ramp incidents at Heathrow and Gatwick in order to prioritize the areas in which we can work with airlines and handling agents to improve matters.

In addition to collecting data to identify trends the whole subject of quantified risk analysis is relevant to this section of these remarks. Recently three analyses of this type have been undertaken at our airports using outside consultants. I now believe that the ability to undertake analysis of this type is a core skill for our business and must be one feature of our safety management system. Such analyses are not an end in themselves but they can help to understand the nature of certain risks and help the prioritization of actions and resources to reduce the overall safety risk. It is clear that the usefulness of a risk analysis depends critically on the data available to the analyst. This is perhaps an area in which there should be greater cooperation between airports in exchanging data on a regular basis and this is possibly one initiative that might come out of this conference. We would certainly be very willing to play our part in such an initiative.

**PACE: Coordinated Safety Management**

The third letter of my PACE acronym is C for coordination. This is a subject which warrants a paper in its own right and I feel sure that much will be said on the subject over the next two days. It can be considered in terms of internal coordination and external coordination. By internal coordination I mean the coordination within a business, be it an airport or any other business, of the activities which are directed to maintaining the safety of the business activity. I will refer to these a little later in the fourth section of these remarks.

I would like to spend a moment on coordination between the numerous businesses that operate at our airports as well as the regulators that supervise the various activities. I know that this subject is topical in the Netherlands currently. At our major airports we have between sixty and a hundred airlines regularly operating, air traffic control is undertaken by our National Air Traffic Services and aircraft are handled by one of three or more handling organizations. Other than the ground handlers we are all regulated by specialist external safety regulators although the standard of regulation for an airline may vary according to its state of registration. Fortunately, the airports, UK registered airlines and National Air Traffic Services are all regulated by the Civil Aviation Authority through its Safety Regulation Group, but this group does not have a specific role in coordinating safety at airports. In addition to the CAA each organization is regulated by the Health and Safety Executive (HSE) which has the responsibility for the regulation of safety at all workplaces in the United Kingdom. Additionally, the government retains for itself certain airport safety responsibilities, including the creation of Public Safety Zones at the end of each major runway.

Overall these various arrangements have worked reasonably well. However, I think that the time has come for serious consideration to be given to making one organization responsible for taking the lead in coordinating the safety strategy both on and off airport. If we were to take such a step it is vital that it should not result in the creation of yet another bureaucracy or talking shop. We may have a good precedent in the Safety Committees that we are required to set up for each workplace.
Where these committees work effectively they are attended by people who want to get things done to improve workplace safety.

To make improvements in any aspect of airport operations usually requires the support and commitment of a number of different organizations. Safety is no different. As an example, we identified that we were beginning to experience a number of incidents where aircraft were seriously off track in the final phase of their approach. We took this up with our ATC provider and urged them to consider the use of Precision Runway Monitoring which has been developed in the United States for close simultaneous parallel runway operations. After some debate they developed a simple system using existing radar equipment which is now on extended trial at Gatwick and I hope will be installed early in the New Year at Heathrow. This is one example of cooperation within the somewhat informal system that currently exists within the United Kingdom. Our inability to make major improvements on the ramp suggests that we should at least be prepared to consider the creation of a more formal and accountable group to drive a safety initiative forward.

One question that is bound to be asked is who should lead such a coordination forum. I would have no hesitation in saying that it should be the airport operator. I would stress that the forum would not be an executive group nor would it be a regulator. Its job would be to coordinate the efforts of all the key players, including government in the United Kingdom’s circumstances, in the drive to ensure that we continue to strive for improving safety standards. As airports we are uniquely placed to fulfill such a role. We have the resources and one of our key skills is coordinating the efforts of a host of organizations.

**PACE: Effective Safety Management**

The final letter of my acronym is E for Effective Safety Management. I have one major concern about the whole subject of safety and that is that there is too much talk and not enough useful action. It is so easy to theorize about what needs to be done that if we are not careful we miss the vital point. Our job is to ensure that safety is seen by our staff, the staff of those working at our airports and the organizations using airports as the priority that we all say it is. All our staff surveys show a strong commitment to safety by the staff working in our airports. To harness that awareness we need to ensure that a safety strategy is developed identifying priorities, and that policies and performance are properly monitored and audited. In addition, the specialist skills need to be available to support the assessment of risk, the identification of practical measures to minimize risk and to monitor and audit performance.

We are currently looking at all these aspects of our safety management system but the end point of all of this work, both for the users of our airports and for those living around them, is to ensure that we have reduced the risk of our operation to the point where it is as low as reasonably practical.

**Conclusion**

Our industry offers many exciting challenges as we head for the 21st century. It offers growth, it offers employment opportunities, it provides the vital link between commercial markets all over the
world and it enables people to experience the cultures of each other in a way that our grandparents would have thought impossible. These challenges come with responsibilities particularly in the area of safety and security. The challenge of accommodating growth means that we need to adapt our safety management approach to the changing set of circumstances that we face. This conference, I am sure, will make a valuable contribution to our thinking on how this may be done. I feel sure that our approach will need to be more proactive, analytical and coordinated if we are to meet the challenge of making further improvements to the safety record of the industry.
Session 1: Introduction
Gerhard Stadler*

Introduction

It is an honor to speak to you in the introductory session of this conference on “Managing Safety In and Around Airports”. You all know that significant changes in the international air transport industry coupled with the continued traffic growth has increased pressure on finite air and ground capacity, with possible consequences for safety.

I will deal here with two aspects: What is under progress in Europe to increase capacity of airports and TMAs while maintaining aviation safety, and which correlation do I see between accidents, safety, airport acceptance and land planning measures.

Our departure point is the present capacity situation at major European airports, the forecast about traffic increases and the enormous difficulties to enlarge airside airport facilities or to build a new airport. At present, the main trip wires for the realization of transport infrastructure are not financial constraints or technical impediments, but the legal procedures and the questions of acceptance by the population living near a project. The new airport of Munich tells us the situation: More than 20 years had to pass between the political decision and the inauguration of the airport. Real construction time was five years, but legal procedures and political uncertainties stopped the work for more than fifteen years.

First, I want to recall the present situation of air traffic at major European airports and the forecasts. The latest statistics of the Airports Council International (ACI) on Europe show us, first of all, a positive sign. Passenger numbers increased by 10 percent between June 1993 and June 1994. That is very good for the industry. But the negative situation is that passengers need to be transported by more movements. However, movements between June 1993 and June 1994 increased by only 3 percent. IATA statistics indicate that there will be an annual growth of 5 percent of passengers up to 2003, while the total movements up to 2003 will increase by 25 percent. An SRI study in 1990 examined the situation at the major European airports, indicating that these airports have serious capacity problems. Since this study was conducted, only Munich has been able to relieve its problems because a new airport was built. The airport of Orly, however, which had access capacity, lost that when its number of movements was restricted by the French government to 200,000 yearly. The problem is even worse than the lack of general capacity. Most airport situatons are not broken down by peak and non-peak hours of the airports’ operation. Looking at those situations, we can almost conclude that we have already reached the limits of possible movements. Are we in a growth industry that cannot grow?

This situation has led the European Civil Aviation Conference (ECAC) into considering how best to improve the performance of the air traffic management system and increase its efficiency without, however, downgrading the safety level or worsening the environment.

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ECAC, which might be regarded as the European branch of the worldwide International Civil Aviation Organization (ICAO), has presently thirty-three Member States. More and more member states are coming from non-European Union countries. We expect another ten new member states from Eastern Europe soon.

ECAC focuses on safety and on how to maintain and possibly improve it under conditions of increasing capacity and higher levels of operations in the coming years. I shall therefore focus on the latter subject, and describe the APATS1 program so as to set the scene for your discussions and stress the need for striking a balance between both elements in the capacity/safety equation.

**APATS1**

First, let me place APATS1 in context. It forms one of the three major initiatives agreed by ECAC Transport Ministers to increase air traffic control capacity in Europe. The first initiative was a decision to establish the Central Flow Management Unit, which is expected to be fully operational in 1995. The second initiative was the decision to launch the “ECAC Strategy for the 1990s”. This is being implemented through the European ATC Harmonization and Integration Program (EATCHIP) in close cooperation with EUROCONTROL and the European Commission. It is my firm conviction that with the different efforts undertaken by various institutions, above all EUROCONTROL, we can reduce and probably solve the congestion problem for the en route airspace. What will remain and what will be the real constraint for the future of European civil aviation are the airport-related issues.

The third initiative was the decision by Ministers in 1992 to extend their “Strategy for the 1990s” to relieve congestion in and around airports. They established an Airports/Air Traffic System Interface Project Board, better known as the APATS1 Project Board, which is responsible for implementing the program, with the assistance of a small executive team, the Airports Bureau, established within the ECAC Secretariat.

The latter initiative—APATS1—was not only sensible, but essential, because a strategy that omits airports as an integral part of the ATM system is a strategy with rather too many holes in it. Comparing the average daily number of arrivals and departures with the average daily number of flights in and above the twenty busiest TMAs in the ECAC area shows that for each TMA, the majority of flights have their origin or destination at the airports concerned. The remainder are overflights. In fact, the major airports in all these TMAs are congested in the sense that they follow the IATA guidelines in resolving scheduling problems. Accordingly, the APATS1 strategy was formulated with as its overall objective the improvement of the potential throughput of European airports and their surrounding airspace while maintaining safety and respecting the environment.

We aim to achieve this by encouraging best practice through exchange of information, encouragement of new standards and recommended practices, and through the provision of advice and assistance, especially to smaller airports. In doing this we have to work with a range of
organizations operating airports and providing infrastructure that lie very largely at a local or national level. The approach that we have adopted is rather along the lines that have been adopted at some of the major airports in Europe—such as Frankfurt, Heathrow, Schiphol and Madrid—where the air traffic authority, major airlines and airport operator have been studying jointly the scope for increasing capacity through improved procedures and other technical means. We have therefore established good working relations with other international organizations that have an interest in airports, including ACI Europe, EUROCAE, ICAO, IATA, AEA, ERA and the European Commission, which has provided financial support to the APATSI program.

At present I believe the APATSI program fills an institutional gap in Europe although we are very much reserving our judgment about how long its life needs to be. Although the project board has been in existence for only just over two years, it has generated a good deal of interest across Europe, which is encouraging.

ATC Procedures

I shall now move on to describe details of a work area which the Board considers as one of its priorities, namely ATC procedures and control techniques.

This activity on procedures and technical systems is well under way. We have focused to date on measures which can be implemented in the short to medium term. But longer-term developments are also being addressed. The board commissioned a report detailing the different procedures and control techniques used at European and American airports, as well as reviewing those under trial and others which were being researched. The report has been circulated widely and formed the basis for a workshop, which I know some of you attended, in Paris last June.

The work on so-called “mature” procedures is summarized in a consultative document approved and published by ECAC. Procedures covered include reduction of radar separation on final approach, reduction of diagonal separation on final approach, reduced runway separation on final approach, reduced runway separation on the same runway, simultaneous operations on intersecting or converging runways, visual approaches, intersection takeoffs, multiple line-ups, landing clearance based on anticipated separation, and modification of the application of wake vortex constraints for departing aircraft and displaced thresholds.

The document includes for each procedure a description of the concept, conditions of application, related ICAO provisions, possible capacity gains, candidate airports and the current implementation and status on tests, trials and implementation. I shall take two of these for illustration:

• reduction of radar separation on final approach
• simultaneous operations on intersecting or converging runways or SIMOPS.
Radar Separation on Final Approach

As many of you will know, ICAO standards specify a minimum radar separation of 3 nautical miles between aircraft on the same localizer course, with additional longitudinal separation as required for wake turbulence. We are recommending a reduction of this separation to 2.5 nautical miles under specified conditions out to 10 nautical miles from the airport. The conditions include wake vortex minima, runway occupation times, visibility of turn-off points from the tower, radar and communication system capabilities, monitoring approach speeds, notification of the procedure to pilots and the need to exit runways expeditiously. U.S. studies have reported average capacity gains of 3 to 5 arrivals per hour per runway.

A procedure along these lines was implemented by the FAA in 1986 and has been adopted at twenty-four major U.S. airports. An operational evaluation of the trial was started at Frankfurt in 1990. Tests were conducted at Charles de Gaulle in 1992 and 1993—and 2.5 nautical mile separation minima on final approach was introduced at Charles de Gaulle on 20 January 1994 for a six-month test period. Operational trials are expected to begin this year at Heathrow. Most major European airports are possible candidates for this procedure.

Since this procedure does not conform to ICAO provisions, states adopting the procedure will need to notify the ICAO Council of noncompliance with the international standard, as required under Article 38 of the Convention. ECAC Member States intend to recommend to ICAO that its provisions be amended to allow this procedure.

SIMOPS

The second procedure I should mention is simultaneous operations on intersecting or converging runways or SIMOPS. Under this procedure we may have an aircraft landing on a crossing or converging runway. The FAA has recently permitted SIMOPS on wet intersecting runways. This may sound rather risky but I am well assured that it is a safe procedure. Not surprisingly, there are a lot of conditions that have to be followed. For example, simultaneous takeoff and landing is only permitted during the day, though simultaneous landings are permitted during day and night. Visibility must be not less than five kilometers and the cloud ceiling not less than three hundred meters. Braking characteristics must be assessed as good by a pilot of an aircraft in the same performance category prior to the landing aircraft being instructed to stop short. And so on.

SIMOPS procedures have been adopted in Australia, Canada and the United States, and to a limited extent at Zurich. There are several possible candidate airports in Europe for this procedure, including Amsterdam and Madrid. I understand that SIMOPS is not excluded by ICAO provisions but there is no ICAO standard covering its application. It is intended to recommend to ICAO that Regional Supplementary Procedures be developed in Europe to ensure a standardized application, and that SARPS be developed worldwide.
Automated Tools

In addition to "mature" procedures, APATSI is planning to define the operational needs for the use of a number of automated tools to increase capacity through new associated procedures in Europe. Amongst these, I shall describe the Converging Runway Display Aid.

The CRDA is a computer tool to assist controllers in sequencing and separating aircraft on dependent converging instrument approaches. The main benefit is that it enables controllers to increase significantly arrivals on converging runways. An average capacity gain of ten arrivals per hour can be obtained.

The system projects electronic ghost images of aircraft on an arrival path for a primary runway onto the arrival path of a secondary runway. This enables the separation spacing between aircraft during the final approach to be verified. The radar controller on the second runway will vector his aircraft exactly between the ghost from the primary runway.

Following trials at St. Louis, Missouri, the FAA issued a national standard authorizing dependent converging instrument approaches using CRDA. NLR, in the Netherlands, has undertaken an assessment of the benefits of CRDA at Schiphol. NLR has developed a prototype, as well as user requirements, and a validation program is being undertaken with the aim of promoting the applicability of the system. APATSI is aiming to reach agreement on user requirements and validation of the system in Europe.

Validation of Procedures

I shall conclude the APATSI part of my presentation on the latter aspect of validation. One of the problems in getting new procedures accepted in Europe is that the results in one state are not readily accepted in other countries. We are therefore, with the financial support of the European Commission, in the process of commissioning a study on the validation of new control procedures and technical systems. The aim is to bring existing validation methods into line, therefore facilitating the sharing of results. This would help in speeding up safely the introduction of new procedures and systems, in attracting confidence of providers of airport facilities and in securing their full commitment to implementation of such procedures and systems.

Let me now change to another serious subject.

It is a fact that a significant part of accidents in civil aviation are occurring in the vicinity of or at airports. ICAO statistics show that in fact 20 percent of total accidents and incidents happen in and around airports. Seventy-five percent of this part occur at the airport, 18 percent within three nautical miles of the airport, and another 5 percent within a distance between three and ten nautical miles of the airport. Looking at the stage of the movement, the majority happened during landing, a minority during takeoff. What is the consequence of this?
Beside the noise problem, the relatively higher probability of accidents happening in the vicinity of airports is a major concern for people living near an airport. In some cases this leads to restrictions of movements with negative effects on the capacity of the aviation system.

In most of the European states, civil aviation administrations have a say only in the constructions of buildings when a limitation of obstacle surface is necessary in accordance with the limits laid down in ICAO Annex XIV. What is out of the competence, even of the co-determination, of civil aviation administrations is the construction of buildings only close to the obstacle areas or the use of buildings. Most of these decisions are in the hand of local authorities which have completely other interests than civil aviation. A politician who decides in favor of land planning measures allowing the construction of residential areas in the vicinity of an airport paves the way for obstruction against this airport: When people living in the new houses realize the noise and the very low, but not completely to be ignored case of an accident, they must become enemies of the airport. And then the politician, looking to the next vote, reacts against the airport, and so on.

“Safety in and around airports” includes also preventing that housing areas, leisure activities and all opportunities leading to the gathering of big masses of people—as, for example, also shopping centers are—happen in the close vicinity of airports, especially in the elongation of a runway, where emergency landings occur comparatively often. Here, I can here only appeal to politicians to think also about events which we all hope never occur, but which nevertheless could happen.

It is time to conclude my presentation on the critical theme of increasing capacity of airports while maintaining or improving safety.

Conclusion

The general pattern in aviation has been to adopt a conservative approach on the grounds that safety is the overriding factor and cannot be compromised. I cannot agree more with the latter position. On the other hand, we should not let aviation lose the pioneering function it always had, particularly at a time when increased demands are placed on the system and when resources are becoming scarce. To meet the challenge, it is essential that all of us—administrations, airlines, ATC and airport authorities—work in full partnership to provide the best service to the traveling public in a cost-effective manner. We must try by all possible means to increase the number of cooperative projects, the results of which could then be used by the widest community and to develop harmonized and uniform procedures in order to minimize implementation costs.
DISCUSSION SESSION 1

Nico de Voogd
The issue of airline losses is intriguing. The huge losses is a big problem. One of the reasons seems to be that there is a low threshold for entrance into the industry. Would it not be interesting for many reasons to encourage the use of large aircraft? You would raise the threshold for entrance, you would reduce the number of movements, and maybe by that improve safety?

Richard Everitt
If the economic rigors were properly applied to our industry and subsidies were significantly reduced, we might find the cost of entry going up, because people would have to pay the full economic costs of what they are engaged in. Economic prescriptions, however, which on the face of it look quite interesting, and other things that lead to distortions are probably what brought on the problems we have in the first place.

Gerhard Stadler
That is not the solution of the problem, because what the customer needs is more connections between points and large aircraft can only be used for a limited number of movements. The development shows that the maximum is between 150 and 200 passengers a plane.

Jeffrey Gazzard
During Mr. Everitt's presentation, he referred to his acronym PACE. BAA says it has done the safety assessment for construction purposes. But they had a tunnel collapse on a underground railway project and I wondered if the safety assessment had covered that possibility and whether he could comment on the use of safety assessment and how accurate they are.

He also referred to tolerability standards and target levels of safety that are used in petrochemical, nuclear, and off-shore oil industries. I would like to ask if he set a target level of safety for airports, such as Heathrow, and it couldn't be achieved, what he then would do?

Richard Everitt
The safety assessment in the case of the underground railway project worked actually very well, because we got the people out. We had a system in place to show that the ground movements were occurring. Once we saw that, the people were moved out. So, I am very confident in the safety assessment.

I am also confident that we can meet proper levels of safety at Heathrow and I think the record bears that examination.
Session 2: Safety Issues
David H. Johnson

Introduction

There is an increasing awareness and concern worldwide on matters of health, safety, and environmental protection. The result is the need for better methods to both measure the impact of different systems and events on society and to provide confidence in decisions affecting our health and safety. Both technological and nontechnological systems are of concern and include transportation, energy, chemical, military, social, cultural, import/export, and geography. It also includes all the supporting systems such as communications, waste sites, and service centers, including large regional airports. The best examples of contemporary attempts to quantify impacts of systems on society have probably come out of the risk assessment field in relation to engineered systems.

Modern risk analysis techniques have been developed and utilized in a wide variety of industries to successfully identify the risk associated with the operation of specific facilities, the nature of the different attributes of these risks, and the sources and contributors of these risks. The development and refinement of these techniques provides one essential element of a successful risk management program.

In addition to the use of a valid and comprehensive methodology that provides a robust and comprehensive framework for the analysis of risk, two additional elements are necessary in establishing a successful risk management program. First, organizations that operate and regulate must be open to change. Rigid adherence to prescriptive procedures and regulations without consideration of their underlying bases in light of the new information provided by the risk assessment can dilute the benefits of conducting a risk assessment and render a risk management program ineffectual. Likewise, the internal structure of an organization can either enhance or dilute the effectiveness of a risk management program.

The second additional requirement of a successful risk management program is the involvement of all affected parties in the risk management process. On one level, this requirement translates to ensuring that all groups within the organization managing the facility, whose activities will be represented in the risk assessment or affected by the risk management program, are aware of the goals of the risk analysis as it is being conducted, and have ample opportunities for contribution to the analysis process. At a typical industrial facility, the organizations or departments that provide information critical to establish a credible risk model, and whose “buy in” is fundamentally important for the longer term success in utilizing the risk models, include Operations, Planning, Maintenance, Engineering and Design, and Management. In addition, it is important that other affected parties are involved in the risk management process. Specifically, it is important that the users of the facility, the affected public, and the relevant government and regulatory bodies be

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involved. In the case of an airport, the “users” would include the airlines, cargo shippers, and the traveling public. Ideally, the “affected public” would include those people that live or work near the airport as well as those people in the broader community that although they enjoy the benefits of the facility, are also asked to bear some of its costs.

A scenario-oriented methodology for risk assessment is well established (based on the robust definition of risk articulated by Kaplan and Garrick)¹ and has been successfully applied in a variety of applications. This approach fulfills the requirement for a framework that systematically identifies the contributors to risk. In fact, this methodology has proven to be quite dynamic and powerful.

The scenario-oriented approach has also proven to facilitate the requirement to involve the affected parties. Two attributes of this methodology facilitate effective communication. First, the natural language adopted in the analysis is that of operations. This feature allows for the effective communication with the true experts of the facilities: those involved in its operation, maintenance, planning, engineering, and management. Information, and therefore opportunities for effective risk management, is not lost in translation from the information supplied by the facility operators to the analysts constructing the mathematical models. The second feature that facilitates communication with all affected parties is the clear delineation of the problem offered by the scenario-oriented approach. Without a doubt, the risk models can and should be quite complex when viewed at a detailed level. However, the scenario-oriented approach is based on a top-down unraveling of the problem that offers a significant degree of clarity and focus. Parties with possible divergent interests are not left with debating solely the “bottom line,” but indeed can use the risk framework to identify specific topics, at various levels of specificity, to focus discussions and risk management actions.

We are highly confident that the application of modern risk assessment techniques to the operation of an airport will result in a clear delineation of the risk contributors that would facilitate both the initiation of a risk management program as well as communication with interested parties.

**Framework for Risk Assessment**

The “risk” of a facility can manifest itself in many ways. One could speak of the likelihood of injury or death to workers or to the public. Health risks could be described as acute or chronic, individual or societal. Perhaps only the impact on a selected portion of the public is of interest. Likewise, one can talk about the “risk” to the facility. One could think about unplanned downtime, major equipment damage, or even the likelihood of success of a particular technology. The point is that when one asks, “What is the risk?” one is asking for the answer to a very complex, multidimensional problem. To put it another way, one is free to choose whatever performance measure is appropriate.

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The framework developed for modern probabilistic safety assessments facilitates answering the question, “What is the risk?”

The framework of modern probabilistic safety assessments is built around the “triplet” definition of risk articulated by Kaplan and Garrick. For each scenario, both the frequency and outcome are completely described. The risk is then defined as the ensemble of all such triplets: scenario descriptions, their frequencies, and consequences.

Note that risk is not confined to a reduced measure such as the expected value (as would be given by a simple multiple of the frequency and consequence). We are to completely describe our state of knowledge that would include uncertainty. The challenge then becomes identifying and structuring the scenarios.

The methodology contains aspects that facilitate scenario identification and structuring. One such element involves the systematic identification and characterization of hazards at the facility. This is a critical first step in the risk analysis process. This step would determine those hazards for which risk scenarios would be developed. For example, if third-party risk of an airport is of interest, what is the basis for excluding fuel transport, fuel storage, material transport, or surface traffic supporting operations from quantitative consideration? Although these hazards, and possibly others, may be shown to not contribute to risk, a viable risk framework should explicitly make this case. Otherwise, public confidence in the process might suffer.

A second element that facilitates scenario identification and construction is the master logic diagram. This element uses “if-and-only-if” top-down logic to systematically unravel the question, “What is the risk?” Scenarios are carefully defined at the level that it is best supported by the available evidence for quantification. The methodology also includes elements that facilitate the use of all sources of evidence, including the knowledge of experts.

In addition, the human element, both the active involvement of people as a scenario plays out and the latent effects that might be due to previous actions such as maintenance, is considered. Quantification of human actions is performed within a framework that intimately involves key operations personnel, using a parametric-metric approach that addresses underlying contributors that can support the identification of potential safety enhancement measures.

A comment is relevant at this point concerning the relationship between the approach taken in a probabilistic safety analysis and that in a precursor approach. In the former, we establish a facility-specific framework that provides a basis to measure risk significance. The latter approach too often extrapolates historical events at one facility to other facilities without adequately considering facility-specific features that may indeed impact their risk significance.

A related source of confusion seems to exist in comparing modern probabilistic safety analyses and causality-based analyses. The former approach first focuses on identifying and structuring the scenarios. A broad ensemble of evidence is then used to populate (quantify their frequency) each
scenario. Scenarios are identified and quantified even if such scenarios have not yet been observed. The latter approach relies heavily on observed events and does not facilitate completeness. One key lesson that we have learned is that scenario construction must consider both breadth and depth and go beyond merely what has been observed (witness the Challenger incident, Three Mile Island, and Chernobyl). Rare facility-unique events must be represented.

The last aspect of the framework to be mentioned here involves the identification of a comprehensive set of performance measures. To facilitate the use of the probabilistic safety assessment to support risk management, a definite set of measurable or calculable parameters should be defined that would allow the performance of the facility to be tracked in real time.

The choice of performance measures is key to developing an adequate understanding of the risk of any system. Here the question is, "Which performance measure is the right one or the best one to use to characterize the risk?" The tendency is to only do what the regulations require. Of course, it is necessary to calculate what the law requires, but experience indicates that, in many cases, regulations cannot anticipate the best indicators for portraying risk. In fact, they seldom do. We should not limit ourselves to one "best" measure. Each measure characterizes one aspect of risk performance, and usually there is interest in many different aspects of risk. Therefore, the best approach is to pick a set of the most important measures, and characterize each and build our confidence and that of the public by presenting all of them. Examples of performance measures are the likelihood of different levels of damage or performance and can be based on such fundamentals as injuries, fatalities, property damage, reliability, productivity, and throughputs.

Experiences in Risk Assessment and Risk Management

We have interacted with many different facility operators in a variety of industries on the subject of risk. It can be said, without exception, that all of the facility operators that we have worked with place a high degree of importance on safety and, in the case of operating facilities, all have felt that their facility was safe. There is a common interest, however, in determining if their facilities could be made even safer in a cost-effective manner. There is the further interest in knowing what actions provide the greatest return to managing the risks.

Besides a common interest in safety, facility operators, prior to conducting a facility-specific probabilistic safety assessment, typically believe that they know what scenarios constitute the risk. Often they are correct, but they cannot quantify their belief in the form of a prioritized list of contributors. Often, they are wrong. "Subtleties" can be important. In other cases, design and regulatory focus on specific issues has diverted attention from more important risk contributors. Probabilistic safety assessment can provide clarity in these cases.

For over twenty years, PLG has been a leader in the development of probabilistic safety assessment methodology and its application. We have found that the most useful viewpoint from which to construct truly meaningful risk management frameworks is that of the facility owner-operator. We outline our experience here to lend credibility to our belief that the application of modern probabilistic safety assessment techniques to the operation of a commercial airport will lead to increased public confidence in its safe operation as well as the development of a powerful
management decision aid. PLG’s experience grew out of the commercial nuclear power field. We have performed over thirty-five plant-specific analyses worldwide, including the first such analysis that was “full scope.” By full scope, we mean that a broad range of initiating events (potential plant upsets) was considered. These upsetting events include reactivity transients, piping failures, seismic activity, flooding from inside as well as outside the plant. The analyses include the explicit consideration of various levels of damage to the plant, the performance of features that influence the transport of radionuclides as well as health effects to the public.

The basic approach that was developed and refined in nuclear power applications has been successfully transferred and specialized for application in a variety of other industries. We have successfully performed probabilistic safety assessments for petroleum facilities (process units, pipeline systems, platforms, tankers and barges), chemical plant (process facilities and transportation systems), aerospace applications, defense applications, manufacturing applications, and automotive applications. Our aerospace applications have included the consideration of specific hazards at commercial airports (for example, the risk to the public of fuel storage tanks), as well as space applications (for example, the risk associated with the Space Shuttle’s auxiliary power units, Space Station Freedom as well as the Japanese Experiment Module for the space station). Defense applications include the consideration of the advanced cruise missile as well as several analyses performed for the Defense Nuclear Agency (such as the B-52 weapon system safety assessment). Our automotive and manufacturing applications have considered both the analysis of the technical feasibility of particular technologies as well as the risk significance of specific processes.

The important message here is that a proven methodology has been developed and that this methodology has been successfully transferred to rather diverse industries. The key to the success of this translation to different industries, besides starting with a robust analytical framework, is the close interaction and participation of the true facility experts—the owner/operators.

**Observations From Our Experience**

Our experience in performing numerous risk assessments for a number of diverse industrial installations provides a basis to draw some interesting general observations. Generalizations are, of course, only to be made with caution, and these observations are made with that warning in mind. We recognize and appreciate the industry-specific, indeed the facility-specific, nature of risk; however, the following are “lessons” that are commonly uncovered in the performance of assessments:

- Risk is very system and location specific. To reap the full benefits of performing a probabilistic safety assessment, the analysis should be facility-specific. Nominally identical facilities have been found to have quite different “risk signatures.” That is to say, the scenarios leading to an undesired event, the causes of failure, the frequency of failure, and the consequences of failure may very well differ for virtually identical facilities. The reasons for this variation are several fold. First, sites differ resulting in different population characteristics near facilities as well as different hazards associated with the site (such hazards as flooding, seismic activity, and severe weather). Second, different site characterizations also contribute to differences in the design or
layout of supporting features (such as the routing of electric power cables). In fact, the construction of a facility properly allows a good deal of supporting features to be specialized to the particular site. The sometimes subtle design features often heavily influence the risk signature of a facility. Third, the “human element” may very well differ between nominally identical facilities. Even with identical procedures and similar training and requirements, the corporate, individual, and regulatory “culture” surrounding a facility can influence the risk profile.

These observations have been expressed in the past simply as “generic facilities do not experience failure—specific facilities do.” Performance of a probabilistic safety analysis on a “generic facility” unavoidably yields diluted insights.

- **Worst case scenarios are seldom important contributors to risk.** We, as engineers and emergency planners, have done a reasonably good job in designing facilities to respond to specified challenges. In the commercial nuclear power field, the “design basis accident,” thought at one time to represent the most challenging event to the plant’s safety systems and operators, involved the failure of a large diameter cooling pipe. Safety analyses, operator training, and plant design focused largely on events. Plant-specific probabilistic safety analyses indicate that this class of events is a rather small contributor to many risk measures. In fact, perhaps in part because we focused on such events in the design phase, these events can hardly be considered “worst case” events for operating plants; seemingly more benign events such as the loss of offsite power sources typically are more risk significant. An important corollary to this point is that the focus on “worst case” events automatically creates an unattainable goal. If we are not restrained by the frequency of specific events, we can always define an event or challenge to a facility that is more severe than a previously postulated insult.

- **Contributors to risk can be isolated and importance ranked.** We begin with the question, “What is the risk associated with the facility?” This is what we mean when we say that we approach the problem “from the top.” We then proceed to formulate our answer to this question by systematically restating the question in a more specific manner. For example, if a hazards analysis concludes that the facility is either associated with risk to the workers, risk to the public, or risk to the physical plant, the second level question would restate the question in three parts:
  — Is the risk associated with worker risk?
  — Is the risk associated with public risk?
  — Is the risk associated with risk to the physical plant?

Supported by the results of the hazards assessment, we can claim that we have fully and completely answered (or restated) the top-level question. We continue this process of moving carefully to the more precise until we have replaced the questions with increasingly more specific representations. At each level, we strive for completeness. Eventually, this recasting process results in specifying families of scenarios characterized by an initiating event followed by human, facility system, or phenomenological responses that link the initiator to one or more of the risk end states of interest. We stop the unraveling process when we can adequately quantify the components of the scenario. By identifying and decomposing the risk into
scenarios, we uncover the contributors to risk in a manner that facilitates the identification of risk management opportunities. Once these contributors have been identified, they can be isolated and importance ranked.

- System insights, not numbers, are the most important result from probabilistic safety assessment. Of course, the quantitative results are of interest in completely describing the risk. What is meant here is that the systematic development of the risk framework itself typically reveals valuable insights as to the nature of the risk of the facility. In addition, the multi-disciplinary nature of the probabilistic risk assessment process (involving operations, planning, design and maintenance, for example) allows for an integrated view of the facility to be developed. The resulting framework clearly shows how these different disciplines interact and facilitates communication between these often isolated departments.

- Risk must be modeled from the top down and quantified from the bottom up. This point expands on an insight discussed above. The top-down approach encourages completeness and clarity of “the answer.” In moving from the top down, we move from the general to the specific. We aim to develop the specific representations in a manner that enhances our ability to quantify the scenarios with confidence.

- Multiple failures, dependencies, and human response dominate the risk of highly redundant systems. That multiple failures are important is not too surprising given the attention given to redundancy in design. What is a bit surprising is how we have allowed subtle interactions partially to defeat our carefully designed redundancy. Motive power, initiation signals, indication of process parameters may be common to several otherwise redundant systems or functions. It is often common to observe that the human element shows up as important in risk scenarios. Of course, all failures might be traced back to a human—in design, construction, training, or operations. We refer here to the human as he or she directly interacts with the facility in defining the scenario.

Typically this is through operations, training, or maintenance activities. Of course, one must observe also that the human element is one of the most beneficial elements in averting or arresting an undesirable scenario. Increasing awareness is being voiced that the answer to the “human factor” is not simply prescribing more procedures and training. It seems sometimes that procedures and training are adequate or even very good. What may be the underlying problem is in some sense cultural—“I know the procedure, why should I follow the check list? If I skip the second party check, I can return the component to service on schedule...I know I corrected the problem.”

- Role of specific safeguards and natural phenomena is clearly defined. As described above, the influence of specific safety measures or natural phenomena (such as severe weather or flooding) can be explicitly revealed if these elements are built into the scenarios.

- Quantification of uncertainty is critical to effective risk management. Simply put, as risk analysts, we have only performed half of our job if we fail to provide a meaningful
representation of the underlying uncertainty of our answers to the decisionmakers. The communication of a range of values in which we are, say, 90 percent confident provides significantly more information to the decisionmakers than a single value. More interesting are the instances sometimes encountered when evaluating design or procedural options. We may be confident that specific options would enhance safety, but sometimes there is a small chance that safety will actually be degraded. Not communicating our uncertainty to the decisionmakers would not provide them sufficient information, particularly if the decisionmakers are risk adverse.

In describing the process of risk assessment to nonanalysts and attempting to communicate the results, several common points of confusion are encountered. A few of these are:

— Risk versus zero risk. All actions carry some level of risk, including the alternative of "doing nothing."

— Risk versus hazard. Hazards represent potential. How this potential plays out is risk. Risk can be managed. The North Atlantic Ocean represents a hazard; how we choose to cross it, either in a row boat or an ocean liner, determines the risk we take.

— Uncertainty versus quantitative analyses. Uncertainty is an integral part of a quantitative analysis, not an optional addendum to one.

— Worst case versus all cases. As discussed above, consideration of "worst case" analyses is an inefficient way to manage risk.

— Probability versus statistics. We reserve the use of the language of probability to express our state of confidence based on all available evidence. This sometimes generates an area of confusion for those who choose a purely academic, statistical viewpoint.

— Hard data versus no data. Evidence is data. This evidence may be in the form of actuarial data, facility histories, or expert knowledge. An essential part of communicating this evidence is the communication of our confidence. The concept of "hard data" has little practical meaning. Likewise, it is difficult to imagine when one would encounter a situation where there is truly no evidence or data.

Conclusion

The application of modern probabilistic safety assessment techniques in several diverse industries has been demonstrated to yield several distinct benefits. Among these are an increased understanding of the integrated operation of the system in question, improved communication both among groups at the facility and between the facility operators and the community, the provision of sound information to support informed operational and regulatory decisionmaking, the provision of one component of a basis to implement an effective risk management program leading to safer facilities, and the provision of a framework to build confidence in the facility’s operation.

We are confident that the specialization of a modern probabilistic safety analysis methodology to airport operations, followed by the application of this methodology to a specific facility, will yield important insights leading to an increased understanding of risk as well as to opportunities to enhance safety. A proven methodological framework already exists that has been successfully applied in a wide variety of applications. Such an application would constitute an integral part of
addressing the recommendations of the recent RAND report on the Schiphol Airport\(^1\) relating to safety management, maintaining and enforcing high standards, implementing safety enhancements, and informing the public and maintaining trust.

Session 2: Safety Issues
Jan L. de Kroes

Managing the Quality of Technology-Based Systems

There are many hazards that threaten human life. First, there are natural disasters, such as earthquakes, eruptions of volcanoes, storms, floods and lightning. Included in this category are most illnesses, still the most important cause of death, loss of health and disability. Second, there are man-made hazards such as wars, revolts, terror and violent crimes. Most of these mentioned hazards also threaten man’s property.

With the start of technology there also came the technology-based hazards: a technology-based system breaks down and this event threatens human life and property. Since the start of the Industrial Revolution the technology-based systems became more complex and these hazards became more predominant. They are man-made, but the crews of these systems, unlike the committers in the first mentioned man-made hazards, do not intend to harm other humans.

Managing safety in and around airports is managing the safety of a technology-based system. In going from one kind of system to another, the details will be different, but the general principles are basically the same. When one encounters a problem in managing the safety of one’s own system, it is very useful to learn from the solutions found for comparable situations in other technology-based systems. It is not necessary to re-invent the wheel each time again. This is not new; in the beginning of air transport much was adopted from the maritime system, such as the nautical mile and the rights and duties of the captain. An indication for the unity of safety aspects of all technology-based systems is the activities of the American National Transportation Safety Board (NTSB). Besides all kinds of transport accidents, the NTSB also investigates accidents in chemical and nuclear plants in depth. As an electrical engineer with practical and teaching experience in telecommunications, traffic guidance systems and transport safety, I learned that managing safety is part of an even greater field: managing the quality of technology-based systems.

The method by which this is done can be described shortly as checking, monitoring, and controlling the abilities of the personnel and facilities of the system. When the abilities are deficient, the relevant persons are retrained or replaced. When the facilities do not meet standards the relevant parts are repaired or replaced. This is the base of Quality Assurance Schemes, as described in the ISO-9000 standards. In these standards, methods are described that show how the organization and management of technology-based systems can be improved with the assistance of independent outside inspectorates and certification bodies. The old situation can be characterized by the Dutch saying: The butcher inspects its own meat; and the new situation by: The butcher inspects its own meat with independent outside help for inspecting his abilities, facilities and products.

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Functional quality and reliability are two sides of quality; safety is a part of reliability. Events of disfunctioning of a system can be seen as precursors of incidents and accidents and should be watched and treated with care. They are a source of loss in revenue of the company and loss of service offered to the customers.

The ISO-9000 standards are an introduction to a hierarchy of standardization bodies, inspectorates and certification bodies. The standardization bodies (e.g., ICAO) make standards that are established with the help and great consensus of all parties concerned. The word standards is used here as a broad term and includes also instructions, rules and recommendations. The standardization bodies can be compared with the legislative power of government, which makes the laws. The inspectorates, on the other hand, should be independent of the parties concerned. The inspectorates can be compared with the executive power of government, which enforces the legislation. The certification bodies should be independent of the parties concerned and of the inspectorates but should be using the files prepared by the inspectorates for a well-considered judgment. The certification bodies can be compared with the judiciary. The spirit of Montesquieu thus hovers over the world of standardization.¹

In the above description, we recognize the proficiency test of pilots and air traffic controllers and their recurrent training. And certification could be the solution to the dangers of counterfeit spare parts.

The close relationship between standards and safety is also apparent in the International Team for Risk Management and Decision Analysis, formed by the American company PLG and KEMA, a well-known Dutch testing house and certification body for electrical equipment.

Safety of Crew, Passengers and Neighbors; Individual and Group Risk; Objective and Subjective Safety

A measurement of unsafety in air transport could be the sum of the loss of human lives and properties during a year. Dividing this sum by the number of passenger miles in that same year will give you a value for the risk that a passenger took in that year while traveling a mile by air. As many accidents occur during takeoff and landing, the model has to be refined so that a long flight is safer per mile than a short one. Also, the unsafety of ground transport to and from the airport should be added. Along the same lines a model for crew risk can be developed.

Also for the neighbors of the airport models can be made and the curves can be drawn around the airport inside which the chance of losing one's life is higher than $10^{-5}$, $10^{-6}$ or $10^{-7}$ per year. This risk will vary during the day and night with the variation of aircraft taking off and landing. These unsafe zones are predominantly at the end of runways.

¹ Montesquieu (1689-1755), president of the parliament of Bordeaux, who traveled to many European countries, including his own country France, England and the Netherlands and studied the laws and related institutions, put forward the three power system (trias politica), in which the legislative, executive and judiciary branches should be independent from each other and check each other. The U.S. Constitution is modeled after this system.
These are all individual risks: risk of an individual who happens to be in the dangerous spot. If it is highly unlikely that there is a person in the unsafe areas, little attention has to be given to this risk. But when the number of people that live, work and travel in the risky areas is considerable, this has to be accounted for in the group risk curves, that are not allowed to exceed a given limit.

All of these risks are objective. They can be objectively assessed, modeled and calculated. They are mostly very different from the personal feelings of unsafety. These subjective unsafety feelings can be assessed by asking people questions, how they rate the different risks in life. In that case hazards with a great number of casualties per accident, as is the case with air transport, receive a relatively higher rating then road traffic in which the number of people involved is mostly small. It can be compared with the fact that the chance of winning in a lottery is overrated if the prize is big.

But publicity is involved as well. For that reason the danger in and around the house is rated much less than the danger on the road, while the opposite is true. And because of publicity the hazard of crime is much overrated. Environmental factors, such as noise, stench and smoke also add to the feeling of unsafety: Where is smoke, there is fire; where is noise, there is danger. The risks of lightning and falling rocks have caused in our nature the association of noise with danger. Noise at night not only contributes to insomnia but also to the subjective feeling of unsafety.

Analysis of Safety; In-Depth Investigation; Safety Impact Assessment; Design for Safety; Safety Audit

In-depth investigations of accidents in the different modes of transport have a number of common elements that can be distinguished:

- the establishing of facts
- the reconstruction of the accident
- the consideration and determination of the possible causes of the accident, also the most distant
- the consideration of the possible measures for improvement
- the recommendations.

Another shared characteristic is the multi-causality of accidents. This is furthered by the measures taken to prevent that one cause only could cause an accident. Still, in general, people are readily content with finding only one cause. Even if other causes cannot be overlooked, some people like to speak of the major cause and the minor causes. These people are looking for only one scapegoat! Very likely the moncausal thinking is deeply rooted in our nature. It is like the conviction of many people that heavy objects fall faster than light ones.

In a number of countries—the United States, Canada and Sweden—the in-depth investigation is done by one independent board or council for all or most modes of transport together. In the Netherlands, we have separate independent councils for the different modes of transport. They are in the course of coming together in one umbrella organization. This will further the flow of
Investigation knowledge from one mode to another. To underline the importance of independence of accident investigation, the International Transport Safety Association (ITSA) was established between the boards and councils of the United States, Sweden, and the Netherlands. It is open to investigation bodies of all countries, either as a member (being independent) or observer. In the European Union the European Transport Safety Council (ETSC) came into being, open to all parties concerned with transport safety in Europe.

As a source of system improvement the in-depth investigation has the disadvantage that first an accident with its casualties or a near accident with its implied danger has to occur before measures can be recommended and taken. Fortunately, there are other sources of improvement that do not have this disadvantage: the safety impact assessment, the design for safety and the safety audit. In the safety impact assessment, an assessment is made of the increase or decrease of risk caused by a new measure or a new system. This is done before the measure is taken or the system is ordered and put into operation. In the design for safety, at every step of the design process the different aspects of safety are assessed and compared with the design requirements. The design for safety principles should be applied for the development of wide-bodied aircraft for 1000 passengers followed by a safety impact assessment conducted by an independent body before worldwide acceptance. In the safety audit, as was done for Amsterdam Airport, the whole system or combination of systems is examined and compared with systems elsewhere. This does not only have to be systems of the same kind but could also be systems of other transportation modes and industrial systems. These audits can be compared with the quality certificates that were mentioned in the beginning of this paper.

**Economics of Safety**

There is an American saying: If you think safety is expensive, try an accident. The loss of reputation for air transport in general and for the airline and airport involved in particular should also be taken into account in the cost of an accident.

Investments in safety will decrease the number and severity of accidents. These investments should be counter-balanced by the diminished damage and loss of life. The diminished damage can be accounted for. But how to account for the diminished loss of life, health and ability? If there is a guilty party, it can be sued for economic and personal damage. These lawsuits and awarded damage claims give the necessary economic signals to management.

There is also an emerging European practice that the community as a whole feels itself offended by the accident. In that case the public prosecutor will claim the damage and an extra fine from the guilty party. Two cases in the Netherlands, both in the chemical industry, were settled out of court. But the economic signal was given.

**A Global System of Auditing**

There are two drawbacks to the above practice. First, multi-causality also leads to more guilty parties and a difficult distribution of damage claims and fines. Second, there has to be an accident with damage and casualties before wrong practices can be changed. It is better to have a regular
(three years according to ISO-9001) safety audit of all the different parties that contribute to the quality, in our case to the safety, in and around the airfield. In this way the safety can be controlled and increased without accidents and casualties. As it is now customary for companies to have a yearly audit of their financial soundness by an independent auditor, it is to be hoped that in the future it will be customary that partners in transportation all have regular independent audits of their soundness in safety. Insurance companies would favor such audits as well, and the safety image of air transport in general would be considerably improved by the practice of auditing by an independent auditor. As the financial audit has considerably improved and harmonized worldwide accounting practices, the safety audit could give rise to better and more uniform registering and handling of incidents and accidents, or more generally events of disfunctioning of systems. When safety auditing becomes common practice, safety requirements will also become more harmonized and tightened in the course of time. Auxiliary systems such as fire brigades and ambulances are part of the system, and also should be fully audited. The independent auditing companies should preferably be multinational and multimodal in order to further the flow of safety knowledge from one country to another and from one mode of transport to another. The multimodality will make these companies also more aware of multimodal hazards, such as gasoline stations at a motorway and a tunnel mouth of a railway in the risk zones at the end of runways. In this situation also an auxiliary system (under control of the airport control tower) should be installed to stop in case of emergency the road and railroad traffic going into the dangerous area. The occupants of the road and railroad vehicles should also be accounted for when determining the group risk.

But who will guarantee the quality of the audit? Or differently stated: who will audit the auditor? Some think that a central world organization is necessary for that. But practice already proves that this can be done by peer assessment. It can be organized by the association of top league independent safety auditing companies themselves, in the following way:

Regularly, each auditing company is audited by two of its fellow auditing companies, selected at random. In the audit, recommendations for improvement can be made and the quality of the safety audits will therefore increase and become more even. As a result of this audit, the rules for auditing in the course of time will be mostly formulated as standards. An auditing company that ignores the recommendations of its fellow auditing companies will make itself vulnerable for expulsion. Also, new members before admission are scrutinized by peer assessment. The rules of the association should be such as to prevent this mechanism from resulting in virtually one auditing company for the whole world. This would lead to petrification and accusations of misuse of its monopoly position.

This system works well for certification bodies for the safety of electrical equipment, in the Committee of Certification Bodies of the International Electrotechnical Commission System for Conformity Testing to Standards for Safety of Electrical Equipment. The already mentioned company KEMA at Arnhem participates in this scheme.

The European Union could contribute greatly to the safety of air transport in Europe by requesting a regular independent safety audit of all European airports and of the airlines that make use of them.
DISCUSSION SESSION 2

Henk Sol
How are you handling the rational approach of risk analysis on the one hand and the often irrational representation of the rational facts on the other?

David Johnson
Most of the irrational people I have had direct experience with have been in the regulatory arena. These were people that saw the rules, just the rules, and you should meet the criteria regardless of the rationale behind them. In the nuclear business, in the energy field with the Department of Energy, and in the defense area we are slowly winning the argument. It does present a challenge to you and you have to be open-minded in the risk assessment area. It is not a perfect science.

Henk Sol
And how should you teach this risk analysis? What kind of people and skills are needed to apply these kinds of techniques?

David Johnson
In putting together an organization that conducts risk analysis, we have found that you need a firm understanding of the industry you are working with. We can teach everybody the modeling skills and such, but a firm engineering insight is the most important skill.

John Van Oudenaren
The plea for a global auditing system seems, at least at some levels, to run counter to Dr. Johnson’s call for a facility-specific approach and Mr. Everitt’s argument of giving prime responsibility for safety at the airport level. How is that being perceived by people from the airports?

Gerhard Stadler
I would like to respond to that from an organizational perspective. Realizing that more and more airport operators from the Eastern European countries are coming to our territories, we decided in ECAC to make audits before we accept new member countries. We must not look at operational safety alone, but also put emphasis on the security of transportation, i.e., terrorism. That is an additional point that is special to aviation. It is our intention to make such audits for all states that want to become a member of ECAC, because if we admit them to our forum, it will have a meaning to the outside world that they have a certain standard of safety. One final point is the problem of liability. If we agree on certain elements within a safety audit, who will be liable when an accident happens?

Henk Sol
A number of organizations receive ISO-certifications and that seems to work quite well. But many of these organizations work in a network or chain of activities, and it is very difficult to set up a certification for these independent organizations in which their connection with other players in the global context is reflected. What could be a solution to that?
John Enders
I support the idea of safety audits very vigorously and standards by which the auditors are judged are quite needed. The Flight Safety Foundation has conducted safety audits of aviation operations for many years and we find we view the airport through the eyes of the airport client, either a corporate operator or an airline. We also find there is quite a variability between airports. As far as the quality of the auditor is concerned, we know that some auditors audit airports based on their own experience as a former associate of a corporate operator or airline. In this respect, certain standard setting for audits should be pursued. IATA has laid out some guidelines for operators and maintenance audits, and I think the same should be done for airports.

Jan de Kroes
This is all very important, but I also stress the point that an independent supervisor will assist the involved parties in maintaining their in-house quality. An internal audit is good, but there definitely should be some outside help to have the independence. This will gain much public appeal and legitimization. Who gives the authority for making these kinds of audits. The real authority comes from a strict, honest audit and good support from people. In this way it can be done effectively, and if you do it, you will see standards of safety increase. That should not be a question of money, because you will save a lot of money by having good quality.

Richard van Otterloo
KEMA certifies according to ISO-9000 standards. It is possible to audit a factory that produces wooden jet engines and hand out an ISO-9000 certification. What I want to illustrate is that if you want to audit the safety of airports, you will need to start with detailed analysis of those airports. From that analysis you will come up with criteria that for example you will have to certify once every two years.

Gilles van Hövell tot Westervlier
I would like to refer to the system we have developed within JAA in Europe. In a maintenance organization, for example, there is an independent organization conducting the auditing. The national aviation authorities audit this independent organization. On its turn, an international maintenance standardization team is auditing the national authorities. This system works very nicely, and could perhaps be used for the airport safety auditing.

Jan de Kroes
Of course, the ISO-9000 certificate does not guarantee safety by itself, but it does give you a very useful structure to think about and it should be completed by other standards made by for example IATA-standards that would forbid the production of wooden engines. Furthermore, ISO-9000 should be enhanced by the users.
Session 3: Safety and Air Transport—Policy and Practice
Ronald Ashford *

CIVIL AIR TRANSPORT SAFETY: ACCIDENT CAUSES AND A PROPOSAL FOR FOCUSED REGULATORY TARGETS

Introduction

This conference is largely focused on safety at and around airports. This paper takes a broader look at the safety of civil air transport, examines the trends and considers the future. An approach is proposed aimed at ensuring a continued improvement in civil aircraft safety in a manner that minimizes the economic consequences.

Safety in Civil Air Transport—The Historical Record

Air transport activity has achieved extraordinary growth over the years. For example, the ICAO world data ¹ (excluding the former USSR) shows that the number of passengers on scheduled services by large airplanes carried annually has increased from 106 million in 1960 to 1070 million in 1992—growth by a factor of over 10. As the average size and seating capacity of airliners has grown, the number of flights has increased less dramatically, from 6.6 million to 14.87 million, an increase by a factor of 2.25².

In the first five years of the period, there were an average of 28.4 fatal accidents per year; this “smoothed” figure gives an annual rate of 4.3 per million departures from 1960-1965. If this accident rate has continued unchanged, the growth in the annual number of flights would have resulted in 64 fatal accidents in 1992, which would probably have been unacceptable to the traveling public. In fact, the average number of fatal accidents per year in the last five year period was 24.8, little changed from the earlier period in spite of the large increase in the number of flights; this is, of course, because the increase in the fatal accident rate has reduced (from 4.3 to 1.67 per million departures).

Due to the reducing accident rate, and the improved survivability in accidents, the actual number of fatalities has changed little. In the first five years it was an average of 764 p.a. and in the last five years 693; if the accident rate had not been reduced one could have expected about 1800 fatalities each year over recent years. This is summarized in Table 1.

* At the time of this writing, Ronald Ashford was Secretary General of the Joint Aviation Authorities. The views expressed in this paper are those of the author and not necessarily those of the Joint Aviation Authorities.
²ICAO : Document 9180/18.
<table>
<thead>
<tr>
<th>Year</th>
<th>No of Flights (M)</th>
<th>No of Fatal Accidents (Smoothed)</th>
<th>Fatal Accidents per million flights</th>
<th>Fatalities (Smoothed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>6.6</td>
<td>28.4</td>
<td>4.3</td>
<td>764</td>
</tr>
<tr>
<td>1992</td>
<td>14.87</td>
<td>24.8 (63.9)</td>
<td>1.67</td>
<td>693 (1784)*</td>
</tr>
</tbody>
</table>

* Figures in brackets result if the accident rate had remained unchanged

Table 1—Accident Rate 1960, 1992

Safety—A Target

Safety standards are, to a large extent, ultimately driven by the need for acceptance by the public. The expectations from the public transport systems are far higher than those accepted for private transport. An increase in the number of civil airliner accidents, or the number of fatalities, by a factor of two or three would be unlikely to be accepted without calls for much improved standards and tighter safety regulation. Governments, authorities and industry would respond to these pressures. In aviation the industry works in close cooperation with its safety regulators (and this can be fully compatible with the absolute need for independence). Both have ensured improving safety standards and the remarkable improvements in the accident rates described above.

The target must always be “zero accidents”. In the real world, however, safety can never be absolute. It is suggested that the minimum acceptable future level of safety is that there should be no increase in the annual number of fatal accidents or in the number of fatalities. For the countries with less satisfactory safety records the priority must be to eliminate this difference so that their level of safety is no worse than the better countries.

The long-term rate of expansion in civil air traffic has been forecast on frequent occasions. It is likely to be far higher in some regions (e.g., the Pacific Rim) than others. A reasonable estimate worldwide might be 6 or 7 percent. To ensure that the number of fatal accidents does not increase this would require a reduction in the fatal accident rate to 28 percent of the current rate over the next 20 years, other things being equal.

In practice, both an increase in the average aircraft size and an improvement in survivability can be expected and each would slightly reduce the improvement otherwise needed in the accident rate to meet the suggested criteria. One can conclude, therefore, that a minimum acceptable reduction in the fatal accident rate is by a factor of three over the next twenty years.

Recent Safety Levels

Achieved safety levels differ widely for aircraft registered in different regions of the world. Figure 1, based on data in an Airclaims note, gives the relative fatal accident rates for jet airliners from different parts of the world, expressed as an average rate for the last five years.

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Boeing has provided similar data\(^1\) for U.S. (and therefore worldwide) operations. Equivalent Airclaims data\(^2\) for individual European countries have been used to produce figures for the present 23 JAA countries from 1973 to 1993 (even though some of these countries have only recently joined JAA). These data, shown in Figure 2 below, show that the record of the JAA countries was significantly less good than that of the United States up to 1984 but appears to be better over the last ten years.

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The improving trend in safety over the most of the last twenty years appears to have leveled off, or reversed, in recent years. Therefore, well targeted action should be taken to ensure a return to clearly declining accident rates.

Analysis of the Factors in Fatal Accidents

With the aim of focusing on the most productive areas for improvement in order to achieve a continuing reduction in the accident rate, data on fatal accidents to civil jet airliners and executive jets have been studied and a judgment made of the causal and circumstantial factors (usually several for each accident)\(^1\). The data have been taken from the UK CAA's World Airline Accident Summary\(^2\) and ICAO "ADREP\(^3\). Aircraft covered are turbojet and turbofan airplanes of 5700 kg or more maximum weight (i.e., not turboprops or piston-engine airplanes). The factors considered under various categories are shown in Table 2. For each accident a judgment has been made of the apparent or probable causal and other factors, in the light of the reported details. Clearly the judgments on such limited data cannot be assumed always reliably to reflect the actual causes, but it is believed that they serve as a useful indication of the relative importance of the various factors. A total of 219 accidents has been considered in the sample and 824 causal factors allocated in all, an average of about 3.8 per accident.

Factors such as "post-crash fire" are only identified where they were considered to be directly relevant to survivability and were not recorded where there was no chance of survival for other reasons.

<table>
<thead>
<tr>
<th>Group</th>
<th>Factor</th>
<th>Number of accidents where factor occurs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aircraft systems</td>
<td>1.1 Nonfitment of currently available safety equipment (GPWS, TCAS, wind shear warning)</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>1.2 Failure/Inadequacy of safety equipment</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>1.3 System failure - reduced controllability</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>1.4 System failure - other</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>1.5 Nonfitment of potential new equipment (enhanced GPWS)</td>
<td>31</td>
</tr>
<tr>
<td>2. ATC/Ground Aids</td>
<td>2.1 Incorrect or inadequate instruction/advice</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>2.2 Failure to provide separation</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>2.3 Lack of ground aids</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>2.4 Wake turbulence - aircraft spacing</td>
<td>1</td>
</tr>
<tr>
<td>3. Atmospheric</td>
<td>3.1 Structural overload</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>3.2 Wind shear/upset/turbulence</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>3.3 Poor visibility</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>3.4 Runway condition (ice, slippery, standing water, etc.)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>3.5 Icing</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Ashford, R., "Casual Factors Attributed to Fatal Accidents: Civil Turbojet/Turbofan Airplanes, Worldwide 1984-93". Issue 1, 16 September 1994.

\(^2\) UK Civil Aviation Authority : CAP 479 : "World Airline Accident Summary; Accidents Occurring to airplanes of more than 5700 kg maximum weight. Volume 2: 1976 onwards".

\(^3\) ICAO : ADREP's : Occurrences from 1984 to 1993 inclusive to turbojet and turbofan aircraft in passenger and/or cargo operations involving fatalities. Reference AN 6/25 (063/94).
| 4. Crew | 4.1 Lack of situational awareness | 75 |
|         | 4.2 Incorrect selection on instrument/navaid | 7 |
|         | 4.3 Action on wrong control/instrument | 4 |
|         | 4.4 Slow/delayed action | 23 |
|         | 4.5 Omission of action/inappropriate action | 57 |
|         | 4.6 Failure to cross-check/co-ordinate | 118 |
|         | 4.7 Fatigue | 6 |
|         | 4.8 State of mind | 6 |
|         | 4.9 Fast/high on approach | 9 |
|         | 4.10 Slow/low on approach | 13 |
|         | 4.11 Loading error | 4 |
|         | 4.12 Flight handling | 60 |
|         | 4.13 Lack of qualification/training | 11 |
|         | 4.14 Incapacitation | 2 |
|         | 4.15 Failure in look-out | 4 |

| 5. Engine | 5.1 Engine failure | 22 |
|           | 5.2 Damage due to noncontainment | 5 |

| 6. Fire | 6.1 Fire due to engine failure | 4 |
|         | 6.2 Fire due to aircraft systems | 4 |
|         | 6.3 Fire-other cause | 8 |
|         | 6.4 Post crash fire | 24 |

| 7. Maintenance | 7.1 Failure to complete due maintenance | 1 |
|                | 7.2 Maintenance or repair error/oversight/inadequacy | 12 |
|                | 7.3 Ground staff struck by aircraft | 2 |

| 8. Structure | 8.1 Corrosion, fatigue | 3 |
|              | 8.2 Structural failure | 7 |

| 9. Failings leading to impact with terrain/obstacle | 9.1 Collision with high ground | 49 |
|                                                    | 9.2 Collision with level ground/airport | 35 |
|                                                    | 9.3 Impact with obstacle/obstruction | 28 |
|                                                    | 9.4 Midair collision | 8 |

Terrorism and sabotage, and test and military-type operations are excluded. Also fatalities to third-parties who were not concerned with the operation of the aircraft are excluded.

**Table 2—Factors Attributed to Fatal Accidents**
*(Each accident may have more than one factor)*

The number of accidents where a given factor has been judged to have occurred is shown in the last column of Table 2.

From the above data a ranking can be made to indicate the apparent relative importance of the factors. The most frequently occurring factors are listed in Table 3.

<table>
<thead>
<tr>
<th>Factor (Group)</th>
<th>No of Occurrences</th>
<th>% of Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure to cross-check/coordinate (crew)</td>
<td>118</td>
<td>34</td>
</tr>
<tr>
<td>Lack of situational awareness (crew)</td>
<td>75</td>
<td>34</td>
</tr>
<tr>
<td>Flight handling (crew)</td>
<td>60</td>
<td>27</td>
</tr>
<tr>
<td>Omission of action/inappropriate action (crew)</td>
<td>57</td>
<td>26</td>
</tr>
<tr>
<td>Collision with high ground (impact with terrain/obstacle)</td>
<td>49</td>
<td>22</td>
</tr>
<tr>
<td>Nonfitment of currently available safety equipment-GPWS/CAS/wind shear warning (Aircraft systems)</td>
<td>47</td>
<td>21</td>
</tr>
<tr>
<td>Failings leading to collision with level ground/airport (impact with terrain/obstacle)</td>
<td>35</td>
<td>16</td>
</tr>
<tr>
<td>Nonfitment of potential new equipment-enhanced GPWS (Aircraft systems)</td>
<td>31</td>
<td>14</td>
</tr>
</tbody>
</table>
Table 3—Ranking of Factors in the Accident Sample

<table>
<thead>
<tr>
<th>Factor</th>
<th>28</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failings leading to impact with obstacle/obstruction (impact with terrain/obstacle)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of ground aids (ATC/ground aids)</td>
<td>24</td>
<td>11</td>
</tr>
<tr>
<td>Post crash fire (fire)</td>
<td>24</td>
<td>11</td>
</tr>
<tr>
<td>Slow/delayed Action (crew)</td>
<td>23</td>
<td>11</td>
</tr>
<tr>
<td>Poor Visibility (Atmospheric)</td>
<td>22</td>
<td>10</td>
</tr>
<tr>
<td>Engine failure (engine)</td>
<td>22</td>
<td>10</td>
</tr>
</tbody>
</table>

It is striking that “failure to cross-check/coordinate” is judged to have been a factor in 118 out of the 219 accidents (54 percent). This was often related to “lack of situational awareness”, the next most frequent item (75 occurrences). This suggests that making the maximum use of all navigational means is of prime importance. “Flight handling” and “omission of action/inappropriate action” by the crew are roughly equal in frequency and next in importance. All of this suggests that human factors, flight deck skills, professionalism, Crew Resource Management (CRM) and training are the key areas for reducing the number of accidents. In other words, it is more important to focus on how airplanes are operated, including the equipment fitted for each kind of operation, than on the airplane itself.

Obviously intrinsically related to “lack of situational awareness” is “collision with high ground” and “collision with level ground/airport” (Controlled Flight Into Terrain—CFIT) which together occurred 84 times (49 and 35 respectively). In 47 cases it appears that the absence of a Ground Proximity Warning System GPWS (usually in older airliners or executive jets) was a factor. Another classification used, however, was “nonfitment of potential new equipment-enhanced GPWS”. There are certain cases where early or current GPWS is not effective, e.g., a modest descent rate in the absence of an ILS glide slope, a very steep mountain side or an obstruction. Work to develop enhancements to the current equipment is being pursued by some companies. The known aircraft position from INS or GPS is compared with stored terrain/obstruction data and potential conflicts initiate a warning; this approach appears to be feasible and has the potential to address the few areas where the present equipment has weaknesses. The analysis suggests that such developed GPWS might have been effective in preventing up to 31 fatal accidents. Such developments should therefore have high priority.

Other areas highlighted as important are a “lack of ground aids” at some airports and “post crash fire”—both areas where some improvements have been made (e.g., the increased provision of ILS and VORs and fire hardening of cabin furnishings). “Slow/delayed action” by the crew again emphasizes the need for improved flight deck skills, professionalism and training referred to earlier.

Engine failure, particularly that involving noncontainment, maintenance problems, corrosion and fatigue and structural failures as well as—inevitably—poor visibility are among the other factors that can be identified. There are also areas that occur quite frequently but are less dominant than the issues discussed previously.
In the context of this conference, it is seen that the direct influence of airports standards is relatively modest. Lack of ground aids is shown to be an important factor as is the importance of good fire and rescue facilities to deal with post-crash fires. In both cases these were factors in 24 out of the 219 accidents (11 percent).

**Improvements to Safety Through Focused Requirement Action**

a. General Areas Indicated by Accident Experience
The analysis and discussion above suggests areas where the authorities and industry should consider focusing their attention to achieve the safety improvements that will be needed. These may be summarized:

- The development of the concept of “quality assurance” in human factors, including major improvements in learning from experience. (JAR-OPS will be the first set of operational rules to address this concept).
- The universal application of high standards of basic conversion and recurrent training, with continuing independent checks of proficiency.
- An emphasis on the need to develop and maintain the correct flight deck culture, command, teamwork and challenge as reflected in the best CRM programs.
- The requirement for the fitment of Ground Proximity Warning Systems (GPWS) by all countries, and extending the range of aircraft for which they are required.
- A program to require the later standard of GPWS to be incorporated and urgent work to develop, and hopefully introduce, “enhanced” GPWS in the future.
- Clear and positive training in all airlines of crew action in response to a GPWS warning.
- An acceleration of programs for the installation of modern navigational and landing aids.
- These priorities should not preclude further attention to other issues—including corrosion, structural fatigue, maintenance, safety of ground staff, crew fatigue and wind shear warning.
- Some potential safety actions can be described as “systemic” changes which are likely to have beneficial effects on more than one identified problem area. Efforts should be made to identify these and particularly consider action in such cases.

b. Response to Individual Accidents/Incidents
There is a need also to ensure that positive and adequate actions are taken in response to individual accidents and known incidents, where this is appropriate. Too often an accident occurs where a particular failure or inadequacy is involved and it is later recognized that this same aspect was a factor in earlier incidents or accidents but the chain of communication failed somewhere between the occurrence and the corrective action. Not to have taken adequate and timely action earlier means that the later accident was avoidable and industry and authorities can be criticized for the lack of earlier action. Unfortunately, there are clear examples where such failures to act appear to be evident and NTSB and other independent air accident investigators have highlighted such cases.
Authorities and industry must ensure that all appropriate corrective actions are taken in the light of accident or incident experience. In some cases this may involve temporary "holding" actions (e.g., regular inspection) pending development of a final solution (terminating action).

c. Application of New Requirements
The third aspect of necessary regulatory actions is the selective application of the latest requirement standards. In the area of aircraft certification there is a constant development and improvement of the requirement standards and a new aircraft type is required to meet the latest rules that are adopted at the time of application for its Type Certification. The same rules are, however, not normally applied to aircraft in development, production or service. This aspect merits further discussion and is addressed in the next section.

The Problem of Using Outdated Requirements on “Derivative” Aircraft

The aviation safety authorities of the major aircraft manufacturing countries have for a long time accepted the principle of generally allowing manufacturers to use the certification basis applied to the first of a new “family” of aircraft for the later variants or “derivatives”, however many years later a new derivative may be launched (and this can be thirty years later). This may mean that in most areas the certification requirements for an aircraft which was one of the last variants of the type and which has had a twenty year service life can be those that were current fifty years previously. Where new features are introduced, however, it is usual for the latest requirements to be applied. The joint FAA/JAA/Industry International Certification Procedures Task Force (ICPTF) has been reviewing this policy and trying to establish new procedures to give a rational basis for deciding when to class a new variant as a derivative or a new aircraft and when to apply new requirements on new production. Another step is to define a general policy which envisages the systematic consideration for the application of all new airworthiness requirements—new type certification only, new variants, new production or retrospectively.

It is perhaps tempting to argue that new variants should always have the safety benefit of the latest requirements in all areas. This is not proposed and is not justified. A structure or item that has had the benefit of the “learning curve” of long service experience and a maintenance program refined over the years and which may have been modified or subject to Airworthiness Directives to rectify early problems can well be safer than a new design to the latest requirements but which is unproved. Also in some cases the cost of design and production changes would be very high for a small and indeterminate safety improvement that is only really practical and justified on a new aircraft type. A policy in this area therefore needs to be developed, applied carefully and reviewed in the light of its application in practice. FAA and JAA intend to work hard to achieve full harmonization.

An area of current contention that well illustrates the difficulty is the continued application of FAR 25-807(c) at Amendment 25-15. This thirty year old requirement allowed an additional 5 passengers per exit pair when approved automatic evacuation slides were incorporated for those exits. This credit was withdrawn about 15 years ago by Amendment 25-32. The original Boeing 737, for example, was allowed up to 149 passengers (subject to the 90 second evacuation demonstration) rather than 139 as was basically allowed by the exit arrangement, and this has
continued to be allowed on later variants (series 200, 300 and 500) with the same exits. The Series 400, with an additional pair of overwing exits, has equally been allowed by the FAA and some European authorities to have up to 189 passengers rather than 179. The manufacturer is now asking for the same additional 10 passengers on the "New generation" 737 (Series 700 and 800) even though no such credit was allowed or requested on later designs such as the Boeing 757/767, Airbus A-320/319/321, ATR 42/72, BAE 146, etc. The FAA is understood to be inclined to continue to allow this credit both on the new 737 and MD-90 families.

JAR-25 has never allowed such credit as the initial issue was based on FAR-25 at Amendments 25-32. Ironically, there is little or no demand in the U.S. market for the extra seats but there is a significant demand from European charter operators. JAA has decided that it will not give credit for the extra seats to any current or new application for existing aircraft or for new variants. There is no design or production change involved in applying the requirement standard that has been current for the last fifteen years but to allow reversion to the thirty-year old standard has clear implications for emergency evacuation. Fatalities would almost certainly have increased in some past accidents if the seating capacity had been higher. This issue is discussed to illustrate the difficult questions raised by such cases. A clear and consistent JAA policy for current and new applications from Europe, the United States or elsewhere would not result in any competitive disadvantage among any newly delivered aircraft. It does, however, raise an anomaly between, say, the 737-700 where no credit will be allowed and the 737-300 where credit has been given by national authorities. It seems to JAA, however, not to be reasonable to continue to allow reversion to a thirty-year old requirement for the start of production of a new variant when for many years newer aircraft types have had to meet a clearly safer standard. JAA intends to propose that the whole question of the maximum number of passengers for particular exit configurations be reviewed under the ARAC (Aviation Requirements Advisory Committee) program to try to achieve JAA/FAA harmonization.

If the safety target proposed above is to be met further work is needed to achieve a harmonized international position on the question of reversion to old and superseded requirements for derivative aircraft.

The Role of ICAO, JAA, FAA and Industry

To achieve the focused approach to safety issues proposed in this paper, it is suggested that the best approach is for the JAA and FAA, together with any other interested authorities to work with industry to carry out an analysis of the factors in accidents as described earlier but in more detail and subsequently using incident data to improve the understanding of the issues. The group could then identify and agree upon the key safety issues where safety effort should be focused.

It is not justified, it would be less effective in terms of safety, and it would be damaging to the industry to adopt a blanket approach in which safety standards are arbitrarily raised in all areas. If a selective or focused program is developed, the question arises of who should take the initiative to start such a work program. It is not felt that this is best carried out within the working structure of ICAO. ICAO itself does not have detailed and comprehensive airworthiness standards. ICAO can
also be slow to develop and adopt new standards (its ETOPS standards followed the work of the FAA and major European authorities, were less specific in some areas and were only completed after such operations had been approved and commenced). It would seem better that such a task should be tackled by the JAA and FAA together as part of their long-term strategy for international harmonization. Increasingly, JARs and FARs are becoming by far the most important regulations worldwide, and increasingly real progress is being made in their harmonization. Such work should undoubtedly be done with the full cooperation and involvement of industry and any other interested authorities who can make a real contribution.

**JAA**

It may be appropriate to give a very brief update on the European Joint Aviation Authorities, bearing in mind the rapid development of the JAA system. JAA now numbers 23 countries of which 18 are full members and 5 are candidate members. JAA is due to complete its initial work on a draft Convention by the end of this year to give it a more formal and legal basis. It is committed to develop to become as close as possible, from the industry’s perspective, to a single authority in the way it operates (“de facto” a single authority); though it will explore the practicality and best form for a true “de jure” single authority, no such decision has yet been made.

On the certification side, joint regulations have now been adopted for all classes of airplanes and helicopters as well as engines, propellers and equipment and joint certification work on small airplanes and helicopters is due to start early in 1995. More efficient and economic joint certification procedures have been devised which allow a flexible approach, from joint international teams, frequently with only one specialist per discipline but supported by a standardization system, to local teams managed by a National Authority jointly accepted as the Primary Certification Authority, according to the size and complexity of the aircraft. JAR-21(Certification Procedures) has also been adopted.

JAR-145, the approval of maintenance organizations, is in place and compliance is already required for both the base and line maintenance of large airplanes, and for engines, and will be required for all helicopters, small airplanes and all components by the end of the year. JAR approvals had been given on September 1st to 876 European companies; 850 U.S. and 46 Canadian companies had been accepted. In the case of the U.S. companies this acceptance of maintenance is agreed between the United States and JAA countries. JAR-65 (Certifying Staff) is due to go out for comment in Spring 1995. JAR-147 (Maintenance Training Schools) is being developed in a JAR Working Group. Maintenance requirements for noncommercial aviation are due to be started in 1995.

The JAA operational regulations (JAR-OPS) for the commercial operation of airplanes and helicopters are due for adoption in spring 1995, and the revisions in the light of the consultation process are now being incorporated in the revised regulations to be approved. Implementation will, however, be two years later—or possibly more. The operational requirements for general aviation are to be started next year and draft requirements for simulators are due for consultation in the coming months.
The licensing requirements for commercial and private pilots of airplanes and the medical requirements are now in the process of the second round of consultation in a revised form. The licensing requirements for helicopter pilots are due for consultation in January 1995. Adoption is planned for the end of 1995.

Finally, common bilateral aviation safety agreements between JAA countries and FAA have been drafted for signature at the end of the year. They will be substantially more comprehensive than existing national bilateral agreements. A phased implementation program for the acceptance of maintenance has been agreed.

Conclusions

The paper has proposed a possible approach to “focused” regulatory activities to improve civil aviation safety. The conclusions may be summarized as follows:

- It is believed that safety standards are, to a large extent, ultimately driven by the need for public acceptance of aviation safety.
- There should be no increase in the annual number of fatal accidents or fatalities in the future.
- To accommodate growth in the industry, the fatal accident rate should progressively be reduced by a factor of three in the next 20 years.
- The improving trend in accident rates has leveled off in recent years and a return to significant improvement is needed.
- A study of accidents can give useful guidance as to where efforts to improve safety should be focused for maximum effect. Such a preliminary study has been carried out and is summarized in this paper.
- The dominant casual factors are shown to be those related in particular to human factors, flight deck skills, professionalism, CRM and crew training.
- There is strong evidence to support the safety benefit of requirements for the wider fitment of GPWS, the use of the later equipment and work to develop “enhanced” GPWS for the future.
- Regulatory actions should be focused on the above two areas and others highlighted in the study, but also in response to failures or weaknesses shown in particular accidents.
- The review to identify justified regulatory action should aim to identify the “systemic” changes needed, i.e., those that will be effective in addressing a range of problem areas.
- There is no case for the arbitrary imposition of all new certification requirements on aircraft already in production or in service, but further work is needed to develop and refine the rules related to derivative aircraft to ensure that they share in the overall safety improvements sought.
- It is proposed that consideration is given to a joint task force to set the goals for future “focused” safety actions, involving at least the JAA, FAA and industry.
Session 3: Safety and Air Transport—Policy and Practice
Charles H. Huettenr *

It is a tremendous honor and pleasure for me to represent the United States to give you the U.S. perspective on aviation safety issues. First, I would like to describe some of the safety issues and challenges that our review of data has shown. It is remarkable to me that much of the information that has come up prior to my presentation has really led very well into what we are seeing and doing in the United States. Second, I would like to look at or discuss a new system to identify emerging safety issues that we are proposing to put together and, finally, challenge you to join with us as we all seek to improve aviation safety.

![Graph showing accident rates for different categories of flights](image)

**Figure 1—Aviation System Indicators: Accident Rates**

Figure 1 shows the current data up through 1993 of the U.S. accident rates. We have been basically pleased with the way these rates have gone down throughout the years. In 1993, we had eight million departures in the commercial airline fleet and 3.1 million departures in the commuter fleet. So we have a tremendous domestic and long-range operation. Tragically, however, the accidents of the last six months of 1994 have made an impression on us. Prior to the Charlotte accident we had gone over two years without a fatal accident involving a passenger. Then, within six months, three major accidents. Safety figures like these, while interesting for historic purposes and giving one at least some sense that we are making progress, certainly show that the fight is not over. We need to work harder and harder and the rates that we are seeing here are not nearly good enough.

* Charles Huettenr is Associate Administrator for Aviation Safety of the Federal Aviation Administration, U.S. Department of Transportation.
Figure 2 shows some system indicators that we also monitored. We are beginning to turn more and more toward incidents. If our real objective is to identify emerging safety issues and prevent accidents, not simply correct what we find in accidents after it has happened, we must look toward the incident-related matters. So we are beginning to use data in a more proactive approach.

![Near Miss Collisions](image1)
![Pilot Deviation Rates](image2)
![Operational Error Rates](image3)
![Runway Incursion Rates](image4)

**SOURCE:** Aviation Systems Indicators Report

**Figure 2—Aviation System Indicators: Incident Rates**

One method that we found can be of help is to disaggregate data. When we looked at the commuter accident rates, we saw the rates starting to go up and were very concerned. After conducting some research, we discovered that in reality the commuter rates in what we would consider normal commuter operations in the United States were actually fairly consistent, not grossly higher than what the airlines were experiencing. But we had a real anomaly in Alaska, finding its origin in the definition of the term “commuter”. The NTSB, which is the official accident investigator in the United States, defines the terms and “commuters” are scheduled operations. In Alaska, a single engine pilot flying in the bush can be a commuter operation.

So we have discovered that we need to get below the definition of terms. Table 1 makes that point. If we look at airline operations and the official NTSB number of (fatal) accidents from the end of 1993, some interesting information comes out once you start disaggregating it. This information is not always considered as an accident by the flying public. First, the risk to the passenger as far as fatal accidents becomes close to zero up to the end of 1993. So when one or two accidents
involving passengers have taken effect, we talk about major fluctuations. Second, ground worker accidents are a significant portion of the fatal accidents and we must pay attention to that.

<table>
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<tr>
<th>Large Air Carrier Accidents, Fatal Accidents, Fatalities and Limited-Risk or Random Events, 1988-1993</th>
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<tr>
<td>Total Accidents</td>
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<tr>
<td>Fatal Accidents</td>
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<tr>
<td>Number of Fatalities</td>
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<tr>
<td>Fatalities-PAX Risk Accidents</td>
</tr>
<tr>
<td>15  268  9  47  27  0</td>
</tr>
</tbody>
</table>

SOURCE: NTSB: 1992 and 1993 data are preliminary and subject to change
* Does not include 12 passengers and crew on board a Skywest Commuter which collided with a USAir B-737.
** Events such as: a passenger’s arm broken when ramp agent opened forward door, stowaway found dead in aft airstair, instances of hot coffee being spilled on passengers, and four people on the ground injured by debris blown up by a taxiing aircraft.

Table 1—Large Air Carrier Accidents

Knowing this, we decided to create a data matrix, disaggregating all of the data to get a broader perspective of what we should focus on. We started to examine this matrix, as shown in Tables 2, 3, and 4 on the following pages, and began to get a feel of what is happening across the board.

We have now gone out to our industry and asked them to provide us with categories where there is 1) a defined constituency, 2) equivalent mission and 3) a reasonably similar risk. This enables us to monitor the data in such a way that we can define specifically the areas over time where safety needs to be improved, to make safety interventions at that area and know who it is we need to talk to. For example, we have had a number of air tour operator accidents in the United States and yet some operate under Part 135, some operate under Part 91. When you look at the data it is not apparent what the real issue is. By subdividing and looking at factors differently we really can learn something.
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*Includes 1,958 Pilot deviations from 1992-1993 not broken out into G/A categories

Sources: 1. National Transportation Safety Board (NTSB)  
2. National Aerospace Information Monitoring System (NAIMS)
<table>
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<tr>
<th>SELECTED CATEGORIES</th>
<th>GENERAL AVIATION</th>
<th>TYPE OF OPERATION</th>
<th>AIR TAXI</th>
<th>COMMUTER</th>
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<th>G/A</th>
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Sources:
1. National Transportation Safety Board (NTSB)
2. General Aviation Annual Survey preliminary numbers
Table 4—Accidents by Broad Cause/Factor and Type of Operation Fixed Wing and Rotorcraft, 1987-1992

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<tr>
<th>BROAD CAUSE/FACTOR</th>
<th>GENERAL AVIATION</th>
<th>TYPE OF OPERATION</th>
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* preliminary numbers
We have also developed a “causal factor probability table”. We have taken each of the NTSB causal factors and, recognizing that the NTSB may have five causal factors for one accident just depending upon the nature of that particular accident, ranked them by the probability of their occurrence based on 100,000 flight hours. Some rather interesting information has come out of this. First, human factors is at the top of the list. But it goes even a little further because what we are also finding is that it is failure to perform in accordance with procedures and directives that have already been established for quite some time. We have situations where for some reason the crew has not yet been able, knowledgeable or desirable enough to follow those procedures. Although some of it is deliberate, most is training, fatigue or inattention. This finding is not unique to pilots, but also applies to maintenance people, ground handling people and airport people across the board. This is where I would look on how to make the first step in intervention. A factor that ranked second on the probability list is night time occurrence. Often times, you would think that night time is an issue but when it ranks as number two by probability, I would suggest to pay some particular attention into night operations.

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Table 5—Causal Factor Probability Table
Crew resource management has also been lacking and is high on the list. In that regard, the FAA is now finally beginning to regulate and require resource management. In my opinion you should consider those kind of skills for ground operations at airports as well. The weather condition is an important factor—fog with the highest number of incidents, wind shear and thunderstorms as the most severe. From an airport’s perspective, vehicle operation and aircraft taxiing accidents and incidents actually rank relatively high on the list, so you should pay some attention in those areas. The last thing I will discuss with regard to this is controlled flight into terrain. I cannot say more emphatically how important we think having a good GPWS is. The number of accidents in the United States has dropped off practically to zero after the introduction of GPWS; in the rest of the world that is not the case. We are now requiring GPWS on aircraft that have more than ten seats.

Next, I’d like to look to the future because looking at the past doesn’t mean that you are catching all the things necessary. We see three major factors that are influencing aviation. Technology: we are looking very strongly at satellite navigation communications and surveillance. Major new thrusts are coming forward as well. We are even experimenting in Boston with using satellite navigation for ground taxiing operations to improve runway incursion situations. Another factor is economics. The money in both the government and the industry is very tight. A third major influence is globalization. It is extremely important to be able to agree on what technology to use and how to use it, on what standards and how to harmonize those standards. The objective is a safer tomorrow, so how do we get there from here. The conclusion of a study we did about a year ago basically affirms everything that has been discussed in this conference. We need better safety data; we need to view matters as an aviation system. Prior to this when FAA developed something, we did not look at how all of these things integrated into one big aviation system. Now, we must do that. The last issue is better risk assessment and risk management (and building that into the way we both require things and the way we look at policy changes.) So how we did respond to this? My organization, which is the safety organization in FAA, is in the process of developing a new system to try to get out in front of the next set of accidents. It consists of four parts: monitoring the system, listening to and informing the users, integrating and analyzing data, and using better information for decisions.

First of all, monitoring the system. We have basically three tools that we use to monitor the system. One is a book called the system indicators, where we developed 26 indicators of the final results to the end user of the flying public. These are accidents and incidents, delay information, all subjects that have an impact on the end user. We are using this information in two ways. First, as a baseline of what is happening in aviation to try to put the single event into some perspective. We try to use it with the media in explaining how this information really fits within other developments. The second usage is as a performance indicator for the agency as a whole. Agency managers have this information up on a computer and we have developed in this sense some top-level performance indicators and some environmental indicators that support a look out into the future. The second tool is the data matrix as just discussed in the previous paragraphs. The third piece is special evaluations: The need to get out and actually look hands on where we in fact find from the data that there might be a problem. This set of tools is the first part of monitoring what is going all right.
The next piece of the system is listening to the users. This is very important. We believe that we need an analytical approach to this. It takes time to build up data. If we are trying to find the emerging safety issues we have to find them now before they become accidents. We have two formal tools and several new methods to achieve this. First is the aviation safety reporting system, which is developed and managed by NASA for us where pilots without discrimination can report their incidents. We are receiving 34,000 reports a year in the NASA ASRS system. (And I must say that in these last two accidents there have been indications within that system that would have helped target this.) We are working hard to turn the ASRS system into a more front-line process, helping us to identify problems in an early stage. The second formal tool is our aviation safety hotline, similar to a whistle blower's hotline. Airline employees can call and report matters that should not have occurred. We get about 100 hotline calls a month in our system that we track and proceed with. We actually do investigate all of these calls. A new area we are stepping into is the Internet. We see this development as very promising, and we would like to build an Internet web that links all the safety organizations of the world together. We would like to put up our own publicly available information and we would like to challenge you to do the same. The last method comprises safety focal points, and that is where we try to get to the non-publicly available information. We need to exchange not only better data but also experiences from our day-to-day activities. Therefore we need to find a way to work together. Two years ago, we put together a study on airport emergency exercises. We had required all of our airports across the country to do emergency demonstrations and we assembled all the lessons learned from over one hundred demonstrations. I don't think many people know that this document exists, yet this information could be very valuable to you.

The third part of our new safety analysis system deals with how we are analyzing information. We have set up a new facility, our National Aviation Safety Data Analyzing Center, which is a computer system that will be expanding over the years. It consists of a library, a series of databases including the entire NTSB database, analytical tools network, a communications network through Internet, and analysis support staff. Basically, what this facility does is to integrate a whole series of off-the-shelf tools and a whole series of databases into the NASDAC system. This is exemplified in the data encyclopedia and the data dictionary for safety data that we have developed. An important part of the effort of integrating these databases has dealt with systematically entering the data elements into the system and making sure that these were consistent across the board. The net result is a system where we can pull up data, across different data systems, owned by different people with different operating systems, that can be compared for analysis. It is a tremendous tool that we are just now beginning to use. Much of the data that I have showed you here was prepared in minutes compared to what would have taken weeks or maybe months in the past.

So this system is providing us the opportunity to ask questions and receive answers quickly. And that means that we can have an effect in the decisionmaking process in the FAA.

The fourth and final piece of the system is to integrate data in a timely way in decisionmaking so that safety can really be maintained. That is where the role of safety risk analysis and safety risk management is very important. It is the way to integrate the safety data into the decisionmaking process. In our strategic plan for the agency, "Goal I—Objective IA" is to develop a policy to
ensure risk assessment that is built into the way we make our decisions. It is a very important part of our process.

We believe that it is very important for all of us to share safety information. The FAA has undergone a lot of cuts lately. We cannot afford to study everything we need to study. We have a lot that we can offer, but we need to learn from you. And the only way we can do that is at conferences like this and I applaud the RAND Corporation for an excellent conference. But it needs to be faster and it needs to be more subtle, I would say. Hans Smits said that we need to build a trusting relationship. We need to use that relationship to pass the sensitive data that cannot be put up on line. My call to you is to join with us to share safety information. First of all, make your publicly available information accessible. In that regard, there is a group called the ideas group, on which CAAs around the world have working members. This is a group of people that is trying to work at lower levels that needs the support of the higher levels to make that exchange work, and I would urge you to do that. Second, use electronic mail. You can get me on electronic mail through Internet. We need to begin to communicate, and I am going to be building an international file so that when we have questions that we think it would be useful to get answers to I can send out a request. I talked about safety focal points for which I would like some volunteers. The last part for information exchange is building the personal relationships by telephone, getting to know one another well enough that we can share our innermost secrets, our wake vortex issues, icing issues or radar control problems—so that we can learn from each other and improve aviation safety.
DISCUSSION SESSION 3

Andre Schmidt Apol
Mr. Ashford showed us comparisons of accident rates between the 1960s and now. These are numbers of the jet age and the propeller age, which are not comparable at all. It is like comparing current car safety statistics with those of the horse and carriage era.

Ronald Ashford
I think you are right in stating that it is now of little importance what happened thirty years ago. But I used the comparison to show that in those first 20 years, the accident rate was continuously descending, and evidence is suggesting that this is not happening anymore for the last ten years. That is something we need to address. The accident rate needs to continue to go down.

W.F. van den Heuvel
It was striking to hear that 27 accidents were caused by night time flying. I would like to point out that the female brain is different from the male brain. Females have a better sensitivity for night vision. So I would suggest to put our efforts in getting more female pilots and you will see night time accidents drop.

Charles Huettner
Hopefully, I did not give you the impression that night time actually caused the accident. It was not the primary cause, but a contributing factor. There are fewer flights in the evening yet there are relatively more accidents happening during night time.

John Enders
I fully endorse Ashford’s approach in calling for a threefold decrease in the accident rate. The Flight Safety Foundation is currently leading an international effort with ICAO and IATA to tackle CFIT accidents. But this shows that there is room for additional activities to be undertaken.

A question for Mr. Huettner: How does FAA view the problem of security of the Internet, being able to protect against malicious hackers from distorting data that might appear on it.

Charles Huettner
We will have a separate server for the publicly available information accessible through the Internet. If hackers choose to distort it, we will just reload it if we need to. All I am suggesting, however, and that is where the major effort should go into, is to collect and share the information available, and to take a careful look at it. And in that respect, our information server will not be available through the Internet.

Henk Sol
I agree that you will have to be very careful opening up information for the general public. This is one of the most important issues in the discussion on the information highway: what information should be available and what not.
Charles Huettner
All the information we produce is publicly available under the Freedom of Information Act anyway. So I would rather frame this information and make sure we have it in the proper perspective, rather than have people doing their own analysis based on whatever they might have available.

Ronald Ashford
But from my experiences with releasing data on incidents and incident reporting to the general public, you do have to be careful that the public and the media interpret data correctly. For example, if company A reports three accidents on each one hundred airplanes, and company B reports eight, it could be concluded that company B has more problems. But maybe company B is more responsible in reporting their problems which is quite the opposite conclusion. I believe in open governments, but there are certainly traps!

W. Brouwer
Your conclusion seems to be that human factors tend to be the major contributor to accidents. I think this is not a proper way of putting it. Of course, technology can be continuously improved, but at the same time we are increasing the complexity of the cockpit operations, or getting airways in and around the airport more crowded. The human itself cannot be improved. You can train him or her only to a certain extent. However, we need the human as soon as the complex technological system breaks down and that puts him or her in a very complex situation. This would lead to the conclusion that in the end the human will always be the cause of the accident. I am not sure how to react to that development.

Charles Huettner
The human is a part of the system. What we are trying to do is break down the nature of those human factor incidents and issues to be able to identify the interface problems and what pieces of equipment need to be adjusted to some degree. The trick is to get enough detailed information to address these particular issues.

Ronald Ashford
There is a limit to what you can expect from a human being, and putting the blame on the human was not the motivation of my paper. What you have to look for in real changes is to produce a more user-friendly cockpit without the potential after failures to saturate the pilot with excessive information. A deeper understanding of technology of modern cockpits is clearly lacking in my view. So it is not mostly crew error, but factors that involve the crew.
Session 4: External Safety of Airports: The State of the Art
Richard Hillestad

Introduction: Safety at SCHIPHOL in Context

As the twentieth century draws to a close, the transportation infrastructure of Western Europe is undergoing a number of changes. Among such changes are the use of high-speed passenger trains, the Alp-transit railway network, the rail tunnel connecting Great Britain and the European continent, and the development of a European inland waterway network, as represented by the newly opened Rhine-Main-Danube channel. Each of these and other developments has implications not only for the particular innovation put in place but for other parts of the transportation system. For example, high-speed passenger trains mean that for some trips (e.g., Amsterdam to Frankfurt or Paris), ground transportation may take less time and cost less money than air.

In addition to technical change, there is also an ongoing organizational change. The European Community (EC) is taking on a number of responsibilities that were formerly handled by member states. National legislation on many topics, not the least of which is transportation, is being harmonized within the Community through EC guidelines and directives. These organizational changes take place in an environment of growth, where Eastern and Western Europe are rapidly increasing their economic interdependence.

One consequence of these changes is a centralization of transportation. A commonly accepted vision of future transportation includes a limited number of “mainports”—large airports that are also road and rail transportation hubs. For passengers, these mainports will serve as gateways to the entire countryside through intermodal feeder lines on transportation corridors. For freight, the mainports in conjunction with equally centralized maritime ports (such as contemporary Rotterdam) will similarly serve as distribution centers for import and export.

Nederland Distributieland

The Netherlands has throughout its history been a nation of traders. Its geographical location made it a natural route for trade between Northwestern and Southwestern Europe, and its seafaring tradition made it a sometimes-dominant world power, from the days of the Dutch East India Company at Hoorn to today’s oil-receiving center at Rotterdam.

To maintain its position as a major transporter in Europe, the Netherlands developed the concept of “Nederland Distributieland,” which emphasizes the need for a new transportation infrastructure in the country. As part of this concept, a number of major projects are planned or under construction, including:

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*Richard Hillestad is Senior Systems Analyst at the RAND Corporation.

1Netherlands Distribution Land.
• A further expansion of Rotterdam seaport;
• The introduction of high-speed passenger trains;
• A dedicated freight line between the German border and Rotterdam (the Betuwe line);
• The development of a more elaborate road traffic system; and
• The expansion of Schiphol, the country’s only major international airport, into a mainport. This includes, among other things, the additions of a fifth runway and a high-speed train station.

The technological projects described above are accompanied by organizational changes within the Netherlands. In concert with developments at the level of the European Community, privatization and deregulation have been introduced. Various government agencies concerned with air, shipping, labor, and mining are undergoing reorganization and are concerning themselves with certification of skills and expertise. The Dutch air traffic control services, formerly a government agency, was privatized effective January 1993.

This development of the transportation infrastructure is not without debate in the Netherlands. A major concern for both the technological and organizational changes to the transportation infrastructure is the possible environmental, social, economic, and technological effect of the proposed projects. Topics such as the allocation of land use in crowded inhabited areas and the noise, pollution, and safety risk imposed upon the population are all debated in the media, at community gatherings, and within the government. For example, the Rotterdam port introduced a “green charter” and a rating system for safe and environment-friendly vessels, which offers discounts in harbor fees. Although safety per se has not occupied a central role in the public debate, it is fair to say that the issue of safety has been present in one way or another in virtually all discussions.

**Safety and International Aviation**

At the same time as economic and political forces push for a consolidation of air transportation in Western Europe, the entire international aviation industry is undergoing rapid changes. Similar to the merging of carriers following deregulation in the United States, some European carriers are merging into multinational companies in response to deregulation, open skies policies, competition for passengers and freight, and the expected global increase of traffic flow. For example, last year the Dutch national carrier KLM substantially merged with the American carrier Northwest Airlines, and just recently British Airways and USAir announced their merger.

Just as the international aviation industry amplifies the economic and political pressures for the expansion of Schiphol to a mainport, so aspects of the changes in international aviation have consequences for safety. These consequences appear in many guises.

• Deregulation, a major driver of the aviation industry, focuses on cost reduction and tends toward pushing economic margins. As a result, economics may dominate safety in decisionmaking.
Examples of this might be laxness in maintenance and status monitoring, keeping aged aircraft in the fleet beyond their time,\(^1\) and operating at more than capacity.

- Smaller and less-industrialized countries are not always capable of coping with the requirements for crew and aircraft to participate safely in modern air traffic.
- Increased traffic leads to increased congestion, not only in the air but also on the ground. When congestion interacts with delays caused by weather, the pressures to maintain strict timetables may influence safety.
- Increases in traffic and technological sophistication may lead to increases in pressure on pilots, ground crew, air traffic controllers, dispatchers, and all others who have some responsibility for safety. This increasing production pressure and mental workload could pose additional risks to safety.

### Safety at Schiphol

The proposed expansion of Schiphol is a central part of the Nederland Distributieland concept. Schiphol, the single international airport for a country of 15 million people, is fourth in Europe in freight traffic (after London, Paris, and Frankfurt) and fifth in passenger traffic (after the same three and Rome). Great Britain, France, Germany, and Italy each have between three and five times the population of the Netherlands and many more times the geographical area. This serves to emphasize the importance of transportation to the Dutch economy. The importance of Schiphol airport is provided by historical and projected work force and added value figures in Table 1.

But along with economic well-being, the Dutch are also concerned about environmental well-being, including safety. Schiphol is located in the middle of the most densely populated part of the country; although that has some advantages in terms of its short distance from major destinations, it also means that large numbers of people are at risk from the consequences of air accidents. As airport expansion is contemplated, so concern about increased safety risk is expressed.

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**Table 1—Employment and Economic Benefit of Schiphol**

The concerns about safety risk were raised to a peak by the crash of an El Al freight carrier on 4 October 1992. That airplane crashed into an apartment complex in the Bijlmermeer; although the eventual death toll was 43 persons, it was originally feared that many hundreds had died. This disaster generated sufficient concern that a careful reexamination of safety at Schiphol was deemed

\(^1\)Some older aircraft will be phased out because they will not be able to meet noise restrictions, however.
necessary. The goals of the reexamination were: (1) to determine to the extent possible the current safety status at Schiphol; (2) to project what additional risks to safety—if any—would be incurred by the plans to expand Schiphol to a mainport; and (3) to recommend safety-enhancing strategies to mitigate the safety risks posed by the expanding airport.

Safety as discussed here is a subjective experience. Almost everybody accepts that air flight is just about the safest form of transportation known; however, because the consequences of an accident are often many lives lost, air mishaps are prominent in the public eye and are less tolerable than a simplistic cost-benefit calculation might indicate. In part for this reason, any discussion of safety must encompass both the technical sense of safety in terms of a probabilistic risk assessment and the popular sense of safety in terms of the public perception of risk and whether that risk is deemed acceptable. Throughout the study, we switched back and forth between the technical and popular view of risk, integrating the two as much as possible, but always striving to keep both in view as we examined safety at Schiphol airport.

Focus of the Study

This study evaluated the current and future safety of Schiphol airport, considering expansion plans, evolution of commercial aviation, and projected changes in the population surrounding the airport. The primary focus was the external or third-party risk to those people living or working in the vicinity of the airport. Of course, most aspects of safety that affect an aircraft in flight affect the external risk as well. Aspects of safety that were largely excluded in this study are causes of accidents during aircraft loading and unloading, during taxi, and during inflight cruise which would not cause fatalities to the surrounding population of Schiphol.

The study also evaluated a number of safety-enhancement measures in terms of their effect on external safety. These measures were derived from various sources including interviews with the Dutch organizations concerned with air safety. The study was not an accident investigation. We had no information about the ongoing El Al crash investigation other than what was available to all in the newspapers.

The study did not attempt to set standards for external safety at Schiphol. Although we commented briefly on standards, we stressed that the choosing of limits should be done by the Dutch people and their government with open debate about the balance between risks, uncertainties in measuring risk, and benefits of Schiphol expansion to a mainport.1

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Defining Risk

a. Measures of Risk

There is no single common measure or metric of risk. Risks can be measured in terms of fatalities or in terms of injuries that have varying degrees of severity. For the purpose of this study, however, we are concerned primarily with fatality as the measure of risk. Risk is commonly defined as the product of the probability or likelihood of an event and the consequence or magnitude of that event integrated over all events being considered. For example, based on historical records since 1970, the crash probability per commercial, scheduled aircraft in the Western hemisphere is about 0.05 fatal crashes per 100,000 hours flown.\footnote{See National Transportation Safety Board (NTSB), Annual Review of Aircraft Accident Data: U.S. Air Carrier Operations, Table 14, Washington, D.C., 1992. The accident rate for all aircraft accidents including fatal ones averages 0.32 crashes per 100,000 flight hours.} If an average individual flies a single two-hour trip per year, then the probability that this average individual will be in an airliner crash is one in a million per year. If the probability of dying given involvement in a crash is 0.8, then the probability that this average person will die in an airline crash is one in 1.25 million per year. This measure is called the individual risk.

As another example of individual risk, we can estimate the risk to people on the ground from an aircraft crashing on them. According to a compilation by Boeing Aircraft,\footnote{Boeing Aircraft of Seattle, Washington, compiled the total number of crew, passenger, and ground population fatalities from 550 commercial jet aircraft accidents from 1970 through 1992.} 879 people on the ground died as a result of commercial jet airline crashes from 1970 through 1992. Assuming a world population of four billion people (average of the 23 years), the probability of third-party fatality is about one in a hundred million per year.\footnote{This is the average individual risk across the world population. For those in the vicinity of an airport, it is likely to be higher, as we shall discuss below.}

The risk measure must also take into account other considerations. One hundred single fatality car accidents are not perceived to be equivalent to a single accident that kills one hundred people. The single high-consequence accident is viewed as more significant than the sum of the low-consequence accidents. We are therefore also interested in the probability of large numbers of fatalities, so we would state the risk as the probability that more than a given number of people are killed in an accident during a specified time period such as a year. This risk-consequence distribution—a second way of measuring risk—is useful in comparing risks in terms of how they are perceived psychologically.

A third metric of risk is the expected number of fatalities in a specified group in a given time period. For example, if there are ten million hours of commercial airliner (air carrier and air taxi) flights per year in the United States and the average number of fatalities in a crash is 50, then the expected number of fatalities in the group of all people who fly airlines is 250 per year.\footnote{NTSB (1992), op. cit.} This is called the group risk.
Another example of group risk can be drawn from the ground population risk discussion above. Eight hundred and seventy-nine third-party fatalities from 1970 through 1992 translates to an average annual group risk of about 40 fatalities per year for the world population group.

b. Third-Party Risk

Various populations may be exposed to a potential harm. Each of those populations exposed may have varying degrees of control over their exposure to the harm. For example, the driver of a car is under direct control of his own safety. His passengers have a lesser degree of control. The driver has willingly volunteered to expose himself to a risk. If he is intoxicated, the passengers can elect not to ride in the car. If an otherwise safe driver has a temporary lapse of performance, the passengers may have relinquished their control. A person sleeping in his bedroom has essentially no control over the fact that a driver could lose control of his car and drive off the road and into the house. Passengers on board an airplane have some control over whether or not they elect to fly. Ground populations have essentially no control over an airplane that crashes into their homes. Populations with little or no control over their exposure are those at third-party risk.

Often, those people who have little or no control over the risky situation have not voluntarily accepted the exposure. Although a primary characteristic of third-party risk is lack of control, a secondary characteristic is often involuntary exposure to the risk.

Third-party risks associated with transportation can be measured. In automobile accidents, the driver and his passengers are not at third-party risk. The pedestrian (excluding, perhaps, pedestrians who elect to jaywalk) hit by a car is at third-party risk. Third-party group risk (expressed as expected annual fatalities) to a ground population adjacent to airports has been estimated around Los Angeles International Airport as about 0.4 and around Burbank Airport (about 50 kilometers northeast of Los Angeles International Airport) as 0.2.¹

Third-party risks are an important part of any consideration in the siting of houses, businesses, and other population centers in and around airports. Although the absolute quantitative value of the risk to an individual on the ground is quite small relative to other risks to which he or she is normally exposed, the number of people living near an airport is often large (one or more millions of people within a 25 kilometer radius), and any consequence of an aircraft crash—no matter how unlikely—could affect hundreds or more people.² Hence, any decisions involving the operation of an airport must consider third-party risk.

¹Kenneth A. Solomon et al., Airplane Crash Risk to Ground Populations, UCLA-ENGR-7424, University of California, Los Angeles, March 1974.
²The third-party risk around an airport is relatively low compared to other third-party risks. The automobile accident fatality rate in a region encompassing, say, two million people surrounding Schiphol is about 200 people per year. Of those fatalities, about 20 percent, or about 40, are likely to be pedestrians (pedestrians are exposed to third-party risk). By comparison, the third-party risk from potential aircraft crashes (expressed as expected annual fatalities) might be only about 0.2 or 0.5 percent the number of pedestrians at risk in the same time frame and in the same region.
c. Important Uncertainties Associated with Airport Risk

Risk assessment is as much an art as it is a science. Risk assessments rely on two somewhat distinct methodologies (analytic based and empirical based) used to varying degrees in a particular assessment depending on the nature of the problem and the availability of the data. When nuclear reactor safety is assessed, the analyst typically relies on historical or empirical data to learn about the failure rates of individual components in the reactor system. Component failure rates such as the failure rate of a valve or a pipe are generally well defined. Then these failure rate data are used along with analytic tools such as event trees to determine the course of events that contribute to an accident and fault trees to determine the reliability of systems. Technologies rich in technical components and well-defined events lend themselves well to risk analyses that rely on both analytic and empirical tools.

However, this risk assessment does not evolve from a technology that has a well-defined set of sequences that could lead to an accident. Unlike a nuclear reactor accident, hundreds of uncertain variables play a role in determining the likelihood of a plane crash, where it crashes, and the effects of that crash. Our current risk assessment becomes especially difficult when we consider the vast amount of uncertainties present in the crash rate data, in the crash distribution, in the consequence assumptions, and in our ability to predict the timeliness and effectiveness of safety-enhancement measures.

Uncertainty arises from the fact that aircraft crashes are relatively infrequent and those factors that determine where a plane will crash are many. So we are dealing with very low probability statistics and wide-ranging consequences. As such it is necessary to aggregate data.

Specific uncertainties and their likely effect on our results are detailed in the main report. In summary, these uncertainties are:

- No two accidents are alike and historical accident data fail to distinguish precisely the causes of past and thus the predictability of future ones. We address this problem in part by reviewing the applicability of a broad set of accidents to Schiphol and rule out many of these accidents because they just would not apply.
- Often when the cause of a past accident is determined, the problem becomes more recognized and thus less likely to happen in the future. So the nature of the accidents in the future is not always the same as the ones in the past.
- Accidents have many known and unknown causes that contribute to their likelihood, location, and severity. Because of these many variables and infrequent occurrences, inferring characteristics of future accidents from past ones is challenging at best.
- During the course of this study, we identify and to the extent possible quantify the effect of applying safety-enhancement measures. Many of these measures are not quantifiable by their very nature. Others that lend themselves to quantification cannot be quantified in sufficient enough detail to justify a precise calculation.
Although these uncertainties limit our ability to calculate a precise third-party risk, they do not prevent us from demonstrating general safety trends and the relative effects of various safety-enhancement measures.

d. Risk Standards in the Netherlands

One approach toward the management of external risks is to define numerical standards of acceptability. A site or an activity is considered to have acceptable risk if the likelihood of the hazard is below a specified level. An example of this approach is the “Delaney Amendment” passed by the U.S. Congress in 1965. It demanded a zero risk of cancer from certain foodstuffs and probabilities of radiation release from nuclear reactors set forth by the U.S. Nuclear Regulatory Commission. A more recent example is the expected likelihood in any given year that Dutch river dikes will not contain floods.

The Dutch government has recently promulgated a single standard for major accidents, exposure to substances, and radiation, such that the combined probability of mortality for these three hazards should not exceed 1 in 100,000 per year. For each activity or substance, the maximum acceptable level has been set at 1 in 1,000,000 per year. Although these standards apply to activities and substances associated with fixed sites (such as toxic emissions from a factory), the Dutch government is currently considering applying the same (or similar) standards to transportation activities, to include Schiphol airport.

The imposition of single standards such as the Dutch regulation is not without debate. Among the objections to uniform standards are:

- Uniform standards do not take into account the benefits of the substance or activity. People may accept greater risk for highly beneficial activities.
- Uniform standards do not take into account social inequities that result when the risks are imposed only on segments of the population.
- Uniform standards assume that the numerical risks are validly and reliably measured—a questionable assumption for many risks that result from complicated technologies.
- Uniform standards tend to be mechanically calculated and do not take into account the human factors that can either greatly multiply the risk or greatly reduce it.

Many proponents of risk standards acknowledge these criticisms but maintain that even a flawed standard is superior to no standard at all.

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Analytical Approach

A safety assessment is composed of technical as well as social issues and any discussion of safety must encompass the technical sense of safety in terms of probabilistic assessment of risk and the popular sense of safety in terms of the public perception of risk and whether that risk is deemed acceptable. Also, because the effects of many possible safety enhancements cannot be easily predicted in measurable quantities, this study has used an interdisciplinary approach involving risk analysis, statistical assessments, focus group interviews, review by aviation experts, safety assessment by Dutch experts, and policy analysis.

The approach involved the following steps, some of which were done in parallel:

2. Survey the Operations and Management of Safety at Schiphol Airport and Compare It to Other Airports.
3. Study the Perceptions of Risk and Benefits of Schiphol Within the Netherlands.
4. Review Worldwide Aviation Accidents and Causes
5. Make Quantitative Assessments of Risk to Third Parties and the Effectiveness of Certain Safety Enhancements
6. Develop Overall Conclusions and Recommendations Regarding Third-Party Risk and Possible Safety Enhancements at Schiphol. Each of the steps, 1–5, suggests possible safety issues and possible areas of improvement at Schiphol. This step involved putting these together in several coherent themes and suggested directions of improvements in the management of safety at Schiphol.

Before summarizing the analysis, it is important to remind the reader of several limitations of this study.

- Uncertainties in Data. These are discussed in some depth in the main report. Some of these uncertainties, such as the joint distribution of the locations of historical crashes with respect to flight path and offset, could possibly be determined with considerable additional review of individual crashes (although even this would be subjective with respect to the exact timing of the failure causing the crash and intended path of the pilot). Other data are likely to remain uncertain regardless of the depth of investigation. For example, it is very difficult to predict footprint size and lethality of crashes, because they depend on how and where and in what configuration an aircraft crashes. The cumulation of these data uncertainties limits the ability to predict risk with certainty.

- Limited Investigation of Runway Alternatives. We are aware that there are several alternative configurations of runways and additional runways that have been proposed and studied. For this study, we considered only the expansion plan involving the addition of a parallel fifth runway in the location and configuration described by Schiphol authorities.

- No Access to the Ongoing El Al Crash Investigation. We did not have access to information from the investigation of the El Al crash and the report of that investigation was not released before the completion of this study.
• Limited Ability to Predict Low-Probability Events. The probability of an airline crash is very small and the probability of an airline crash that causes third-party casualties is even lower. The ability to predict when and where a future accident might occur is, as a result, also very low. Despite the quantitative estimates provided in this study indicating low external risk, a crash is still possible, as evidenced by the El Al crash in 1992.

Conclusions

The main report suggested or implied conclusions about the current and future safety at Schiphol airport as well as possible safety-enhancement measures. We attempt here to organize the conclusions into major themes and ultimately to suggest recommendations for the management of safety at Schiphol.

a. Schiphol Is a Modern, Safe Airport

Despite the tragedy of the El Al aircraft crash into the Bijlmermeer apartment complex, our safety survey, comparisons to other airports, and estimates of current third-party or external risk find Schiphol to have safety comparable to that of other modern airports in Europe and the United States. We find that safety is an important consideration for the various organizations associated with aviation management in the Netherlands and at Schiphol, including the ministry (RLD), the airport (NVLS), air traffic control (LVB), and the major airline at Schiphol (KLM). The managers of these organizations are quite aware that there are economic as well as moral and societal reasons for maintaining a high standard of safety at Schiphol. Quantitative comparisons show that Schiphol’s current operations and surrounding population fall within a range bounded by those at Frankfurt and London Heathrow.¹ The estimated average individual risk satisfies a standard that is under Dutch government consideration for application to airport operations, although small regions of population may exceed that standard.

Schiphol is generally perceived to be safe by the public. In our interviews of public perceptions and in the news content analysis we found that, in general, third-party risk was not a strong concern of the public before the El Al crash and in the absence of a finding that gives the airport authorities blame in the accident, the public largely absolves the airport of responsibility and believes that mechanical failure or crew error in the aircraft was the primary causal factor. This analysis also indicates that other negatives associated with the airport have been and will probably continue to be more important, including noise, environmental damage, and, for some of those living near the airport, lower property values. For the limited sample of people we interviewed, as long as certain minimum standards of safety are maintained, the benefit of the airport balances the low external risk. Maintaining that perception, however, requires continued trust in the management of aviation safety, and this may require qualitative changes in that management as well as more open information about incidents and safety-related decisionmaking.

¹Group risk is directly proportional to the population and the number of flight operations at an airport. With respect to the product of these two factors, Schiphol falls between Frankfurt and London Heathrow using current operations and populations. Many other factors such as flight path, distribution of population, and fleet mix affect the group risk, so this comparison is a very crude measure.
b. Safety Considerations May Change as Schiphol Evolves into a Mainport

The growth projected for 2015 (2.7 times the number of passengers and 4.5 times the freight tonnage of the current operations) will increase third-party risk simply because the number of flights will increase. However, mitigating factors such as a safer fleet of aircraft, likely adoption of technological improvements in air traffic control and aircraft avionics, a new runway, and improved international control of risky airlines should keep the external or third-party risk from growing significantly. Indeed, our quantitative analysis suggests that despite the projected growth and increased number of flights implied, the third-party risk could actually decrease as the fleet becomes safer and technological advances are implemented.

However, there is also some concern that growth will increase external risks and there is a natural distrust in the hypothesis that technology will make operations and airports safer. Large changes in magnitude bring about qualitative changes that might produce unanticipated side effects from interactions of modes of transportation, taxiway and ramp traffic multiplication on the ground, increasing severity of weather-related queuing (and possible pressure to reduce safety margins), problems with volume-related incidents such as bird strikes, and risks during the airport-to-mainport transition process. There is also concern about the reduced government control implied by privatization, the effects of the EC open employment market on standards and skills, the increase in freight flights (which generally use older aircraft), and the possible use of technology to compress operations or reduce safety margins rather than to increase safety.

Thus, the evolution of Schiphol from an airport to a mainport is seen by both experts and the lay public as generating potential risks to safety, but those risks can be mitigated if the managers of aviation safety anticipate and correct problems associated with growth before they occur and if safety has an advocacy that can balance the economic, environmental, and political aspects of growth.

c. Schiphol Airport Safety Must Be Taken in Context

A broad array of changes on the economic, political, and environmental fronts will affect aviation safety during the next decades. The Nederland Distributieland concept emphasizes the central importance of the transportation infrastructure and expansion of that infrastructure, including Schiphol airport, for long-term economic benefit to the Netherlands. The EC is taking on a number of responsibilities that were formerly handled by member states.

Environmental concerns, already dictating choices of routing to satisfy noise standards, are likely to increase as concerns about growth in air traffic, new construction projects, and increasing auto and rail traffic in the vicinity of Schiphol are realized. The political, economic, and management actions to satisfy environmental concerns will not always be consistent with improvements in external safety (for example, compression of flight operations into more acceptable time periods, or more complicated departure routes to reduce noise to residences may also be more hazardous).
Changes in international aviation that will affect aviation safety include deregulation and its possible effect on airlines and their fleets, increasing flights from new states and concern for the air safety standards of those airlines, and increasing air traffic, which leads to increasing congestion and schedule pressures. At Schiphol, there will continue to be tensions between the economic importance of expansion, the environmental effects, and safety. Some risks must be taken and there will be tradeoffs between noise and economic benefits, but this will generally be acceptable if risks are well managed and the safety implications have been considered.

There are also limits to what Schiphol and the Dutch government can do themselves. There is no effective international air regulatory body to enforce the high standards of aviation safety of Western Europe in other countries. Control of other countries' risky carriers and assurance of high standards of crew training and maintenance for all airlines using Schiphol will either require difficult decisions by the government to exercise unilateral restrictions with consequent political and economic reactions or will require actions by organizations such as ICAO, the EC, JAA, or even a regional coalition of airports with higher standards and controls.

d. Safety Is an Airportwide Problem

Our safety survey indicates that coordination of safety is currently dealt with informally across the various operating organizations associated with aviation safety at Schiphol and within the government. An integrated safety-management system/office is needed to coordinate and assess the safety procedures of the various operational organizations at Schiphol. We have identified other possible functions of this office to include that of collecting, reviewing, and acting on incident and hazard reports. The office should coordinate emergency planning and integrated emergency exercises. It would generally act as the safety advocate to balance decisions that are made on an economic or environmental basis and that might inadvertently overlook important safety concerns. It would monitor the safety aspects of the growth of Schiphol to a mainport.

The public information aspects of safety should not be overlooked. As indicated in the study of risk perception, there are rumors about incidents and hazards at Schiphol that are not effectively dispelled or explained. There also exist misperceptions about unsafe operations because of lay observations and interpretations of situations. For example, noisy takeoffs or wobbling of wings during a landing approach are sometimes interpreted as problems. Because each organization currently deals internally with safety, there is some bureaucratic reluctance within the organizations to respond openly to inquiries from the outside. Another important function of an integrated safety-assurance office would be to provide information to deal with public concerns and to act as a safety spokesman.

e. No "Magic Bullet" Dramatically Reduces the Quantitative Risk Estimates

Throughout the main report, we have discussed possible changes that could enhance aviation safety at Schiphol as it relates to third-party risk, but many of the options are not quantifiable for risk
assessment. For example, we have suggested an integrated safety-management system for Schiphol and have indicated some of its desired functions. Although we believe this is an important safety-enhancement measure, its actual effects on risk are not quantifiable. We have also discussed possible enhancement measures that are more quantifiable, such as the removal of risky aircraft and the use of public safety zones. Using the quantifiable measures, we have shown that actions can be taken to reduce risk now and in the future. In fact a number of these are planned (moving most general aviation flights to other airports, for example). We have found no “magic bullets” in the sense of measures that make dramatic changes in the quantitative estimation of external risk. This is to be expected given the safety consciousness that already exists at Schiphol. Some measures dramatically affect the risk-estimation inputs but still make only marginal changes in the individual and group risk estimates. For example, public safety zones near the runways dramatically reduce the fatality risk in those zones, but, because only a small proportion of the population lives in such areas now, the effect on group risk is not dramatic. Similarly, removal of general aviation significantly reduces the probability of crash for small aircraft at Schiphol, but because there are far fewer small aircraft operations and their crash footprint is smaller, the external risk estimates change by a much lesser amount. An important aspect of the quantitative risk-assessment model used in the analysis is the ability to measure enhancements in context. But, even when measures are evaluated as a group, the effects are limited because they are not necessarily additive.

f. Airport Third-Party Risk Assessment Is Not a Well-Developed Science

Although the quantitative aspects of risk-assessment models are fairly well developed and have been used for other areas of risk for many years, there are components of airport third-party risk assessment that are still in a somewhat primitive stage. A key problem is that the complete data for risk estimation are either not collected or are very difficult to obtain from available sources (particularly for a short-term risk assessment). Fortunately for safety, there are few accident data points, but this also means that statistical estimates suffer from large uncertainties. For example, the paucity of accident data by aircraft type or airport means that the data across aircraft types and airports must be aggregated to have any statistical significance. Despite the fact that many aviation accidents are well documented, the specific causal chains for those accidents are frequently missing, either because they were indeterminate or because of sensitivity they have been suppressed. (Under ICAO rules, the responsibility for accident investigation lies with the country in which the accident occurred, and in some countries there is little open discussion of blame.) The data regarding aviation incidents are even less complete and not systematically collected. We have discussed in the report some of the other data difficulties that make it difficult to assess the probability of crash, the locational distributions of crashes with respect to flight paths, and the effects of crashes in an arbitrary built-up area. Judging by a review of several airport risk models,¹ there does not seem to be a consensus among the community of experts as to how to represent various aspects in the estimation of risk.

The data uncertainties can easily swamp estimates of risk and make definitive estimates difficult. There are other important uncertainties, described in the appendixes of the main report, such as the fact that in many cases once the cause of an accident has been determined the aviation industry

¹Solomon (1975), op. cit.
takes steps to remove it as a possible future cause, thus at the same time improving safety and reducing the prediction value of the historical crash data.

The recognition of these broad uncertainties in airport risk assessment is important both for this study and for future actions predicated on the ability to predict risk. Although we state the absolute risks from our calculations and compare the influence on this risk of various scenario changes and safety-enhancement options, we believe that these should be considered primarily in terms of the comparative assessments and possible directions of improvement. And, the variance in the results should be explicitly stated and considered.

The uncertainties have implications for risk standards. As stated in the introduction, risk standards make the most sense when there is an ability to reasonably predict the risk definitively. In the case of airport risk assessment, our results indicate that there is some doubt about this definitiveness. The uncertainties also make it more difficult to argue that certain possible safety enhancements are worth the costs and possible political consequences. These include the building of safety barriers, zoning, designing of flight paths to reduce risk, etc.

It is well known that the perception of risk is important and that this may swamp the quantitative considerations. For this reason we relied heavily on the safety survey, the interviews, and the content analysis to understand how external risk was perceived and how it is currently balanced against other factors. This aspect of a risk assessment, used before by RAND/EAC in the Netherlands in the case of flood risks associated with riverdikes,1 provides an important complement to quantitative assessments and helps to address issues that cannot be addressed with quantitative risk calculations, particularly when there are large uncertainties. We also believe that additional research at the international level is both desirable and possible to improve the state of airport risk assessment. Much more could be done in assessing the dimensions, applicability, and underlying models of the aviation accident data. We discuss some of this in the recommendations below.

**Recommendations**

Throughout the body of the main report we have suggested certain safety improvement options. In this section we organize and repeat these recommendations.

a. Safety Management

The safety survey suggests that in accordance with the growth of Schiphol airport to a mainport, the informal nature of aviation safety management and coordination associated with Schiphol should be replaced by an integrated safety-management system/office, which can perform the following functions:

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1 Walker et al. (1993), op. cit.
• Coordinate and assess the safety procedures of the various operational organizations at Schiphol.
• Develop and coordinate airportwide emergency exercises, training, and plans, including joint exercises with controllers and pilots involved.
• Centrally collect and review incident and hazard reports from all operating organizations at Schiphol. Develop actions and track their implementation based on the review. Collect and review incident and accident data from other sources, including U.S. and international aviation safety organizations, airlines, aircraft, and manufacturers.
• Perform ongoing reviews of operating decisions and Schiphol expansion plans as a safety advocate to balance economically, politically, and environmentally based decisions. Examples of safety issues and practices that should be reviewed by this office include:
  — The low fuel pricing discussed in the main report.
  — The use of a single controller for both approaches and departures.
  — The safety aspects of new Standard Instrument Departures (SIDs) and Standard Terminal Arrival Routes (STARs).
  — Fleet management including the outplacement of general aviation, etc.
• Provide information and act as a spokesman for safety to the public.

This integrated office should be implemented at Schiphol and consideration should be given to the establishment of an associated safety advisory panel of aviation safety experts, which would be independent of the airport management. The advisory panel would have no executive power but its advice would be made public.¹

b. Maintaining and Enforcing High Standards

Schiphol and the Dutch organizations managing aviation safety already have high safety standards but some areas can be improved. It was observed during the safety audit that, of the major European airports visited, Schiphol is the only one without a formal airport or aerodrome certification process. The procedures for government certification and reexamination of air traffic controllers after privatization await acceptance by Parliament. As stated above, the government, while withdrawing in favor of decentralization and privatization, must still bear the responsibility for setting and verifying high safety standards. We have suggested that relevant certification programs be developed.

The small size of the Netherlands and the economic and political dependence of the Dutch on the rest of Europe and the world make it difficult to enforce aviation safety standards with respect to foreign carriers, particularly when these standards exceed the minimum international standards (ICAO). We discussed in the main report the problem of restricting operations of suspected risky carriers, or of verifying unsafe operations of foreign aircraft and airlines. We also discuss how the United States has taken a more proactive stance in this regard. Because this is an important area of aviation safety (and will be even more important with growth and increasing flights from the new countries of Eastern Europe and the Commonwealth of Independent States (CIS)), it is important that the Netherlands begin examining ways to identify risky carriers and considering the appropriate coalition within which to enforce limitations on them.

¹Because public perception is such an important part of risk, this structure should enhance the public confidence that airport safety is well managed.
Currently, only two groups can report hazards and incidents anonymously or confidentially with respect to Schiphol and aviation safety in general. These are Dutch pilots and air traffic controllers, respectively. However, such reports are held and acted on independently by their respective organizations. There are no similar channels for other groups at Schiphol, such as the dispatchers, maintenance workers, and emergency teams. Because the lack of such a process is likely to result in some important safety-related incidents being unreported for fear of retribution, it is important that procedures be developed to permit anonymity to all possible reporters of aviation hazards and incidents and to assure that such is the case for the existing two processes.

Public safety zoning is another aspect that the government should address. Because the majority of aircraft crashes have historically occurred in a relatively tight region near the ends of runways, it is possible to create public safety zones that mitigate some of the highest individual third-party risk associated with the airport. This is currently done in the United Kingdom. In the Netherlands, only residential noise zoning limits development in these risky areas. Furthermore, because even these standards do not apply to businesses, it is possible for the business population to increase in these important areas of risk. The government should consider creating public safety zones in the regions near runway approach and departure points, as discussed in the main report.

In general, the management should set “safety first” as a goal of all organizations associated with Schiphol. Although it is understood that levels of safety and risk must often be traded off against costs and other benefits, it should also be clear that safety is a first consideration and is not unnecessarily or unconsciously subordinated.

The government should also exercise caution in setting standards for external risk at Schiphol. We noted in several places in the report some of the potential problems with standards, most notably that there are tremendous uncertainties in our ability to predict the external risks definitively. The benefits and risks associated with Schiphol are different in scale and type from those of other industrial facilities and therefore common standards that lump the airport with such facilities may not be appropriate.

c. Implementing Other Safety Enhancements

A number of potential safety-enhancement measures were discussed in the body of the report that have not been included in the recommendations so far. Technical measures such as the installation of Ground Proximity Warning System (GPWS) in all classes of aircraft are not within the purview of the government, but for such developed technology it is possible for the RLD to advance recommendations to carriers or to propose ICAO initiatives that advance the timetable and comprehensiveness of implementation. The additional runway was shown to reduce third-party risk. This should be examined in more detail with the NLR risk model for verification. If found to be true, there is a safety incentive for this aspect of airport expansion. We have concluded through sensitivity testing with our risk model that optimization of SIDs and STARs for external risk reduction does not have high payoff once the effects of a new runway have been considered. This result depends on the model and data assumptions and should be verified by additional testing with the NLR model. If it is upheld, then we would recommend that the primary safety consideration of SID and STAR design be that associated with reducing complexity and workload for pilots and Air
Traffic Control (ATC). We also mention the practice of Cockpit Resource Management (CRM) as a possibly important safety enhancement because of the frequency of aircrew causes in accidents. Although we are aware that KLM currently practices CRM, it is possible for the government to be more proactive by requiring all Dutch operators to practice CRM and to advance an ICAO initiative that all international carriers include CRM in aircrew training.

d. Informing the Public and Maintaining Trust in Safety Management

The parts of the main report that describe public perceptions about airport risk at Schiphol indicate that there are concerns about growth, misperceptions about what constitutes risk in flight operations, and a belief that the various organizations are not telling the whole truth about some risks. Although it is not generally believed that there is a conspiracy to withhold information, it is clear that there is a perception of a bureaucracy that is not open to the public. Although various organizations have valid concerns about disclosing information that cannot be judged in context, or that may lead to further misperceptions or exaggeration of risk, we have suggested some ways that a more open exchange might be achieved. The existing stakeholder and neighborhood groups, which meet periodically with Schiphol authorities, provide one forum for discussions of risk. An integrated safety-management office described above would provide another. The important point is that the trust engendered by openness is critical to the acceptance and discussion of risks associated with expansion of the airport to a mainport.

In addition to more open communication, the public view of independence in the management of safety issues is important. If an integrated safety-management system is not viewed as independent of organizational pressures on important safety matters, then the public perception of airport safety management will be tainted by skepticism. For this reason, the government should consider the use of an independent safety review panel to act in an advisory (nonbinding but public) capacity in conjunction with the proposed integrated safety-management system.

e. Additional Research

Important research should be undertaken at the international level. There should be more definitive studies of historical crash data to understand better the causes, crash location distributions, and patterns associated with risky carriers, third-world airlines, older aircraft, the effect of airport size on safety, etc. These all have important implications for predicting risks for public safety zoning and standards, routing of arrivals and departures, limiting risky carriers or operations, and setting international standards. Research is needed on how to identify and control risky airlines and how to collect, analyze and disseminate incident data, and international or regional databases for airport risk determination should be developed. Approaches and assumptions used in modeling airport risk should be published and debated in an open forum. It would also be useful to perform additional international airport safety comparisons to highlight alternative approaches to safety management and measure their effectiveness. The Netherlands could advance an EC initiative to perform this type of research for the enhancement of European aviation safety.
Session 4: External Safety of Airports: The State of the Art
Frédéric Rico

In early September this year, when I first heard about this conference, I decided that I should definitely attend it. Then I was asked to address the conference, a totally different matter. But the organizers were very persistent. You might imagine that I came with many general principles and guidelines, but not with specific answers to these questions. I intend to present the problematic issues as I see them, then to focus on the air traffic operation’s point of view, and end up with a few suggestions for organizing and conducting studies at the European level.

New basics have appeared in recent years, which the air transport industry should be considering. I have identified three of these basics for you:

- the ICANNOT-principle
- the NIMBY-theorem
- the BANANA-corollary.

The ICANNOT-principle stands for “I Condone Aircraft Noise, Nevertheless provided it is Over There”. The NIMBY theorem is “Not In My BackYard”, indicating that you can put an aircraft anywhere you want to as long as it is not in my backyard, and—to be scientifically sound—the corollary derived from the theorem is to “Build Absolutely Nothing Anywhere Near Anybody”, the BANANA-corollary. As a matter of fact, there is an addition to these three, the NIET-postulate, particularly appropriate for France at the moment: “Not In Election Time”. Do not dare to think about airport development in election time. We, at least, learned that the hard way.

Next, I would like to state that although the risk in air transport is low, aircraft accidents are a very hot item for the media. A recent study, commissioned by the French Minister of Transport, estimated that the risk of living near Orly Airport and to die of an aircraft accident was equal to a ride from Paris to Lyon and back by car, a distance of about 900 km. There is definitely a problem in the relationship between the general population and the air transport industry. When you see the problem from a scientific perspective, everyone reaches the conclusion that air transport is one of the safest modes of transport. But we could take a poll in the streets, and I think that the answers about transport safety would not be coherent with scientific results. That is a major part of our problem. Although I am not a psychologist, I would declare that I am convinced that people in Europe love to travel, but not everyone loves to fly. On the ground, many people are afraid, bothered or worried by an aircraft that they can hear or see. When these same people take on the role of air travelers, they do not accept any lack of air transport system capacity. But as an airport neighbor, they will support any kind of system constraints. Orly Airport had its capacity

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* Frederic Rico is Director of Air Operations at Orly Airport in Paris (Aéroports de Paris).
constrained to 200,000 movements annually, a number that does not have any scientific basis, but is a result due to a communication problem.

The question that should be addressed is how to reconcile our industry with the general population. Why do aircraft accidents seem to be more unacceptable than road or rail accidents? Whenever there is a crash with more than ten casualties, that accident will make the headlines of all the newspapers in the developed countries. If there is a problem with the air transport industry, there are people to solve it.

What is our current approach of the problem at Orly Airport? Even if we consider that the risk is minimal and largely psychological by nature, we cannot ignore it. We also have to take into account the similarities between noise and accident sensitivity. Whenever people complain about noise problems, more than once the root of their anxiety is accident sensitivity. Thus, we must convince our customers that our main objective as an airport authority is to minimize risk. In our in-house project and organization we must prepare for the worst and try to minimize the consequences of an accident should it happen.

What do we do to minimize the risk? First of all, external safety around an airport is a multi-disciplinary concern. We will have to look at the airworthiness flight operation aspects of the problem. But minimizing the risk is also a communication problem and we should develop information and communication skills. A rather unpleasant thought. We are convinced that whenever we try to communicate at the rational level, we fail to get our message through about accidents. There is a basic principle in psychology that whenever you fail to communicate at the rational level, when you cannot speak to someone's mind, you will have to speak to their emotion. We are trying to address the affective part of the personality of our neighbors. Twenty years ago, there was pure love relationship between the French population and the airport. Those times are long gone.

I will now focus my presentation on the perspective of the air traffic operations. Air traffic operations are closely linked to noise and accident anxiety. People think these operations are very flexible by nature, because you cannot see an air route the same way as you can see a highway or a railroad. For the general public, an air route is something that is almost free of charge. This perception of our profession generates quite a number of proposals on how to change the air routes. I often wonder why sensible people propose to completely reshuffle the very complex organization of the air space near Orly or Charles de Gaulle airport. The main objective is to avoid the overflight over the initiators' own houses or communities. Another question we should be asking ourselves is why people working in the air transport industry cooperate with those kind of initiatives. Why does this problem exists? We think that is due to a lack of communication from our part. We are not successful in passing along the message that airspace organization is not as simple as it appears. Starting December 1994, we will have an "Environment House" at the airport. People will be invited to create noise and recreate the exact noise one is suffering at their own house. Demonstrations of ATC screens will be there, and in principle no question should be left unanswered. If we cannot speak to their minds, we might be able to speak to their emotions.
Another aspect of minimizing risk from air traffic operations’ perspective is the worldwide system coordinated by ICAO. Air traffic operations from the groundside is part of a standard and safe system. Air traffic operations should be as simple, repetitive and standard as possible if we want to improve controller and air group proficiency. We should try to avoid specifics, because we are convinced that nonstandard procedures might lead to an overall decrease in the safety of the global system.

Air traffic operations also need to manage the conflict between the technical requirements and the public perception of aviation matters. There are two examples in that context, the air space problem and the runway problem. When we look at air traffic operations near airports we are very hungry for air space for radar vectoring purposes. But people will misperceive activities to constrain aircraft movements on fixed routes. We need multiple runways for capacity purposes, either dedicated runways, as we have in Orly, or independent runways as is the case at Charles de Gaulle. Our ideal solution would be two independent pairs, 344 meters apart, which became impossible to realize as our movements were constrained. We hope that in June 1995 the problem will be taken up again by our government.

What can air traffic operations do to prepare for the worst? We should minimize the consequences of an accident or incident by addressing the problem of training. We train our specialists for rescuing operations, fire fighting, and medical evacuation. ICAO prescribes a yearly simulation, but we learned a few facts about simulation the hard way. First, a simulated accident is not a media show. Second, whenever you have a simulation, you should run it as a training exercise and not as an opportunity to re-open debate on the accident plans. One of the main objectives of the exercise is not to train fire fighters—this is their job—but to exercise your own controlling, commanding and reporting procedures, and your information system. Whenever you have an aircraft accident near an airport many authorities are involved: national, regional, local, airport authorities, civil aviation authorities, police, health authorities and so on. At that point, the first question is what your information strategy will be. When you start raising this question when people are lying on the ground, most of the time it is too late.

I have a few suggestions for further studies. ICAO is on the verge—in March 1995—of introducing a new instrument landing system. We do think that such a system, be it LNS or GPS, should permit different instrument approach trajectories as close to the runway threshold as possible. We definitely need a system that would allow us to minimize population overflight. In Europe, we have been concerned for years about our en route problems. Most of the ongoing programs, at EUROCONTROL or the European Commission, have been focused on the en route controller’s problem. But the approach controllers’ problems are of a quite different nature. They have to process a large number of parameters: wake turbulence, runway separation, final approach separation procedures. On two runways at Charles de Gaulle, 200,000 to 300,000 operations a year are being handled; we need new tools for the airport approach controller. Stateside, there are new developments with TCAS, on the final approach spacing tool, on the decentered runway. I am not aware of similar endeavors on the European scene.
We had an accident in Paris in 1973. Then, twenty years without a single accident. Another accident at Charles de Gaulle in January 1993, but well within the airport's limits, followed by a real accident with a Romanian aircraft near Orly in September 1994. This has caused major concerns at Paris Airport about the link with the external safety at airports. But we think that the population’s sensitivity to the noise or the accident concern is part of the same global problem: the acceptance of the air transport industry. We have to consider that the European population has accepted accidents linked to road and rail transport, but an aircraft accident is still unacceptable to the general public. We do have zoning regulation, which is different from one European country to another. But as we progress toward more European awareness, we should consider developing a common policy for the external safety of airports, which should be flexible enough and adaptable to cater to the various sensitivities and cultures.
DISCUSSION SESSION 4

Carl Vogt
In the United States we have statistics on the risk of flying on domestic, scheduled airliners. Most of the statistics we have been pertained to the safety rate and to the numbers of accidents of an aircraft. On the question of safety, external to airports, is there any empirical data about the safety of living in the immediate vicinity—however you would want to define that—of a large commercial airport?

Richard Hillestad
We have the empirical data that describes specific accidents that have occurred in the vicinity of airports. One of the problems is extrapolating this worldwide data, something you will need to do to have any kind of representative sample. Using that data, you can see a pattern.

Carl Vogt
Do we have data in Europe—do we think there is any in the United States—on the number of people killed due to crashes within the immediate vicinity of an airport?

Gerhard Stadler
ICAO statistics show the numbers within 3 nautical miles and up to 10 nautical miles. They show us the circle, but not the elongation of the runway. If you analyze the accidents properly we see a high probability of accidents at the elongation of the runway and not on the side of it.

Michel Piers
Concerning available statistics on accident locations, there has been another Schiphol study on the calculation of risk contours. A location model was required and an extensive amount of data has been studied. Two hundred accident locations in the vicinity of airports have been identified and statistically modeled. This allowed for the calculation of the accident probability of an accident in the vicinity of an airport. Of course, it shows that the probability tends to be higher close to the extended runway center lines. Also, the probability tends to increase with a decrease of the distance to the runway threshold.

Carl Vogt
From a quantitative point of view, what do these figures look like, if you live for ten years in the vicinity of the approach end of the runway?

Michel Piers
Individual risk levels around Schiphol in the high risk areas are at about $10^{-5}$, i.e., one in 100,000 annual probability of being killed. This probability, again, decreases with an increase of the distance from the runway threshold. The zoning of the external safety contours is based on these figures.

Jan de Kroes
I have seen some interesting statistics on the number of accidents per million flights, figures that are now going up. This is similar to the trend in road traffic from 15 years ago. That was certainly
due to the increase in the number of possibilities to encounter other vehicles. I wonder if it is not the congestion which could be the reason for the increase of the accident number.

Richard de Neufville
How does the opening up of a second airport in the region affect the third-party risk?

Richard Hillestad
Obviously, if you are flying over a less populated area, the risk—measured in number of people that would be killed—would go down. But I think you might want to take the decision of moving part of the operations to a second airport based on other than third-party risk impact. For instance, on economic and surface transport aspects of having another airport and the risks associated with surface transportation.

Andre Schmidt Apol
The RAND study on external risk states that moving general aviation from Schiphol decreases the risk by nearly 30 percent. But the impact of small planes on risk seems much lower than that of bigger airplanes. I think this number of 30 percent needs to be looked at very critically.

Richard Hillestad
There are two reasons to remove general aviation away from Schiphol. One is based on the risk calculation we did. The accident rate of general aviation is a magnitude larger than that for commercial aviation. Yet the projection of risk is smaller because of the smaller footprint. The number of 30 percent has taken both these factors into account. But the other reason, and this is more important, is the interface of general aviation with commercial aviation, and the risk of problems in that interface of having two different kinds of airplanes with different sizes, different speeds, that you want to avoid.
Session 5: Safety and Aircraft Design
Bernard Ziegler

FLIGHT SAFETY FOR THE NEXT DECADE

Toulouse, the nest of Airbus, is a nice place to live in. This was already known some 25,000 years ago. People settled along the Dordogne river, well before British, the Franks, or the Visigoths. These people left some messages on the walls of their caves. I recently had the opportunity to decipher a significant one which answered a famous archaeological mystery, and is of some relevance to our aviation concerns today. Sometimes, the past can tell us the future.

Two types of civilizations were present along the Dordogne, the Homo Sapiens and the Neanderthal. Both had a common problem, fire safety. Fire was causing a number of accidents in the caves and both civilizations decided to establish a congress to enact some regulations. The Neanderthal experts were, at that time, among the best in the world and their power was unlimited. The rules they established and enforced were so stringent that they almost prohibited the use of fire in all caves. In contrast, the Homo Sapiens experts were reasonably good but their authority was limited by a quite powerful fire oligarchy. Therefore, they reluctantly had to compromise and the Homo Sapiens were allowed to keep fires burning in the caves at the cost of some special training for the fire watchers. Then came the Wurms glaciation. The Neanderthal, who enjoyed a probability of fire accidents of less than $10^{-9}$, were frozen to death. The Homo Sapiens survived at the cost of a few burnt fingers.

Apart from the fact that the Neanderthal have disappeared, it might well be that the scientific community will not back up my understanding of those prehistoric drawings. However, I see, in some parts of the current world, some tendency to replay a similar drama. This is especially true in our small aviation world. This realization brings me to a fundamental point which is the focus of this paper. We must take a “global view” when solving problems. Otherwise, we will suffer the fate of the Neandertaliens.

In the matter of flight safety, let’s take a look at our aviation past. Although there are many ways to record and classify accidents, they all tell us the same basic story.

It is interesting to compare the accident record for scheduled domestic airlines flying in the United States for which we have reliable data since 1939. A review of our progress since that time shows some very promising signs in many areas. First, it is worth noting that the relative number of accidents, based on fatalities per mile flown has decreased by more than two orders of magnitude: If the accident rate had not improved since 1939, there would have been more than 15,000 airline fatalities last year in the United States alone. Since the actual number was much, much lower (averaging at about 100 per year for the past ten years), we know that in many areas significant improvements have been made.

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We should be pleased that, compared to 1939, the contributions to the accident rate of design and production, maintenance, weather, airport, and ATC factors are currently much lower. It is important to note that these large reductions are due, for the most part, to major advances in technology. Unfortunately, we see that "personnel errors" currently contribute to a much larger percentage of accidents (69 percent versus 35 percent). I will have more to say about "personnel errors" in a moment.

If we now take a look at the turbojet era, we see that about 9 out of 10 serious accidents have primary causes that are "operational" in nature; attributed to the flight crew, maintenance, weather, airport infrastructure, and ATC. Only about 1 out of 10 serious accidents is directly attributed to design-related failures; caused by engines, landing gear and brakes, electronics, flight controls, hydraulics, etc.

Having that in mind, I must tell you that I am troubled by the ever increasing difficulty of trying to comply with the constantly expanding list of airworthiness requirements that are being imposed on us by the airworthiness authorities. For example, the A300-B2 was certified in 1974 to all FAR 25 requirements up through Amendment 19. A340 was recently certified to JAR 25 requirements that were equivalent to FAR 25, Amendment 66 plus an additional twenty-three special conditions (about 70 major additional requirements). All of this is in spite of a "global view" which shows that the turbojet-accident rate is very low and that design-related failures only cause about 10 percent of the accidents. It seems to me that our time and money could be much better spent on developing methods to prevent human-related accidents instead of working to further sophisticate our systems theoretically to prevent the few remaining design deficiencies or to better survive a crash.

I am certainly not questioning the individual value of these additional airworthiness requirements, but I am questioning our focus. There are many roads to possibly follow in our accident-prevention quest. Some are dead-end roads doomed by economic realities and the extreme difficulty of designing systems that will improve significantly today’s safety record. Anti-misting fuel and water spray systems are typical examples of these dead-end roads.

A better way for the regulatory authorities to go would be to focus on a "global approach" to accident prevention and to develop "golden keys" (criteria) which foster and encourage industry innovation to eliminate or minimize the factors which cause 9 out of 10 accidents: the "operational" factors. For example, encouraging implementation of satellite navigation and navigation "containment surface" (tunnel) concepts would be much more constructive than today’s reluctant approach to innovation which makes extensive use of "special conditions" as a shield against technological progress.

We must change the focus of our efforts and we must change the paradigms we use to solve problems. Because there are indeed problems: The worldwide accident rate has been almost stable for the last fifteen years with about one serious accident per million departures (.73 for the Airbus fleet), but in the meantime, the world population and the number of aircraft accidents and the number of fatalities will continue to increase unless we make major changes to reduce the overall accident rate.
Let me assure you that Airbus Industrie is working very hard to continuously improve the safety of our aircraft. However, since alone we can act only on the small 10 percent of the accidents which are related to aircraft design, we must have the help of our operators, regulatory authorities, airport and air traffic service providers, leasing companies, insurance companies, and safety organizations in our attempts to significantly reduce the other big 90 percent of the problem.

For example, a majority of accidents (8 out of 10) may be classified as Controlled Flight Into Terrain (CFIT). In recent years, we have significantly improved position awareness through the use of inertial navigation, radio updating, FMS, improved navigation displays, and CAT-III capability, and it can be further improved through satellite navigation and on-board terrain databases. However, the same effort has not been expended for the ground infrastructure or ATC. We must still wait for significant ground-based improvements before we can fully use the capability that already exists in our aircraft.

Although data on worldwide commercial jet accidents distinctly show that the safety record of new technology aircraft is clearly superior to the record of previous generation aircraft, articles in the press and in trade journals continue to raise major questions about "automation accidents" and have served to intensify the debate on cockpit automation and the use of new technology. Is this true?

As a high-tech aircraft manufacturer, I could appear as not too trustworthy in this matter and will therefore largely quote Dr. John Lauber, a distinguished human performance expert and member of the U.S. National Transportation Safety Board (NTSB), who recently made some very interesting and thought provoking comments concerning accidents with automated aircraft, in general, and the SAS DC10-30, China Airlines B-747, and A320 accidents specifically.

Dr. Lauber began these comments by saying "The three high visibility A-320 accidents have focused a great deal of public and professional attention on automation and technology issues, and have served to intensify the debate on cockpit automation and technology. But are any of these really automation accidents, or are they more simply accidents that have happened to automated aircraft, but for which the root causes aren't fundamentally different from accidents that have happened throughout the history of aviation? Are we being profound by saying that automation generates new opportunities for human error, or is that statement equally true of any technology, whether 'automation' is involved or not? By stating that automated equipment requires new or special training, are we simply repeating a lesson learned with the introduction of even the most rudimentary technology—that the human operator must be trained properly if he or she is to use the system properly?"

Dr. Lauber continued his remarks, saying "I think that careful examination of all of the facts and circumstances involved in the so-called 'automation accidents' reveals that the only real problem is that we have, once again, failed to appreciate the support requirements of the humans who end up having to use these systems...... Each of the A-320 accidents, for example, involved, among other things, major breakdowns in crew coordination, failure to follow approved procedures, and at least in one instance, a shocking disregard for basic airmanship, which led to the airplane being too low and too slow—conditions likely to lead to a disastrous outcome in any airplane, low-tech or high-
tech... Operating procedures, flight crew training, quality assurance, and flight crew discipline are as fundamentally important in glass cockpit airplanes as they are in the ‘classics’, and while new cockpit technology may provide many more options for getting an airplane into precarious positions, it also provides many more opportunities for preventing unwanted outcomes."

I strongly support Dr. Lauber’s comments and his plea for a “global view” of our problems. Please do not take this to mean that I believe that there are no real issues associated with automated cockpits; there are many real challenges with automation. At Airbus Industrie, we are constantly striving to further optimize our designs by continuously monitoring in-service experience and actively seeking feedback from our operators so that we can better understand their needs and support requirements.

These efforts recently led Airbus Industrie to host a Flight Safety Conference, for all operators of our aircraft, to discuss factors related to several recent accidents and to obtain their feedback on means which could be implemented to prevent future accidents. From this meeting, it was made clear that our first priority should not be with technological modifications but with a drastic improvement of our operational support and our communication line with the operators.

It was, however, also clear that it is essential for all of us to continue to emphasize the old, but too easily forgotten lessons about the critical importance of rigid adherence to standard operating procedures and the absolute importance of good cockpit discipline during all flight operations, especially during takeoff, approach and landing. It is clear that nearly all human performance accidents are related to the fundamentals of crew coordination, communication, and leadership. Failure to exercise these fundamentals still remains the primary cause of accidents; modern technology has not changed this fact.

A few years ago an accident board concluded that “the circumstances leading to the accident are the usual melange of procedural short-cuts, assumption by certain individuals about the actions and responsibilities of other key individuals, equipment design and the usual pressures of real-world operations, including schedule pressures”. Although these comments were made by the Board investigating a shipping accident in 1987, they are equally appropriate to the unfortunate accident we recently experienced during flight testing at Toulouse.

The development of good operating practices and procedures, commonly called Standard Operating Procedures (SOPs), is an important aspect of introducing a new aircraft into service. Adherence to these SOPs is a critical aspect of any accident prevention program. Historically, there has been a strong correlation between accident history and the operating practices and procedures used by different operators. SOPs are the “glue” that binds a good flight operation together. It has been frequently said that every SOP and every checklist has been written with someone’s blood! This means that every item on every checklist and every SOP is derived from the fact that somewhere in the course of aviation history, someone was seriously hurt or worse because they did not perform that action. Good training and proper procedures will keep us from burning our fingers.
What should be our priorities for the next decade?

By far the first priority is to attack the CFTT issue. We have the technological tools to do so. Our salvation comes from space. Four-dimensional satellite navigation is rapidly becoming a reality, including the capability to provide high quality precision approach guidance, lateral and vertical, to any runway end in the world. When it is properly combined with an on-board or ground-based terrain database, satellite navigation can assure safe separation from the killer, the ground. We will even have the capability to implement systems that warn the crew when the “total system error”, including navigation sensor and flight technical error, will be greater than the obstacle clearance surfaces.

Allow me to put it in very simple terms. Right now, you can buy for less than $600 a handheld GPS which will, at any point in the world, tell you quite accurately where you are. For a little more than a $1000, it will also tell your height above mean sea level. This means that, at any airport in the world, you can now construct and fly very precise three-dimensional flight paths that are similar to but much more flexible than an ILS. With this very precise navigation capability readily available, it will be very difficult for you to try to explain to the public, after the next catastrophic CFTT accident during a VOR/DME nonprecision approach, that some of your experts are not completely satisfied with the reliability of the satellite constellation or that you feel shy about adding one megaword to your FMS database.

Satellite communication, with a proper data link to ATC, can dramatically reduce the problem of misunderstood communications and connect the high capability of current aircraft systems (FMS) with the enhanced ground-based ATC capability. Just imagine the aging Latin Captain that I am being in the middle of the Bay of Bengal, trying to pass a position report to Madras control on HF, desperate to climb out of the monsoon turbulence, wondering how many CBs are in front of my track and what is the weather in Hong Kong, and what will the unforecasted wind changes do to my fuel reserves? Let me dream that I push a button, that this nice guy in Madras almost instantaneously receives my FMS routing, time predictions, and optimum performance profile, and pushes a button which instantaneously updates my FMS weather data, brings up the approach page for the latest approach in Hong Kong, highlights probable CBs on my Nav display, and hosanna, approves a steep climb to get out of this awful turbulence.

The next priority is to improve the Air Traffic Control surveillance and management system. Satellite and ground-based automatic dependent surveillance, coupled with an automated air traffic management system, should reduce pilot and controller workload, dramatically reduce position unawareness and improve the flow of traffic across the world. It should allow a captain to select the optimum dynamic track with a higher potential reduction of fuel burnt than any of the aerodynamic or thermodynamic development currently contemplated. The problem we must overcome in this area is much more socio-political (think of the saga of EUROCONTROL) than it is technical or operational. We are now celebrating the 50th anniversary of the “Chicago” convention; is it not the right time to achieve the original goal of F.D. Roosevelt: a free air for a free humanity?
As already mentioned, crew resource management (CRM) is the next significant and fruitful area of safety development. The airline pilot is the “final common path” for safety in flight operations, and as such, bears a unique individual and personal responsibility for the safety of the traveling public. Implementing CRM concepts is the cheapest way to improve flight safety. Unfortunately, it requires the maximum of courage, sincerity, diplomacy, and imagination to face the social, cultural, and educational barriers to its implementation. CRM should apply to the whole organization, not just the flight crew, and it should be a major part of the “corporate culture”. It means a strict safety discipline with no “cutting corners”, honestly agreed cross-checking procedures, good channels for receipt and dissemination of information, and clear and professional management and command structure.

Some of these ideas are rather disturbing in our social environment since they address duties rather than rights and ask for an ethical code which is out of fashion. But there is no way to escape: maybe one day the public will understand that it is easy to correct a design deficiency, but it is much more difficult to change an organization, its historic culture, or its employees. It is interesting to note that the focus of human performance improvements is shifting from the performance of individuals to the performance of organizations, but which have to be individually endorsed. “Corporate culture” is a critical element of an organization’s safety program.

Improving situation awareness, clarifying communications, enhancing air traffic control, and enhancing the role of the crew in our mutual accident prevention efforts do not require significant technological advances. With the exceptions of SATCOM and SATNAV which are just being implemented, the technology already exists in today’s “glass cockpit” aircraft. However, we must all have strong determination to implement these “global” system improvements. At the verge of the 21st century, let me hope that by working together we can overcome all political, social, and economic resistance to ensure that our accident record continues to improve with each passing year. I assure you that Airbus Industrie stands ready to do our part to see that this happens.
Session 5: Safety and Aircraft Design
T. Khoen Liem

European Commission Activities to Promote Aircraft Safety Research

Introduction

May I start by thanking the organizers of this conference for inviting the European Commission to speak about the Aeronautic Safety activities in DG XII. For those that are not familiar with the organizational structure of the Commission, DG XII deals with Science, Research and Development. Within the Union’s Fourth Framework Program we are responsible for the industry-focused program Industrial and Materials Technologies and also for aeronautics research. We are concerned that the design of the aircraft ensures that the “safety” of air transportation is maximized.

Indeed, we support an important part of the Aeronautics Technologies RTD activities dedicated towards “safety”. Before I return to our research programs I would like to report on the recently completed “Aerosafe” study on improving the air transport safety. This was undertaken by a consortium of Europe’s aeronautics research institutes.

The Aerosafe study was conducted in 1993-1994 by four European aeronautics research establishments, the German DLR, the Dutch NLR, the French ONERA and the DRA from the United Kingdom. The mission of the study was to define a strategic approach to improving air transportation safety—to define the methodology to address safety critical issues. The output of the study has been discussed with all sections of the air transport industry such that the study has provided a useful input into the aeronautics safety activities included in the Fourth Framework Program.

The Aerosafe study was motivated by the fact that since the eighties no significant improvements have been made in the “safety” of air transportation. Despite high levels of safety, the relative number of fatal accidents in scheduled and nonscheduled commercial aviation seems to have leveled off during the last ten years. The expected increase of air transport and also the prospect of larger capacity aircraft will place increasing pressure on safety. We believe that the annual rate of occurrence of serious accidents should not go beyond current levels, in fact it should preferably be reduced even further. This calls for new initiatives in order to achieve substantial improvements, thereby taking into consideration the need to increase the efficiency and capacity of air transportation. In other words, in improving safety, European industrial competitiveness must go hand in hand with complying with the needs of the European (air) transport infrastructure. This is a responsibility that must be shared among all concerned—the aircraft producers, the airlines, the regulatory authorities and the governments. As safety does not know national boundaries, action at Union level can be instrumental at bringing the interested parties together. In this context, the study

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was intended to help establish a basis for assessing which RTD actions would have the largest impact in improving safety.

The study came up with a list of research actions that should receive attention. The research topics that are considered urgent are vehicle safety, human factors and ATM safety. With the introduction of new ATM technologies in the coming years the excellent safety record of (Western) European ATC must be maintained. The next two figures list the areas, as identified by the study, where additional actions are considered appropriate:

**AEROSAFE: Actions (1/2)**

- Strategic approach: - New safety targets
  - Root causes
  - Causalistic risk model
  - Research priorities

- Vehicle safety: - Airframe — structural integrity
  - Engines — damage tolerance
  - flight / engine control
  - Avionics — modular systems

Figure 1 — Aerosafe (1)

### Strategic Approach

A top-down approach towards safety improvements is called for. Realistic targets must be defined. We have to give consideration to economical, operational and technological feasibility, as well as the safety perception of the general public.

An understanding of the root causes and contributing factors to aircraft accidents/incidents is a fundamental requirement if we are to improve safety. This should help us eliminate reoccurrence of negative events. With this knowledge, it should be possible to develop models or “causal trees” to enable cost benefit analysis to be undertaken to prioritize the research topics.

### Vehicle Safety

Turning to the safety issues associated with the aircraft:

- **The Airframe.** Although the proportion of accidents related to airframe failure has decreased dramatically over the past decade, experience in service and emerging new concepts and technologies call for safety-oriented research. Attention should go to the main areas that relate to structural integrity - the loss of strength from fatigue and excessive loading (aging world aircraft fleets); the aero-elastic instability (of great importance for the larger air vehicle of the future); and
the post crash behavior of the air frame (high energy absorbing potential of novel composite structures).

- *The Aero-Engine*. Here research is required to characterize the properties and behavior of new generations of advanced materials. Material utilization could be more efficient if a more precise knowledge of the variability of the usage cycle under all operating scenarios were available. The Aerosafe study also suggests that we look at the viability of integrating flight and engine control systems. This should improve the “landability” of damaged aircraft (we learn that the NASA-Ames-Center seems to have done very useful simulations of such cases).

- *The Avionics*. The reliability requirement of equipment fitted in the aircraft has to be very high (the famous $10^{-9}$ per flight hour). Nevertheless, avionics systems with higher reliability can be designed. In addition, we need to investigate the safety improvement potential of using integrated architectures as well as the need to improve the cockpit “human factors”.

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Figure 2—Aerosafe (2)

**Human Factors**

I believe that this is one of the key areas in safety research. “Humans” are implicated as “the causal factor” in 70 to 80 percent of accidents. According to the statistics, “human error” is the main cause of fatal accidents. Human factors not only relate to direct faults of man but can also reflect the training, crew coordination, communication and the extent of human engineering in the design.

The Aerosafe report considered that the human operator, the human factors certification, human centered automation and the passenger were areas to have important effects on the future safety of aviation:

- **Human operator**: Here work is needed to enhance situation awareness and to optimize the mental workload.
- **Human factors certification**: Certification procedures do not yet exist to cover the human factors aspects of systems.
- **Human centered automation**: The report subscribed to the concept of the human centered automation. It should provide the environment for both the human and the automated system to perform the tasks they are best suited for.

- **Passenger**: A special treatment of this issue is needed in light of the future introduction of the ultra high capacity aircraft. Procedures to handle such a mass of people in an evacuation following an emergency will need attention.

**ATM Safety**

The ATM system of today has grown in an evolutionary development process over more than sixty years to its present standard. It is the result of learning from accidents, from statistical evaluations and of permanent improvement of the ATM components. The current very high level of safety of the ATM system had been maintained following the principles of gradual introduction of new features while avoiding degradation of the overall system safety with increasing traffic.

However, in the past decade the ATM system with which we are familiar has reached its limits of capacity. The traffic is continuing to grow, and innovative solutions are being sought to improve the system capacity to avoid a collapse of the air traffic system. Four research areas have been recommended for consideration:

- **Safety assessment methodology**: The main task of the ATC is to guide the aircraft under control in such a way that a collision will be nearly impossible. For many years discussions have been in progress about the question: "what measures can be used to quantify safety". Presently the ICAO advises a Target Level of Safety (TLS) of between $10^{-8}$ to $10^{-9}$ collisions per aircraft flight hour, i.e. there are years between collisions. If we wish to assess collision risks we need to find other methods than just counting collisions.

- **Risk of ATM architectures**: Advanced ATM concepts are being developed. They have many new functions, such as advanced automation tools and system elements which are not available today. No experience exists regarding their impact on safety. There is at present no consistent and proven methodology to assess the contribution of the ATM system design and architecture to safety. Appropriate mathematical models and methods have to be developed for the analytical validation of safety.

- **Risk of ATM components**: The future ATM system will rely on the collaborative functioning of many different components each contributing to the required increase of capacity, but will also have an impact on safety. Studies are to be conducted to allow the safety evaluation of new functions and components.

- **Validation of the ATM system**: The ATM system is a highly complex system with a very low number of critical events. Obtaining valid quantitative safety data is very difficult. It could be advantageous to correlate indicators such as traffic flow, incident data, and so forth in its safety assessment.

Overall, we believe that the AEROSAFE study has made an important contribution to identifying the areas to be worked on in order to secure the safety of air transportation in the future.
The Fourth Framework RTD Program

The 1994-1998 “Fourth Framework Program” includes all Community activities in the area of research and technological development, including demonstration projects. It is implemented through specific programs, each with precise scientific and technological objectives. The Commission is mandated to “manage” the Fourth Framework Program, reporting to the European Parliament and Council of the Union.

The Fourth Framework Program has been formally adopted, and so have most of its specific programs. This has allowed the Commission to publish the first call for proposals on 15 December 1994.

I would like to draw your attention to the themes containing research programs related to the improvement of air transport safety.

- Information and Communication Technologies
- Industrial Technologies
- Research for a European Transport Policy.

The next three figures give further details:

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<th>4th R&amp;TD Framework Program 1994-98</th>
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<td>Air Transport Safety-Related RTD activities (1/3)</td>
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**Transport** (240 MECU)
- Air Transport (approx. 45 MECU)
  - Includes research projects, mainly of pre-normative nature, in the areas of:
    - Operations
    - Human factors
    - ATM safety

Figure 3—Fourth Framework Program (1)

DG VII manages this Transport program. The actual volume of the safety-related activities will certainly depend on the project proposals received. We may expect a budget of somewhere between 5 to 10 MECU of EC support.
Information and Communication Technologies,  

**Telematics** (843 MECU)  

Air Transport Telematics (approx. 90 MECU)  
Includes pre-competitive research in the Air Transport Telematics areas, where “Safety” is inherent in projects related to:  
- Data network  
- Vehicle equipment  
- Human factors  
- ATM  

Figure 4—Fourth Framework Program (2)

DG XIII, which manages the Telematics program, is not planning to run projects that are specifically “safety” research; however, the safety aspects will be inherent in pursuing new telematic technologies to serve air transportation.

DG XII is managing the “IMT” or the “Brite EuRam III” program. The “safety” activities under this program have an emphasis on the development of advanced technologies for application in future aircraft.

The volume of safety-related activities will again depend on the proposals for research projects received. We would, however, expect to be able to provide an EC co-funding budget of somewhere between 20 to 30 MECU for safety-related research.

Industrial Technologies  

**Industrial & Materials Technologies** (1707 MECU)  

**Aeronautics Technologies** (230 MECU)  
Includes pre-competitive research projects related to Technologies for Aircraft Safety:  
- Systematic Safety Analysis  
- Human Factors  
- Crashworthiness and Explosion Proofing  
- Operational Safety — Atmospherics  
- Operational Safety — Collision avoidance  
- Operational Safety — Electromagnetics  
- Structural Maintenance and Integrity  

Figure 5—Fourth Framework Program (3)
It is worth pointing out that the safety part of our program, as with all the other parts, has been
developed in close collaboration with the interested actors including industry, the regulatory
authorities and the research establishments.

**Systematic Safety Analysis**

This builds on Aerosafe and will cover work on quantitative risk assessment models, based on the
analysis and assessment of past aviation accidents and incidents to establish the contributing factors
to the causation of accidents, thus providing the basis for cost-benefit analysis of safety measures,
including research. We also work to explore the consequences for aircraft safety of the effects of
growing complexity of on-board systems, increased airframe and system interaction, and increased
information processing integration. This should lead to the development of techniques for
minimizing errors in system requirement capture, realization and through-life support.

**Human Factors**

Research is being directed to new approaches to better understand the safety-related aspects of
human-machine interaction in future generation, highly automated aircraft cockpits. Attention will
be paid to “human effectiveness”, particularly when faced with abnormal situations. We also want
to cover the assessment of accidents and incidents related to human factors in maintenance and
dispatch.

**Crashworthiness and Explosion Proofing**

This is to establish an improved structural design capability, by looking at new analytical techniques
to describe structural deformations of airframes, landing gears and seats during crash impact or
explosive loading, focusing on the use of composite and laminate materials. We also want to look
at the passive and active techniques to improve cabin safety. This will include those for impact
shock alleviation as well as materials and techniques to minimize the occurrence and to reduce the
consequences of post-event fires.

**Operational Safety: Atmospherics**

Under this heading we expect to cover:

- the early detection of wake vortexes and wind sheers.
- the issues related to icing, to quantify factors which affect formation and accumulation of ice
  upon aircraft surfaces and its effect on the aerodynamics. Also: to look at ground based or
  on-board methods for detection.
- effects of lightning on primary and secondary structures; special attention on composite/laminate
  materials and integral fuel tanks.
- impact of engine foreign object ingestion and subsequent damage assessment for improved
  post-event aircraft controllability.
Operational Safety: Collision Avoidance

Controlled Flight Into Terrain is a major safety issue. More effective means than GPWS to prevent CFIT are needed. Better airborne techniques for avoidance of collision of an aircraft with ground based vehicles or obstacles are also needed.

Operational Safety: Electromagnetics

Research into new or aggravated sources of electromagnetic interference and potentially vulnerable aircraft equipment and systems, taking into account future use of composite structural materials is needed.

Structural Maintenance and Integrity

New, improved NDT and analysis techniques for field and workshop use should be developed and validated to allow rapid, large area defect localization. Strategies should be developed for maintaining airworthiness of aging aircraft, including the accurate prediction of residual life of repaired structures. Techniques should also be developed to improve the modeling of engine burst risk after disk failure and engine containment capability.

Finally, for those interested in our DG XII safety activities, I would like to draw your attention to the IMT work program. You will find in there a whole chapter in the Aeronautics Technologies devoted to safety.

I do hope to have given you some feeling on our approach to increasing the safety of air transportation.
DISCUSSION SESSION 5

Jan Kamphuis
I was surprised about Mr. Ziegler’s intense arguments for new technology. His view didn’t show any concern about further automation and using new technologies. If we are going to successfully use satellite receivers for flight critical operations, it won’t be the currently installed receivers in the aircraft. All of that will need to be completely redesigned, and there is yet no guarantee that satellite receivers will get the same flight critical standardization as ILS and the radio altimeter meter. The human elements and the integrity of the data are the most critical elements before using them in the enhancement of safety. It has not been proven yet that using satellite technology in highly populated areas will increase safety. How far do we have to go with automation?

Bernard Ziegler
I totally agree that for the time being GPS has not yet proven the reliability level we would like it to have. As far as the accuracy, it could be extremely good, if the U.S. Air Force wouldn’t have decided to degrade that. The problem with the reliability right now is to find ways and means on board that consolidate the data that are being received from GPS. There is also the possibility to cross-check the very details of the GPS data with the ground stations, and there is a system being developed for that purpose in the United States. Obviously, that is limited to terrestrial area. And then there is the possibility to put additional satellites in the sky. I would very much hope that the EU will invest some money in this area to achieve good reliability in the short term. Having said that, I would like to add the following. You have to look for a reasonable compromise. Right now, everyone is using GPS in a satisfactory way, except the people in aviation. We are using nothing. It is either using GPS or nothing. And I agree, we have to make it more reliable, invest European money in it, but let’s do that. That is the right solution and there is no other way.

Khoen Liem
The European Commission has been addressed to look into the issue of satellite navigation. As a matter of fact, I completely agree with Mr. Ziegler that it is much less a technological problem than it is an institutional one. The solutions that are being discussed in Brussels fit in two different frameworks. In the context of the GNSS-1 plan, we investigate the augmentation of the GPS space infrastructure with regard to additional satellites, differential correction systems, thus providing an immediate solution toward the current institutional issues. The GNSS-2 plan is the more long-term plan, dealing with the establishment of a satellite navigation infrastructure, that is not controlled only by the U.S. Department of Defense.

Carl Burleson
I wanted to express my support for what Airbus said about SATNAV. We have made great progress in satellite navigation. I think that in the European context too often we tend to focus on the precision of the system and forget about the tremendous improvement of safety that is occurring today. The United States has already improved 2500 nonprecision approach landings or runways. If the international community adopted for in-route and nonprecision approaches, which if we put it into the worldwide context is 85 percent of the airspace, the ability to improve safety
will be dramatic. I think we need to consider this as we assess the technological revolution. Of course, there are institutional questions of adapting the system to the required integrity for precision landing. In the longer context, we need to look at improving the safety in the world, not just the developed aviation countries, the United States and Europe.

Carl Vogt
In assessing today’s presentations, I think we can distinguish some issues that speakers generally agreed upon. First, there is a need to improve our safety rates in view of the enormous increase in traffic, which will happen. Second, we need to concentrate on the human factors issues, both inside and outside the cockpit. Third, there is the need to apply technology to the persistent problem of CFIT, and to ATM systems. Finally, there is a need for a global approach to all of these systems and to commend those organizations that are trying to reach consensus on a globalized standardization of all aspects of the system.
Session 6: Flight Operations
Captain L. R. Ganse

FLIGHT OPERATIONS ROLE IN AIRPORT SAFETY

There can be no debating that the last line of defense to avoid an accident on or adjacent to the airport environment lies with the operator of the aircraft, both in a general sense for the enterprise owning or operating the airplane and in the specific sense of the knowledge, skills and abilities of the individual crew members who fly the airplane. This paper, however, will focus only that of the corporate entity. Additionally, I will examine the role of the airport operator and how that entity can impact both the airline and the pilot.

The Airline Operator’s Role

The airline operator bears the burden of providing an airworthy aircraft and a trained flight crew. In the end, it is the latter, with a special emphasis on TRAINING that provides the maximum benefit to the customer, to the airline and to the airport operator. The flight crew training must go beyond the mere manipulation of the controls, although I do stipulate that training for handling mechanical malfunctions and emergencies is certainly necessary. The training must also include extensive knowledge of international standards and regulations, familiarity with local air traffic procedures and local airport peculiarities.

A second major contribution that the operator can make is to have an active flight safety program. This must include ongoing data collection and analysis by trained investigators capable of picking out latent hazards, including those in and around the airport. These hazards can lie in air traffic procedures that create the need for unusual aircraft configurations or high workload induced by complex navigation procedures. They can also lie in improper, inadequate or confusing signage or markings on the airport surface as well as obstacles both on and off the airport.

The third contribution that the airline can make is a natural outgrowth of the second. We must COMMUNICATE the safety issues that we identify. Sometimes this is much easier said than done. In my experience it can be very difficult at times to find a responsible party when a particularly difficult problem arises. Many large airports are run by complex bureaucracies that can make the job of locating exactly the right person to address the problem very difficult. Here it would be very nice, indeed, if each airport authority had a individual designated to deal with airline safety specialists.

The fourth thing that an airline can do to promote safety on and around your airports is to be an active participant in industry safety activities. By promoting safety initiatives around the world, sharing information and pressing for higher standards through ICAO we work to raise the overall level of safety.

* Larry Ganse is Director Flight Safety of Northwest Airlines, Inc.
The final item that I feel is often overlooked is the airline’s role in supporting an airport authority that is encountering resistance when it makes an effort to improve safety at its facility. Sometimes we, as airlines, are not even aware of what is being sought until we read about a rebuffed effort. Unhappily, more often the requests for support find their way to our station management who are, almost without fail, from the commercial side of the house. You can count on them to assume that any improvement you are proposing will ultimately come back to them as a higher cost. I would suggest to you that you need to find a voice on the technical side of the airline, primarily through the operations division.

These are the direct contributions that I believe an airline operator through its flight operations division can make to improving the safety on and around the airport. What, now, of the role that the airport operating authority might play in how we operate our airplanes?

The Airport Operator’s Role

First, and foremost, the operator needs to provide a “Non-Challenging” environment for flight operations. Ideally, this starts with a site that is free of geographic hazards like high terrain in close proximity, man-made obstacles like broadcast antennas and steep drop off from runway or overrun areas.

Next, there should be proper zoning of adjacent properties that allows for straight in approaches and straight out departures over a distance of at least five kilometers so that dangerous low altitude maneuvers are not required in the name of noise abatement. A corollary to this is resistance of any noise abatement procedure that degrades aircraft performance by thrust reduction at low altitude (less than 1000 feet) and/or creates undue cockpit workload through the creation of complex thrust and aircraft configuration changes or complex navigation maneuvers.

A friendly environment also means providing suitable navigation aids and lighting. There is simply no excuse at this time not to have vertical guidance in the form of electronic signals or lighting on every runway served by large turbojet aircraft.

Airport signs should be kept in good repair and lighted where necessary. Surface markings on taxi ways and runways must be ICAO standard and repainted regularly so that they are plainly visible both day and night.

Finally, airport authorities should insist that your country’s regulatory authority exercise some oversight of the airlines and aircraft that use your airport. I do not mean to infer that they must duplicate the presence of the airline’s home state authority, but they should determine by some means that 1) the home state of each airline serving your facility does, in fact, have an aviation infrastructure and a regulatory agency capable of meeting the minimum ICAO standards and 2) that appropriate national legislation is in place that allows for the exclusion of demonstrably nonairworthy aircraft, including authority for random inspections.
Recent efforts on the part of the U.S. Federal Aviation Administration have demonstrated that there are serious shortcomings in this area. I quote from the October 24, 1994, edition of Aviation Week & Space Technology.

by September of this year the FAA has assessed 30 nations and determined that 17 were classified as Category 1 nations, and met ICAO rules. Nine countries—Belize, Dominican Republic, Gambia, Ghana, Honduras, Nicaragua, Paraguay, Uruguay and Zaire—failed to adhere to ICAO minimums and were classified as Category 2 countries.

Bolivia, El Salvador, Guatemala and Netherlands Antilles were ranked as category 3 countries, meaning they did not comply with safety standards in certain areas and have 'failings in the basic aviation infrastructure.'

These included no inspectors to supervise operations or to ensure airworthiness, no aviation regulations or handbooks, lack of an operations surveillance program, (and) no annual proficiency checks for pilots and other key crew members. [emphasis supplied]

Three of these four airlines are operating large turbojet aircraft in international service. A review of the IATA safety record for the past three years clearly demonstrates that many states, particularly on the African and South American continents as well as the newly independent states, pose statistically significant higher levels of risk.

I realize that what I have just said may be controversial, but I submit to you that the airport operator has a right, perhaps even a responsibility in terms of the adjacent communities, to insist that airplanes transiting their airport are in an air worthy condition.

Although these suggestions appear brief in number, they nearly all create major problems for implementation. After all, it is hardly feasible to pick up an airport and move it to a more user friendly location. What I would hope to accomplish with this presentation is to point out that, from the operational safety standpoint, it is in everyone's best interest for the airport authority to cultivate a relationship with the operations side of their tenant airlines. By engaging in a dialogue with the operators you will learn what the safety concerns are and will be in a better position to make adjustments that will lower the level of risk of an accident involving your airport.
Session 6: Flight Operations
Jean Pol Henrotte *

It is a pleasure to present to you the contribution from the European Commission on air safety. My presentation will be focused on the safety aspects which are related to our general air transport policy as developed in the Directorate General for Transport, the DG VII.

I would like to open with a general observation. If we look at the distribution of accidents by flight phase, we can distinguish several phases that are related to the airport. Although the percentage of flight time during the cruise, climb and descent is far greater than the flight time spent in and around airports, 30 percent of the accidents happen during the phases that are related to takeoff, and another 30 percent occur during those phases related to landing. This, in fact, means that when we speak about safety in and around airports we speak about 60 percent of the fatal accidents. Furthermore, if we would take the nonfatal accidents and the incidents into account, you would see those percentages increase even more.

If we are to describe the past activities of the Commission on air safety, we do not have to go back a very long time. We only started to work on air safety issues when we organized a safety symposium in 1987. That was the starting point of setting up a common policy on air safety. Based on the outcome of that symposium, we conducted additional studies of which the results were available in 1989 and 1990. From these activities and their findings we were able to issue a communication of the Commission to the Council of Ministers in 1991 on Community initiatives concerning air transport incidents and accidents. This communication concerns initiatives on civil aviation incidents and accidents. The contents of this document is certainly the basis for all the activities that my unit is performing. Our efforts are focused on three main items:

- Accident investigations
- Mandatory incident reporting systems
- Confidential incident reporting systems.

Accident Investigations

In the Commission communication to the Council on Community initiatives concerning air transport incidents and accidents, we have mentioned the need for action in different areas of accident investigation. First, we need to establish criteria for a basic accident investigation structure in each of the member states. Our studies have clearly shown that accident investigation is dealt with in a very different manner in the EU countries. Some have very large accident investigating bodies, mainly in those member states where you have an aviation manufacturing industry. In other member states there is a very elementary structure if there is any structure at all. We also saw that there was the necessity to adapt existing regulation. This is done by taking into account international standards and practices, such as the ICAO-30. Another issue is to provide training for

* Jean Pol Henrotte is with the Air Safety Unit at the Directorate General for Transport of the European Commission.
accident investigators. We would like to provide joint training opportunities for investigators to give them a Community feeling and the sense that they will be able to rely on their neighbors.

We would also like to reinforce investigating bodies. Again, there is a wide difference in the way member states conduct investigations. In particular in those countries where the judicial order flows from the Napoleonic code, the person conducting the judicial inquiry is very powerful. This person is coming to the site of the accident, is helped by the local police and is the one who has all the rights. But in the past, this has caused difficulties between judicial and technical investigators—between two investigations which have two very different objectives. The one’s objective is to find out the reason of an accident and to avoid its recurrence. The other’s is to figure out the responsibilities. The order of urgency of both inquiries is very different. We think it is a necessary to try to find a way to reinforce the technical investigation in order to enable the technical investigators to carry out their duty in the most expeditious manner.

We have also conducted a study on establishing a possible disaster fund. Unfortunately, this development had to be delayed due to budgetary problems. Finally, we want to improve the dissemination of information. It is very important, of course, to carry out very good investigations, but we also have to be able to disseminate the information derived from the investigation. In that way it could have an impact on the improvement of air safety.

Based on all of these needs, we put forward a proposal for a Council directive in September 1993. This proposal should be adopted by the Council of Ministers at their meeting on 21 November 1994. It establishes six fundamental principles governing the investigation of civil aviation accidents and incidents.

The first principle determines a mandatory investigation of each accident and—what is new—each serious incident be carried out. This kind of investigation has only one objective, the prevention of accidents. Further, we want to establish the clear separation between the judicial inquiry and the technical investigation by reinforcing the latter. In saying that, we do not mean that we want to take any of the powers from the judicial inquiry, contrary to what people have claimed to be the approach of the Commission. Third, investigation bodies should be permanent and independent. A truly independent investigation body is very important. We do not want a situation in which accident investigation is carried out by a regulatory authority that, for example, bears responsibility for licensing pilots, certifying aircraft, giving flying or operating permits to airlines, managing air traffic control, managing airports, licensing maintenance organizations and so forth. Those authorities could be partly responsible for the accident itself, and that conflict of interest should be avoided. Subsequently, when the accident investigation is finished, the results will have to be published in a report containing conclusions, analysis, and most importantly, safety recommendations. Publishing a report, however, is not enough. Often, recommendations are sent to the national authorities and we have lost control on the follow up. More grip on the follow up does not mean that the recommendation will become mandatory. But there will need to be a further dialogue between the investigating body and the organizations that have been addressed, to see if the recommendations can be implemented or if there are any alternative means of reaching the same objective. The final principle is the protection of the investigation and its results against its usage for purposes other than accident prevention. In carrying out and reporting on an investigation
you should focus your analysis on the prevention of accidents. For this reason the content of a report could perhaps be misleading if it would be used, for example, to address organizations' responsibilities for the accident.

**Mandatory Incident Reporting System**

The 1991 Commission communication states that we have to implement a system that coordinates existing databases and establishes minimum criteria for national systems in the member states. On this matter as well, we have a wide diversity of systems in the European Union. There are actually three types of member states. The first category has regulations that require operators to report incidents. Those incidents are described in a very detailed list, analyzed and put into an electronic database. These are the rich countries. The second type also has regulation on incident reporting, but this data is processed manually. The third group does not have any form of regulation to report incidents.

To improve this situation, we started a pilot project in our Joint Research Center. This project, called ECCS (European Coordination Centers for aviation incident reporting Systems), aims to improve air safety by bringing together the knowledge derived from our unfortunately incompatible current reporting systems in the various member states. To achieve this, we are to provide our Joint Research Center with all the information necessary to make the decision on whether or not it is desirable to implement a permanent coordination activity at the European level.

The first stage of this project will be the development of an incident reporting system that can comprehend the data from those member states with automated systems. In this way we can increase our statistical coverage and evaluate the applicability of this system as a technical solution for those member states that actually have no automated reporting system. Having built a database, we would want to encourage these member states from the second category to enter their data in the database as well. In a third phase we will ask those member states without incident reporting regulations or systems to create these and enter their information into our central database. This would enable these member states to make the saving of not having to design a new system but to use a system which is already designed and operating for the other EU countries. This program will be completed by the middle of 1995.

**Confidential Incident Reporting**

Activities in this area will focus on the establishment of a European system taking into account other existing systems worldwide. At the moment, confidential incident reporting systems already exist in the United States, Australia, Canada, the United Kingdom and a newly established one in Germany. A mandatory incident reporting system, as I have described before, deals mostly with technical defects or those incidents that are measurable or easy to detect and out in the open right away. Confidential incident reporting is human factors oriented. If a pilot, for example, pushes the wrong switch in the auto pilot he would be the only one to ever notice it. If a maintenance engineer puts the wrong part in an engine and he detects that, he would try to correct it. Those people will try to correct the mistake and not report on it because it would be dangerous for them to do so. They might loose their license, be faced with disciplinary action or even loose their job. It is
normal that they will not volunteer to report to their authority or their employer. At the same time, people who are working in aviation industry are usually very safety-minded. They notice that what happened to them and ended very luckily could happen to someone else and be the cause of an accident later on. People in aviation should be able to share the knowledge of the errors, although presently we do not call it errors or mistakes anymore, but human factors. It does not have to be the mistake of the person involved, it could also be because of poor design of a system or engine or bad procedure.

The confidentiality of a reporting system as I have described is certainly the prerequisite. It will have to be independent from regulators because that will be the only way to receive reports from the aviation community. We have to ensure the confidentiality and we have to be critical. However, it cannot be an anonymous system. We will have to know who reports. First, because we want to investigate on the report. Second, we do not want this system to be used as a leverage against a company, against a regulation or for any other purposes. It will also not be a protection against criminal acts. We will not cover the people who deliberately breached the regulation.

Having studied the currently existing systems in the world and having noticed that it was difficult to integrate and use them in a multinational system—as would be necessary in a European Union of twelve or more member states—we decided that it would be better to start from scratch. As we intended to set up such a new system and had issued our communication from the Commission, people from Germany contacted us and explained that they had the same ideas and intentions. We discussed this with them and suggested that we would be ready to partly finance the German system on the condition that, from the start, it will be designed as the prototype of a European system.

The organizational format in which this system will be put is decentralized. There will be a central headquarters but there will also be national or regional offices. This format has been chosen to be able to respond to the specific cultural and situational aspects related to safety. The human factor aspect is very dependent on local and on cultural issues. The fact that some of these offices will be regional is due to the size of some of the countries in the European Union. These are too small to be able to guarantee complete confidentiality.

The role of the national or regional offices will be to receive the reports, to analyze the report at a first level, to make local recommendations as necessary and then to enter the data into the database. The headquarters' role will be to ensure the coherency and compatibility of the data. One of the ways of doing that is by training analysts. We want, for example, that the data will be coded in the same way in each country. Headquarters will be responsible for the storage of the data and the general recommendations. This is to ensure that after the first level of analysis at the national level, the incident can be seen in the wider context of the European Union, that examinations can be made whether similar incidents have occurred before, and that recommendations can be formulated on the basis of a more general analysis.

I have described three initiatives of the Commission. Those are not its sole activities on air safety, but at least the ones that are part of our directorate general. I think, and this is just a personal feeling, that the third of these three activities is the most promising. It will be challenging because it
will be difficult to establish the credibility of such a system. We will need to receive the reports from the aviation community, from the pilots, from the air traffic controllers, from any of the people whose activities are related to safety. But it is also promising because if you look at the trend in accidents, you can see that human factors are cited as one of the causal factors in 80 percent of aircraft accidents. By establishing a confidential incident reporting system, we will be able to improve our knowledge and our comprehension of human factors. There is still much room to improve air safety in general.
DISCUSSION SESSION 6

Ben Spee
In your speech you remarked that noise abatement procedures have a negative effect on safety, because it causes a higher workload on pilots. Is there enough material at hand to support this conclusion?

Larry Ganse
Noise abatement procedures per se need not be detrimental to safety. But some type procedures involving complex navigational maneuvers close to the ground, power thrust adjustments and configuration changes do have an impact.

New standard noise abate procedures adopted by the United States are quite user-friendly to the pilot and do not pose any risk in the operation.

John Stants
You suggested that you should have proper zoning regulation. But when an airport is built, it will attract all sorts of facilities shortly after, and after some time people will move into the area. The airport authorities stimulate building facilities to pay for the airport. You cannot avoid these developments to be happening. How would you deal with that?

Larry Ganse
We cannot eliminate risk, we can only manage risk. Proper zoning regulations would put the type of construction that exposes the least number of people to either an accidental crash of an airplane or the noise environment close to the airport. I realize that an airport cannot operate in isolation, but within that environment we will have to try to manage risk as carefully as we can.

John Van Oudenaren
Captain Ganse highlighted the problem of the risky carriers from Africa, South America and such, and the need to enforce regulation. But there is of course also the training and development assistance issue. These countries will need help and have to learn from the Western experiences to come up to the safety level in the United States and Europe. Do you think, as an operator and safety director of a major airline, that the European and North American authorities are organized well enough to train and provide technical support to countries where these carriers originate from? There is obviously a need for financial resources, but what more can be done?

Larry Ganse
It is certain that much more needs to be done. The current frustration is the inability to get support from the commercial side of airlines to take safety programs to the places where they are needed. Twice a year, we meet in Geneva and Montreal with IATA. I can assure you that the Canadians and the Swiss do not need our assistance. The countries that do need it cannot afford to send their representatives to these meetings. We have attempted to organize meetings outside of Europe and North America, and go to Africa, South America. Another method to support these countries is through direct cooperation of airlines with aviation organizations in these areas. Currently, there are
some individual initiatives underway, for example by Finnair, my airline, and in New Zealand cooperating with organizations in the NIS, the Far East, Africa. But, I would stress that we need an organized effort to do this and we can take all the help we can get from all parties involved.

Ben Spee
In that context, we are building planes for the Western world and the pilots’ training programs are set up for Western pilots. What to think of the cultural aspect involved in that. What is the effect on safety? This is maybe also an issue that should be thought about in training and in which there should be an exchange of cross-cultural experiences.

Larry Ganse
I think this is indeed an issue, now being recognized by two major organizations in the aviation industry, Boeing and Airbus. They conduct research on these cross-cultural aspects. But, the results will probably not be available any sooner than 3 to 4 years from now.

Ed Highton
From my experiences with safety in the petrochemical industry, I believe that there can be a useful exchange from the expertise with the safety issue built up in the petrochemical industry. For example, putting the human factor in a better perspective as Mr. Henrotte just did. Of the accidents happening in the petrochemical industry, 90 percent were invoked by human factors; but three quarters of that had some background in the organizational setting, such as system failures or other failures that were already latently present in the organization.

Another finding from our industry I would like to share with you regards incident reporting, which I think is a very good system. But the problem with incident reporting is that you are running behind the incidents. You make sure that one type of accident will not occur, but there are so many ways in which an accident might happen, that it will happen anyway. What is important, is that you develop a strategy for accidents not to occur, deal with the issue of loss prevention.

Jean Pol Henrotte
I agree completely with your remarks, but I have a more positive view. You might be running behind the incidents, but this will prevent an major accident to happen. Incident reporting and accident investigation is not enough; research is needed, but you will have to collect some facts and evidence to base your strategy on.

Lidy Wesseling
What does the EC do to prevent risky carriers coming to Europe?

Jean Pol Henrotte
The EC does not do anything on that matter. At the moment, this is the responsibility of the national member states deriving from the Chicago Convention. The convention states that each country has the right to allow the passing or operation of aircraft over or on its territory.
John Enders
In response to the issues of training and incident reporting, I can tell that Russia has developed a safety reporting system in conjunction with the Flight Safety Foundation in 1992. Substantive incident data is now being collected as the pilots begin to trust the system. I think that could answer what we can do about the risky carriers; it demands an inculcation of a safety culture. We will have to start at the very beginning, and build it gradually and consistently.

Martin Ket
What research has been done on accidents caused by human factors linked to the design of technological systems in which human factors have not been sufficiently incorporated. Are there differences between presumption of human behavior versus the actual behavior of people in a technological system?

Jean Pol Henrotte
Presently, the designing of systems has taken the ergonomic aspects into account. Many people think ergonomics is equal to the human factor involved in accidents. But it is clear that ergonomics is only one aspect of the human factor, and we will need to improve our knowledge of the human factor in other areas. We will work on, for example, the training of engineers in order to bring human factors as one of the techniques that should be taught. In the design of technological systems the human factor will of course have to be considered.

Larry Ganse
Another issue is that the human factor aspects that have come forward in research programs in the field of automation (e.g., cognitive skills) have all found their way into the literature for engineers. But one of the fundamental matters that has yet to be addressed and what seems to be missing in new aircraft technology is the pilot's perspective, not just that of the engineer's perspective of the pilot.

Martin Ket
And yet another factor could be the fragmented approach of the human factor involvement toward multiple aspects of the design. These approaches are not integrated.

Erik de Boer
In the discussion about safety it has appeared that the perception of aviation safety in the communities surrounding the airport is very important. One of the methods to address these concerns is the establishment of independent investigation bodies. But we seem to be confronted with a problem: the investigation of incidents and accidents needs a high level of expertise and knowledge. Quite often this knowledge is very scarce and it could be that this can only be found in institutes that in one way or another are involved in the investigated accident or itself are under scrutiny. How can we address this problem in the European context?

Jean Pol Henrotte
Independence is difficult to define. It is an important issue when we discuss where to place the EC investigation body. Certainly, we have to keep it in the aviation field to avoid political pressure and maintain the existing expertise. But also, we would not like to have it too closely related to the
aircraft industry. It probably would be best if it could be directly reporting to a minister of transport. There will need to be a close contact between the investigation body and the regulatory authority, while at the same time avoiding any form of pressure from one to the other.

John Stants
In Canada, we have not experienced this problem at all. If we have an open position for our transport safety board, we receive many applications from people with all sorts of degrees, and with much expertise. People who have retired from their jobs in the air safety industry, and do not have any links with their former organizations are happy to provide their expertise to the Transport Safety Board in Canada. The training is available, so I do not experience the problems that were just addressed. Our board is by the way reporting to Canadian parliament; we have no ministers to report to, and I am pleased to see the developments going on in the EC in this area.

Andre Schmidt Apol
The issue of loss prevention as was mentioned is very important. David Johnson suggested specific analysis dealing with that. I would like to suggest a pilot project with a major company in the field, in which incident data are analyzed while simultaneously the inherent risks of the whole system are structurally researched as well.
Session 7: Air Traffic Control
Xavier Fron

It is a great honor for me to speak before this distinguished audience in a country with such a long tradition of excellence in aviation. The title of this presentation is “EUROCONTROL, the European Organization for the Safety of Air Navigation”. As you can see, safety is at the root of EUROCONTROL. As you may know, the EUROCONTROL Organization is composed of seventeen states and its Agency which is the permanent body; this Agency being led by Director General Yves Lambert. This presentation is not intended as an official position paper of EUROCONTROL, but rather to provide food for thought, and to assist in proceedings of the symposium whose topic, safety in and around airports, is very timely. I will address the general context, the notion of risk, and then concentrate on the Air Traffic Management risk and its evolution. I will give you a few hints about EUROCONTROL initiatives, which are related to the topic of this symposium, consider cooperation, and finally present some conclusions.

Let me first turn a more general view of the value of air transport to our society. Air transport exists because it gives benefits to its users and to the society at large. There are, however, associated costs. I would like to suggest that beyond the direct operating costs, there are also generalized costs to society: cost of “unsafety” and cost to the environment. The cost of “unsafety” can be seen as the actuarial cost of “unsafety”, that is the product of the rate of occurrence of accidents multiplied by the average cost an accident. In fact, emotional aspects may give a different weight to safety. The cost to the environment has to be considered in general, that is not only pollution and noise but also the cost to the external users of aviation, I mean the general public.

There is no doubt that these three factors (cost, safety and environment) are interrelated, and that there is a tradeoff amongst them. For example, improving safety impacts cost, and possibly also environment due to more conservative arrival and departure procedures.

There is, therefore, a global optimum society’s point of view, which must be found, and which cannot be expressed in pure economic terms; the psychological side of safety question must also be taken into account.

* Xavier Fron is Head of Division B2 at the Experimental Centre of EUROCONTROL. This presentation was given on on behalf of Yves Lambert, Director General of EUROCONTROL.
Concentrating now on safety, we have to define some metrics and, therefore, quantify risk. I suggest that risk can be assessed in several ways, depending on the point of view. If you are an insurance broker, for example, the salient risk is the number of accidents per passenger-kilometer. If you are concerned with aircraft operation, or if you are a passenger boarding an aircraft, the most significant risk is the risk per flight-hour. Finally, if you are a political decisionmaker, the risk in which you are most interested is probably the number of accidents per year. That is the number of headlines in the newspapers and public perception. The generalized cost of “unsafety” as I mentioned previously is, I suggest, closest to the risk per year.

If we consider that the effective risk must be lower than the risk acceptable to society, then the figure which should remain constant is the number of accidents per year. If traffic doubles, in order to maintain the same number of accidents per year, then the number of accidents per flight hour must be halved. This is a very significant challenge, which indeed has been met by aviation so far, as we shall see in a minute.

That leads me to consider the risk factors and their evolution into the future. From statistics, you can see that accidents related to Air Traffic Management, that is the collision of two aircraft, is only a small proportion of all accidents, about 5 percent.
RISK AND EVOLUTION

85% Aircraft Operations
5% ATM
5% Weather (35% in Europe)
5% Miscellaneous

Scheduled Services over 40 years
- Traffic in PAX-KM x 60
- Fatal Accidents Relatively Stable (25 per year)
- Casualties Relatively Stable (600 per year)

Figure 2—Risk and Evolution

Another in my opinion surprising factor that I found while preparing this paper is the fact that the number of accidents related to weather is much higher in Europe than elsewhere; about 35 percent of the total number of accidents in Europe. I suggest it is a matter worth considering in the follow-up to this symposium. Talking about risk evolution, it must clearly be said that risk has indeed been decreasing to a very large extent over the last 40 years. Traffic in terms of passenger-kilometers has multiplied by 60, whereas the number of fatal accidents has remained relatively stable at an average of about 25 per year worldwide. Casualties have also remained relatively stable, around 600 per year. Tremendous improvement in aviation safety has been achieved so far.

ATM RISK EVOLUTION

- Continue to Reduce Risk per Flight Hour
- Event Frequency \( \frac{kN^2vlr}{Ah} \) per Hour
- Increases as Square of Traffic Density
  - Safety Concern
- Increases as Average Relative Speed
  - Organize Traffic in TMA

Figure 3— ATM Risk Evolution

Figure 3 considers evolution of risk in the future. First, we observe that the risk per flight hour flattens out whereas I mentioned before that this risk should be reduced if the number of accidents per year is to be maintained. It has been shown from statistical physics by R. Machol, former FAA Chief Scientist, that the natural level of safety is as shown in the equation, i.e., the frequency of accidents per hour is proportional to:
• The square of aircraft density over a given Area (N^2/A)
• The average speed of aircraft (V), and
• Lateral separation (r).

It is inversely proportional to the number of available flight levels (h).

From this equation, we can draw two major conclusions: first, the number of accidents involving two aircraft increases as the square of traffic density, meaning that the 5 percent fraction of the ATM-related accidents may increase to 20 percent when traffic doubles if care is not taken. Second, the square of traffic density is of particular concern in terminal areas. Typical density in a TMA may be one hundred times as high as typical density of en route which means that the risk may be ten thousand times higher in TMA than en route.

The risk of air/air collisions in the TMA is of particular concern as you can see. In the equation there is a factor V which is the average speed. It can be further shown that in the case where traffic is not random but organized, the factor V is no longer the average speed but the average relative speed. I suggest this is an important leverage factor, which enables us to reduce risk in terminal area. If aircraft are sequenced on organized inbound and outbound paths, the relative speed is necessarily smaller, which has a beneficial effect on risk. I suggest, therefore, that in dense terminal areas, traffic must be organized and free flight should not be permitted.

Other factors to be considered when planning airports and safety around airports are the following. A positive contributor to safety in and around airports is probably the airborne collision avoidance systems. There is evidence that TCAS-II as it currently exists actually reduces the risk of collision by a factor of around ten. Whilst this safety benefit has to be recognized, it must also be clear that there are some shortcomings associated with TCAS operations; in particular uncoordinated aircraft deviations do occur outside ground control in complex traffic patterns, which may result in potentially dangerous situations, lost capacity, or excessive vertical deviations. The next factor is the fact that there is a limit to airport capacity and therefore traffic cannot increase to great extents around most heavily loaded airports. If, however, you consider that traffic will increase, then by necessity many smaller airports will be used to a larger extent, and will have to cater to heavier traffic loads. The safety concern in and around airports will, therefore, extend to more places, and more diverse scenarios. The next factor, looking even further into the future, is that experts see the air-ground loop being subject to automatic checks for consistency of ATC clearances with on-board selected commands.

However, controllers will have to rely more and more on automation. The same is true for pilots, which means that systems will be more safety critical, and that any system failure may have severe effects. Consider the following comparison: it is possible to fly at low speed with flaps and slats extended. If flaps or slats are retracted, the aircraft stalls. The same is true for automation: if suddenly automation fails the controller is put in a critical situation. Continuity of service of automation will therefore become an even more crucial factor. We considered risks associated with Air Traffic Management and their evolution, which must be taken into account in airport development.
I would like to point to a number of EUROCONTROL initiatives that are relevant to the topic of this symposium.

First, as you may know, the European Air Traffic Control Harmonization and Integration Program (EATCHIP) is one of EUROCONTROL’s main tasks. The EATCHIP Program is composed of a number of domains, and in particular that of safety. The major driver for the safety domain is to manage safety, which is reflected in the three Executive Views of this domain; namely: common safety policy and principles, safety improvement and safety assessment. The latter implies a monitoring process, whereby safety is constantly assessed so that corrective action can be taken.

There are, in the Studies, Test and Applied Research Program of EUROCONTROL, a number of actions taking place to develop procedures and tools for the terminal area. Typical examples are the ODID4 simulation, which looked at man-machine interface for use by the controller in terminal area, and the demonstration number 2 of PHARE, the Program for Harmonized ATM Research in EUROCONTROL, which will be hosted in 1996 by the German DLR, and will demonstrate advanced tools for managing arriving and departing traffic in terminal areas.

The next item is CAS policy. At the last EUROCONTROL’s Committee of Management, which took place this month (November 1994), it was clearly decided that there should be a Europe-wide policymaking process in relation to TCAS; this has been taken up very actively by the agency together with its member states. I also want to mention that the operational evaluation of TCAS, conducted under the auspices of ICAO, is supported by the EUROCONTROL Experimental Center at Bretigny, which holds an up-to-date database of all ACAS events in Europe.

The next item, which has an indirect bearing on safety, is the implementation of the Central Flow Management Unit (CFMU) in Europe, which will enable to maintain traffic under acceptable thresholds in the airspace, and in particular in terminal airspace.

The next item, where EUROCONTROL has taken a highly active role, together with the European Commission, the European Space Agency, and Member States is the implementation of the Global Navigation Satellite System (GNSS). As I said before, there will be many more airports used by commercial aviation, and it is worth noting that, worldwide, nearly 50 percent of approaches are conducted without precision approach landing aid. This is an area where early GNSS implementation can probably help safety. There is also work under the PHARE Program, which is looking into special meteo models for terminal areas. These are highlights of a number of EUROCONTROL initiatives which have impact on safety in and around airports.

I would like to state that, so far, EUROCONTROL has not been entrusted to work directly for airports, which is under ECAC’s APATSI Program. As you can see, there is nevertheless a significant amount of relevant work in progress.
Of course, Europe and EUROCONTROL in particular cannot conduct all these tasks in isolation. Aviation is worldwide, and there is obviously intense cooperation amongst the EUROCONTROL agency, its Member States, and also airports through the APATSI Program. Close links are being established with the European Commission, and with the European Space Agency under the European Coordinated Approach to Research and Development for ATM (ECARDA). A number of memoranda of cooperation are in different states of existence with: the Joint Aviation Authorities, ICAO, the FAA in the United States, the European Space Agency and a number of states worldwide.

To conclude, I have tried to offer some contributions to this very timely symposium, and to propose some recommendations. The organizers have certainly to be commended for assembling such an audience. I am sure this symposium will bear fruit, and help to assure that airports can further develop with safety maintained at acceptable levels. To summarize the major items:

- The objective of reducing the risk per flight-hour is indeed a tremendous challenge. It can only be achieved through very pro-active management of safety at all levels.
- It is clear that global solutions must be found. ICAO is certainly the forum to reach agreement on standards and recommended practices, but such symposia are very useful contributions to this end.
- The work is of such magnitude and complexity that only initiatives and funding can achieve significant results. Research for airports is certainly one topic which is taken up under the different components of the APATSI and ECARDA Programs.

Finally, I want to draw your attention to the new draft wording for the amended EUROCONTROL Convention Article 1.m., which reads: “to develop coordinated or common policies to improve ATM in the vicinity of airports”. As you can see, safety in and around airports will be dealt with by EUROCONTROL to a larger extent in the future.
Session 7: Air Traffic Control
Stephan Pascall

REVIEW OF PROGRESS TO DATE OF THE ATLAS STUDY FOR THE DEFINITION OF A CANDIDATE FUTURE EUROPEAN SYSTEM —SAFETY ASPECTS—

I am honored to be invited to address the distinguished audience of the Conference on “Managing Safety In and Around Airports”. I am particularly happy to see that speakers today include distinguished leaders of the air transport industry.

In my presentation I shall describe some of the findings of the ATLAS study to date with particular emphasis on matters of safety which is the theme of this conference. I hope that these findings will make a small indirect contribution to improving the air safety in the years to come. I wish to add that this presentation reflects only some preliminary findings of the ATLAS Study and does not represent the official position of the Commission in this matter.

Introduction

The present concept of ground based Air Traffic Control (ATC) has been in use for more than 40 years. There have been improvements due to the introduction of SSR, refinements in radar processing and automation of the coordination process increasing controller productivity; this concept of operation has relied mainly on the splitting up of control sectors as a means of increasing the capacity of the system.

Air traffic delays and a degree of congestion in the Air Traffic Management System remain as concerns. The indications are that the systems currently in place will not be able to cope with the forecast increase in traffic thereby imposing operational constraints or economic penalties on the users of airspace.

In order to find a concept, which will satisfy the anticipated long term traffic demand, there are many ways of proceeding. However, there is no clear indication of which concept will prove to be effective or indeed which will be safest to operate by 2020.

It is therefore now timely to assess new ideas and assess new approaches to the management and control of air traffic which might avoid the inherent limitations of historical concepts of control. Ideally, these should have ample “conceptual headroom” to provide the greater capacity, higher safety levels and lower costs appropriate to European ATM needs in the first quarter of the next century. They should also take into account relevant and emerging technologies such as satellite navigation and communications and cellular based techniques.

* Stephan Pascall is Principal Administrator with the Transport Telematics Unit at the Directorate General for Telecommunication and Information Technology of the European Commission. The presentation was delivered by Doug Ferguson.
The ATLAS study was conceived by the Commission in close collaboration with EUROCONTROL and other interested organizations as an impartial and independent contribution to identify at least one “prime candidate” solution for consideration by the authorities concerned in the context of the European Air Traffic Management System (EATMS) elaborated by EUROCONTROL.

Study Background

The overall ATLAS study is divided into seven main tasks. The first, consisting of a survey of existing European ATM and ATC-related facilities was completed in 1993. The second task is concerned with the definition of requirements for an ATM system having the capability to serve the traffic in European airspace up to the year 2020, and for the identification and selection of a “prime candidate” philosophy, or concept, which would appear capable of satisfying these needs. Subsequent tasks will define the system architecture, transition plans, RTD programs and initial system specifications which would enable such a system to be implemented for trials and further development as required.

A substantial amount of work has been carried out on Task 2 and the products are contained in a number of reports. However, the work on Task 2 is not yet completed, and deliverables to date have introduced some concepts which require further critical review.

Requirements for Independence, Impartiality and Innovation

Existing European programs are already seeking to harmonize, integrate and augment the present systems so as to meet demand growth and traffic in the immediate future. However, work to date in both EUROCONTROL and ATLAS has indicated that the limits of capacity under safe conditions could be reached for the busiest sections of Europe early next century. The prime role of ATLAS is as an independent, impartial and innovative study of conceptual approaches which could eliminate this possible “capacity wall”. The study seeks, as a first target, that the philosophy and concepts recommended should meet the maximum European traffic demand likely to arise from 2005 to 2020.

The long term intent favors integration to increase capacity, reduce crew and controller workload, and harmonization to provide transparency of safety standards for the user. There are a multitude of ways of proceeding, but there is no clear indication or methodology to pre-determine which approach will be the most effective in handling increased traffic in a safe manner.

The Atlas approach examines the problem from a more fundamental standpoint without the constraints of the inherent limitations imposed by historical developments. This has required:

- An understanding of the current traffic patterns and the demographic factors that affect them, and an idea of how they are likely to change in the future.
- The definition of technical strategic objectives for an ATM/ATC system.
- The formulation of a set of operational and functional requirements (collectively referred to as the system requirements) that could meet the strategic objectives and be flexible enough to handle a range of traffic conditions.
- An assessment of the applicability of the tools and techniques that are currently available for the implementation of the system requirements and the identification of the necessary research and technological development to cover the cases where these are needed.

This requires a top-down study that develops through the successive refinement of basic concepts. Having defined the system requirements, the study would then test a number of architectural and airspace options that would be appropriate to the implementation of the ATM/ATC system best suited to meet the strategic objectives.

A single Unified Air Traffic Management System could therefore be defined as: an Integrated System design to achieve a common functionality for all aspects of European Air Traffic Management (ATM), Communications, Navigation and Surveillance (CNS) to generate a configuration of Air Traffic Control centers operated within common procedures determined by operational effectiveness at minimum cost. Conformance with international standards and recommended practices would be an essential requirement of dual system.

I shall now deal with the fundamental idea behind the study. The basic data for this section has been extracted from a number of working papers.

The Disparity of Current Developments

The challenge to capacity and safety resides in the complexity and number of current viewpoints which need to be reconciled. There are 173 states that are members of ICAO. Of these, 32 are members of the European Civil Aviation Conference and of those about 10 are members of EUROCONTROL and/or the European Union (EU). The picture is continually changing with some states applying for membership of the European Union and others for membership of EUROCONTROL. The concept of a Single Unified Air Traffic Management System (SUATMS) could be applicable to the wider context of the ECAC states. Within that grouping there are 51 ATC centers (ATCC), 31 different systems, 22 operating systems and 33 programming languages. Each state has different training, practices and certification processes and these may not be recognized by the other states. The man-machine interfaces in each lack a common approach to data manipulation, storage and presentation. In spite of the deliberations of the FEATS (Future European ATS Systems) Working Group the majority of the developments within each nation state remain strongly influenced by local considerations.

Airspace for en route traffic is rarely a limiting factor. Air Traffic Flow Management (ATFM) has been implemented in many European Union and ECAC states mainly to prevent control sectors from becoming too congested. A number of factors such as sector overloading, controller workload, the quality and volume of Air-to-Ground and Ground-to-Ground communications together with the complexity of radar transfers and handovers has encouraged individual Area Control Centers (ACC) to declare flow rates that they consider will not overload their capability.
Downstream restrictions at destination airports or adjacent ACCs persuade them to apply even tighter constraints.

The Central Flow Management Unit (CFMU) was defined in 1988 by EUROCONTROL. This has the objective of using the entire ATC capacity and to manage the flows in a more flexible and orderly manner.

While this is an important exercise in integration it should be one of the aims of a future ATM/ACT system to eliminate the restrictions of flow control as presently conceived. A re-examination of the basic premises and establishment of the relationships between airspace structure and navigation, communication and surveillance techniques and safety, capacity and workload is therefore an essential foundation of the ATLAS work.

The Strategic Objectives for an ATM System

Strategic objectives are overall high level requirements. They define criteria which the Air Traffic Management System should aim for and against which it should be assessed. Clearly they can be defined since collectively the strategic objectives also serve to define constraints that will apply to the formulation of the operational requirements and, later, the functional requirements themselves.

The ATLAS study has identified seven strategic objectives as follows:

- **Safety**: The service should maximize expedition of traffic at all levels of capacity while maintaining acceptable or definable levels of safety.
- **Suitability**: The service should be suited to customer needs within agreed international standards and practices and take account of environmental issues.
- **Effectiveness**: The service should use all available airspace effectively and not introduce delays of its own due to its internal structure.
- **Availability**: The service should be continuously available.
- **Reliability**: The service should be reliable, consistent, secure and should degrade gracefully.
- **Flexibility**: The services should be responsive to changing levels of demand and changes in customer requirements within the time scale appropriate to the stage of planning or operation or phase of flight of the aircraft.
- **Value for money**: The service should provide good value for money to the customers it services.

This is considered to be a reasonable set of operational objectives. The value-for-money objective is innovative. This paper will concentrate on the safety objectives.

**Safety**

The factors that affect the safety objective are difficult and complex since they are partly theoretical and partly empirical. Under certain conditions theoretical studies have been confirmed by long years of practical operation (e.g., the North Atlantic). It is also possible to observe and calculate the
actual safety standards that have obtained in a given region or for a given airline (at least in terms of accident or incident probabilities of various kinds). It may even be possible to “fine tune” the system, but the effect of this would take years of observations to assess statistically. In general, there is no accepted way to change the system parameters and assess their detailed effect on safety. There are, however, broad principles and it is possible to use these to make judgments about future systems based on past performance, theoretical analysis and experienced assessments.

ATLAS utilizes Collision Risk Modeling which is a reasonable theoretical approach to safety calculations. The following definitions are relevant to this method:

- **Natural Level of Safety (NLS).** This is the collision rate that would arise if each aircraft acted completely independently of all the others. Each aircraft would choose its own departure and arrival time and fly its optimum profile. The NLS would then be computed as a collision rate per hour or per flight as appropriate.

  - The NLS depends only on the distribution of traffic between departure and arrival airports, the meteorological situation, TMA procedures (which can be standardized if necessary) and the performance characteristics of the whole fleet under consideration.

  The NLS is known for some of today’s traffic patterns and aircraft mixes, e.g., the North Atlantic and possibly some parts of Europe, but it would need to be computed for the traffic mix under review if it, or something similar, was not available.

- **Target Level of Safety (TLS).** This is an accident rate in terms of midair collisions per flight hour or per flight.

  - Confusingly, this term is sometimes used to denote incident, as opposed to accident rates. Furthermore, incident rates are sometimes arbitrarily taken to be ten times higher than accident rates and sometimes there is a formula or an algorithm for going from one to the other. ATLAS work has been based on collision rate rather than incident rate.

  As an example, ICAO has suggested a TLS of $0.5 \times 10^{-9}$ mid air collisions per aircraft flight hour for the North Atlantic parallel track system for the year 2000.

- **Target Safety Gain (TSG).** This is the ratio between the NLS and the TLS. It is a nondimensional number representing the improvement required on the NLS to meet the requirements of the TLS.

  - Sometimes, just to be confusing, it is quoted in terms of log10. Thus, for the North Atlantic the NLS is approximately 20 collisions per aircraft flight hour. Thus the required TSG to achieve the TLS is approximately 1010 or, in logarithmic terms, approximately 10 (i.e., about 100dB).

ATLAS has adopted these definitions and has outlined generic models to show the possible ways in which the TLS can be sustained in the face of long-term traffic growth.
Safety/Density Models

The principal characteristic of a safety model is that it should follow a monotonically decreasing curve which either crosses or is asymptotic to a minimum acceptable safety level which can be arbitrarily defined. For a given system environment, there is a safety density at which the safety level falls to this value due to the size of the available airspace and the way it is allocated and used. The safety objective therefore affects the functional requirement (and subsequently the functional architecture) more than the operational requirement. The operational requirement can be stated quite simply as “the target level of safety shall not be lower than the safety level currently observed in European airspace”. The essential way that this objective affects the system requirements for SUATMS lies in being able to define the shape of the density/safety relationship and the subsequent density/capacity relationship for a number of different functional specifications and airspace structures.

This is illustrated in Figure 1:

![Figure 1—Density/Safety Relationships](image)

The various densities D1 may have different density/capacity relationships due to different airspace structures. Since safety is not the only objective there may be other reasons for choosing a set of functional requirements that do not lead to the highest value of traffic density but numerical values for the various alternatives should be estimated before a proper operational philosophy can be chosen.
The key questions which relate airspace capacity must test the feasibility for a given Operational Philosophy. The test of performance would judge how, under normal operating conditions, the peak hour traffic demand could be accommodated. For the purposes of future systems this would relate to a scenario for 2020 where traffic growth has developed to reach up to five times the traffic from present levels. This test would seek to answer the following questions:

- Is the defined Target Level of Safety assured?
- How effective and efficient is the detection and management of inherent uncertainty in the system?
- What are the relationships between airspace capacity, runway capacity and aircraft movements under maximum load conditions?

**Difficulties with Future Predictions**

Predictions which are extrapolated from the current situation are prone to uncertainties because:

- the ultimate capacity limits of the existing operational philosophy for ATM are not known, are unlikely to be uniform throughout the system and may not be capable of precise definition.
- the means to predict the capacity limits of any alternative operational philosophy for ATM introduces a new set of uncertainties.

Reliance must therefore be placed upon empirical knowledge at a detailed level which can be incorporated into mathematical modeling technologies. These will support judgments of relative performance between respective operating philosophies and functional architectures which could be created for their implementation. At this time there is little evidence to demonstrate the structure or reliability of suitable mathematical models to predict absolute levels of safety.

**Basis for Methodology**

Consideration of the potentiality critical parameters for the model indicate the complexity of the problem.

a. Essential parameters

- Increasing system performance.
  Different independent aspects of the ATM system performance can potentially be improved to generate greater safety, capacity and flight efficiency. For example:
    - improvements in safety-related system integrity and reliability, and in Demand Capacity Balancing (DCB) control mechanisms generate safety
    - improvements in system throughput and responsiveness generate capacity
    - the quality of information and algorithms to determine optimal trajectories generate flight efficiency.
Improvements in system throughput and responsiveness are also essential to enable other generators, such as increased traffic density, to be utilized.

- Improving safety net systems
  Safety net systems increase safety directly by reducing collision risk.

b. Interrelated parameters

- Increasing traffic organization
  This can increase safety by reducing relative aircraft velocities and simplifying the problems of identifying and resolving conflicts, but simultaneously can reduce flight efficiency for aircraft that are unable to follow their optimal trajectory.

- Increasing navigation and surveillance accuracy
  Improving accuracy reduces the uncertainty in aircraft position and so can be used to increase safety. Alternatively, aircraft minimum separation could be reduced without any net effect on safety, allowing freedom for aircraft to obtain trajectories that increase flight efficiency.

- Increasing planning and synchronization
  Increasing synchronization reduces the possibility of clustering of aircraft for any given average density, and so could be used to increase safety. Alternatively, it could be used to reduce penalties associated with congested areas and critical resources such as runways, so improving flight efficiency or to maximize the throughput of those congested resources, so increasing capacity. In either case, there could be some reduction in flight efficiency due to the synchronization activities themselves, such as speed adjustment or path stretching.

- Increasing maximum permitted traffic density
  Increasing the maximum density that traffic is permitted to reach increases capacity but simultaneously decreases safety by raising the potential for aircraft conflicts. There is a small positive effect on flight efficiency, since the number of aircraft allowed into the most desired airspace can increase, and there is a greater likelihood of them achieving efficient trajectories.

- Increasing useful airspace
  More airspace directly increases capacity by allowing more aircraft to be accommodated for a given maximum density limit. It also generates safety, from making it possible to reduce average traffic density and flight efficiency by utilizing the additional airspace near to the preferred trajectories to increase the likelihood of aircraft achieving efficient trajectories.

These safety/capacity judgments, if properly considered could help to identify a preferred operational philosophy that would be more likely to succeed than any other. It is not necessary to perform full scale modeling and it may even be a waste of time to do so since there is a limit to the level of detail and accuracy that can be achieved by such methods, however complex.
Conclusions

I have dealt with some of the safety studies coming under the scope of ATLAS, but I should re-emphasize that these are embodied in a much wider study context, the scope of which includes:

- Automation and human factors
- Air traffic analysis
- International regulations
- Centralized versus distributed systems
- Fixed and free systems (including 3D and 4D planned trajectories)
- Track monitoring and conflict identification.

As a result of work to date, two significantly different broad approaches have been identified and described. The principal work remaining in the present phase of work is to complete a set of operational and functional requirements for a "prime candidate" concept of further study and elaboration.

The ATLAS study is far-reaching and consequently introduces many complex considerations. As the results are published so they will be available to support the EUROCONTROL work for EATMS and the research and development programs within both DG VII and DG XIII under ECARDA and the Fourth Framework programs.
DISCUSSION SESSION 7

Richard van Otterloo
When can we expect any specific, quantitative risk and reliability criteria concerning the safety of airports as is being used for nuclear power stations and in the shipping world? If it is possible there, must it not be possible for air safety?

Xavier Fron
At the moment no direct contribution from EUROCONTROL should be expected; our approach is to look into safety models and look at air traffic management. For this there are two time scales: the short term, in which we can only focus on pragmatic actions to introduce better ATM procedures; and the long term, that will concentrate more explicitly on the designing of safety systems. You cannot achieve major changes in a short period of time.

Martin Ket
I have some difficulty with your triangle of risk indicators. If this would be true, then reducing the risk per flight hour will not change the public perception to air safety. Consequently, reducing risk per flight hour will not provide political parties with more support to look into this issue.

My question regards the introduction of GNSS after the degeneration of ILS in 1988. This might introduce four dimensional systems. But this is only possible if planes have high-tech systems, which use area navigation. This would transfer the responsibilities to the pilots and the aircraft, while reducing the control over aircraft operations for ATC. How do you think to manage the control from that position?

Xavier Fron
What I was trying to show with the risk indicator triangle was that if traffic doubles and you want to keep the number of accidents constant, you will need to reduce the number of accidents per flight hours. If you are a politician you might prefer having cheaper transport operations, but for a director of air navigation this might mean that you have an accident at the average of every five years. This is too high. That consideration is what I was trying to clarify.

I cannot see your second point. If the procedures are such that it is the responsibility of airport operators to avoid collision with the ground, I do not see the difference between ILS and GNSS. ATC has no responsibility to avoid hitting the ground.
Session 8: Case Study—Safety Enhancement and Airport Operations at Schiphol

Jurek Keur

I would like to start my presentation by giving you some detailed background information to the Schiphol case. I will do that by, first, giving you an introduction to Schiphol as it was in 1992, before the EL Al Boeing 747 crash happened. Then, showing you what has happened since that, I will elaborate on the results of several studies that were conducted after the crash and indicate how that has led to certain policies and measures. What have we done since 1992, what has the Dutch government done and where do we stand now? The second part of my presentation will focus on the implications for the industry and I will give you an impression about some ideas that we had and are still developing on the problem of external safety, and about actions that should be taken, including on the international level.

It all started with the long term development plans of Schiphol in the middle of 1989. We started together with the national, regional and local governments and included KLM from the side of the air transport industry on a long-term development plan with a set of very challenging targets. The first target was to develop Schiphol into a mainport, and equally important, the second target was to improve or stabilize the environmental impact on the area around Schiphol. In 1991, two years later, a covenant was signed by all parties that included a package of measures. This package contained environmental and infrastructural measures. One of the measures was the construction of an additional runway, which was very important for the airport, especially to meet punctuality requirements but also to reduce the environmental and noise impact around the airport. Then one year later, in 1992, we had the EL Al Boeing 747 accident. Decisionmaking was delayed and the points of view on the development of the airport were reconsidered. Besides the standard accident investigation, two main projects for further investigation and research were initiated.

First of all, the quantification of external risk by the National Aerospace Laboratory (NLR). That study’s main issue was the quantification of individual risk. It resulted, in fact, in external risk, individual risk and group risk calculations for three years, 1990, 2003, and 2015. The individual risk contours for $10^{-6}$ (or the chance of one in a million) for a four and a five runway system were calculated, and that shows that the impact is not insignificant for the area. In general, you have to say that the environment of the airport is considerably affected by these individual risk contours.

The second study was conducted by RAND and MIT. I would like to stress that the RAND study was especially focused on the policy and the management side of the problem. In that sense those two studies are complementary to each other. That is very important to keep in mind. I refer to Dick Hillestad’s presentation for a more detailed overview of the objective and the tasks of the study. The safety enhancement measures that were proposed in the study were very important for us, and on that part the RAND study was developed very well. Another very important task—in many cases not very well understood by the technical parties involved—was the risk

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communication part. It is obvious that it is very difficult to explain to someone, living at the end of the runway, that he has a chance of one in a thousand to get involved in a fatal accident. The fact that you will have to pay a lot of attention to that has been a very important outcome of the study.

The first conclusion from the RAND study was that Schiphol is a modern and safe airport. You could not improve the safety situation drastically given today's situation. But on the other hand, given the typical development plans of Schiphol, the increase of the traffic volume will have some sort of impact on safety and external risk. Thus, the second conclusion stated that safety considerations may change as Schiphol evolves to a mainport. I think that is a straightforward conclusion. On the other hand, and that leads to the next conclusion, we have to recognize that an airport is not just flights. An airport operation involves economic, social, and a whole range of environmental issues and you will have to look at the total picture. Politicians will have to balance these elements, and it is not our role as airport operator to do that. The fourth conclusion was that safety is an airport-wide problem and this has been very well recognized in the previous sessions of this conference. Another conclusion of the RAND study stated that there is not one specific measure that you can take to solve the problem; there is no "magic bullet". You will have to take many measures which hopefully together result in a positive effect on external risk. And last but not least, the very important statement that airport third-party risk assessment is not a very well developed science.

The recommendations of the study were for us the most important. What can we do to enhance external safety? We were very happy that RAND introduced the idea of an integral airport safety management system, and from our point of view it is very clear that the management of safety or risk is one of the main issues. That system has now been very well recognized and defined. The second point of attention is maintaining and enforcing high standards. It has been mentioned in several presentations that certification, training, monitoring, and auditing are very relevant aspects. We all felt that these were key elements to improve the safety as well and that this includes airports, air traffic control, and operators and their aircraft. Some of these improvements are still very hard to implement, such as international bilateral agreements, the issue of difficult carriers, and much will remain to be done on the standards issue. The third recommendation on measures to be taken concerns physical planning. With regard to the development of airports in the last twenty to thirty years, physical planning has been one of the big issues. Last but not least, I have already mentioned establishing open communication links with people and organizations involved in the airport’s operations was very important for the environment. That is why the RAND study introduced the idea of an independent safety advisory commission. This commission will be installed in a few months.

We have been taking up all the elements that RAND has addressed and we are currently working on it and developing it. Again, the main issues for us are the management system and the communication with the environment.

After the completion of those studies, the Dutch government has adjusted its policy, especially in the field of physical planning. They have established/defined individual risk contours of several sizes. In the area where the individual risk exceeds the chance of $5 \times 10^{-5}$, existing houses will have
to be pulled down. In the contours that are slightly bigger, and where the individual risk is smaller, exceeding $10^3$, no new housing or business locations are allowed. The last contour has been defined as a combination of noise contours and external risk contours of $10^{-6}$. In this area new large scale housing construction developments and addition of new high risk activities should be avoided. The Dutch government will be evaluating this safety policy every five years.

We think that the combination of noise contours and individual risk is very interesting, and very important with respect to future development in that area. The area is of significant size and takes it all, noise and risk. For the airport and the air transport industry in this region it is a point of high interest. It is a major step to have developed ways to avoid new large house building in that area. Figure 1 indicates the development relating to the house building situation as has been used in an environmental impact assessment study in 1990. We calculated, based on the numbers from that study and the individual risk contours of 1990, 2003 (with a four or a five runway system), and 2015 with a five runway system, the number of houses within those contours. You see that in 1990 there are approximately 4000 houses within the contours. It descends slightly with a four runway system in 2003, dropping significantly with the introduction of a five runway system. Then it increases again. But in this situation it remains below the base line. So with these given facts we can achieve a stabilization of external risk as it is defined in this manner.

![Graph](image-url)

**Figure 1—Land Use Planning: Policy and Reality**

But actual developments have to be taken into account. There is a policy to avoid large scale construction, but as it might go, building could go on. That is the situation as is drawn in the upper line. Then you can see that you are losing relative to your base line, and you will not be able to stabilize the environmental impact. To avoid new construction in that area is one of the main issues we are fighting for at the moment.
Schiphol has adjusted its approach to policy on external safety as well. I have mentioned the Integral Safety Management System. In the situation in 1991, all companies present at the airport and their related activities were subject under their own individual safety management systems. Some were very well developed, others were less developed. All, of course, concentrated around the handling of aircraft in and around the airport. However, these safety-oriented activities were not integrated and the different organizations were not communicating with each other about it. What we are working toward now is bringing the systems within the TMA of Schiphol together. There are a large number of companies who are active in the aircraft handling one way or the other in this area. Each partner, each company in the system will remain responsible for its own activities. You cannot take over the responsibility of other companies. But we will be trying to have those systems speak to each other. One of the major elements in that is incident reporting and incident analysis. It is almost a traditional situation which probably has happened many times in other industries as well, and there is a lot of experience on the development of these models. But it is even more important that there is a commitment of all parties involved to develop such a system. We think this is one of the main issues and I could not stress that enough. Developing a model is one thing, implementing it and making it work well is another and that will take some years. But we have started, there is the commitment so I am very confident that we will make it.

Having discussed the Schiphol case in some detail, I would like to address the implications for the industry regarding external safety and show you some observations we made in 1992 when we were faced with this enormous problem. Looking at the PAX volumes at the top airports it was of course very clear that Schiphol was not the largest airport in the world. In 1992, we had approximately 19 million passengers and there were quite a number of airports—Chicago O’Hare with 65 million passengers as absolute number one—that had higher volumes. But at the time, we had plans to develop to 45 million passengers in 2015, in the range of Atlanta, Tokyo Hanada, London Heathrow, Los Angeles. Those airports realized that volume in 1992. The assumption was that this volume in combination with the Netherlands being one of the most densely populated countries in the world would be detrimental to external safety. Thus, we decided to look at a number of European airports (Charles de Gaulle, Orly, Heathrow, Zaventem Brussels, Gatwick, Manchester, Frankfurt) and their physical planning situation in 1992, in particular the density of populated areas, to see how other airports were dealing with that problem. After that examination, we were able to conclude that Schiphol did not have the worst situation, and that it is not a problem that is only hitting Schiphol. This is a major problem that will affect the total air transport industry.
Figure 2—Structure of Safety Management in Air Transport

Figure 2 gives a simple but clear picture of the regulatory framework that was and is still available. You have the regulator and the four major stakeholders. This whole regulatory international system has been built up from the right side of the figure. In the beginning, the manufacturers were very important. If you had a broken wing in 1920, you had a crash and you had to do something about that. And then later, if you had solved that problem, there was a guy flying an aircraft who did not have a license and flew into the ground. So you had to do something about that. Then ATC was introduced, and finally the airport. It is a very technical system because air transport is a very technically-oriented industry. But now, a new stakeholder has been introduced in this whole system, the environment of the airport, and at the time there was nothing available to show the effect on that environment. There was not a standard on external risk or an external risk model or whatever.

On the other hand, if you look at the whole system from the left hand side of the figure you can see that at an airport you have an enormous range of aircraft. That means an enormous range of manufacturers, East European as well as West European manufacturers. We have a whole bunch of airlines coming out of different cultures, different stages of economic development, different thoughts about life and death.

What I am trying to make clear is that at an airport you have good and the bad factors together. And from the point of view of the new stakeholder the environment is not very well regulated. So there is a lot to be done still. If you want to know how that system works you will have to look at the way that system collects its data. There is enough data available per aircraft. You can think of anything that is introduced by a manufacturer or whatsoever and you will be able to find data on it. But you can hardly find any data for specific airports, or on very specific elements that are important for airports. Collecting data on specific airport characteristics is very much required, and what the FAA is developing impresses me very much.

So far the current situation—but things are changing. What will the future be looking like? There are a few trends in the air transport industry that can be distinguished. First of all, there are the continuing growth opportunities. I am not stating here that growth will be realized. But there is a
potential of five to six percent on an annual rate. The way the industry will process that growth is through the development of hubs. It means that large airports will be even larger. That means that the whole air transport system will be connected to a relatively large number of hubs. That implies that the local aspects of that hub will have an enormous impact on the whole system. All the major European airports are experiencing that development and I think it will continue. It will lead to more destinations, more connections, more flights. A third trend I have distinguished is the development of new large aircraft. That development is very important because it will have an impact on the environmental progress on board. Emission characteristics, noise and pollution, and fuel consumption will be improved. But where is the external safety issue? Where is that mentioned? I do not think it has surfaced yet, but it has been recognized as an important issue.

My conclusion from this all is as follows:

- **External safety is a local as well as an internal issue but the local issue is becoming bigger and bigger.**
- **Local environmental conditions, including external safety, will increasingly become a limiting factor for capacity of large hubs and consequently for the air transport industry.**
- **Airports are in fact managers of capacity. Presuming that, they will also be manager of environmental conditions, and that means that they will be the manager of external safety. That makes their role clear and they should take that up.**

**Required Actions**

We have made quite some progress in addressing the important issues in the past few years. These issues have been emphasized in the various presentations that have been made here, and I will indicate the actions that I think are required in several fields for the next years.

In the research area, the activities on external safety will need to focus on three issues:

- improving the accident and incident data collection on airport circumstances
- improving our knowledge on airport-related safety
- developing a “causal” model for policymaking on external safety.

In the international policy arena the development of an international standard on external risk and risk modeling for airports is required, particularly given the fact that this problem is an air transport worldwide problem and recognized as such. Another action that is required on an international level is the enforcement of international safety procedures and requirements. The FAA until a few years ago was alone in trying to do something about that, but more people are starting to attend to the issue.

My biggest frustration has been with the land use planning enforcement based upon noise and external safety on the national policy level. I have just shown you that this is one of the big issues. The airports cannot give that space away to the housing construction. That is something that we have experienced with noise in the last 25 years, and we have to stop that now. That is an issue that has to be taken up in the broadest possible sense.
In terms of the industry, required actions lie with the improvement of the safety level with respect to technology and management. A few years ago this topic was almost not discussible, but now I have heard people say that it is impossible to have the industry grow if you cannot achieve improvement of safety levels.

Finally, the action to undertake for airports is to develop an integrated airport safety management system. I have mentioned this more than once and I will not stop doing that. In particular large airports will have to deal with that issue and take up the challenge.

During the conference, Dick Hillestad showed a table that accounted for third parties involved in aircraft accidents. Schiphol was on top of that list with the accident in 1992. I think that it is the big challenge for all of us in the air transport industry to keep Schiphol on top of that list.
Session 8: Case Study—Safety Enhancement and Airport Operations at Schiphol
Gilles van Hövell tot Westervlier

I am very pleased to be invited to talk to you about the “airline maintenance organization and safety enhancement”. First, I would like to make some general comments. The issue I will be discussing has been developed for more than seventy-five years and logically includes continuous attention to achieve substantial safety improvements. I assume that many of you had the opportunity to fly KLM in coming to this conference. A flight has many different aspects. Normally a passenger does not see the maintenance aspects. He is only confronted with maintenance aspects in case there is a technical delay. It is a great pleasure for me to give this presentation about our airline maintenance organization, which is responsible for a safe flight and which is always present in the background during that flight, twenty-four hours a day, seven days a week. We are very well aware that safety is a continuing matter of public concern and I am pleased to make this presentation to this audience, which represents a broad part of our society.

Core issues with respect to safety and maintenance are airworthiness and the task of an approved maintenance organization to safeguard airworthiness. Our assumption is that when we concentrate on quality, we assure safety at the same time. I will address airworthiness and safeguarding airworthiness by means of the maintenance program, the maintenance organization and certifications. My presentation, of course, bears a direct relation to KLM Engineering & Maintenance. Finally, I will review some main developments which are of importance to maintenance organizations.

Who and What is KLM Engineering & Maintenance?

KLM Engineering & Maintenance is a people business. Over 4,000 people are dedicated to satisfying our customers. It is a separate business entity of KLM Royal Dutch Airlines. It has in addition to KLM itself other airlines as customers. The main base of this organization is located at Schiphol Airport. Here and at another 156 line stations worldwide, we conduct line maintenance.

The main activities are the maintenance of the Boeing 747, maintenance of the MD11, the DC10, the Airbus A310, the Boeing 737, and the Fokker 100. We do have a large engine maintenance shop for General Electric CF6 engines. We do components overall. We have state of the art engineering and we provide total care services.

KLM has a broad range of activities and operates under approximately twenty-five different certificates of civil aviation authorities. Most important are the certificates of the Dutch Civil Aviation Authorities, the RLD, which is part of the Joint Aviation Authorities (JAA), and the certificates of the United States Federal Aviation Administration (FAA). Working under these

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certificates leads us to compare our Engineering and Maintenance business with a democratic society. In such a society, everything is allowed except if something is not allowed. In aircraft maintenance, everything is forbidden except when it is allowed.

Our total business is over $600 million (U.S.) per year. As I mentioned, we have 4,000 highly trained and experienced employees. The output in man hours is approximately 4 million per year. Just for KLM we are releasing 96,000 aircraft and at Schiphol we are releasing 42,000 aircraft a year.

Our organizational design contains six business units. We have the Business Unit 747, the Airbus Unit, a Business Unit for the 737, the CF6 Business Unit, and units for LM and material services.

All of these business units are supported by staff units. Two important staff units are, first, the quality assurance and consulting staff unit, which is an independent unit reporting directly to the executive vice president, and, second, the staff unit of engineering, which employs over 250 engineers.

**Tasks of Engineering and Maintenance**

For each flight we have to provide an aircraft in an airworthy condition on time in an economically acceptable manner to KLM operations and to third parties.

In this context, on time means in accordance with KLM flight schedules or to third parties in accordance with the deadlines as specified in our contract with them. Punctuality is an important factor and we have high targets aiming at a punctuality of 95 percent for our intercontinental flights, which means that 95 percent of these flights may not have a technical delay of more than 15 minutes. As you know, airline fares have decreased tremendously. Over-capacity exists worldwide for maintenance which means that we have to monitor costs continuously. Within our organization we are working hard to further improve effectiveness and efficiency in order to compete on a worldwide level.

**Airworthiness**

In the long term the airworthiness of an aircraft must be kept on the originally certified level and we strive to enhance airworthiness during the lifetime of the aircraft. Airworthiness is the ability of the aircraft to perform the task for which it is designated. That means that we consider safety in a very broad sense.

Another part of safety is survivability. To achieve this we have to provide emergency equipment according to the standards. It means considering flight crew workload, operational envelope, passenger comfort, economics and punctuality. Several factors that may have an impact on airworthiness during the lifetime of an aircraft are:

- Degradation and registration by wear and tear, corrosion and fatigue.
- Upgrading of airworthiness standards, for example, to meet higher noise standards.
• Repairs because of incidental or time-related damage.
• Modifications initiated by the operator, manufacturer or regulatory authorities.
• Changes in ownership, type of operations and registration.

Safeguarding Airworthiness

In order to safeguard the airworthiness of airplanes we have set up a maintenance work program, the maintenance organization and certifications.

The chart explains how we are developing our maintenance program. We start with the maintenance planning document and the maintenance review board information which we receive from the manufacturers. Another baseline is the airworthiness directives and feedback from the operator. Out of the airworthiness maintenance program, which is a living document, jobcards are provided which we use to provide the maintenance. And of course we have feedback systems; we have reliability programs to further improve the maintenance programs during the lifetime.

![Maintenance Program Diagram]

**Figure 1—Maintenance Program**

We have different kinds of maintenance. We have the scheduled maintenance based on the maintenance planning document. In addition, we have unscheduled maintenance, for instance repairs, when possible based on a shop repair manual. Then, we have special programs such as special programs to address aging aircraft, corrosion prevention and control and modifications. Modifications are very important. For instance last year we installed the personal video system in our cabins. And last week we started to install a telephone system working through satellites, so we like to stay with the state of the art techniques.
An example is the maintenance program for the Boeing 747. For each flight we have a preflight check. We also have an A-check every 600 hours, a C-check every 18 months and we have a heavy maintenance check every 60 months.

The Maintenance Organization

The KLM Engineering & Maintenance organization is based on a quality standard, composed of the ISO-9000 standards and requirements, as laid down in the different civil aviation requirements. We are continuously analyzing the organization and also analyzing these standards in the process leading to procedures. We recently introduced a very modern computer-based system which we use to analyze our procedures and processes. This is a very advanced system and so far we have had very good experiences with it. The Dutch company AKZO is using this system as well.

So the end results are the procedures. Then if we compare all the different requirements—and Jan de Kroes talked about that yesterday—we see that the different regulations and ISO-9000 standards relate to some main subjects like organization. It must be very well specified how the responsibilities are allocated within the organization and how the tasks are divided. What are the authorities?

Personnel is also very important. You need enough personnel, but we also need qualified personnel. Qualifications standards for our technicians and engineers are of a high level. People are highly skilled and normally we know we have lifetime employment. Data is very important. We only use approved data meaning that most data has to be approved by the authorities. Facilities have to be acceptable, equipment has to be adapted for the tasks. The material which we are using has to be traceably identified and also the quality of the storage has to be acceptable. And last but not least it is very important to keep the technical records.

We have a quality system, which is integrated in the total organization. That means that all persons are involved and each person has his responsibilities and that they are down in all these procedure manuals. These procedures are also available on an on-line computer system, available for everybody.

Staff Unit Quality Assurance and Consulting

Then the quality assurance task. The staff unit quality assurance monitors the quality system from an independent position. The quality control task, for instance the inspection of the product, is the responsibility of the executive process. I will explicate a little more on this.

In quality assurance and consulting, we have two main functions. We have the monitoring function and we have the support system. Within the monitoring function we have several tasks. We continuously perform system audits, which means that we are looking to the procedures and comparing these procedures to the quality standard. Then we go to the work floor to see if the procedures are working, and we have reports of course about our findings. These reports go to the different business and staff unit managers, but the final reports go to the executive vice president.
Subsequently, we do vendor auditing. We have approximately 700 different vendors and we share this effort in cooperation with two large international organizations. We are sharing it with a United States organization, which is the “CASE” organization, which stands for Coordinating Agency for Supplier Evaluation. There we share the output of the vendor audits, but we also share the information about the methods we are using.

Another task in the monitoring function is incident investigation. We have heard different remarks during this conference about incident investigation, so I would like to make some additional remarks. If we have a technical incident, we are going to investigate that incident. What we like to know is first, what was the technical reason for an incident, and second we like to know why our organization was not able to avoid that incident. So we have quite some investigations. What is very important is that all the people in the organization are aware of what is going on. So we provide the different reports to the appropriate people in our organization, but we also summarize the reports. The reports go to the management team of Engineering and Maintenance, and they are discussed over there and the management team tries to make decisions about major follow up actions. So it is very important to get everybody involved in these incident investigations just to avoid the same incidents in the future.

Another task is to be directly involved in issuing personnel authorizations. Further, we perform the liaison functions with the authorities. The last task—which is a special one for our U.S. customers—is quality control management. Those are the monitoring functions.

Then we have the consulting or support functions. We provide consulting services to the different business and staff units and we also provide these services to third parties. Because of developments worldwide, we get more and more invitations to provide these services, but of course they are not free of charge.

We safeguard airworthiness by using certified maintenance programs. The aircraft is certified in the Netherlands. For each aircraft we have to renew the certification every year. But we also have for every flight a release to service, which is done by our authorized persons. Then we have the certification of our maintenance organization, which, as I mentioned, is done by different international civil aviation authorities. And I would again say that I think we have a very good system in Europe developed by the Joint Aviation Authorities. This means that first we are responsible for monitoring our own organization, which is done by quality assurance and consulting. Then the national civil aviation authority also monitors our performance. And what is really new is that there is now an international European team which is monitoring the authorities. Just to be sure that we are using the same standards is quite an effort in this system. I was involved when we developed this system, having been delegated by the Association of European Airlines. We were one of the organizations which asked for such a system, because we wanted to be sure that if we developed a standard here in Europe that that standard would be used in a standard way.

The aviation and airline industry operates worldwide. National borders have disappeared. To make common operations possible there is a need for harmonization and standardization of regulations
and there is a need for a supranational approach. Air transport regulations are growing in volume and complexity. We have an example of this, and that is the newly developed Joint Aviation Requirements (JAR) operations. In Europe, we have made some major progress during the past years. The JAR-145, the requirement covering the requirements for approved maintenance organizations, has been developed and adopted. And the implementation period deadline falls at the end of this year. JAR-65 for certifying staff and JAR operations for the total commercial flight operation are nearly ready for the formal approval process, which we may expect in the beginning of next year. Harmonization is reached by close cooperation among various civil aviation authorities, industry and airlines. Europe, the United States and Canada are playing an important role.

Many other countries and parts of the world are interested in taking part in these joint efforts. Recently, I was at a conference in London about quality in aviation. There were a lot of other civil aviation authorities present, for instance the authorities from New Zealand. They are very willing and they would like very much to participate in these processes. A clear sign of growing partnerships between authorities is the further development of bilateral airworthiness and maintenance agreements. We expect the first bilateral maintenance agreements between the United States and European countries in April of 1995. This will eliminate duplication of supervisory activities. The manpower that becomes available can be dedicated to other main issues and problem areas.

Finally, I would like to mention the KLM efforts in implementing total quality management. These efforts also result in further improvements, so that we can meet our high quality standards in a dynamic and exciting environment.
DISCUSSION SESSION 8

Michael Rich
How will the airport integrate the new stakeholder you identified—those concerned with environmental risk and external risk concerns—into, first, the preparation of an integral safety management plan, and, second, the formation of an independent safety commission?

Jurek Keur
To answer your second question first, the formation of a safety advisory committee was one of the recommendations from the RAND study. This independent committee will look very carefully at the airport operations and the way we interact with the external groups. It will serve as a mirror for our operations on how we perform and could improve. The committee will also report externally to all parties involved about their findings, and will advise us on specific elements.

To get the stakeholders into the process of the safety management system, the issue of communication is again very important. The system is responsible for reporting on incidents, analysis, actions around Schiphol. A third point of integrating the stakeholders is that we have involved all principal parties, including the local governments, in our decisionmaking process. Finally, we have also set up an information center, to establish one uniform point of contact. People can direct their questions to this center and we give them information. We are trying to be as open and reliable as possible.

R. Simonis
The plans for the expansion of Schiphol exclude the construction of housing in external safety zones. These will have to be built somewhere else. This puts costs on other parties. What is the contribution of those involved at the Schiphol operations?

Jurek Keur
The zoning policy as applied here will concern a relatively small number of houses, about 1,500 at the maximum. The construction of the fifth runway as part of the expansion of Schiphol will put the risks of operations to less densely populated areas, and at the same time change the shape of the existing external safety zones. That will open up the opportunity to construct housing in these areas, which will not be possible before the fifth runway.

Jeffrey Gazzard
Looking at the location where the EL Al Boeing crashed and comparing that with the individual risk contours, what does that say about the reliability of those contours? And could removing housing in the safety zones have prevented the crash?

Jurek Keur
It is true that statistics do not give us a clue where the next accidents might happen. We can only try to make the situation more safe. We turned from the hard quantification of risk to the management question. Management development is most important; individual risk contours are important to safeguard land, and can serve as an extra dimension for that.
John Van Oudenaren
Mr. van Hövell tot Westervlier, you mentioned the KLM vendor monitoring programs. From your perspective, how serious is the counterfeit parts problem and is there a need for further international actions?

Gilles van Hövell tot Westervlier
The counterfeit problem is a worldwide problem, and at the moment there are no real solutions. One of my recommendations is to communicate with each other, with colleague airlines, but also with the authorities about the occurrence of counterfeit problems.
Session 9: Institutional and Policy Issues
William R. Fromme

TECHNOLOGY TO IMPROVE AVIATION SAFETY IN AND AROUND AIRPORTS

It is both a pleasure and privilege for me to revisit the charming city of Amsterdam, a center of culture, education, finance and trade. For more than a century, Amsterdam was Europe’s most important commercial center.

In another great center of commerce, a half-century ago, the Convention on International Civil Aviation was signed. On the first of November 1944, 400 delegates from fifty-two countries met in Chicago to open the International Conference at the invitation of the United States. The Netherlands was lead by its Chief Delegate, Mr. M.P.L. Steenberghe, who was later appointed Chairman of the Technical Standards and Procedures Committee. Mr. Steenberghe guided the important conference deliberations on communications; rules of the air; air traffic; licensing; airworthiness; meteorology; maps and charts; and accident investigation, among other subjects. All of us sharing technical responsibilities in our industry are indebted to Mr. Steenberghe and the fine work of his committee on technical standards.

The institutional framework drafted by the delegates to the Chicago Conference is, of course, ICAO itself. Through the efforts of the Netherlands, and of the many other states and people of ICAO, this institutional framework has successfully met the challenges of the past half-century — challenges such as the introduction of jet aircraft, the threat posed by unlawful interference to civil aviation, the aviation-related concerns for our environment, to name but a few. Without the organizational arrangements provided by the Chicago Convention, civil aviation would not have experienced the safe and orderly growth that it has known.

The delegates to the Chicago Conference drafted an international instrument which laid out a philosophy for the development of international civil aviation. It established principles, structures and procedures for a permanent aviation body, and with its eighteen annexes it provided a flexible system for the adoption of technical standards to govern the safety and regularity of international civil aviation.

So much for history. In his welcoming letter to our conference this week on safety, Mr. Hans Smits, President, Amsterdam Airport Schiphol, alluded to challenges facing our industry. One of these must be pervasiveness of change. For example, we are planning a most significant transition to the new technology of FANS. Our challenge is how to most successfully exploit this new technology. Mr. Robert Coleman, Director General for Transport, European Commission, in his letter cited the sobering reality that some 75 percent of all aviation accidents occur at or around airports. My message to this conference suggests that the new technology can and will contribute

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to aviation safety improvements, and reduce the risk of aircraft accidents everywhere, most
certainly including airports and the surrounding areas.

First, the new technology. ICAO, after considerable exploration and collaboration with its member
states and international organizations, has defined, literally, the future of air navigation. The future
scenario includes data links, automation, and satellites to support communications, navigation,
surveillance, and air traffic management (CNS/ATM) systems. And let me point out that for much
of ICAO’s CNS/ATM (FANS) scenario, the future is now.

To a considerable degree, the international standardization necessary to support the new systems,
particularly the communications and surveillance systems, is written and under review by states
and international organizations. Indeed, the availability of the communications data link standards
— satellite, VHF and SSR Mode S — by themselves represent an achievement of enormous
significance. In what is perhaps the largest, most technically challenging task ever undertaken by
the organization, ICAO has materially advanced implementation of the CNS/ATM systems with
the availability of these data link provisions.

With particular regard to navigation, I bring to your attention that three weeks ago, on Wednesday,
26 October, the ICAO Council in a most significant decision accepted the offer of the standard
positioning service of the United States’ global positioning satellite navigation system (GPS). It
was a decision with important institutional implications, but consistent with recently established
ICAO policy. You may recall that the statement of ICAO’s policy on CNS/ATM systems
implementation and operation encourages the early use of the new technologies, and the
evolutionary transition from today’s GPS/GLONASS system to a civil, internationally controlled
global navigation satellite system (GNSS). As well, the Council in its review of the report of the
fourth meeting of the FANS (Phase II) Committee, agreed to encourage states to exploit the
benefits of early use of the new CNS/ATM technology, including, explicitly, GPS. The Secretary
General of ICAO will transmit to you, presently, more information on ICAO’s acceptance of the
United States’ GPS offer. I will return to this point later.

Let us turn now to the subject of aircraft safety, particularly in and around airports. A study by the
Boeing Commercial Airplane Group found that between 1979 and 1991 more than 3,000 people
were killed in accidents in which the flight crew was unaware of the impending collision with the
terrain. These incidents are referred to as controlled flight into terrain (CFIT). More than 50
percent of all fatal accidents reported over the period were classified as CFIT accidents. And, as
noted earlier, three-fourths of all accidents occur in or around airports. What all these statistics
mean, simply put, is that if we wish to improve safety in and around airports, the most significant
gains are achieved by reducing the risk of CFIT.

To address the problem, a special industry task force was established by the Flight Safety
Foundation (FSF) with the support and active cooperation of ICAO. The task force includes
representatives from airlines, airframe manufacturers, equipment manufacturers, professional
aviation associations, and technical and research organizations. Its objective is to reduce by 50
percent within five years the number of CFIT accidents worldwide.
The task force made its initial report, including a CFIT prevention program, and specific recommendations to achieve a substantial reduction in the number of CFIT accidents at the FSF 47th International Air Safety Seminar in Lisbon, Portugal, 1 November 1994. The prevention program includes awareness, risk assessment and training initiatives addressed to regulatory authorities, airline management and operational personnel.

ICAO welcomes the announcement of a CFIT prevention program and will take prompt and positive action on the recommendations of the task force. Indeed, the ICAO Council during its session in the spring of 1995 will review a proposal for revised ground proximity warning system (GPWS) standards for Annex 6. Several task force recommendations focused, understandably, on GPWS equipment and procedures.

With respect to new technology and safety improvements, the task force emphasized the important CFIT avoidance benefits of the increased use of the GPS/GNSS. It recognized on the worldwide, four dimensional accuracy of the GPS/GNSS and its contribution both to situation awareness and navigational accuracy. The task force was convinced, as am I, that the GPS/GNSS can reduce the number of CFIT accidents.

Here, then, is a recommendation to improve safety in and around airports, developed by an industry task force recognized and supported by ICAO. It is based on new technology which is now available. And returning to my earlier comments on the subject of policy, ICAO has accepted the United States’ offer of the GPS standard positioning service for international use.

I urge state administrations and the user community to carefully consider these potential safety advantages of the GPS when evaluating the state letter conveying ICAO’s acceptance of the United States’ offer of GPS, and in subsequent deliberations with respect to GPS use.

On our conference theme aviation safety, permit me one additional observation. In 1945, one year after the signing of the Chicago Convention, our records show nine million passengers were carried in scheduled revenue service worldwide. Two years later—I have no earlier information—ICAO Contracting States reported thirty-four fatal accidents in scheduled air services, with a total of 590 fatalities. That year, 1947, the rate of passenger fatalities for 100 million passenger kilometers was 3.12. Last year, by comparison, over 1.2 billion passengers were carried, an increase of some two orders of magnitude. The fatality rate by 1993 has decreased to 0.05. This represents an improvement of—gain—two orders of magnitude. In fact, every decade since the signing of the Chicago Convention we have witnessed forty percent reduction in the fatal accident rate for scheduled air carriers worldwide. While we will not rest on our laurels, this anniversary year gives us an opportunity to reflect on the successful effort of the dedicated men and women working in our dynamic industry. In the last few years, the safety rate has shown little improvement. With the help of the dedicated professionals in our industry, and, again with the exploitation of appropriate new technologies, we can continue to make gains in safety, and ICAO can continue to plan for the safe and orderly growth of civil aviation throughout the world.
Mr. Chairman, I commend the Amsterdam Airport Schiphol and the Commission of the European Communities for sponsoring this conference and thank them and the RAND European-American Center for Policy Analysis for inviting ICAO to participate.
Session 9: Institutional and Policy Issues
Jan Willem Weck

I am glad to have the opportunity to participate in this conference because the concern for safety has been paramount during all these years, for the private sector as well as for the authorities involved. As the last speaker before the panel discussion I will just briefly touch upon some issues that involve institutional and policymaking elements.

The overall conviction I would like to convey and that has been stressed many times in these two days is that we can not continue to do more of the same as we did (successfully until now) for many, many years.

During the last thirty years the number of accidents and fatalities remained more or less stable notwithstanding the enormous growth of civil aviation. To continue the trend is our aim for the future. In other words: further growth should be compensated by increased safety and, if possible, with some overcompensation on the safety side.

I want to cover three items in addition to all that has been said by previous speakers. (All three have to do with joining forces). First, I want to say some words about the European airspace. Second, I want to give my view on the importance of institutional measures at local airport level. And third, I want to consider the state of the art with regard to the control of foreign aircraft (safety compliance).

Sadly enough, it is a well known fact internationally that within Europe the civil aviation community is wrestling with increasing shortcomings of our total ATC-system due to a considerable growth of traffic, a still suboptimal utilization of airspace, and inefficient use of technical systems.

The main driving force for important and successful measures to cope with some of these problems and the pressure to look for new ways is the (lack of)cost-effectiveness of the systems and the capacity restrictions encountered.

Safety (en route and in and around airports) is not at stake; but if in time no sufficient solution can be found to make efficient use of the total system, taking into account the enormous cost of the investments to be made, external pressure to give in on the necessary requirements of the system could gain momentum. Several comprehensive and worthwhile actions are undertaken. Those bear well known acronyms such as EATCHIP, APATSI, and EATMS.

Recently, the ministers of transport of the ECAC States have decided to explore an additional road to possible solutions, this time called for short: INSTAR. The ministerial decision was to examine what institutional arrangements for Air Traffic Control/Management System(s) will most effectively ensure and support the operational services of the system(s), while respecting the sovereign interests of the states. (All kinds of options have to be taken into consideration including

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one single European authority). The Netherlands has been asked to be the focal point for this project. Several European states and the EU are working together and hope to present a report to the ECAC/DGA by the end of next year.

Institutional arrangements will certainly not be the only road to Valhalla. And most certainly it will not be the only way to solve the problem. It is one of many. There is a strong conviction particularly among the users, i.e., the airlines, that a lot of the problems can be solved by addressing the institutional issues of the EATMS.

While assessing this belief, it is important to quantify the benefits of the individual institutional arrangements. What exactly would be the advantage in terms of efficiency and money?

The users, having advocated or rather “visioned” great and fast profits from this way of approaching the European air space, now will have to translate this idea into firm figures or in terms of clear efficiency benefits. This way they can assist the study group.

Another advocate of the “institutional” approach is the EU, which actively contributes to the discussion and to the funding of this study. In all reality—I personally believe—the EU is the most obvious geographical area in which the first implementation of any institutional arrangements can be realized. Therefore I look forward to any contribution in the thinking process brought on the ECAC floor by the EU.

The study group will also stay in close liaison with EUROCONTROL. EUROCONTROL, as you know, is heading the practical, technical side of the attack on Europe’s foremost problem of air traffic safety. The seriousness of this problem can perhaps be best explained by stating that it is not the safety which is endangered—ATC-people will never allow that to happen—but the system as such, which could collapse under the pressure of a traffic growth of more than 5 percent per year, if forces are not joined in an optimal way. Doing so will contribute to the safe economic growth within European states. And that in the end is the most important target.

My second item deals with the RAND study commissioned by the Minister of Transport on the external risks of Schiphol Airport.

Much has been said about the outcome of this study, an outcome that has been confirmed by an international panel of high level experts. The main conclusion: Schiphol is a modern and safe airport compared to similar airports in Europe and the United States; this is important but not enough. Together with Schiphol, the carriers and the ATC, we are working on the 25 safety enhancement recommendations (to improve further the level of safety especially in relation to the intended expansion of the airport).

The most important recommendation is the institutional arrangement at local airport level to improve the overall safety management. There is a clear additional gain to be reached now and in the future by a more coordinated approach of the players in the field of safety in and around our airports. My agency is strongly in favor and also actively taking part in setting up such an integral
safety management system, not to hand over governmental powers to a nongovernmental body but to ensure that by a coordinated approach based on quality assurance criteria all the existing expertise, experience and know-how is being used in a pro-active and efficient way to minimize safety risks. In two words, joining forces.

Coordinated safety management at local airport level will be complemented by expert monitoring and auditing, not on details or specific incidents but on trends and amongst other things with a helicopter point of view. Therefore we decided to install a special safety advisory panel for the airport of Schiphol. Having such an independent panel has also an additional gain which is: promotion of public acceptance. A very important issue because public perception with regard to safety is policy-wise as important as all the factual information based on the still under developed risk-assessment models. We hope that within a few weeks the Minister of Transport will install the advisory panel.

Talking about factual information: I want to stress that one of the most difficult aspects of safety policy is that, when considering all the available data, in the end you will have to decide on a standard: this is the level of acceptability of analyzed risks. This is a highly political activity as we have seen when the cabinet decided on the standards for the public safety zones for Schiphol. This being so does not release us from the obligation to collect and optimize the data.

In this respect I do want to emphasize the importance of the collection of complete data on accidents and their causes in view of the uncertainties in the ability to predict external risk. Despite the fact that many aviation accidents are well documented, the specific causal chains for those accidents are frequently missing. The data regarding aviation incidents are even less complete and not systematically collated. It is most important for additional research on the international level to be carried out and a uniform method to assess risk to be established. It will not only improve the state of airport risk assessment but will give us better possibilities to take preventive measures. For that reason we will ask the NLR to carry out a study of the CFIT (Controlled Flight Into Terrain) accidents worldwide in close cooperation with the Flight Safety Foundation.

It seems that the availability of technical equipment on airports (instrument landing systems) plays an important role in this type of accident. If this is an essential factor, it might give us an opportunity to rank airports accordingly.

Safety cannot be regarded in an isolated way. There are tradeoffs between safety and environment. In a densely populated country as ours, noise is a problem that needs a lot of attention. But as the RAND study pointed out, one should be aware of the vulnerable balance between safety and environment. For that reason a special group of experts has been set up to decide on new SIDs and STARS.

The RAND report also draws attention to the subject of the safety of foreign carriers. It is recommended by RAND that “the Netherlands begin examining ways to identify risky carriers and considering the appropriate coalition within which to enforce limitations on them”. In their report
RAND makes it perfectly clear that there are limits to what Schiphol and the Dutch government can do themselves.

This aspect regards my third example of joining forces.

RAND pointed out that in their opinion there is no effective international air regulatory body to enforce the high standards of aviation safety of Western Europe in other countries. And although this problem has been brought on the agendas of international meetings by the Dutch authorities, the solution has not yet been found. It is discussed within ECAC, JAA and ICAO. But until now only the FAA took formal steps to attack this problem for their own territory.

Based on their Foreign Aviation Safety Assessment program a number of states were found inadequate in the safety oversight of their air carrier operations. No operations to and from the United States were permitted by airlines registered in those states. (For me it is strange to see that despite this fact the FAA still allows U.S. airlines to operate to and from airports of those states.) In the opinion of the FAA, safety assessment should be carried out by ICAO instead of a contracting state and I fully agree.

In the ICAO Convention the principle is accepted that every state is fully responsible for the implementation of international standards and recommended practices (SARPs). And although the ICAO standards are considered binding, every state is allowed to notify differences if it finds it impossible to comply with them. In this respect ICAO until now has put in a lot of effort to help contracting states to reach the international agreed aviation standards. The monitoring and enforcement, however, are responsibilities of each individual state.

Within Europe ECAC as an intergovernmental organization aims to promote a safe and orderly development of civil aviation. Resolutions and policy statements issued by ECAC have to be incorporated in the national regulations to reach legislative status. In this respect ECAC seeks to harmonize civil aviation policies and practices among its member states and to promote understanding on policy matters between them and other parts of the world. But enforcing standards in other countries by ECAC is not possible.

The objective of the JAA is also to ensure, through joint development of national regulations, common high levels of aviation safety within the European member states. But enforcing standards in other countries than the member states is not possible. Since 1992, however, JAA codes, once they are completed, are referenced in the European Community Regulation on Harmonized Technical Standards and therefore become law in the EU. The JAA also put Joint Implementation Procedures into practice, such as MAST teams (Mutually auditing national oversight procedures).

However, all these European efforts do not improve safety on a worldwide level.

There is also an option to deal with this problem in the same way as is done in the maritime sector in Europe by a sort of “Airport State Control”. This option however has been discussed within the
JAA and rejected because it seems hardly possible to carry out a full inspection of an aircraft during the short turn-around time available on airports.

Thus the weakest part in the international chain to ensure high safety levels seems to be enforcement. So far this situation has been acceptable. It is doubtful, however, whether this acceptance will continue in future. In my view it will not. We must improve enforcement mechanisms, as we did fifty years ago on an international level (preferably global but also regional).

ECAC has already formed a task force, and very recently an ICAO working group recommended the Air Navigation Commission to establish an ICAO oversight program, incorporating safety oversight auditing by an ICAO team as its core function. This is in some way comparable with the MAST teams in the JAA.

It is my conviction that the implementation of this recommendation will benefit the development of international civil aviation in a safe and orderly manner. This recommendation, however, focuses on personnel licensing, aircraft operation and airworthiness. It is surprising that the scope of such safety audit has no bearing on airports and air traffic services at all. Airports and ATC are also important parts of the safety chain! Furthermore, it is not clear what should be done if the outcome of such an audit is negative for certain contracting states.

In this report only a common policy by all ICAO contracting states to refuse operations of air carriers from states with a lack of supervision (and to operate on their airports as well) will force them to change their attitude. I do realize that this solution takes time but in the end I think that this is the only way to improve aviation safety worldwide.

If we could create an EU regulation at short notice in the same way as has been done for chapter three and two aircraft, this might be a short-term solution, especially should other countries outside Europe join us in this policy.

In my opinion ICAO should be and remain the ultimate organization to watch over the safety of aviation worldwide. In this respect it is important that ICAO intensify assisting programs in the developing countries so that in the long term ICAO safety programs show good results in all states. In addition, effective enforcement should become an integral part of the international mechanism to ensure the safety of air transport.

Because global solutions (especially institutional ones) take time, a good interim solution would be regional cooperation in this field, for instance joining forces between FAA and JAA. To ensure a balance between those two important players, a further strengthening of the status of JAA is urgently needed. Also, in this field the European Union could provide the joined forces within the JAA with effective legal powers and with sufficient financial resources.
In the future it is not enough for society that accident rates remain on the same level as at present. To prevent an increase in accidents with the current growth of aviation, accident rates must be pushed down.

To reach this goal many roads have to be explored and intensified (research, technical innovation, attitude, political attention, public awareness, etc.). Joining forces on a global level, on a regional European level, and a local airport level is one of these roads and an important one. I hope that by giving you three very different examples, it also is clear that my approach, even as a lawyer, is not to build a new Babylon but to find pragmatic workable solutions.
DISCUSSION SESSION 9

Andre Schmidt Apol
During the whole conference, the safety numbers used are often based on either flight hours or flight distance. This has resulted in the conclusion that safety has increased. But the major risk is experienced during takeoff and landing and thus other conclusions might be reached if we would compare the number of accidents by each flight movement. Wouldn’t it be more appropriate—especially taking the subject of this conference into account—to use this type of measure?

William Fromme
The issue of the science of statistics in aviation is a very interesting one and it has been debated since we started using them. The same argument could be made for the use of incidents instead of accidents. I think incidents are a better indicator for the health and safety of the system. So why do we use distance as a measure against fatalities? I think it is because we have become most familiar with that type of measurement, and it might be a little arbitrary. But the differences between the measures are decimal points, and I think it is important to view the two observations that can be concluded from the use of any statistics:

- some remarkable progress has been made over the last fifty years,
- but these improvements are not enough; we are now somewhat on a plateau, but we definitely need to even make more progress at this point in time.

Erik de Boer
ICAO is the only worldwide regulatory body in the aviation safety world. In that world external safety has been increasingly considered as an important issue, equally to the internal safety, i.e., the people on the plane. Shouldn’t ICAO also formulate policy to set up regulations with regard to external safety, and urge its member states to avoid, for example, the increase of population density around airports? If ICAO is serious about the issue of external safety, should it not be formalized into ICAO policy?

William Fromme
According to Article 44 of the Chicago convention, ICAO is entrusted with the responsibility to plan for the safe and orderly growth of international civil aviation, globally. How does it do that, without increasing activity levels in and around airports? The only acceptable answer is that we have to ensure that traffic density is increased only when safety standards are maintained or improved. What could ICAO’s role and responsibility be in that? ICAO, as you know, only has regulatory authority, but does not have enforcement authority—that is the responsibility of the states that have established ICAO.

W.P.M. Tijbosch
The new safety body at Schiphol will be responsible for conducting safety analysis and setting trends for what can be expected. But how will it be able to set trends if it would only be investigating accidents and not making use of reports and data on unsafe acts and incidents. Wouldn’t it become much more pro-active?
Jan Willem Weck

The new Dutch safety panel will not be an accident investigation body—we have another institution to do that—but will deal with the several safety institutions in the Netherlands. It will look at safety issues, incorporating all the information that is available on accidents and incidents—from a broad expert’s view. It will also be looking at international trends, but not reporting on specific incidents. Their role is to set up preventive measures that will avoid accidents from occurring at Schiphol.
Session 10: Discussion and Conclusions
Frank Cruise

The ACI handbook 1993 edition contains as the first listed objective of the organization the following statement: “To promote a safe, secure, efficient and environmentally compatible air transport system for the benefit of the traveling public and national and international economies.” The ECAC ministers of transport in their ECAC Strategy for the 1990s referred to “the overall objective of improving the potential throughput of European airports and their surrounding airspace while maintaining safety and respecting the environment.”

I feel that both of these statements are significant in that they give official high profile recognition to the overriding priority that is attached to safety where airport operations are concerned. It is important to emphasize that airports are, in practical terms, at least as concerned as any other authority or interest group with safety. There are two very compelling reasons for this. First, airports as providers of public infrastructure have an absolute need to ensure that the public are and continue to be confident about the use to which that infrastructure is put. Second, airports as economic entities must be in a position to respond operationally to the needs of the traveling public. This implies acceptance by communities and cooperation with any proposed developmental changes in facilities at the airports.

Airports have been active in the management of external and in-airport safety for many years past but, perhaps, have been less active in publicizing the fact. Examples of the ongoing activity are the existence of public safety zones at many airports in the approaches to runways where planning controls are implemented and also regular auditing of the condition, operating practices and procedures associated with airside installations. All of these tasks are usually mandated by states and either carried out directly by or on behalf of states.

You will have seen many statistics in all the presentations. I believe that three facts are relevant and I quote from ICAO’s publications:

- In 1993, almost 1.2 billion passengers were carried representing approximately 25 percent of the world population.
- In 1992, the fatality rate per 100 million passenger kilometers stood at 0.06. In 1947 the rate was 3.12.
- Records over the period 1978-1991 indicate that 60 percent of all accidents occur in the approach and departure phases of flights. In other words adjacent to the ends of runways.

I quote these facts to attempt to set the issue in context.

Consideration of future strategies for management of safety at and in the vicinity of airports might be considered under the headings:

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• Outside the airport
• On-airport

With regard to the former, the issue is linked to the concept of compatible land use. The need for action on a Europe-wide basis in regard to this has been urged by the EU, principally in their *Green Paper on Sustainable Mobility*, and in the *White Paper on the Common Transport Policy*. More recently, it has been a key element of the deliberations in regard to the trans-European airport networks. The achievement of this will not be easy. The ability in the present day to allocate or zone large tracts of relatively undeveloped land, such as happened in the cases of Denver, Dallas/Fort Worth, Mirabel and so forth, is doubtful in Europe. Nevertheless, the issue of balancing the needs of the traveling public at large with the legitimate concerns of users and neighbors of airports must be tackled. Legislators have a duty to address and resolve the problem.

I can refer here to a methodology that has been used at one airport. The acceptance by the local authorities that some restrictions on development in the vicinity of the airport were in the interests of the public at large has led to the publication of this methodology in the local development plan. This, in turn has enabled rejection of development proposals which are deemed to impact adversely on the future operation of the airport. The essential feature of this was the backing of the department of transport for the concept and the acceptance of the issue by the local authority.

In regard to on-airport safety, I have earlier mentioned audits of the procedures and practices and level of conformity with appropriate standards. I remind you again that safety as a culture is intrinsic to most airports but perhaps the value attached to it is not well publicized.

You have heard earlier about the value of an integrated safety management system. At one airport, it was possible to link the safety management system to the overall achievement by the airport of accreditation under ISO-9000. This provided the catalyst for developing an ongoing process.

The entire literature and background science of airport operations is mainly devoted to maintenance of the highest safety standards. The corpus of the ICAO Annexes prescribes certain common standards and practices which are directed at ensuring a safe environment within which aircraft can operate. More recently, ACI produced the Ramp Safety Handbook which is aimed at instilling a safety minded culture in airside ground activities.

I refer to the joint ACI/IATA ramp safety campaigns of recent years, and the multitude of training courses and seminars on which significant funds are expended by airports. Those of you who have dealt with the financial consequences of safety negligence will be very aware of the cost of liability premia for insurance and the parallel overriding need to maintain a high level of safety awareness.

In conclusion, I reiterate that safety in and around airports is a principal focus of the management activities at airports and also amongst the relevant professional organizations. Airports have been to the fore in ensuring that users of airport facilities can do so with full confidence in their own
safety. Airports will continue to press for a balanced approach to legislation affecting their operational activities and, also, for full consideration of the needs of the whole community in regard to land use in the vicinity of airports.
I think we would all agree that the airport plays a very pivotal role in the aviation system and exerts great leverage on safety and risk of air operations because of its close relationship with all of the other parts of the system. I would like to comment on some of the presentations. They have all touched on a wide range of issues. But I also want to raise a few more that were not touched on. Overall, I think that the presentations and discussions reflect a great amount of progress and maturing of the industry over the past decade and a half. If you would have gone to a safety meeting twenty years ago, probably most of the discussion would have been on accidents and analyzing accidents, not about the proactive types of issues we are addressing here, trying to reach out and prevent the accident from happening.

My alma mater, the Flight Safety Foundation (FSF), addresses some of the expressed concerns about eliminating or reducing accidents in the airport arena. Bill Fromme referred to the CFIT task force that the FSF has led in cooperation with ICAO, IATA, IFALPA, and the FSF international advisory committee. The goal is to reduce the accident rate by 50 percent over a five year period. The effort involves much more than 150 volunteer specialists from the foundation’s membership (630-plus member organizations in 76 countries) and elsewhere. The effort has produced several strategies that attacked the CFIT problem. Among these are a self-administered CFIT checklist. The foundation has made a first printing of over ten thousand of these. They are available and I urge you to take a look at them. We feel that this will help focus the individual on areas needing special attention within his own operation. Another portion of that CFIT activity is the improvement of charting, to highlight dangerous areas around airports, and the approach and departure areas that bear special attention. Another focus is on fostering the proper installation and use of an effective GPWS type of system, and then to provide special briefings to operations management and states’ regulatory bodies to alert them of the dangers of CFIT and measures that they can take to avoid it.

On a broader basis, the FSF has also fielded the Icarus Committee, named after the first person who made a gross human factors error by flying too close to the sun with improper structural design. It has addressed human factors issues in air transport, and has come up with eighteen findings which form the basis of ten recommendations to industry and government for specific actions. These will be appearing in a FSF publication shortly. But key among the recommendations is one dealing with gaining top management commitment to safety and risk management. That applies not only to the airline, but to the airport management or any other organization operating on the airport. It is essential that top management shows visible and demonstrated commitment to safety objectives of the organization frequently. Safety is not a one-time purchase that you put on the shelf and say “we now have safety”. You have to work at it all the time. Other recommendations deal with training issues and improved communications between the airport, ATC, flight operations, and other infrastructure support.

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Another FSF initiative that affects airport safety is the recently concluded wind shear training aid developed for the smaller operator and the corporate operator in general aviation. It extends the large wind shear training aid developed several years ago to this class of operator. There is much effort going on, not just by the FSF, but other organizations likewise.

The Foundation is an excellent conduit for information. Our publications are probably read by over ten thousand people in the aviation community worldwide. If you have messages that you want to get out, write for the FSF and get the information published and shared. The FSF bimonthly airport safety bulletin features discussion on a broad range of safety issues involving airport personnel. We have issued special reports on counterfeit parts recently, and cabin safety, evacuation in emergencies, and a special report on lessons learned from safety audits. This last report gives insights in the operators’ own activities and interaction with their airport environment.

Mention has been made about the risky operator. The FSF has done some missionary work, beginning in 1988, working with the former USSR in fostering a safety culture in their civil aviation structure. That is, of course, going in all sorts of chaos, but at the same time we have been able to foster their formation of a similar flight safety foundation organization in Moscow, which supports the dissemination of safety information in airports and air operations. They have also introduced a voluntary safety reporting system.

Virtually all of the issues mentioned at this conference involve the need for more effective communication and I cannot stress that enough. I sometimes feel that the various elements of the aviation community operate as separate tribes. There is the airport tribe that meets with the ACI, the operations tribe meets with IATA, and so forth. It is essential that we have cross-talk. We need to sow seeds of thoughts and ways of thinking about safety problems that others can take home and think about.

Another concern that was not mentioned is the “decay of knowledge”. That alludes to the fact that many people in the aviation system, both on the ground and in the air, get their initial training that might be very thorough. But, unless they are in a very structured organization, they might not have any recurrent training or updating. I think that especially applies to ground personnel around many airports. ACI has done a great amount of work to correct that deficiency, but some of the ramp personnel servicing aircraft in the various parts of the world probably do not even have any initial training. I am concerned that people who work around airplanes are qualified and that they have received training. Even under the eyes of an experienced supervisor, they must understand why they are on the ramp in the first place.

I strongly agree with Bernard Ziegler’s comments. He noted that the capability of the current modern aircraft far exceed those of the ATC system and some of the ground-based navigation facilities and airport physical facilities. These discrepancies can significantly add to workload for both the aircrew and the groundcrew. They often provide opportunities for error that may lead to an accident.

Human factors knowledge is rapidly increasing. Human factors embraces a very broad area of activities. Ergonomic aspects are well developed in my opinion, but cognitive engineering is in the
process of being developed. As new systems, whether airport, ATC or aircraft, are designed and conceived, it is important that human factors, particularly cognitive functioning-related, be an integral part of the initial process, rather than an expensive and less effective add-on later in the process.

Safety audits were mentioned. I think they are important. There are two kinds of safety audits. The internal safety audit that a company or organization administers itself, which should be paired with a periodic external audit as Jan de Kroes suggested. There are many people who do audits but if they are done in a introspective way, with self-honesty, they can be extremely revealing in pointing the way where improvement and attention is needed.

Apron safety was not specifically mentioned. It is a major loss category in damaged aircraft and ground equipment and in personnel injuries. Insurance companies see that as a large segment of their loss payouts. Strong central management in airport organizations, with strict procedures coupled with hiring practices that screen out those that lack discipline, can substantially reduce that problem. Another area that was not mentioned is wildlife control. Birds and animals continue to lurk as latent hazards, despite progress made in FOD tolerance engines and structures. However, we have had a chronic weakness in the three decade long bird hazard area in the honest reporting of bird strikes and presence on and around airports. It is to everyone’s advantage that these reports are as high in integrity as possible.

I am concerned, while I strongly favor the intermodal features of mainports, that it raises some security concerns.

Concluding, the conference served a very useful purpose in bringing together experts from several specialties in all critical aviation safety sectors. I hope that the networking process continues.
Ruth Frommer

On behalf of the European Commission and more in particular on behalf of the directorate general for transport, we very much welcome the initiative for this conference. Not in the least because the Commission is developing a framework in which the European Union will deal with issues such as airports, environment and safety in the future. First, let me stress that airports were not always part of the Common Transport Policy. It is only since 1993 that we have a legal basis, most specifically, in the Treaty on the European Union, to deal with airports. Until then, airports were always excluded. However, they are the infrastructure of the air transport sector. But the founding fathers of the European Community, those who actually wrote the Treaty of Rome, did not deem the airports important enough. That has changed and with the Treaty of Maastricht we have now started working very efficiently and very rapidly on a framework for airport policy. The legal basis is to be found in articles 129b to d in the Treaty on the European Union. These articles deal with the establishment of the trans-European networks for energy, telecommunications and transport infrastructure.

We started work in 1992 on the basis of a more global approach, which had already been developed in two important policy papers, the Green Paper on the Impact of Transport on the Environment and the White Paper on the Future Development of the Common Transport Policy. So we went ahead with a certain package, so to speak. We managed to complete the outline of the framework for the trans-European airport network in 1994, by working in very close cooperation with the member states for about two years. The objective of the trans-European airport network is to provide a framework that will make it possible to develop airport capacity in the European Union, so that it can meet existing as well as future demand. Another aspect that we also have to take into account is the sustainable mobility factor. Therefore, the development of this airport capacity must go hand in hand with environmental impact and safety requirements.

I will give you a short overview of what the four development priorities are in that framework. These priorities will apply to different airports in different circumstances. The first one is the enhancement of existing airport capacity. We will enhance what exists in terms of aircraft movements, passenger movements and freight throughput, including air traffic control equipment. It does, however, not mean that we will develop new capacity. We will only make more efficient what is already there. The second priority is the development of new capacity. This is where we will physically extend the existing capacity. A third one is the enhancement of environmental protection, the environmental compatibility of the airport. The final development priority is the enhancement and the development of airport access and interconnections with other networks, such as the railway network, conventional as well as high speed, the road network and the rapid rail links with city centers. Within these four development priorities we have also identified a number of priority actions. These are the ones that should be given priority in meeting the most immediate objectives within the next five to ten years. Some of these actions, for example, include—under the enhancement of existing airport capacity—the enhancement of airport safety and security. For

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enhancing the environmental compatibility, we have, for example, the enhancement of the noise performance of airports.

This trans-European airport network framework has been integrated into a proposal which provides the guidelines for the development of the trans-European transport network. It is an integral component of the transport network together with the road, the railway network, the high speed train, and the inland navigation network. This proposal was adopted in March 1994 and has been submitted to the European Parliament and the European Council for adoption. We hope that it will be adopted in the course of 1995. One other element that I would like to include in my outline is the importance of the subsidiarity principle. This principle has also been put down in the Maastricht Treaty. It means many things to many people. In other words, it is a concept that can be interpreted in many ways. But it is an extremely important concept for airport development, because airports are never identical and often not easy to compare. Thus, the subsidiarity principle is important because it is the member state, the airport and the regional or the local authorities that perhaps know best what is needed for its development and what can be done with regard to the local population, the environmental impact and the safety considerations. So the stakeholders play a very important role in our framework. In fact, the stakeholders have already been at a fairly early stage. We consulted the airports, the air carriers, the local authorities, the environmental protection groups, the consumers, of course, the national governments and many others. They contributed much in the development of airport capacity in the European Union, at least in the approach that we have adopted.

Also important are the environmental and the safety aspects. For the safety aspects I will refer to the presentation by Jean Pol Henrotte. I would like to address the environmental aspects. In the field of the environment, we have been working on standards. We have gradually tried to increase the environmental quality and standards of aircraft. The latest of such measures is the phase out of Chapter Two aircraft. We want to make sure that the gains that we achieve by that phase out are not offset by the increase in traffic volume. Technologically and technically, we may perhaps have reached a certain margin where it has become very difficult to gain more on the aircraft side. What we will need to do now is to look at preventive action. The issues that you have been discussing at this conference are part of such preventive action. That is for an individual airport. On a wider base and more broadly speaking, we are looking as well into the sort of preventive actions that we can recommend to our member states, for example on noise standards. There were no common noise standards in the European Union, while we believe that there is a great need for it. We are working on this, not only in the Commission with the member states, but also in a wider context with ECAC and ICAO. That is very important. On a narrower base, we are also looking at noise monitoring, what we can do and need to encourage. We also feel that the information provision to, in particular, the local population about the sort of levels they are having to cope with or sustain is important. In that respect, we are looking into the sort of recommendations we can make on the type of information the population needs and psychologically actually can internalize.

The next stage, and people have already mentioned this, is noise zoning and land use rules. But we are still a long way away from that—not necessarily in terms of ideas and work but what is legally
feasible. Again, here the subsidiarity principle will play a very important part. We have to make sure that the member states understand that we are not trying to usurp their authority in the area of noise zoning and land use rules. But we feel that we should be making recommendations or presenting them with guidelines. This more or less sums up the work that we have been doing in the Commission and how we are moving along and developing a framework for airport capacity and for airport infrastructure.
Andrea Kneeland *

The focus of this conference, of course, has been safety. Another major area of activity in Europe in aviation is capacity. My organization is particularly involved with capacity issues at airports in Europe which is becoming a major issue. I am confident after being at the conference that the concerns with safety and capacity are leading to solutions that will cover the two issues. In other words, I believe that the work being done on capacity coincides with the work that is being done on safety. To perhaps go more into detail, I will mention a little more about the issues that have been covered and link them to the work that has been done on capacity at airports.

Of course, the major issue seems to be human factors. It has been cited as a major causal factor in 85 percent of fatal accidents. I think that human factors issues are able to be dealt with through automation. Automation will contribute to capacity, it will contribute to safety. As an illustration, Datalink, which is part of the global CNS ATM implementation plan, will allow the solution of communication errors which are due to the lack of adherence to procedures, the language problems that might exist, problems of feedbacks. Through datalink these problems will be solved and at the same time controller and pilot workload will be reduced, although voice communication will remain as an alternative, particularly in TMA applications. A second area of human factors I believe we are able to deal with in the near future is the area of automated tools for controllers, such as arrival sequencing systems. Arrival sequencing systems will permit controllers to smooth out the traffic flow inbound to their airports with less workload involved. Similarly, other systems will deal with weather. We know that accidents are to some extent linked causally with degrading weather and a number of systems are emerging now that will permit capacity and safety to be maintained in conditions of instrument meteorological conditions (IMC). An example of this is the precision runway monitor (PRM), which is developed by MITRE Corporation in the United States, and which is now being validated at Amsterdam Airport Schiphol for their own use. This system will increase capacity by allowing converging streams of traffic to converging runway configurations and at the same time easing the task of the controller in staggering the traffic arriving at the converging runways. This system will therefore increase capacity in IMC, at the same time will reduce controller workload, and will increase capacity and safety. Speaking about human factors issues, I noticed a cartoon at the airport with two scenes. One showed a cockpit, two pilots, and lots and lots of switches and buttons. On the other was one cockpit, one pilot, and one toggle switch, marked up and down. Maybe that is the way we are going.

An issue that I feel is very important and was touched on briefly was the question of responsibility. With the emergence of automation tools for controllers, the traditional understanding of controller-pilot responsibilities will have to be re-thought in great detail. A third partner will be entering into this picture, the automated system itself. In fact there might even be a fourth partner, which is the manufacturer of the system. So I think that this issue relating both to safety and capacity will have to be dealt with very soon as these systems are being introduced. Controllers must be confident in

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the system and there must be clear relationships among controllers, pilots and other components in this development.

We mentioned the creation of incident reporting systems. This, of course, exists already, but we would like to see this introduced more at a local as well as a national and international level. I think it is important that the partners, meaning airlines, airport operators and ATC, are all included in any such scheme. ATC was not mentioned as one of the partners, but I think it has a great deal to contribute to any such reporting scheme.

Last of all, we mentioned night vision. I was very happy to hear that women have better night vision than men. It was mentioned therefore that we should have more female pilots. As you may know, radar rooms are very dark, they are like night time, so maybe this another area we can look at.
Richard de Neufville *

I would like to talk to you from the point of view of somebody who has spent a career thinking about how to implement intelligent policies for technological areas, and in particular, specializing in the domain of airport planning. It is under that joint rubric that I would like to address the situation as I have heard it at the conference and also on visiting Amsterdam Airport Schiphol. I would like to take the perspective of Hans Smits and of the airport company of Schiphol. Their primary responsibility, not withstanding the importance of safety, is to provide long term and effective capacity in air transportation on the airport for Amsterdam. That is a very important issue for them and the driving force of their concern. Jurek Keur has stressed that the plans for additional capacity have been a motivation for many of the studies we have been talking about. In this context, how should we react to the proposed noise contours, safety zones as they have been defined?

It is only my opinion and I come from a distance, but based on worldwide experience, I think this particular policy will not work. This is not a reflection on the method used, but of what the political realities are as I interpret them. These realities are that if such a policy is to be carried forward, it is going to imply the expense of billions of ECU's for tearing down houses, sterilizing lands, and moving people around. This is going to be a very difficult situation. People are going to argue about that policy. In doing so, they are going to bring other experts who have other ideas of what the safety zones are going to be. I can assure you that there is no agreement among technical experts as how to exactly calculate these probabilities of very small events which have not been observed and will not be observed until we get there many years from now. This could be a wonderful situation for academics, plenty of consulting work for everybody, but for somebody looking from the outside and trying to decide what the truth of the matter is they will be left aghast. We had the same kind of experience twenty years ago around London when there was a question about trying to optimize for the third London airport site, there were arguments about the value at the time and all the experts were shouting at each other for a long time. This is an endless quagmire.

Thus, I would like to suggest an alternative view of the problem. One way to think about how to deal with this is to look at what seems to have worked worldwide in similar circumstances. To draw our attention to that, I would like to suggest that the safety issue is just one manifestation of a more general problem, which is a local environmental argument of the desirability of an airport. There are segments of the community that very reasonably are concerned about an airport in a whole variety of dimensions. Safety is just one, noise, pollution, traffic congestion are many others. How, in this context, do we think about airport development in an effective way? I would like to suggest that there are two complementary approaches to be taken. One is the effective mobilization of those segments of the community that are very interested in the continued development of the airport—people who have jobs, industry and commerce. They are out there as well, but are typically not mobilized immediately when there is proposed expansion. They are not losing something. The people who are losing are most obviously the ones to protest the development, and very reasonably so. The second approach is to recognize that in these

* Richard de Neufville is Chairman of the Technology and Policy Program at the Massachusetts Institute of Technology (MIT).
circumstances, the development of a fifth runway for Schiphol is an extremely costly proposition and it is often useful to develop, as a positive thing, an alternative. For example, the development of runway capacity out somewhere where it is not so congested, where it will not be so expensive, and where, in particular, the runway could be used from both ends as it is not proposed to be able to do here in Schiphol. Such a facility does exist in fact for Schiphol, out in the Northeast polder in the Netherlands. It should be mentioned that the airport authority for Schiphol has taken a substantial if not major share in an existing small airport, Lelystad.

These two approaches are complementary. On the one hand, developing the potential of a second airport, which for a city the size of Amsterdam is almost certainly going to be necessary in twenty or thirty years, demonstrates the good faith actions to take care of environmental noise, because you are shifting the environmental effects out to where there are fewer people. On the other hand, it does mobilize the people who think that they might have to relocate their jobs and have to move out to a different area. What I am suggesting is that the development of those kinds of options leads to a more complete discussion about how we should think about airport development and the tradeoff with safety between the involved parties. It will also lead to the possibility of a political settlement about developing it that is deemed to be effective. For example, when we look at the discussion in London twenty years ago and think about the caps that were put on the development of Heathrow, it seemed to be very firm at the time. Now, these caps are widely eliminated as they were stated twenty-five years ago, largely because BAA really put much effort in developing Gatwick in the first instance, and Stansted in a second instance as possibilities of doing other things. It made people focus on what it really cost to deal with this issue. The same thing has happened at Osaka, where they spent twenty-five billion ECUs to develop the airport with the prospect of closing down the other one for environmental reasons. The moment they really started to think about moving it, the local population around the old airport insisted that it would be kept there and that they needed that kind of opportunity. The same happened in Sydney and so forth.

So what I am suggesting is that there might be an advantage to standing back and rethinking the safety, environmental and capacity issues, not as an issue for the airport Schiphol, but for the metropolis of Amsterdam and to think about the possibility of an effective tradeoff between the environment and capacity at different locations.
Michel A. Piers

Introduction

Airports are hubs in the air transport system. Consequently, their presence causes a convergence of air traffic over the area surrounding the airport. For the population living in the vicinity of an airport this implies involuntary exposure to the risk of aircraft accidents. Although the public is generally aware of the fact that flying is a very safe mode of transportation and hence the probability of an accident is very small, the frequent noise associated with aircraft passing overhead nevertheless acts as a strong reminder that sooner or later one may come down. While this may seem irrational, actual local risk levels around airports are higher than one might expect. Although the probability of an accident per flight is very small (typically in the order of one in one million), accidents tend to happen during takeoff and landing and hence close to an airport. In addition, the small probability of an accident per movement is combined with the large number of movements (typically several hundred thousand) to arrive at the probability of an accident per year. This probability is of course much greater than the well-known and very small probability of being involved in an aircraft accident as passenger. Local risk levels around large airports are consequently of the same order of magnitude as those concerned with participation in road traffic. Because an increase in airport capacity usually involves changes to runway configurations, route structures and traffic distributions which in turn affect the risk levels around the airport, third-party risk is an important issue in decisionmaking on airport development.

Major airport development plans, such as building additional runways, invariably involve government decisionmaking and public inquiries. Therefore, public perception of the local consequences of developments is of paramount importance. This applies in particular in the Netherlands, where the El Al Boeing 747 accident in suburban Amsterdam occurred while the Dutch government was carrying out the environmental impact analysis for further development of Amsterdam Airport Schiphol. The plans of Schiphol involve more than doubling its current capacity, for example, by adding a fifth runway.

To prevent a predominantly emotion-driven role of third-party risk in the evaluation of airport development options, objective and accurate risk information is required to provide guidance to local and national government, the population around the airport and the airport authorities. Because no adequate method for third-party risk assessment did exist worldwide, the National Aerospace Laboratory NLR of the Netherlands was contracted by the Netherlands government to develop a comprehensive method for the assessment of third-party risk around airports and to apply this method to the Schiphol development plans.

Definitions of Risk

To investigate third-party risk around airports, objective measures of risk are required. Risk is generally defined as a combination of the probability of an event and the severity of that event. For

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third-party risk analysis two dedicated measures of risk are often used: individual risk and societal risk.

Individual risk is defined as the probability (per year) that a person permanently residing at a particular location in the area around the airport is killed as a direct consequence of an aircraft accident.

Societal risk is defined as the probability (per year) that more than N people are killed as a direct consequence of a single aircraft accident.

While individual risk is location specific, it is present regardless of whether or not someone is actually residing at that location. Societal risk applies to the entire area around the airport and hence is not location specific within that area. Societal risk only exists when people are actually present in the area around the airport. In a nonpopulated area, individual risk levels may vary from location to location but societal risk is zero by definition.

To be able to calculate risk in terms of the risk measures defined above, a methodology was developed by NLR under contract with the Ministry of Transport and Public Works of the Netherlands. This methodology is described in available NLR publications.¹

Results

a. Individual Risk

After local individual risks has been calculated for the entire area around an airport, risk contours can be generated and plotted on a geographical map, not unlike noise contours. The highest risk levels ($10^{-5}$) occur close to the runway thresholds and are present in a relatively small area only. The lower risk levels occur at larger distances from the runways and the routes followed by arriving and departing traffic. The runways which are used by the majority of traffic show larger individual risk contours than those which are used less often. Individual risk contours are often used for zoning purposes. If maximum allowable risk levels have been defined, the contours can be used to check for local excesses.

A maximum allowable individual risk level of $10^{-6}$ is often enforced with concern to new housing projects. The contours can then be used to determine whether houses can be built at a particular location. Also, airport development plans can be evaluated with concern to their "risk-claim" on the development potential of the area around the airport. An individual risk level of $10^{-5}$ is often considered the maximum allowable for existing build-up areas. The risk contours are used to determine whether allowable risk levels are locally exceeded when a particular airport development option is carried out. If so, either the plan must be changed, the buildings must be removed or risk reduction measures must be applied.

¹ Piers M.A., et. al., The development of a method for the analysis of societal and individual risk due to aircraft accidents in the vicinity of airports, Amsterdam: NLR, NLR CR 93372 L.

b. Societal Risk
Societal risk is a measure which is more difficult to use than individual risk. Commonly adopted criteria with concern to maximum allowable societal risk levels around airports are not yet available. For third-party risk around chemical industries, maximum allowable risk is often defined by $F_{\text{max}} = (10^3 / N^2)$ for existing situations. This function defines a straight descending line in the societal risk curve which for example intersects $F=10^5$ for $N=10$ and $F=10^{-7}$ for $N=100$, the societal risk curve should remain under this line. When comparing societal risk curves for different airport development options, it may be difficult to identify the most favorable motion if the associated risk curves intersect. Therefore, a derived metric is sometimes used which is based on a comparison of the area under the societal risk curve for different airport development options. Due to the fact that societal risk concerns the entire area around the airport it is often difficult to determine which measures will be most effective in preventing excesses of maximum allowable societal risk levels. To allow better discrimination, societal risk is often calculated for each runway individually.

c. Risk perception
Risk information in itself is of limited use unless it is supported by some kind of acceptability criteria. This is also true for instances where risk information is used in a comparative way because it has to be decided whether the difference in risk between two scenarios/options justifies the associated additional cost or negative impact on issues other than risk.

It must be noted, however, that it is very difficult to judge risk solely on objective criteria because the perception by the people who are exposed to the risk is of a subjective nature. A few well-known dimensions of risk perception indicate the subjectivity:

- personal benefit of risk bearing activity
- scale, nature and controllability of accident consequences
- voluntary/involuntary exposure
- knowledge concerning the risk bearing activity.

It is a common oversight to embark on a third-party risk analysis for an airport without at the same time initiating an activity which will result in a scheme for the evaluation of the outcomes of the risk analysis. To promote an effective decision-making process, it is highly beneficial to establish a way of evaluating the issue of risk among the other issues in the decision-making process before the results of the risk analysis are available. Unfortunately, commonly accepted risk-acceptability criteria for third-party risk around airports are not yet available. Government regulations with concern to chemical processing facilities may be useful for reference purposes in this regard.

**Uncertainty of Risk Estimates**

a. Calculating uncertainty
Risk analysis using statistical models in combination with historical data invariably involves a certain degree of uncertainty. For this reason the results of a risk analysis must be interpreted as a best estimate of the risk levels actually present. Because the results of a risk analysis may have far reaching (and costly) consequences for airport development it is important to obtain insight in the
degree of uncertainty of the results. For the Schiphol analysis, uncertainty in the accident rates, accident location model and the accident consequence model were calculated and combined to allow the calculation of 95 percent confidence intervals for individual risk and societal risk. Because the location probability model consists of a number of two-dimensional statistical functions and the consequence model has the local type of terrain as one of its input parameters, uncertainty in individual risk is not the same in the entire area around the airport, but differs from location to location. In order to show the uncertainty in the location of the risk contours for a particular risk level, 95 percent upper and lower confidence limit risk values are calculated in addition to the nominal risk value (the best estimate). By generating two additional risk contours, one using the 95 percent upper confidence limit values of individual risk and one using the 95 percent lower confidence limit values of individual risk, a 95 percent confidence area emerges for the nominal risk contour for this particular risk level. The probability that the actual risk contours are entirely located within the shaded area is 95 percent. The confidence area is much narrower for the higher risk levels ($10^{-5}$) and gets wider for the lower risk levels ($10^{-6}$). This behavior is caused by the accident location probability model which has a steep gradient for the higher risk levels and becomes more shallow for the lower risk levels at larger distances from the route.

b. The interpretation of uncertainty
Risk levels are usually calculated for a number of airport development options in order allow comparison. When differences between options are relatively small relative to the 95 percent confidence interval, the options are sometimes considered to be not significantly different in terms of risk. This is a misconception. Since risk levels for different airport development options are calculated using the same models with the same parameter estimations, differences between calculated risk and actual risk are approximately equal for both options. In other words, if the results of the risk analysis for option A is an overestimation of the actual risk, the results for option B are an approximately equal overestimation. For this reason, conclusions concerning differences between airport development options in terms of risk must be based on the nominal (best estimate) results of the risk analysis. Whether the differences in risk found for two airport development options should be considered such as to justify particular airport development decisions in view of the associated uncertainties, is a matter of subjective evaluation.

Conclusions

Because airports tend to be located close to major cities, many airport authorities are facing problems with concern to airport growth and third-party risk. Particularly in Europe, an urgent need for objective and accurate risk information exists. The method described in this paper provides an adequate solution.

The method has been successfully applied to Amsterdam Airport Schiphol and other airports. The results were used as factual information by all parties involved in the decisionmaking process and facilitated effective discussions on airport development and associated third-party risk.
The results of this type of risk analysis support the identification of ways to reduce risk by providing insight into the influence of factors such as the runway layout, traffic routing and safety enhancement measures on third-party risk around the airport.

Considerable improvements with regard to the quality of movement data are required to allow the development of detailed quantitative causal accident rate models. The development of commonly accepted risk acceptability criteria, which are needed in support of the evaluation of risk analysis results, should receive due attention.
Discussion Session 10 and Conclusion

Jeff Gazzard
I wonder if in a world of expansion of the airport industry on the one hand and the need for sustainable mobility on the other, suggestions such as the ones given by Richard de Neufville about alternatives and sensible compromise can be part of the European Commission’s brief for the whole industry and all the stakeholders. It seems to me that the current balance is much in favor of the aviation industry, in particular the airport operators. Does Ruth Frommer think a better balance can be struck that does use developments at other airports. How do you view that balance to be struck? You have explained the framework of analyzing it, but how is that going to be a policy that is going to stick?

Ruth Frommer
We are only at the beginning of our policymaking, so that will be at a later stage. In all of this we have to take account of the subsidiarity principle. What we can do is to provide the stakeholders with a framework, guideline and recommendations so that whatever option they have for decisionmaking they will make use of the framework and hopefully come to a solution that is the best combination of all interests involved. That is what sustainable mobility is about. It is about the conflict of interest. We must make sure that all the interests are given an equal opportunity and put in the decisionmaking process, so that we come up with something that is fairly well balanced.

Jan de Kroes
Mr. Piers, you have shown us the (un)safety zones you have calculated and you are complaining that people have different perceptions of risk than your objective risk. But first, there are many more models for calculating contours and that does not increase the public confidence in these objective contours. I would suggest that scientists would come to an agreement how they should be calculated. But if agreement is not possible, you should be adding these different calculated contours and take the whole area within your safety zone. That is the safest solution. Second, people’s perception of probability is already present and based on a trial and error principle. Sometimes they trust the situation, an event occurs, and their confidence goes down. Building confidence is not a mathematical issue, but a psychological matter. In your research you should involve people who know something about refining people’s perception on risk. Third point, at the end of the runways you have an extended zone. But there are different shapes at the different sides of the runway. What is the explanation?

Michel Piers
I do not think that you should use the risk calculation results as the reality for people who are exposed to the risk. In fact, risk as perceived by the people living around the airport should be considered the only measure of managing risk. It is irrational to think that calculated risk can be used to manage risk. So I don’t think we disagree on that. However, you still need risk calculation results to explain the risk levels actually present.

The reason that the contours are different on other sides of the runway is that the sides are used differently. One side most of time for takeoff, the other for landing. The accident location distribution for landing is different from takeoff accident. Therefore you will see a different
distribution of risk at the landing side of the runway as opposed to the takeoff side. In addition, landing aircraft may have an accident location before reaching the runway, but also after. So we have an overrun location model which is more rounded than the landing one. We have different models which result in different risk contours.

Ed Haighton
Previously I have already said that there is much to be learned from the experiences in petrochemical industry. In the petrochemical industry as well there used to be holy belief in risk calculation, but the problem is that accidents still occur in the industry, sometimes very big accidents at companies with all the permits, where risk calculations have been conducted, even with ISO-certificates. So it is very difficult to make a relation between all those risk calculations and the safety of a company. To run a company safely, you will need different requirements than just risk calculation. You need to manage safety, which means that you will have to know what the problems in your company are, what may go wrong in your company, find out what scenarios might go wrong, and what the consequences are. That is the major part of managing safety.

Michel Piers
Making a safety analysis and risk calculations obviously do not prevent accidents. I agree with you that these are just a tool in managing risk, but they are an important tool. It allows you, first of all, to see in what way you can reach the biggest reduction in risk. If the objective is to reduce risk and you want to take measures to reduce risk, it would be interesting to see what you can expect from the measures you take. Risk calculations are an instrument to reduce risk.

Ed Haighton
I agree, it is one of the many sets of tools, and mainly used to compare options for, for example, different runway configurations. But in the end, once you have calculated the risk for those options, I do not think you have a safety indication. Safety is not determined by the calculation.

Michel Piers
That is right, safety is not achieved by risk calculations. That is one of the reasons why the RAND study was carried out and why work is currently underway to make a causal risk model in which the cause-consequence relationship is quantified. It is encouraging to me that the Commission has solicited studies to measure causal relationships in aviation safety to be able to estimate what measures need to be taken to reach target safety levels. You should not separate these issues; they use the same data, instruments and methodologies, and are really complementary to each other.

Jurek Keur
First, I would like to ask how long, you think, it will take for Third World countries to catch up with the safety level of the Western world, and what can be done to assist these countries in reaching these levels? Second, a question directed to EUROCONTROL. At the moment we have a very diverse system with different languages, thirty different computer languages. How long will it take to have a uniform system in this area in Europe?
John Enders
I do not think you can confidently predict a particular year in which the Third World will have caught up with the safety level of the Western, developed countries. They will be chasing a moving target, because the European, North American and other industrialized countries will be improving at the same time. It depends on the amount of aid and commitment, and the economic pressure put on the home states of the carriers to improve their operations. I would hope to see some improvement within the decade, that is about as close as I could get. If that is up to current standards, I would not know.

Carl Burleson
I thought I would follow up on that. As people might know, I think the FAA has the most experience in looking at that issue right now. Our experience is that to date the CAAs we have visited, including the ones that do not really meet ICAO standards, want to do the right thing. It is not the issue of the aviation community or regulators not wanting to accomplish their mission. Governments have tended not to fund the regulators to the degree that they need to basically meet the international contract obligations they have given to the international community. Our experience in terms of technical assistance is very positive, even with those countries that either did not meet the criteria or have failed in some areas. We are working with them right now. Particular countries have already made great strides. The degree to which we in the international community can mobilize our own governments to pay attention to this issue is very important. If we are going to tackle the global safety, we need the help of international aid and assistance programs.

Andrea Kneeland
I would like to comment on the issue of diversity. The key words we have adopted in Europe are harmonization and integration. The decision has been taken at all levels to go ahead now with harmonizing and integrating all aspects of the ATC system and efforts are well underway. Phase one and two have been completed, phase three is underway. Phase four will come into effect in 2005. User requirements are being captured for the future systems to create similarity of approach within the states of Europe. The efforts are very great and I do not think there is any doubt that in the future we will have common standards of separation and automated communication links between ATC units and centers.

Frank Cruise
The ACI perspective on how Europe can help the industry of the Third World is that we have been very anxious that airports in less developed area are given an opportunity to participate in the work of ACI. Very often these countries would lack the financial resources to be able to travel to meetings. As a result, ACI has encouraged and made a policy to organize meetings within Eastern Europe. I would also mention seminars held on operational safety issues in South America and Africa. These seminars brought together the representatives of airports within the region, but the speakers were generally from Europe or the United States who had traveled down there.

John Enders
One general comment to conclude. We have mentioned these voluntary aviation reporting systems in another context. I think it would be especially useful for airports to institute some organizational
system for voluntary reports. I am sure that some do already, but it could be very widespread and useful to gather information on safety problems.

CONCLUSION

Michael Rich

The conference presentations and the discussions that followed them underscored several facts:

1. The aviation safety community is a multi-faceted community and has an impressive track record of long term progress
2. New challenges abound and new stakeholders have entered the picture
3. Addressing the new challenges successfully will require active participation and collaboration of all the stakeholders, both old and customary as new.

One aim of this conference, of course, was to help to advance that cause by providing a forum for the free exchange of information and viewpoints. I think we have succeeded in that. Thank you all for your contribution and participation. The conference is concluded.
Agenda of the Conference

16 - 18 November 1994
Amsterdam, The Netherlands

Wednesday 16 November

18:00-20:00  Cocktail reception offered by Amsterdam Airport Schiphol

Thursday 17 November

9:00-9:25  WELCOME TO THE CONFERENCE

Speakers:  
Hans Smits  
President, Amsterdam Airport Schiphol

Robert Coleman  
Director-General, Directorate General for Transport (DG VII), European Commission

9:25-10:30  Session 1: INTRODUCTION

Chairman:  
Nico de Voogd  
President, Delft University of Technology

Speakers:  
Richard Everitt,  
Strategy and Compliance Director, BAA

Gerhard Stadler,  
Director-General of Civil Aviation, Austria;  
Chairman of the European Civil Aviation Conference (ECAC)  
Airports - Air Traffic System Interface (APATSI) Project Board

Discussion

10:50-12:00  Session 2: SAFETY ISSUES

Chairman:  
Henk Sol  
Dean, School of System Engineering, Policy Analysis and Management  
Delft University of Technology

Speakers:  
David H. Johnson,  
Director, Advanced Technology Applications, PLG, Inc.

Jan L. de Kroes,  
Emeritus Professor of Transport Safety,  
Delft University of Technology

Discussion
12:00-13:10  Session 3:  
SAFETY AND AIR TRANSPORT-POLICY AND PRACTICE  

Speakers:  
Ronald Ashford  
Secretary General, Joint Aviation Authorities  

Charles H. Huettner  
Associate Administrator for Aviation Safety,  
Federal Aviation Administration  

Discussion  

13:10-14:30  Lunch  

14:30-15:40  Session 4:  
EXTERNAL SAFETY OF AIRPORTS: THE STATE OF THE ART  

Chairman:  
Carl W. Vogt  
Former Chairman,  
National Transportation Safety Board, USA  

Speakers:  
Richard Hillesstad  
Senior Systems Analyst, RAND  

Frédéric Rico  
Director Air Traffic Operations, Aéroports de Paris  

Discussion  

15:40-16:50  Session 5: SAFETY AND AIRCRAFT DESIGN  

Speakers:  
Bernard Ziegler  
Senior Vice President for Engineering, Airbus Industrie  

T. Khoen Liem  
Technology for Transport Means Unit, Directorate General for Science, Research and Development(DG XII), European Commission  

Discussion  

End of Day 1
Friday 18 November 1994

9:00-10:10  Session 6: FLIGHT OPERATIONS
            Chairman:  Ben M. Spee
                          Director, National Aerospace Laboratory (NLR)
            Speakers:  Captain Larry R. Ganse
                          Director of Flight Safety, Northwest Airlines
                          Jean Pol Henrotte
                          Air Safety Unit, DG VII, European Commission

            Discussion

10:10-11:20  Session 7: AIR TRAFFIC CONTROL
            Speakers:  Xavier Fron
                          EUROCONTROL Experimental Centre
                          Stephan Pascall (represented by Douglas Ferguson)
                          Principal Administrator, ATLAS Project, DG XIII,
                          European Commission

            Discussion

11:20-11:40  Coffee

11:40-12:50  Session 8:
            CASE STUDY—SAFETY ENHANCEMENT
            AND AIRPORT OPERATIONS AT SCHIPHOL
            Chairman:  Michael D. Rich
                          Senior Vice President, RAND
            Speakers:  Jurek Keur
                          Head, Airside, Environment and Strategy Department
                          Amsterdam Airport Schiphol
                          Gilles A.M. van Hövell tot Westervliert
                          Director, Quality Assurance & Consulting, KLM Royal Dutch Airlines

            Discussion

12:50-14:10  Lunch
14:10-15:20 Session 9: INSTITUTIONAL AND POLICY ISSUES

Speakers:

William R. Fromme
Director, Air Navigation Bureau, ICAO

Jan Willem Weck
Director-General, Civil Aviation, Ministry of Transport, Public Works and Water Management, the Netherlands

Discussion

15:20-17:00 Session 10: DISCUSSION AND CONCLUSIONS

Panel discussion:

Frank Cruise
General Manager—Operations, Aer Rianta Dublin Airport;
Member, Technical and Safety Committee, ACI Europe

John H. Enders
Retired Vice Chairman, Flight Safety Foundation

Ruth Frommer
Head of Unit for Airport Policy, DG VII,
European Commission

Andrea Kneeland
ECAC Airports Bureau

Richard de Neufville
Chairman, Technology and Policy Program,
Massachusetts Institute of Technology

Michel A. Piers
Head, System Group Operations Research Department,
Flight Division, NLR

17:00-17:15 Concluding Remarks and Adjourn
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