Welcome Address

Stuart Matthews
Chairman, Board of Governors,
Flight Safety Foundation

For those of you who keep track of such things, this really should be the fifth annual seminar. But events of a year ago — notably the Persian Gulf War — necessitated our postponement of last year's meeting.

While the war was paramount in our minds, other difficulties beset us simultaneously. World economics were — and continue to be — in various states of disarray, budget deficits abound and everyone wonders whether or not there will be an international "peace dividend."

The aviation industry itself fell victim to lagging world economies. As turbulence hit the air transport industry, upon which we rely for financial support, the Foundation was also buffeted severely.

That was the bad news during 1991. We had to make some difficult decisions and make some severe cutbacks in both people and expenditures. However, all that is behind us and I am pleased to tell you that the numerous belt-tightening measures taken in the last year have been successful.

As we begin to see signs of an economic recovery, the future outlook for the Foundation is very promising. Indeed, I am more optimistic about the Foundation's financial situation than I have ever been since I became chairman. We are now on an even keel; the seas are calmer and a fair wind is blowing to help us along.

Even with the cuts we had to make, the Foundation has continued to provide all of its basic services to members. It has become more task oriented and, although on a lesser scale for the moment, we are once again embarked on a comprehensive program of renewed safety efforts.

While there are other organizations within the air transport industry concerned about aviation safety, the fact is that the Flight Safety Foundation is the only non-profit, non-partisan, non-political, totally independent institution of its kind covering all aspects of flight safety. It provides a neutral forum, such as this one, for industry to discuss and disseminate objective information aimed at improving aviation safety.

Of course, this effort also means a need for continued funding and there is increasing concern being voiced by industry that the level of financial support required is becoming too expensive. I do not have to remind you of the generally repressed state of our industry, or of how every penny spent now has to be justified.

We all recognize the benefits, indeed the necessity, of having conferences, such as this one, where we can focus on problems and discuss solutions. But it is true that attendance at such conferences is not cheap. I am not talking just about conference fees. I'm also thinking of the cost of people's time and particularly (for the non-airline people) the cost of travel, hotels and meals. Think of it. For some of us that alone can amount to several thousand dollars. And of course there are other organizations doing much the same sort of thing — holding conferences in various parts of the world, discussing topics, some of which might even overlap with our own.

Most of us here, I know, are funded by our companies. But that does not make it any cheaper. Industry cannot afford to keep sending so many people to so many conferences in so many places. "Industrial tourism," as I have heard it called, has to be curtailed. Industry is asking us (even telling us) to reduce it or industry may not continue to support us. At the Foundation, we have been listening and seeking to respond to the message.

Perhaps mergers or consolidation of various like-minded organizations might come about someday as a way to reduce costs. However, for the moment, each group has its own particular focus, therefore a more appropriate way is to reduce travel costs. We have listened to industry and this year the Flight Safety Foundation's major conference, the International Air Safety Seminar, will be held jointly with another respected body, the International Federation of Airworthiness (IFA).

Many of us belong to both organizations. This year, instead of two separate conferences in two widely separated places, we will hold just one conference together in Long Beach, California, in November. It is a start, but it is one which should bring about significant savings in travel and time-out-of-the-office costs for those companies that normally like to be represented at both meetings.

While we are trying to respond to industry's requests to reduce costs, I would hope that some of the savings will be passed back to us through their continued support for the essential work we are doing.

Today, the Foundation provides leadership to 550 member organizations in 75 countries. Long acknowledged as "the conscience of the industry," the Foundation is credited with being instrumental in the development of many of the significant advances in air safety over the years that are taken for granted today. But we still have a lot of work to do.

While air travel is undoubtedly now the safest form of modern mass transportation, the actual safety rate (accidents per number of passenger miles flown) has tended to remain constant in recent years, albeit at a very low level.

Stuart Matthews

The challenge we face is to further reduce this rate to ensure that the projected increase in traffic, expected to double over the next 10 years, does not lead to a doubling of the actual number of aircraft accidents.

Obviously, such a situation — which would mean some 25 major accidents per year or about one every two weeks — would be totally unacceptable to the public perception of our industry and could lead to undesirable and hasty political solutions. I believe that this challenge is best dealt with by industry itself and that the Flight Safety Foundation continues to be one of the best forums in which to facilitate them.

However, there is a paradox associated with this goal. We know that reducing accident rates, when these rates are already extremely low, is going to cost much more to achieve the same benefit in the future than it has in the past.

Thus, if the Foundation is to attain its objectives, we have to seek more support. It is going to require more financial resources at a time when we have been receiving less.

I believe that it is unfair to return yet again to the same industry leaders and companies who have solidly supported the Foundation in the past. We certainly need them to continue their support. But in the end, reducing risk and saving lives are problems that face us all equally. Therefore, the best way to fund the Foundation's very necessary programs is not to ask for more funding from the same individuals and firms, but to seek support from a wider cross-section of our industry in order to share the load. Clearly, to do this we need to expand the Foundation's membership, and we need your help in accomplishing this.

We have to reduce the accident rate. It is an industry problem that should be shared and funded by all elements of our industry. And that's the message I want to impart to you. If you are members already, we thank you for your support. If you are not members, or if you know other individuals or organizations who should be members, you will be doing a great service by enlisting their support and encouraging them to join the Foundation.

There is much to be optimistic about, for it is clear to me that the Foundation's worldwide impact continues to be felt, and that it is highly regarded by the aviation community and the public.

The Foundation positively influences safety thinking — in many ways and in many parts of the world. We must strive together to restore the Foundation's vigor and maintain its viability. I hope you will join me in pledging anew to work collectively in achieving that goal.

New Challenges for Aviation Safety

John H. Enders
Vice Chairman, Board of Governors,
Flight Safety Foundation

The present political and economic environments confront corporate and regional aviation operations with new problems, many of which have a heavy bearing on safety. Economic and political corporate survival are strong contenders for attention and can, unless safety awareness and commitment are great, divert one's thinking away from the essentials of safe and reliable operations.

The never-ending task of ensuring safety of flight is especially important today, as the necessity for and ability of the industry to operate at a highly-efficient level have increased dramatically in recent years. The introduction of newer technologies that offer safety improvements as well as performance gains has raised questions about the effectiveness of traditional training approaches or even the human's ability to absorb the required training and thinking to utilize the newer equipment.

To be certain, the potential for high achievement is present, but in reality, our failures are surprising and dismaying in their causes. Few aviation accidents occur today that were, in retrospect, not potentially preventable.

The good news is that our collective understanding of the chain of events that are individually subject to errors, and can combine to cause an accident, is steadily increasing.

John H. Enders

Accident Prevention Requires Fundamental Changes

Flight Safety Foundation (FSF), in pursuit of our objective of reducing landing and approach accidents, is focusing on multiple, rather than single, causes for accidents. By doing this, we are drawing attention to those enabling factors present in every operation that, in themselves, may not cause an accident, but would break the chain of events and prevent an accident if eliminated.

Care must be taken with this approach, for the progression of errors leading to an accident is complex, comprising multiple paths. Evolving a pre-emptive or preventive strategy to curtail accidents is essential if we are to reduce, or even maintain, the present number of accidents. To implement successfully this prevention strategy requires some fundamental changes to the traditional thinking we have employed to date.

We must recognize our failure to communicate effectively within the greater aviation community. This failure has resulted in many serious incidents and accidents. It is present at all levels of activities and we must work to correct the process so that the understanding of enabling factors is adequate throughout the entire spectrum of aviation activities to prevent the progression of cumulative errors.

For many years, we have placed most of our attention on the flight operations phase itself and the supporting maintenance activity. While popular statistics place the primary cause on flight crew and maintenance error, in reality, the origin of causal or enabling factors all too frequently lies far outside this sphere. For example:

- Legislative and regulatory actions can inhibit essential knowledge from being shared.

- Budgetary authority for infrastructure support, such as air traffic control (ATC) improvement, weather information, navigation facilities, etc., is usually inadequate and deprives the operation of the protection that is otherwise possible.

- Design and manufacturing flaws, while rare, are nevertheless real and need to be corrected. Commercial competition and accident litigation may inhibit prompt implementation of corrective measures.

- Unreported ground service vehicle damage to aircraft may escape inspection and become a problem for an unsuspecting flight crew.

- Maintenance, while integrity is usually very high, on rare occasions passes an unairworthy aircraft to the crew.

Some form of these enabling factors are often passed along the line without notice, until the crew is forced to deal with them at a critical moment in flight. Depending on training, mental state and external circumstances, the crew is sometimes able to rescue a situation not of its own making.

We satisfy our collective conscience by usually recognizing them for valor or professionalism and ignore the real circumstances that placed them in hazard. The time has come for us to change our approach to safety through a fully integrated preventive strategy.

The Foundation Fosters Communication

The independent and non-profit FSF serves its 550 member organizations in 75 countries with unique and objective perspectives on safety. In turn, we depend upon our members' financial and information support. Through this relationship, we are able to foster and encourage the sharing of safety information and experience through our publications, direct contacts and meetings such as seminars and workshops. For example, we just conducted a seminar in Iceland, featuring expert speakers on a variety of topics that were of special interest to the country's international airline, regulatory authorities, air traffic officials, university professionals and private pilots. The value of such regional seminars is that they bring experts on a variety of safety topics together with a group of aviation people who typically never have such an opportunity. One can sense the flow of information and sharing of thoughts that takes place in these seminars.

One of our U.S. corporate aviation department heads observed a couple of years ago that many organizations and managements typically undervalue the benefits that flow from open workshops and seminars, and therefore do not take advantage of them. Yet it is the constant intangible, non-quantifiable reminders that FSF conveys to its members that serves as a sort of safety conscience within the industry. The company accountants are uncomfortable with expenditures for such purposes because they cannot assign a ledgerable value to these knowledge transfers and so tend to discourage them. In virtually each of our member organizations, the operations people expresses a common frustration with the inability of the non-technical people within their organizations to understand the value of investing in accident prevention programs. FSF's seminars and publications provide the ideal objective forum where debates can offer education and understanding to all parties.

Apportioning Human Causal Factors

The search for a greater understanding of the role that human judgment plays in creating or eliminating errors in aviation is accelerating, as our behavioral psychologists work more closely with the engineering research community. The 70 or so percent of fatal accident causes ascribed to pilot or flight crew error is now being unmasked as a misleading statistic, and the Foundation is joined by many other analysts in encouraging people to focus on multiple causes. Viewed in this context, the distribution of contributing causes for the past decade's fatal accidents appears to be around 40-45 percent flight crew; 15-20 percent design and manufacturing; 30-35 percent maintenance deficiencies; and perhaps 60-80 percent management inattention. Because they are multiple causal factors, they total more than 100 percent. Imprecise as they may seem, these allocations are nevertheless more "honest" than the single probable causal factor, and their validity is beginning to be borne out by the various airline flight data analysis programs in place around the world. There is no reason to expect that corporate or regional aircraft operations accident causes differ substantially from the above distribution within the air carrier industry.

Safety's Achilles Heel Is Ineffective Communication

Earlier the problem of adequate communication of knowledge and understanding has been noted. Sharing this information is of the utmost importance, not only for safety, but also for the economic health of an aviation enterprise. British Airways, a world leader in the use of on-board recorders for mechanical and performance analysis, has probably achieved the greatest degree of success in effective corporate safety communications. Working with their airworthiness authorities, their BASIS and SESMA programs have effectively brought union and company (flight operations and maintenance, and ground and passenger services) much closer together in a single cooperative corporate culture than perhaps occurs in many other carriers. Open sharing of detailed malfunction reports, performance data trends and incidents—all non-attributable—has resulted in a sharper focus on fixing emerging problems quickly and raising the safety awareness of employees to new high levels. This is the way a pre-emptive accident avoidance strategy can work. Swissair, Lufthansa, KLM, SAS, Qantas, Singapore Airlines, Air Canada, JAL and ANA are representative of the many other carriers who have adopted and benefited from similar programs. These programs focus heavily on raising human sensitivity levels in inspection and detection of faults in the system, to ensure a fully airworthy airplane is turned over to the flight crew. This is aided by flight data recorder (FDR) analysis programs that provide feedback to the other parts of the organizations about the results of their efforts.

A Zero Accident Rate Is Eventually Possible

FSF strongly believes that achieving a zero fatality rate and eventually a zero accident rate is well within our collective knowledge and understanding. There are many operators who have flown for many years without a fatal accident. To achieve this on a worldwide scale within permissible economic parameters requires strong efforts in the proper education, training, development and management of the humans who design, build, fly and maintain the modern airplane, as well as those who regulate, legislate and budget and those who provide the essential infrastructures of air navigation services, air traffic services, airports and weather information services.

This is not a simple task. But the time has come to cooperate more closely on efforts that preserve safety and to pursue these as much as possible isolated from industrial and political concerns.

ECAROSS is one step further along the path of improving knowledge and understanding that will equip all of us to raise the safety level. Constant work in this direction will eventually produce our ideal goal of true Duty of Care . . . to hurt no one.

Liberalization in Europe

CAPT. JACK JESSOP, CBE
Board Member, British Airways PLC (retired)

Before I agreed to address you on the subject of European air transport liberalization, I thought quite hard about a subject that has rolled in earnest around the corridors of the Berlaymont and the committee rooms of Strasbourg since 1979.

That was when the Swedish member of the European Parliament, Andres Bjorck, produced his report that resulted in the European Commission (EC) issuing a discussion document known as the "Contribution of the European Communities to the Development of Air Transport Services."

It proposed a total European network unhampered by national barriers, with efficient services, beneficial to all user groups, at prices as low as possible, without discrimination.

That was pretty radical thinking for a community whose air transport activities danced to the unharmonious tune of disparate and sometimes conflicting national policies that served to restrict and constrain, rather than create freedom.

Indeed, at the time, there was a great deal of cynicism, not just about air transport, but about European harmony in general.

Not long before, the British historian E.P. Thompson, had said: "This going into Europe will not turn out to be the thrilling mutual exchange supposed. It is more like nine middle-aged couples with failing marriages meeting in a darkened bedroom in a Brussels hotel for a group grope!”

I do not know whether that prospect had any bearing on European development, but not long after the nine nations metaphorically referred to were joined eagerly by three others, to form the European Economic Community (EEC) 12.

In any event, the EC’s first, tentative move towards liberalization came at an auspicious time. It was a year after deregulation of the U.S. airlines under President Jimmy Carter; and the same year that Margaret Thatcher came to power in Britain. In her political armory were, of course, the big guns of privatization for the then state-owned British Airways and overall domestic deregulation of air transport.

I believe that subsequent events in Europe as a whole have been profoundly influenced by the civil aviation policies of the United States and Britain.

I wonder if Thompson ever recalls his cynical, if colorful, comment as we are on short final, preparing to cross the threshold of the single European market set to emerge in 1993. The group grope he warned about is becoming an orgy of competition. And as with the failing marriages Thompson referred to, it was the lawyers who sorted out dissent and confusion.

It was, in fact, a decision of the Court of Justice in 1986 that ruled that the competition rules of the Treaty of Rome (the equivalent to the U.S. anti-trust laws) applied to air transport. This forced the Council of Ministers to take the first steps towards liberalizing air transport regulation.

Unlike the United States, where the federal nature of the country allowed deregulation to occur virtually overnight, the patchwork of separate, sovereign states that makes up the EEC meant that liberalization had to be an evolution, rather than a revolution.

Therefore, the process is being achieved by a series of staged measures — so-called packages. The first package was approved in late 1987 and the second in the middle of 1990.

The third, and final, package was drawn up last year and is set for implementation in January 1993, once it has been ratified by the Council of Transport Ministers. Overall, the liberalization process works towards promoting full and fair opportunity for EEC airlines, together with open competition. It proposes freedom of market access, freedom in pricing, freedom from capacity and frequency constraints, and freedom from the old ownership rules. The three key points of the third package concern the following:

- Licensing. EEC member states must harmonize air carrier licensing rules, so that any airline of any EEC country can establish itself in any other country. Importantly, existing national ownership and control criteria would be replaced by community-wide criteria. Also, in principle, there would be no distinction between scheduled and charter licensing.

- Market Access. EEC airlines would have completely free access to intra-community international routes and the introduction of cabotage rights for community carriers on EEC domestic routes. There would, however, be some protection from competition by additional carriers on so-called public service routes and on new regional routes where aircraft of less than 80-seat capacity are used.

- Pricing. The double disapproval system, would be introduced for the immediate future, where fares can only be denied if the governments at both ends of a route object; and full, unbridled pricing freedom on the major air routes would be introduced by 1996.

It has to be said that there is some doubt that the whole package will be approved, as scheduled, by the Council of Ministers’ meeting this summer. It could hang on for finalization until the October meeting. That is dangerously close to the Jan. 1, 1993, implementation date.

There are serious disagreements on the timing of implementation of the market access rules that need to be resolved before the package is finally approved. We say that all freedom should be available now.

At the same time, there are obstacles to the process being placed by some carriers and their governments. Whether they are matters of genuine concern that need to be resolved or the last vestiges of protectionism that should be exposed remains to be seen.

What is certain is that anybody who expects full open skies to emerge in Europe at the stroke of midnight on Jan. 31 next year will be disappointed.

The key reason is that most of the major airlines in Europe remain either wholly or partially state-owned and, therefore, government controlled. If the full intent of European liberalization is to be achieved to fulfill the promises made over the years to the European consumer, the Council of Ministers must work toward a total airline privatization program.

Although privatization will not, in itself, automatically eliminate nationalism and protectionism, it will exclude ownership and financial considerations from national policies, reducing such pressures immensely. Private ownership is also crucial in opening the way for foreign investment.

One of those obstacles mentioned earlier is the continuing frequency of state aid, or subsidy, to government-owned airlines. It is a competitive distortion that forces airlines confronting the full forces of the market to compete with others who receive open and secret subsidies.

It is an indefensible practice that must be tackled by the EC Commission and the Council of Ministers. This is a priority prerequisite to further liberalization. The final stages of liberalization should not be agreed on until a satisfactory policy on this issue is in place.

A great deal has been written and said about the process known as globalization. It is not some practice that has appeared out of the blue, but a logical strategy evolving from the competitive pressures of liberalization and deregulation. We are already seeing embryonic global conglomerates maneuvering into position, especially here in Europe.

There is no question that deregulation, having taken root in North America and in Europe, will extend to other major markets. The ability to succeed in an environment where vast markets will be unprotected by the national policies and sovereignty prohibitions of the past will depend on strategic global deployment and the financial ability to invest in equipment and product enhancement. There will be a vital need to achieve economies of scale to gain higher yields, higher load factors and increased purchasing power that, in turn, will lead to lower aircraft costs and borrowing.

Despite the current economic setbacks, this industry is set to grow by an annual average rate of 6 percent per year through the 1990s and beyond. By 2000, scheduled passenger traffic will have doubled beyond its current level of 1.2 billion passengers. By around 2015, it will have quadrupled. The future is ripe with potential.

But to meet that demand, the industry is estimated to need about $40 billion in aircraft investment each year. Shortly into the 21st century, that will increase to something like $60 billion annually.

Such financial demands, by the way, are one of the reasons why full airline privatization will come about — because governments will no longer wish to contemplate supporting massive airline investments from the taxpayers' pockets.

It is reasonable to propose that the major airlines of the future will be formed by multinational companies operating from strategic international hubs, providing a comprehensive range of global services, consistent in product standards, service and operational integrity. There will, ultimately, probably be no more than 10 or 12 such global carriers. Three or four will originate in Europe, with similar numbers from among the existing airlines in North America and the Asia/Pacific region. They will create more intense levels of competition than could ever have been imagined back in 1979 when Anders Bjorck, supported by a few progressive carriers, first sought to open up Europe. They will create vast opportunities for regional and commuter carriers whose services will be needed more than ever to underpin the global networks.

Naturally, there are obstacles to air transport development. Who can remember a time when there were none? Not least among them is the problem of inadequate operating infrastructure — not only in finding methods to create more space at the airports and in the air in a way that is entirely efficient and entirely safe, but also in how to pay for these vitally essential improvements.

It will not be easy to find comprehensive, satisfactory solutions quickly. But I remain confident that the problems will be resolved. The alternative, stagnation of our industry, is unthinkable.

The smaller carriers, therefore, will in the future not just be out there on their own, plying whatever route opportunities might come along. They will have the freedom of full-market access and, in many cases, preference over larger operators because of the market development potential of smaller aircraft. In fact, size will be the only real difference between them and the major airlines because they too will need to become integrated, regional operations within the overall global air transport structure. Standards of service, reliability, operational integrity and safety will have to be precisely the same.

That is why, in the context of a European single market, the work of the Joint Airworthiness Authority is not just useful and commendable, but essential. Air safety, ultimately, depends on management attitude and commitment to that most fundamental aspect of commercial air transport.

The seminar theme is, after all, "Maintaining High Safety Standards in the Turbulent '90s." That achievement would form probably the biggest single contribution we could make to competitive demands and pressures that will come with the single European market in air transport.

We must not just hope to manage change as it comes, we must anticipate, plan and be ready for it with professionalism and dedication.

Another British writer, Arnold Bennett, could well have been prophesying the changes we are grappling with in Europe and around the world when he wrote much earlier this century: "The people who live in the past must yield to the people who live in the future — otherwise the world would begin to turn the other way round!"

The Year in Perspective — Corporate and Regional Operations

RONALD ASHFORD
Group Director Safety Services,
U.K. Civil Aviation Authority

Corporate and regional operations enjoy, if that is the right word, a lower profile than the major airlines with their large airplanes. This means that their successes and their failures largely go unremarked by the public and the press (but not, I hope, by the authorities!). This gives me the opportunity to review both aspects. You will not be surprised, I am sure, if this review leads me to dwell somewhat on safety.

But before jumping ahead to safety matters, it is important to look at the major success of regional and corporate operations in terms of both their size and their growth. In the five years to 1990, the number of hours flown by regional aircraft, including commuters, increased by70 percent worldwide, and seems set to continue. In Europe, the members of the European Regional Airlines Organization (ERA) operate more than three times as many flights as the largest of the European flag carriers and carry 40 percent more European passengers. The U.S. regional airlines, which carry almost three times as many passengers as the Europeans, are expecting to double their passenger loads in this decade.

The corporate operation is somewhat less dramatic. The number of hours flown by corporate jets has increased by about 20 percent in the five years to 1990 and again shows every indication that there will be steady long-term growth.

Ronald Ashford

So far I have deliberately avoided doing what I was asked to do, which was to put 1991 "in perspective." It has been a difficult year by any standards. First, the industry was faced with the Persian Gulf War and its aftermath and now the recession appears to be more persistent than expected. While it undoubtedly represents a significant pause in achievement and growth, it would be a mistake to draw long-term inferences from the statistics for the year. However, it is extremely encouraging that the European regional airlines recorded positive growth in every month last year, albeit at very low levels in February and March. Overall, the ERA registered a growth of 10.3 percent in 1991.

All of this indicates a remarkably vigorous and buoyant industry that has maintained growth in 1991 in spite of a very difficult economic climate.

Worldwide Regional and Corporate Accident Rates Compared

There is no clear distinction between a regional or a commuter operation. However, it is helpful to distinguish between the smaller airliners certificated to Part 25 standards and the even smaller "commuter" aircraft certificated to modified Part 23 standards [Special U.S. Federal Aviation Administration Regulations (SFAR) 41 or Part 23 Amendment 34]. For our purposes a commuter aircraft is assumed to be one with less than 20 seats and a regional aircraft one with 20 to 80 seats.

Regional and corporate operations have their problems as well as their successes. The major problem is that they do not appear to offer their passengers the same safety levels as do the medium and large passenger jets with which they are often linked. Using worldwide data for the major types of aircraft used in regional and corporate operations, the following picture (Figure 1) shows that even regional aircraft have an accident rate per hour that is about 3.5 times worse than for the large jet transports. Commuter turboprops with less than 20 seats and corporate jet aircraft are about 1.5 times as bad again. However, most accidents occur at the beginning and end of flights and there is an argument that a comparison on a "per flight" basis is more meaningful. Due to the shorter flight times typical of regional or commuter operations, this difference is reduced and the safety levels per flight are closer to those for large jet transports.

Worldwide Regional and Corporate Aircraft Accident Rates

Graphic Unavaiable

Figure 1

Before turning to the detail of the accident picture, it may be instructive to show the regional commuter and corporate safety levels in comparison with their true competitors — trains, cars, buses and ferries (Figure 2). This shows that for every 100-mile journey, the regional aircraft fatal accident risk is somewhat better than that for motor cars. A fatal accident is, however, more probable than for the large jet airliners or buses and, perhaps, 10 times more than for trains. The record for commuter aircraft is slightly less good than that for the larger regional or corporate aircraft.

These worldwide figures may not be representative across all of the continents; there are, of course, regional variations. While they are indicative of the general situation, they should be treated with caution. For example, a recent analysis in the United States suggests that there is only a factor of three between commuter accident rates and scheduled Part 121 carriers.

Risk per Million for Each 100 Nautical Miles Traveled		
Train passenger	U.K.	0.03
	U.S.	0.11
Bus passenger	U.K.	0.09
	U.S.	0.03
Jet airline passenger	World	0.16
Heavy goods vehicle driver	U.K.	0.37
Corporate jet passenger	World	0.8
Regional aircraft passenger	World	0.8
Car driver	U.K.	0.9
	U.S.	1.1
Commuter turboprop passenger	World	1.3
Pedal cyclist	U.K.	11.5
Motor cyclist	U.K.	22.2
	U.S.	41.0

Figure 2

An accident to a scheduled airliner killing 50 or more passengers will generate intense and long-lasting press coverage in the country in which it occurs and will certainly be reported worldwide. If it is in Europe, the public in all other European countries will be made aware of it. By contrast, if it is a smaller airplane from a local service operator that is not widely known and in which perhaps 10 people are killed, the accident will probably only be given low priority mention on the day that it occurred. Public concern following a commuter or corporate aircraft accident is usually limited and short-lived. The industry does not advocate "regulation by media pressure," but the relative lack of press attention does nothing to lessen the responsibility for those of us who are concerned that the regional and corporate industry apply the lessons learned from accidents.

Figure 1 suggests that the smoothed accident rates for the last three-year period (1988-90) show a continuing improvement.

Accident Causes

Each and every accident is different and the best we can do is to try to identify the recurring factors. This should give us some guidance on priorities for improving our regulations or their application. A review of accidents and their causes yields the information displayed in Figure 3 (page 15). These data are to some extent subjective because accidents to aircraft in these categories are not deeply investigated or reported upon.

The most dominant factor is controlled flight into terrain and it is clear that any improvement in this area would have a direct impact on the accident rate. Even in large aircraft, ground proximity warning systems (GPWS) are not mandatory throughout the world, and there are even a number of countries within Europe where they are not required. In commuter aircraft, the presence of GPWS is even rarer, although the FAA has recently taken a lead and proposes to make it a requirement. Europe should increase its implementation of GPWS overall and extend it to commuters.

Another major contributor is airmanship — the pilot. It is all too easy to blame the pilot. The subject is much bigger than that — it covers his training, education, experience and the interface with his aircraft. The aircraft in regional service have, until recent years, been using older technology and operating on routes that are probably more demanding. The higher level of weather-related accidents may reflect this, as well as, less-experienced crews operating in a less-disciplined and standardized environment.

In the United Kingdom, and doubtless other countries, operational safety shortcomings are being addressed in several ways, e.g., the introduction of International Civil Aviation Organization (ICAO) recommended human factors training and exams for commercial pilots; flight deck management training for all commercial air transport operators; and increased requirements for two-pilot commercial air transport instrument flight rules (IFR) operations. Additionally, simulators are now being produced for regional type aircraft that should lead to improved training standards.

Graphic Unavailable

Figure 3

However, the machine itself cannot go free of criticism. It is a broad fact that, as the aircraft get smaller, the accident rate gets higher.

In part, the environment becomes more difficult. Propeller aircraft, for example, are less able to avoid severe weather and icing. This can increase pilot workload and this may need to be reflected in the design standards that are applied. There is a worrying proportion of engine and fuel-related accidents. But these, to some extent, reflect engine emergencies that should not have become accidents, i.e., in some cases the emergency procedures were not followed correctly.

The main conclusion to be drawn from Figure 3 is that, in addition to GPWS, an effort is needed across the board to improve the aircraft, the infrastructure and the capability of the pilot.

Future Trends Include More Versatile Turboprop Aircraft

It is probably sensible to review overall trends in the character of regional aircraft and operations. It is likely that the nature of corporate aircraft and their operation will not be changing significantly.

Regional operations are currently dominated by turboprops both in the commuter category with less than 20 seats and also in the larger 20- to 80-seat category. The only jet that has had significant application in this field has been the Fokker F-28 but that is now beginning to change with Canadair and British Aerospace regional jets and others in the design stage. Jet aircraft, however, already account for one in seven of the ERA fleets, though some of these are in the 100-seat bracket and operating on mainline routes. Nonetheless, it will be some years before a major proportion of operations into regional airports are carried out by jet aircraft.

Another significant development, which is not unrelated, is the development of derivative turboprop aircraft with a much higher speed capability, such as the Saab 2000. These aircraft will have greater range and will bring increased sector length routes within the scope of regional operations. This is likely to bring higher comfort levels and lower cabin noise — areas in which turboprops have sometimes left something to be desired in the past.

Finally, in common with all aviation, there will be pressure for reduced environmental impact — lower external noise and emission levels.

Safety Standards Must Be Harmonized

The industry needs harmonized and high safety standards. Improved safety requirements should be introduced. This should be acceptable to operators if the requirements are imposed without a commercial disadvantage placed on some operators and not others. The European Joint Aviation Authorities (JAA) are working on harmonized standards and common requirements are complete for the certification of large airplanes (but not yet commuters), engines, all-weather operations, propellers, auxilary power units (APUs); and equipment Technical Standards Orders (TSOs) as well as for the approval of maintenance organizations. There is a need now for much greater effort to be put into harmonization with the U.S. Federal Aviation Regulations (FAR). Joint Aviation Regulations (JAR) Ops Parts One and Three covering commercial air transportation are well advanced and the whole JAR-Ops is due for publication and adoption by Dec. 1, 1993, to take effect two years later.

The certification code for light airplanes up to 5,700 kg (JAR 23) is now complete as a draft code and is due to be the subject of full consultation this month. The success story here is that the code has been developed with close cooperation between the JAA, FAA and industry organizations. A very high level of agreement has been reached on the content of JAR 23 and FAA-proposed Notices of Proposed Rule Making (NPRM) for FAR 23 to produce similar codes. This begins a much closer transatlantic cooperation in the early stages of requirement development. This should be greatly helped by the JAA participation in the FAA's Aviation Rulemaking Advisory Committee (ARAC) system. The extension of JAR 23 to cover commuters is now starting. This is an area where improved standards are required and it is hoped JAA/FAA cooperation will again result in agreed solutions and that there will be the political will to implement them. The authorities should agree on safety targets.

Particular issues that should be addressed for commuter aircraft are the provision of GPWS, safer operation in extreme icing conditions, gust response, fatigue and damage tolerance, and enhanced performance standards. There is a case for closer monitoring and regulation of corporate operations, but with a notably lighter touch than for public transport.

Meanwhile, JAA joint certification is under way on several aircraft and engine types of relevance to regional and corporate aviation, e.g., Dornier 328, Saab 2000, Casa N235, Jetstream 4100, Canadair Regional Jet and Falcon 2000 aircraft and the PW-119, Allison GMA2100, Williams FJ44, Allison GMA 3007, CFE 738 and PW206 engines.

The European Economic Community (EEC) regulation on Harmonized Technical Standards and Procedures went into effect on Jan. 1, 1992. This requires all Economic Commission (EC) countries to adopt and apply the JARs that have been completed and to accept products from other countries designed, manufactured, operated and maintained in compliance with the common technical standards and procedures where those products have been certificated by another member state. "National variants" are not allowed in the final published codes.

Our position in 1992 is likely to be in the following terms:

- This sector of the industry has enjoyed very rapid growth over the past decade and maintained some growth right through the difficult times of 1991.

- The accident rates continue to improve, but are still not as good as those for the larger operators. We should all work to narrow this gap.

- The accident causes are dominated by controlled flight into terrain, airmanship, weather and engine, fuel, and fuel system problems.

- Improved and harmonized safety standards are required. The JAA work and close cooperation between JAA, FAA and industry are the key elements of this objective.

- JAA standards covering all aspects of corporate and regional operations are complete or in preparation.

Air Safety in Regional Airlines: Who Owns the Problem?

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Aviation has a good safety record overall, although at the 1990 Flight Safety Foundation International Air Safety Seminar in Rome, several speakers made the point that the worldwide safety record is no longer improving and may, in fact, be worsening. Whether or not that apparent reduction in safety is confirmed, the fact that the matter can be discussed in those terms suggests that there is no room for complacency.

The safety of any aircraft operation depends on the people concerned with a flight doing their jobs properly. Moreover, key aviation personnel hold licenses from a regulatory authority, and the organization itself has undergone scrutiny before it was allowed to offer a service to the public. Is there a need to do more?

I believe that there is. The aim must be to create within the organization a climate that makes certain that everyone will do his job properly, and that if he fails, for whatever reason, the failure will be identified and corrected. This climate is a function of two separate, but linked, points. First, there must be an organization that determines the processes to be followed in particular circumstances. Second, and just as important, there must be a feeling throughout the organization that safety is paramount and that everyone, including the finance director, adheres to that philosophy.

The following are two examples where things went wrong in organizations that had the best intentions.

In November 1987, a disastrous fire occurred at King's Cross Underground station in London that claimed 31 lives. The accident report states that "many witnesses emphasized that safety was enshrined in the ethos of railway operation, and that staff at all levels were aware of their responsibilities for passenger safety." Nevertheless, London Underground developed a blind spot to the hazard of fire on wooden escalators, due in part to lack of clear thinking about who was responsible for what.

In December 1988, British Rail had a collision at Clapham Junction that claimed 35 lives. The accident report states "BR's commitment to safety is unequivocal. The accident and its causes have shown that bad workmanship, poor supervision and poor management combined to undermine that commitment. The appearance of a proper regard to safety was not the reality."

Thus, good intentions coupled with an assumption that everyone is aware of the need for safety is no guarantee that safety will, during a period of time, be achieved.

The safety objective of an airline can be stated very simply. *It is the primary aim that a safe operation be achieved at all times.* An airline will, very properly, have a number of other objectives. Making a profit is obviously one objective, unless there are special circumstances. But even the most profit-conscious airline must have safety as its first objective, because if it fails in safety, it is unlikely to survive.

Management of Safety Demands More Than Good Intentions

If intentions will not produce safety, it may be useful to look at some of the reasons why this is so.

There is no doubt that employees often identify very closely with the aims of their company and such identification is usually to be applauded. However, it can sometimes prove counterproductive. An employee may consider that getting a service away on time has a very high priority and that a short cut (which appears to him at the time to be adequately safe) will be in the best interests of the company. On a rare occasion, he may be tragically mistaken — the short cut omitted a check or procedure which, on that occasion, was vital.

Or consider the supervisor who knows the excellent quality of one of his staff, and does not make sure that the staff has understood an instruction on how to perform a certain task.

Consider too, the occasion when the time to do a job was misjudged and a tired employee missed an important check due to fatigue, or a task was not completed at the end of a shift, and the hand-over to the new shift was not comprehensive, and some vital activity was not finished by the incoming shift?

You may think the above examples are hypothetical. In fact, they come from accidents involving major organizations during the past five years.

Safety will not just happen. It must be managed. Of course, an airline will not be allowed to operate unless it has some safety management arrangements in place to the satisfaction of its regulatory authority, but my point is that the perception must be that *we have this machinery in place because we need it to do a good job, not because the authority says we must.* Of course, an authority should not impose standards without good reason, and it must be able to demonstrate that reason to the operator. But the operator must take ownership of the result not because "we do it because we must, but we don't understand why." An operator must be prepared to go further than is required by the supervisory authority. It must ask itself if there is a need to put additional safeguards in place. The requirements of an authority are, inevitably, related to general situations. Only each operator can identify a potential pitfall in his operation and make adequate provision to protect against it.

Each operator must also take precautions against terrorism in all its various forms. Appropriate action must be taken if weaknesses are identified. This will involve cooperation with other organizations such as airports, baggage handling organizations, catering organizations and so on.

Safety of staff in the workplace, at least in the United Kingdom, is governed by different legislation. However, from the point of view of the attitude to safety in an organization, the two are really indivisible. The aim must be the same.

The following are the essential elements of safety management:

- The safety objectives of the organization must be clearly defined.
- The organizational structure to achieve those objectives must also be clearly defined, with a clear definition of the role of each component of the whole.
- The terms of reference of staff must explicitly define their responsibilities in safety matters.
- There must be machinery for assuring the senior management that what they intend to happen is indeed happening.
- There must be a process whereby the organization can be monitored to ensure that any weaknesses are identified, drawn to the attention of management an corrected.

Although this may look ponderous for a small organization, I do not believe that it is. In a small organization, it is usually possible for the safety role to be combined with some other task, provided that it is made clear that time must be provided for the safety duties, and that they may not be set aside or deferred for other, seemingly more urgent tasks. A big organization may need a full-time staff in some of the roles. If there is proper monitoring of what is happening, senior management can become aware if something is being omitted or skimped, or is not working. It is wrong to have a procedure that does not work adequately, so that people deviate from it. Once staff becomes accustomed to ignoring the procedure in one respect, there will be a temptation to ignore it in others.

Compatible Safety Objectives Echoed by Organizations’ Subdivisions

Every airline has two essential operational elements — engineering and flight operations. This is true even if the engineering work is subcontracted to another organization. Clearly, the needs of these two arms of the company differ, and great care must be taken that they communicate properly with each other, and that they have compatible safety objectives.

A satisfactory way of achieving this is to have a cascade arrangement, whereby the objectives of the company are defined in a document that is accepted by the board of the organization. Then each arm determines its own objectives based upon company objectives tailored to its particular needs. In turn, each arm’s subdivision should have its own objectives, based upon the previously determined objective.

Such a structure of documents must be regularly reviewed and amended to accommodate changing circumstances. Someone must be responsible for maintaining the documents, both at the corporate level and at the departmental level. Also, there must be a continuing check that the various documents remain compatible with each other. It is also important to make sure that some departments, which may appear peripheral in safety matters, are included in any aspects that are safety related. In many airlines, for example, cabin crew report to a commercial department. They have a vital safety function to perform, so their work must be correctly woven into the safety structure. All parts of the organization have responsibilities relating to health and safety at work, and it would be appropriate to incorporate these aspects into the genreal structure as well.

Finally, a means of checking its effectiveness and alerting the highest levels of management must be built into the safety structure.

All this may seem very bureaucratic. I do not believe this to be true. First, the actual arrangement of people must be visibly related to the task in hand. Second, the people whose task it is to achieve the objective should either write the local instructions, or be responsible for agreeing to them, so that they have ownership. Moreover, the question of ownership must start at the very top. The board cannot avoid its responsibility for safety, even though it may have experts such as a flight operations director or an engineering director who will be responsible for most of the day-to-day preservation of safety.

What does this mean in the small airline?

First, the board must make its intentions clear. It can do this in more than one way. It can and should issue a statement on its overall objectives showing safety as the highest priority. In this respect, it is necessary for the objectives to be comprehensive, so that it is clear to the staff where safety stands in the priority order. If a statement such as "Safety is paramount in our operation" is issued in isolation, there is the risk that it may be seen as equal to, or even subservient to some other objective expressed in a different way on a different occasion. The board must make it clear that if a responsible member of staff decides that a particular flight cannot be conducted safely and aborts it, or that a particular aircraft is no longer airworthy and should be withdrawn from service, he will be supported, even if a subsequent and more leisurely study suggests that he had acted overcautiously.

Second, the board should make clear its continued interest in safety matters. There may be a number of ways in which it can do this, depending upon the particular skills and responsibilities of the board members. The concept of a safety committee chaired at board level and having some independent membership — such as non-executive directors — is one that has been adopted by several airlines.

The role of the chief executive officer (CEO) is an important one on safety-related matters. The CEO may be someone with little technical knowledge, in which case he will be very reliant on his senior management for advice. He must make it clear that he is a part of the safety team, even if only in the sense of aiding and supporting his managers. If, on the other hand, he is someone with operational experience, he must be very careful not to usurp the roles of his senior managers and appear to second-guess their decisions. Great tact and skill must be displayed by the CEO.

Below the board and the CEO will be a number of departments, some of which will have operational safety responsibilities, and all of which will be concerned with general safety matters. The responsibilities of each department must be defined, and those for safety of the various key staff must also be defined. Thus, the director of flight operations should have "to achieve and maintain a safe operation" as one term of reference. The manager responsible for recruiting may not need any reference to safety in that job description.

Within each department, there must again be a structured set of objectives, cascaded down as far as is appropriate. It may not be necessary to carry this to the same level in all parts of the organization. For example, there may be safety support for a particular task at a main base that has to be provided differently at a line base, and so the terms of reference may need to be different.

Someone must be responsible for making sure that the various documents knit together properly and do not contain gaps. In a small organization, this is unlikely to merit full-time attention, and so someone must be picked who will have that responsibility even though he may also have departmental responsibilities. To the fullest extent possible, the documents should be written by those who have to apply them. In a small organization, this may not always be possible. If it is not, then the author must develop a close relationship with those for whom he is writing, so that what emerges is appropriate and applicable. Again, it is important to be alert for procedures that, good though they may look on paper, do not work in practice. Apart from the liability risk (if it can be shown after an incident that a procedure had not been followed), it seems bad practice to leave impracticable processes in place.

Someone must also be responsible for ensuring that the board is supplied with the information that it needs. While the information will largely emerge from the line departments, there must be a way to allow information from other areas to identify safety gaps. A safety committee may be the right place to report any such matters.

It is important to recognize that an organization such as a safety committee exists to keep the board informed. It must not become an executive body, and take away responsibility from the nominated directors (who may or may not be board members). At the same time, it must be properly serviced and should meet (and be known to meet) at regular intervals.

It will usually be appropriate, no matter how small the organization, to have a flight safety officer. There will also, on the engineering side, be a quality control group of some type. These two elements are well-placed to make important inputs at all levels. In a larger organization, it may be appropriate to have a safety department that spans all disciplines and perhaps embraces health and safety of work issues as well. This may not be realistic in a smaller organization. In such a case, great care is needed to ensure that those working on safety issues are not departmentally polarized so that feelings of unequal treatment emerge.

The constitution and terms of reference of an air safety committee are set out in Appendix 1. They relate to regional airlines, and may be adaptable to others.

Reporting and Follow-up of Incidents Requires Cooperation

No organization will succeed in acting faultlessly on every occasion.

Many countries, including the United Kingdom, have reporting schemes run by the safety authorities. However, those schemes can only handle those incidents perceived to be significant. Were they to do more, they would sink under a mass of information. But sometimes the "pointer" to an accident is a relatively minor thing repeated many times. An individual airline may be able to spot an event of this type when it is of an operational nature. Of course, if the event is of an airworthiness nature this may not be possible, because the experience of other operators may not be available. Yet it is worth considering if the information flow from the airframe and engine manufacturer is as complete as desired, and, if it seems weak, asking the manufacturer to do better.

It is important that the airline has (in addition to a system for reporting when appropriate to the safety authority), an internal system for receiving and evaluating reports of a lesser nature, and that it maintains a system for checking that any necessary follow-up action has been taken. If it has an air safety committee, this can constitute a forum that can routinely review these matters. Such a review has two benefits. It assures senior management that the system is working and it spurs staff to keep the system moving. Unfortunately, it is too easy for the review of a task to be pushed into the background when other urgent pressures occur.

Full cooperation of the aircrew must be established if the system is to operate efficiently. Even in small airlines, it is not unknown for the flight crew to vanish after a flight, leaving only a cryptic comment in the technical log about some defect. The result of this inadequate communication may be that the engineers have insufficient information to properly diagnose the problem and fix it. Apart from the potential effect on safety, there is a real financial cost to repetitive defects due to needless removal and re-certification of items that are in fact serviceable.

An operational incident form that has been found to work well in practice is reproduced in Appendix 2.

Management and Safety Authorities Maintain Balance

The role of senior management can be summarized below:

- The board must make known its safety objectives and must keep itself informed about how those objectives are being achieved.
- Senior executive management must ensure that the overall objectives are interpreted into departmental objectives and that the staff terms of reference are clear.
- Middle management must ensure that they understand their own role, and that those reporting to middle management are also clear about them.

It is not enough to assume that everyone will understand the need for safety and the means by which it is to be achieved. Each level of management must periodically remind those reporting to them of the objectives. For example, if a notice is issued drawing attention to the need to improve timekeeping, it could be coupled with a reminder that this must not be at the expense of safety.

A further quotation from the report of the Clapham accident seems pertinent. The author of the report states:

. . . it is the task of management to be aware of the working practices to which its work force works and to ensure that those standards are of the highest. It is the task of management to ensure that its instructions to its work force on how work is to be done are clear and that they are in fact being obeyed. It is the duty of management to see that its work force is properly trained and that such training is renewed from time to time. It is the duty of management to ensure that the efforts of the work force are properly monitored and supervised so that the quality of the work may be maintained at the proper levels.

A temptation to think that none of the above applies to an airline would be understandable. A great deal of effort is devoted by the airline and by its supervising authority to ensure that good systems are in place and working. This system has served the industry well for a long period of time. However, it is not a perfect system. The resources of any authority are limited — indeed, tiny compared with those of the airlines that it supervises. Experience demonstrates that airlines, even with those disciplines, can still suffer accidents. The safety record may be no longer improving. Some improvement may be had if all airlines act in accordance with the tenets of the best. This means making clear a company's aim for impeccable safety and also emphasizing that this is the company's wish, not simply an act of compliance with the edict of outside authorities.

Incident Management

It may be felt that the reaction of the operator in the event of a major incident is not strictly a safety matter. I cannot agree.

There are two aspects of incident management that are of great importance, and for which the operator must have a structured plan. First, of course, there is the task of dealing with the incident itself. For this, a plan must be in place that covers all the facets that may arise — notifying the appropriate authorities, alerting senior management, being prepared to deal with the relatives of passengers and crew, and attending to press queries and demands for interviews. The list is long, and if there is no plan for dealing with it, an untidy situation can easily develop. This has two disadvantages — the image of the airline externally will be one of confusion, and the effect on staff morale, likely to be low anyway, will be very negative.

The second point relates to continued operation. While the responsibility of identifying the cause of the incident lies with the accident investigation authorities, the airline cannot just wait for the results of inquiries. Of course, the authorities have the right to intervene if they deem it appropriate, but the operator itself must make its own judgment about whether it is right to continue in the immediate aftermath of an incident (either unchanged or with a modified operation) and must be prepared to explain the rationale for the decision.

Experience suggests that it is not enough to have a plan. Inevitably there will be problems with it, if only that key staff will not be fully familiar with the role they are expected to play. The plan must be rehearsed periodically and amended in the light of that experience.

So Who Owns the Problem?

Many people in an airline own part of the problem. The greatest degree of responsibility, as in so many other matters, lies with the board, who must ensure that its wishes are clear, followed and effectively implemented.

Acknowledgments

I am grateful to many colleagues for their constructive suggestions that they made during preparation of this paper. Thanks also to Birmingham European Airways for permission to use their Air Safety Report form and the terms of reference of their Air Safety Committee.

Reference

Chaplin, J.C. "The Management of Safety: Some Lessons from Accidents." Flight Safety Foundation, 43rd International Air Safety Seminar, Rome, 1990.

Appendix 1 — Air Safety Committee Terms of Reference

Function

The Air Safety Committee (ASC) will report to the board. The function of the ASC is to stimulate thought and action to promote safe methods of operation and to encourage preventive action against unsafe operation. It will monitor the safety performance of the airline and ensure that appropriate action is taken to correct deficiencies. The ASC does not reduce in any way the responsibility of the general manager, flight operations or of the chief engineer under the terms of the Air Navigation Order or the conditions of the company's air operator's certificate.

Constitution

The ASC will have at least the following membership:

Chairman
Managing Director
Non-executive member

Secretary: Air Safety Officer

In regular attendance:

General Manager, Flight Operations
Chief Engineer

The ASC will meet at monthly intervals. If GMFO or CE are unable to attend, they will send deputies.

The air safety officer will be responsible for collating and delivering all items of safety for review by the committee.

Procedure

In its function as a recommending body for safe practices, the ASC will give its findings on correction or prevention to the departmental heads concerned. Departmental heads will in turn advise what corrective/preventive action has been taken on the various matters before the committee.

The ASC has the power to investigate any incident affecting the safety of either flight or ground operating practices. It will maintain a regard for the experience of other operations relevant to the BEA operation. It is totally independent of either the operations or engineering departments and has direct access to Civil Aviation Authority (CAA) should the need arise.

On matters such as hijacking or bomb threats, the purpose of the ASC is to investigate how the airline responded. Security will investigate how such an incident happened.

A record will be kept of all meetings of the ASC.

Matters for the Committee

The ASC will review, as a matter of routine, the following:

- Mandatory Occurrence Reports (MOR)
- ADDs and, in particular, the reason for any adverse trend
- Any safety report from any member of either the airline staff or their agents not thought to warrant an MOR.

It will keep these matters under review until they are closed.

In addition, the air safety officer will bring to the attention of the ASC any reports from other operators that may be relevant to the BEA operation.

All members of the committee should be alerted in the event of an accident involving serious injury or equipment damage.

Action

Because the ASC is not an executive body, all actions will be taken by the appropriate staff in accordance with normal procedures. It is important, however, that safety actions are not delayed pending a meeting of the committee. The ASC is a reviewing body only.

Conclusion

It is important that the committee be accessible to anyone who has a safety concern. To that end, excessive formality in approaching the committee is not appropriate, and staff should be encouraged to put forward worries without ponderous paperwork. The committee is, however, the mechanism by which the board's dedication to the safe operation of the airline is made known to staff.

Appendix 2

Graphic Unavailable

Appendix 2 (cont.)

Graphic Unavailable

Confidential Human Factors Incident Reporting Program (CHIRP) Analysis and Trends

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Confidential Human Factors Reports (CHIRP) Office
Royal Air Force Institute of Aviation Medicine

By the 1970s civil passenger aircraft had become more reliable than the immediate post-World War II types and had achieved a gradually decreasing failure rate of equipment and engines. The overall accident rate had been declining. The International Civil Aviation Organization (ICAO) produced figures that showed a dramatic reduction in accidents, but also indicated that the rate of improvement was also declining (Figure 1).

Although throughout the same period there had been improved training methods for flight crews, the incidence of crew errors resulting in accidents had become a greater proportion of the total accident rate (Figure 2).

There was a reporting system in existence that allowed aircrews to report incidents that had highlighted equipment deficiencies while not actually causing an accident. In specific instances, a report became mandatory (a Mandatory Occurrence Report or MOR). The objective was to evaluate these reports to identify any trend towards disaster and take preventive technical action.

The same action was attempted in the field of human error. It could be shown that many human errors were caused by cockpit equipment being easy to manipulate incorrectly. Pilots found that some of the procedures designed specifically to prevent errors could be

Fatalities/100 Million Passenger Kilometers Scheduled Airline Operations

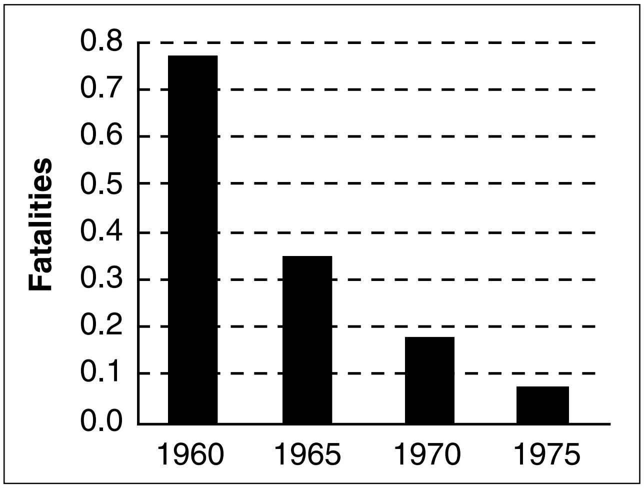

Figure 1

misapplied, especially under conditions of high workload or stress. It was hoped that reports of errors would identify problem areas so that modifications could be provided that would prevent accidents.

A distinction has to be drawn between the human errors that result from incompetence, lack of training or ability, and those caused by limitations on human performance from which everyone suffers (Figures 3 and 4).

A uniform with four stripes and 20,000 flying hours still does not make one immune from

Fatal accident causes	No. of accidents	No. of fatalities
Aircrew error	34	1132
ATC error	2	148
Weather	7	346
Engine failure/fire	6	212
Mechanical failure	3	23
Structural failure	2	64
Hit high ground	15	
Sabotage	2	278
Hijack	1	6
Shootdown	1	30

Figure 2

human limitations. Specific sets of circumstances can combine to drive the pilot towards physiological and psychological limits that are intrinsic to all human beings.

Some people could interpret any reporting of errors as incompetence on the part of the reporter as a vindictive complaint. Because of this, a reporting process had to ensure complete confidentiality for those who felt strongly enough to submit a report.

It was decided in the early 1980s that the body best able to perform this task, and most acceptable to civil aircrews in the United Kingdom was the Royal Air Force Institute of Aviation Medicine (RAFIAM) at Farnborough. The CHIRP group is a subdivision of the Psychology Division, housed at and supported by the RAFIAM on behalf of the Civil Aviation Authority (CAA). CHIRP operates independently but the opinions it provides are produced with the support of the RAFIAM Psychology Division.

The Impossible Triangle

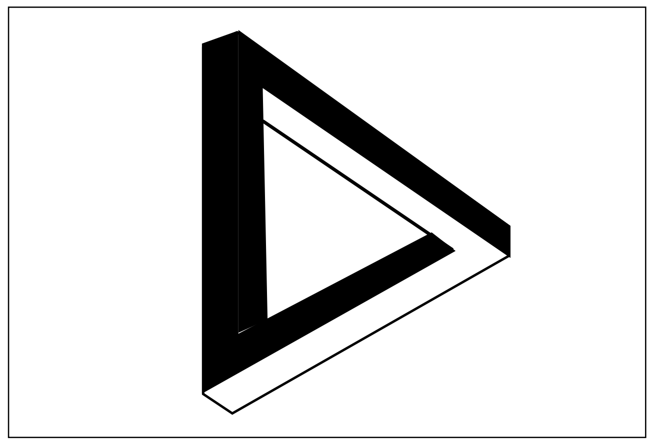

Figure 3

Accurate Reports Reflect Crew Concerns

The reports have come to CHIRP at a fairly constant rate during the years of operation. They accurately reflect the concerns of the crews as can be seen from the topics which have

An Ambiguous Figure: Is X the Corner Closest to You, OR is Y?

Graphic Unavailable

Figure 4

come and gone. Great care was taken in the design of the report form to encourage reporters to submit, in text form, all of the information that they thought to be important. A minimum of significant information was asked about the reporter, aircraft and environmental factors (Figure 5).

The more detailed forms, used by some organizations, with a mass of questions and boxes, can be counterproductive in encouraging the reporter into sending his impression of the event.

Four years after the start of CHIRP, it had proved to be so successful that a parallel reporting system for air traffic controllers was set up in 1986. They have problems associated with their own tasks and equipment. Once again, the form was designed to obtain the profile of the reporter without detracting from the text of the event (Figure 6).

As the job of the air traffic controller has developed, there has been a gradual change in the experience of recruits to the profession. Originally, a controller had experience as a member of a flight crew, often military. This produced a level of understanding between air and ground that made for smooth operation, even though this produced some professional criticism at times. Today, there is often no personal aircraft experience to help a controller understand the constraints felt by flight crews when trying to conform to a requested flight path. This has prompted a number of issues that have been aired in *Feedback,* the CHIRP newsletter.

The peaks and troughs in the numbers of reports received are produced mainly by the effect of circulating the *Feedback*. This newsletter is sent about three times a year to all aircrew and controllers licensed by the U.K. CAA and contains extracts from reports together with comment from interested parties. The information is highly technical and specific. Because of its technical nature, it is often misunderstood by laymen and sometimes even the more technically literate of the media. For this reason, circulation is rigorously restricted. It is also difficult enough to persuade people who have made errors to “bare their souls” to their peers. Further exposure to the uniniti-

Graphic Unavailable

Figure 5

Graphic Unavailable

Figure 6

ated would make the process even more difficult.

All of the information, in a confidential and disidentified form, is eventually sent to the CAA at the Safety Data and Analysis Unit.

About 10 percent of the reports sent to Farnborough come from general and corporate aviation. The problems sometimes reflect a microcosm of airline operations where a fundamental human problem is highlighted. The following examples show the wide range of subjects reported to CHIRP.

The Supervisor's Dilemma

I was sitting in the jump seat in a supervisory position on this trip. Prior to incident for the takeoff which was hot, we had discussed length of runway in detail, takeoff speeds, and the effect of heat on thrust and brakes in the event of RTO [rejected takeoff]. During pre-T/O checks, V_1, V_R and V_2 were calculated, discussed and argued over for final accuracy. During T/O roll, copilot shouted rotate at V_{REF} for previous landing. At that instant I saw he had not reset his bug. The first words that came to my mind were stifled by another brain loop which did not want to say the wrong words in a crisis. By the time I got to speak the captain had responded to the false rotate command and we were airborne. The V_{REF} was 110 knots. V_1/V_R should have been 131 knots. Stall speed at takeoff weight was 120 knots (we were airborne on vectored thrust). Privately, I initially blamed the copilot. Ten minutes later I had included the captain who was after all commander and therefore responsible for safe conduct. Over the following days, I got to blame myself, as I was there to see they could cope. Leaving blame aside, there was a train of minor trip wires not noticed. I did not see that the copilot's bug had not been set. Although I never saw the captain's bug, that may not have been set either. The copilot then called a speed he should have known was in error (if that analytical bit of the brain had been working). Then the captain responded to a call that he too should have known was in error. I was indeed thankful that [the aircraft manufacturer] put a lot of work into investigating minimum rotation speeds, and that the aircraft is docile in such a maneuver, and has stall warning devices.

Supervision is not instruction. Because the supervisor does not generally have enough time for formal instruction, but merely comments on the critical areas of operation, the supervisor has to follow all the actions meticulously. Human error can be observed by the supervisor but also be effected by him during the supervisory process. Keeping in the loop by maintaining a feedback of information is the only way to minimize the risk.

Pressure Tested

I was flying a business jet around Europe. All checks were done and the flight was perfect. We waited around for five hours for the boss to return, as he was on a mission that required not letting the *girlfriend know he is visiting his wife. We ask for start clearance, get it after a while and, after starting both engines, we ask for taxi. Just as I am about to taxi the oil bypass filter light comes on. I point this out to the copilot and tell him I am shutting the right engine down. He immediately stops me from doing it by putting his hand on mine and tells me it happened two or three days previously and that it was alright and only a micro switch was faulty. Now, I accept this because we have had some electrical problems before. I get to the hold and the light is still on, so I tell the copilot to tell ground I am returning. Now, bearing in mind we have a slot and the boss could be put into a difficult position, I tell him I am returning and like a gentleman [he] accepts it. My copilot is giving me a hard time telling me "You know what you have just done, if his girlfriend finds out there's going to be a lot of trouble!"*

Me not worried to a certain extent, thinking about my wife and daughter and thinking I'd like to live a few more years. Anyway, as the copilot tells ground we are returning, I put the throttle forward to turn right and the light goes out and stays out. Now the situation is a go item, and the copilot says I told you it was only the micro switch, so disregarding my reservations I tell the boss it's alright to go now. We get airborne. Lights on all instruments including oil pressure all normal as usual.

We get to our European destination and I ask the copilot to get maintenance to check it. At 10 p.m. the phone rings. My copilot says "Guess what?" The oil filter was completely clogged with metal due to a failed bearing and he tells me not to mention anything to my boss that the light came on three days ago.

If you do not have a happy cockpit your flying deteriorates and so does safety and everything else because that person can upset the others, either captain or copilot. It is not fatigue but being irritated which causes mistakes to be made.

There can be few things in aviation which are worse than the intermittent fault. The effect of stress is cumulative to any fatigue and produces a degradation of professional judgment which is not apparent to the affected person. There is just as much need for good cockpit resource management in smaller aircraft as in the airliner flight deck. Try to devise your own way of involving others in the decision-making and responsibility for actions, but never forget that the authority of the captain is paramount — it is his responsibility.

That Wary Feeling

Approaching from the west, approach instructed: "Report visual before joining. Expect clearance to join downwind left-hand for runway 31, QFE. . . ." Reported visual and told to call tower. Tower instructed us to "join downwind left-hand for runway 13, QFE. . . ." The other pilot and I both wrote this down independently, and read it back. In view of the previous message, I wondered whether to query it, but this ATC was usually pretty good, so I decided I might have misheard the previous. Approaching the airport boundary I coached the student on descending dead-side and crossing the live at circuit height. Just about airport boundary we saw an aircraft on short final for 31, and I called to confirm that we were cleared to join downwind for 13. Tower called back rather irately: "You were cleared to join downwind left-hand for 31." There was just time to turn sharp right and join "very late downwind" for 31. There was an obvious hazard since we were flying directly across the real downwind leg at circuit height. There was also a lot of potential embarrassment, distraction and reduction in confidence for all concerned.

No matter how meticulous the communications procedure, the possibility of error always exists. If you have a niggling doubt, check — not always easy at New York or Chicago. The vague suspicion at the back of the head is sometimes the only warning you get of impending disaster.

Overall, it seems likely that technical improvements will make operations safer. There have been a number of less-than-effective attempts to teach pilots about human factor problems. However, there is a great deal of interest now being shown by designers of aircraft and equipment in how to improve the relationship between human and machine. This not only means installing knobs that work in a natural way and within reach, but also making the presentation of information more readily understood and easy to act upon. Pilots have been allowed to fulfill their desire to overcome the shortcomings of their aircraft for too long. The net result of the current drive to improve the human factors aspects in the cockpit will be that the pilots will be able to operate more safely and efficiently and this will have the added effect of making the operations more cost effective and profitable. When this becomes more apparent to operators they will bring pressure to bear on manufacturers to make the recommended improvements.

Flight safety expenditure is often thought to be not cost effective. If you think this is the case try quantifying the cost of an accident.

The Future of Confidential Reporting Systems

There is a great deal of information to be gleaned from the folklore recited in the "watering holes" of any profession. The events that are so readily discussed with colleagues, after work over a drink, seldom find their way into a reporting system that follows the usual chain of command, through their superiors. In order to tap this rich source of information, a CHIRP system is essential. This is recognized in the United States, Canada, Australia and New Zealand, where such schemes exist. In Europe, the Germans are setting up such a program and the Irish are interested. There is a move to produce an integrated European system by the Directorate of Transport at the EC in Brussels. The next meeting of ICAO Human Factors Committee will be looking at the possibility of setting criteria to be recommended when such a scheme is instituted. If this is successful, then it will make the interchange of information in reports more effective on an international scale.

There is much interest in this system from the worlds of manufacturing, medicine, transport and industry, e.g., the power generation and supply companies. They would like to make use of confidential reporting if they can convince reporters of the reliability of the safeguards for confidentiality, so that all can benefit from the safety lessons learned.

New Training Approaches Emerge for Corporate and Regional Aircraft Operators

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New training approaches are available to both the corporate and regional operator that promise training more closely focused on the challenges of real-world flight operations. The increasing sophistication of these approaches demands more from trainers and end-users than ever before. But trainer and evaluator qualification, evaluation and training integration must keep pace to be effective.

Aviation training has become much more capable during the past 15 years with the advent of advanced simulation, cockpit resource management (CRM) and objectives-based training. Today, it is easier to isolate and modify specific behaviors that lead to accidents. The power of new training tools and techniques has in some cases, however, left both the trainer and user behind, unable to really make full advantage of them.

Overcoming Flight-check Limitations

Many operators limit their training to the government checkride. Thus, most recurrent training in the United States, for example, tends to be aimed at preparing crews for the Federal Aviation Regulations (FAR) 61.58 proficiency check in the cases of corporate operators or the FAR 135.293/.297 or 121.441 checks if they are air carriers. The arguments against limiting training in this fashion derive from the limitations of the check itself:

- Because the checkride tends to consist of an unrelated string of maneuvers and procedural tasks, it does not reflect realistically the way in which actual emergencies tend to unfold or the environment in which they develop.

- Checkride challenges may not match the ones that lead to accidents. Checkride content does not reflect all the hazards with which crews must cope.

Thus, the content and execution of the checkride may not provide the best test of the proficiency of crews who fly in today's demanding environment. Training limited to the scope of the check is similarly limited in value.

Problems with the check are well known and are being addressed to some extent. In the United States, the Advanced Qualification Program (AQP) initiative is tackling the issue by encouraging operators to determine what training tasks are critical and how often crews need to be trained.

But AQP is expensive, requiring fresh task analysis, and may therefore be limited to only a subset of operators. But to the extent that AQP is successful and feasible, it will bring more real-world-oriented checking with it. In the interim, progressive checking will upgrade checkride execution if not checkride content.

Under special circumstances, checkride tasks can be integrated in a training course and can be accomplished "progressively." When embedded in mission-oriented simulator training sessions designed to reflect realistic flight scenarios, check accomplishment becomes much more meaningful.

SimuFlite Training International first conducted proficiency checks for corporate operators in this manner and was recently awarded first-time authority to conduct progressive air carrier checks. Progressive checking builds realism into the check and bolsters the operator's confidence in pilots who pass such a check.

Mission-oriented Training Reflects Real Operating Environment

Line-oriented flight training (LOFT) advantages are being realized more and more in regular simulator training through the greater use of mission-oriented training.

The conduct of simulator and airplane training preceding checking has been modeled for years on the check itself. Thus, conventional simulator training emphasizes practice of procedures that are often introduced without regard to the way in which actual emergencies and abnormalities develop. In the hands of inadequately trained instructors, such training often leads to "gotcha" games whereby crews unwittingly collaborate with instructors to see how many faults and emergencies can be tolerated while keeping the airplane airborne. The stimulus for this kind of training often grows from an instructor's efforts to prevent boredom.

Recurrent simulator training sessions ought to be shaped to mirror realistic flight conditions beginning with preflight planning. Then, and only then, can emergency and abnormal conditions be dealt with in a training environment that reflects the demands of coping with problems, while continuing to maintain situational awareness and deal with air traffic control.

Guidelines for mission-oriented training sessions or Line Operational Simulation (LOS) sessions have been outlined recently in an U.S. Federal Aviation Administration (FAA) advisory circular.

New Training Programs

As an industry, we are getting better at developing focused training tools. This has led to more self-contained training regimens designed from the outset to combat specific hazards. The windshear training aid is an excellent example. Also, a rejected takeoff training aid is being developed under Boeing's leadership.

New part-task training devices and computer-aided instructional software can also be exploited to deliver highly specific training programs. Avionics training, for example, is a natural for this delivery method.

But there are limitations. First, the economics of training restrict the extent to which you can use these programs. Consider the wind shear training aid, for example. Does your training organization take an hour of simulator time to implement this or are your crews just “exposed” to one or two windshear encounters? If you are in the latter situation you are not alone. Windshear training takes time, and operators often have neither the budget nor crew-hours to take full advantage of these programs.

Another problem is integration. As with the check — unless we are talking about initial or transition training — the more mission-oriented the training, the better. But it takes planning and resources to integrate things such as the wind shear training exercises into full mission simulator scenarios. Consider judgment and decision-making training techniques that have been developed in recent years, but failure to implement these techniques in full-mission simulations has relegated them to self-study exercises.

Integration makes training powerful. But it takes frequent redesigning of the entire training regimen to integrate new programs and techniques effectively.

Better Evaluations Lead to Improved Training

One of the most exciting developments for corporate training is the “CRM Performance Markers” being developed by Dr. Robert Helmreich, et. al. at the University of Texas. This promises to provide the first concrete, easy-to-use measure of cockpit resource management. Its biggest payoff could be the restoration of “evaluation” to its rightful role in the management of training. After all, without concrete evaluation, we cannot honestly measure either the need for training or the effectiveness of training. Better evaluation tools will allow us to truly tailor training in terms of both time and content.

Conventional training is aimed at restoring performance at arbitrary intervals. It does not tell you about performance decrements or improvements over time. It does not answer certain key questions such as: Was the training given too soon or too late? Did crew performance deteriorate below minimum acceptable levels between training events? How do you know when its time to train again? These questions and others are usually never addressed. Instead, training frequency, like training content, is most often dictated by regulatory requirements.

Thus, you have no assurance of continuity of performance. If you have a weak pilot or a systematic problem (e.g., lack of standardization), can you reasonably expect it to be fixed with one dose of training administered without regard to the entry condition of your crews?

Better evaluation tools and more involvement by flight department management will allow you to pinpoint more accurately when it is time to train and in what area. As we get smarter about pinpointing the need for training, we will better learn how to deliver compensating training in smaller, more efficient doses. We will be able to gradually flatten-out the retention curve. Training in its smallest doses usually comes in the form of coaching. Have your standardization pilots or captains been trained as coaches? Or does coaching sound out of place in aviation training? Well, as Nancy Austin and Tom Peters define it in *A Passion for Excellence*, coaching is:

face-to-face leadership that pulls together people with diverse backgrounds, talents, experiences and interests, encourages them to step up to responsibility and continued achievement, and treats them as full-scale partners and contributors.

Now, does anything sound foreign about this? It is really CRM. Standardization or line check pilots can learn to identify CRM deficiencies and, through timely structured debriefing, coach against the problem. If you think about it, much of the behaviors that we see in cockpits are habitual. They are thus much more amenable to change through steady coaching versus one-shot training. Of course, to realize this vision, operators will have to invest in better training for their standardization pilots and place greater emphasis on evaluation.

Computer-aided Instruction Has Limitations

One payoff of computer-aided instruction is its ability to accommodate the crew member at his own convenience and pace. Advances in training device design, along with government training credit for its use, offer additional bonuses. While these devices are often perceived only as a means to off-load procedures training from expensive simulator schedules, they also aid continuous training approaches by allowing inexpensive devices to be located at crew bases. These simple devices can be used profitably in two important applications that up to now have been reserved for full-flight simulators.

First, simple devices can aid crews with certain skills that we deliberately overlearn, such as an aborted takeoff. A simple device can help crews in motor skill retention by allowing them to practice the procedural steps without a full-flight simulator. The device becomes an extension of armchair flying. Simple devices will also find use as CRM laboratories where crews simulate pre-planned LOFT-style exercises in decision-making, workload distribution, inflight planning and communication. Again, skills in these areas can be developed without the risk of in-airplane training or the expense of advanced simulation training. The simulator can be reserved for final integration and complete mission simulation.

Computer-aided instruction still suffers from limitations that must be overcome if its full impact is to be realized. First, it will have to become "smarter" about remediation. The vast majority of computer-aided instruction simply presents the same instructional material to the crew member in the same fashion when testing shows that he or she did not master it. Obviously, a different instructional slant might be all that is needed, rather than repetition.

Second, today's computer systems still fail to present true simulation, especially of aircraft systems. This robs pilots of the chance to employ powerful instructional tools: curiosity and exploration.

These limitations will be overcome, but until then, computer-aided instruction is really not much more than book-based programmed instruction best used during initial training.

Crews Acquire Self-training Skills

Crews can be taught self-diagnostic and self-correcting skills to maintain skills after formal training. In the future, more training organizations will work with crews to sharpen those skills. Openness among crew members can provide an early-warning system for hazardous behavior.

It is the job of the accident investigator to search back from the accident and identify hazards. But why wait for the accident? That is, why not build debriefing skills into crew members that allow them to review performance on a just-completed flight for the purpose of identifying hazards, incidents and accidents to be avoided? To use the words of a colleague: "How do you know that this safely-completed flight was not an accident?"

Instead of passive experience from which we formulate lessons-learned, we will be better able to teach crews to analyze actively their own performance for the purpose of identifying hazardous behavior before the incident or accident occurs.

We call this "self-discovery" and it is a technique, used upon completion of a flight, aimed at facilitating self-critique by crew members. The goal is to develop a skill for critical self-appraisal in the crew member that will accompany him or her into the field.

Of course, teaching self-discovery to crews is a delicate process that requires carefully trained instructors. But the payoff for this investment in personnel is tremendous.

Training Aids Employee Development

Traditionally, training has been aimed at restoring instead of improving performance. Why do we not aim for improvement over time? Once we do, we will probably find it to be a powerful employee development tool.

Are there not certain areas of knowledge and even certain skills that we would reasonably expect to improve over time? Would not the employee satisfaction benefits to be derived from this help boost motivation? Pilots, as compared with other professionals, tend to spend a greater portion of their time restoring skills instead of improving them or adding new material to their knowledge base. Designing training for improvement instead of just restoration can add to job enrichment for the individual pilot and, of course, develop more competent pilots. Once again, this places a burden on current evaluation habits. Improvements, especially in skills, can only be demonstrated using measures that are valid and reliable. And evaluators must receive sufficient training and practice.

Take this one step further. Research has demonstrated (Helmreich, 1990, p. 576) that pilot attitudes can be shaped by training. Operators should work with their in-house or vendor trainers to use the training process as a means of enhancing the pilot's regard for safety.

Regimens Must Include Standard Operating Procedures

Typical training and checking regimens are not designed to allow full use of an operator's standard operating procedure (SOP) during simulator training. Lack of mission-oriented or realistic training coupled with weak contract instructor indoctrination block effective SOP training and evaluation. Yet, the data show that one of the smartest moves you can make is to ensure compliance with SOPs (Nagel, p. 272).

Training vendors through the years have brought at best a half-baked approach to this effort. It is not enough for a contract instructor to skim an operations manual. A system must be developed that puts pertinent information about crew callouts, briefing procedures, crew coordination and similar information into the hands of the simulator instructor/evaluator so that he or she can compare crew behavior against it. SimuFlite has taken a first step in this direction by condensing significant data from air carrier operations specifications into a form usable by the instructor in the simulator.

We are in the prototype stage now with a course dedicated to implementing or restoring SOP compliance. Such a course is ideal for peer review that allows for simultaneous development of evaluation skills from other crew members undergoing the training.

Tailored Training Pinpoints Behaviors to Improve

New evaluation measures will allow crews to be measured at the front end of training instead of just at the back end. By not measuring performance at beginning of training, management wastes valuable measures of how crew performance changed since the last dose of training. Typically, training begins with air work that is not indicative of all the tasks the pilot is called upon to complete. We need to ask ourselves if this ordering is really necessary. A LOFT or LOS approach at the beginning of training provides a much better laboratory for pinpointing crew behaviors in need of change.

Without measuring performance at the beginning of training, training cannot be tailored to the individual. A pre-training evaluation or an initial training diagnosis must be capable of being formulated and acted upon (preferably both).

If no prescription is offered at end of training, the training stops. (In fact, an excellent test of an instructor is to use what a client has discovered about his or her performance in training to prescribe future self-study, practice or training.) Good training should provide the pilot with a *plan for improvement* to bolster both performance and motivation.

Tailored training reflects the unique challenges faced by the individual operator. But this requires an effective feedback system. Management must be pro-active in communicating to trainers ever-changing challenges and conditions. There must be an up-front communication process. My organization is now implementing a before-training survey of the client's needs and tailoring the simulator training menu to fit those needs.

In vendor training especially, post-training evaluation ought to measure the success of the training in addressing the unique challenges faced by the operators. Managements ought to hold training vendors accountable for such success.

What does the future hold? Well, greater use of a full-mission simulation coupled with instructor/evaluator ability to measure deviations from SOP promise to make tailored training a reality.

Exploit LOS in Future Training

Simulators capable of duplicating the performance of the airplane and environmental conditions will allow greater exploration of error-chain development and execution of training aimed at identifying and breaking the error chain.

Transition through busy terminal areas under marginal VFR (visual flight rules) conditions in a full-motion simulator, for example, strains crews to fly the airplane through complex air traffic control (ATC) restrictions while remaining vigilant for outside traffic. New simulators can produce high quality dusk scenes with area traffic. It is these demanding situations that set the stage for the error chain and allow practice of error chain identification and intervention.

In recurrent training, LOFT will move over for LOS. LOS training does not place restrictions on the abnormalities or emergencies simulated. It does require mission orientation including preflight planning and ATC interaction. Trainers are learning a hard lesson—LOFT can be boring. The best balance is struck by dispensing with the combination of simulator training sessions followed by a LOFT, in favor of all-LOS simulator sessions that spread out mission orientation and realism throughout the training.

Training Will Be More Satisfying

Trainers are learning to balance nice-to-know and need-to-know. Too much nice-to-know is usually characterized by training that delves too much into arcane trivia. It is training that concentrates too much on nuts and bolts, usually delivered by instructors more intent on showing what they know instead of teaching what the client needs to learn. On the other hand, training approaches that adhere to the premise that pilots should only know when to throw the switch instead of what the switch does, rob pilots of the opportunity to understand fully their aircraft. More and more a balance will be struck between the two approaches.

Evaluate, Integrate and Qualify Trainer/Evaluator

The training payoffs depend to varying degrees on trainer/evaluator qualification, sophistication of evaluation and integration of training. These are the keys to training advances in the future, more so than the supporting technology itself.

Proper training evaluation has been neglected for typically human reasons. First, it is difficult. Trainers are motivated first and foremost to deliver training. Evaluation is a much more painstaking and passive activity. Evaluation to the trainer can be what monitoring is to the pilot—boring.

Second, evaluation measures are difficult to devise. In CRM, only quite recently have measures for anything beyond crew attitude shifts been tentatively identified. Trainers not skilled in evaluation tend to focus on crew mistakes more than their skilled contemporaries who can leverage their observations of crew performance into positive prescriptions for improvement.

Civil aviation authorities must also meet the challenge of better understanding evaluation. They must learn more about evaluating the pilot product of training and the training program. Deemphasizing the use of programmed training hours as a measure of training quality or compliance is not enough. This must be dismissed, except perhaps, for first-time training program development by an operator. Instead, authorities must learn to measure a training program by its objectives and its capability to help crews meet those objectives.

The next hurdle is training integration. Without proper integration into total training regimens, individual techniques and approaches bear little fruit:

- CRM must become seamlessly integrated into the overall training curriculum;

- Individual training packages like windshear and rejected takeoff must be integrated into mission-oriented training plans; and

- Decision-making training must be woven throughout training.

CRM training has tended to leave human factors issues behind and concentrate on interpersonal skills. Mistakes often start with only one crew member, therefore it is essential to not forget sources of individual human error in future training curricula.

We can generalize the integration problem even further. You might be surprised to see some ideas that your trainers have never seen. Let me list some for you:

- The relationship between communication patterns and crew coordination;

- Research into effective checklist design; and

- Probing and coaching techniques to promote crew self-discovery.

Do your trainers and evaluators use this information? Probably not. There is a fairly substantial body of literature growing about flight safety that trainers simply do not have time to explore, translate and integrate into practical instructional strategies.

Excellent instructors and evaluators get that way by combining experience, talent, enthusiasm and concentrated training. It takes training and practice to learn to let the training focus on the crew and not the trainer. At SimuFlite, for example, instructors receive approximately two months of training before being released to the "line." This is coupled with a strong ongoing instructor quality assurance program.

Greater use of evaluation will allow management to use training as a management tool. Training will be held accountable for incidents and accidents and will be the first focus of attention instead of the individual crew members. Again, the burden falls on training evaluation systems to provide management with adequate feedback to realize this management control.

Evaluation and integration will be the next training buzzwords. Effective implementation of each will depend upon comprehensive indoctrination of instructors and evaluators. I urge you to begin exploring now how you can better employ these concepts to prevent accidents.

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JAA/European Community Flight Time Limitations

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In common with most other operational aspects of aviation, the need to harmonize standards of flight time limitations (FTL) across the 19 Joint Aviation Authorities (JAA) member states, including the 12 European Commission (EC) countries, began some time ago. I became involved and attended my first FTL study group meeting in January 1990.

To set the scene, let me talk briefly about the situation in the United Kingdom at that time. We had just completed our investigations into FTL as they were being implemented by operators under rules that stemmed from the Sir Douglas Bader Report of 1973. Those investigations convinced the authority that there was a need to alter the rules to prevent the various excesses that had become evident. Those were boom times and crews were in very short supply and were having to be utilized to the legal limits. The first thing that suffered under these conditions was the “spirit” of the rules (CAP 371 2nd Edition). It was a wide-based document and operators were expected to compile a FTL scheme within its boundaries to suit their particular operations. However, as demand increased and crews became scarce, rule limitations increasingly became the norm for some operators.

In order to compile a suitable amendment to CAP 371 2nd Edition, two working groups were set up under the Operations Advisory Committee, a committee of representatives from all sides of the aviation industry, one dealing with fixed-wing aircraft and rotor-wing aircraft.

Generally, one flies fixed-wing or rotor-wing and the rate of onset of tiredness and fatigue in each type of aircraft are different, so two different sets of experts were required to contribute to the deliberations. There were representatives from both the operators and the crews and that is when I first became aware of just how emotional and complex the subject of FTL is.

I should try and put this complexity into perspective. It is a very simple matter to set limits — maximum flying, minimum rest, maximum duty hours, minimum days off and so on — based on a number of things (personal experience, medical advice, etc.). But wherever those limits are pitched I guarantee I could compile a roster using probably only half the maximum duty and flying hour limits that would, during a fairly short period of time cause fatigue problems. Similarly, one could probably compile a roster — 9 a.m. to 5 p.m., five days a week, and achieve far more flying, say 1,200-1,300 hours a year, quite safely. It is essential that the operator retains the spirit of the legislation and (understanding what the human being can safely undertake) compiles schedules and rosters that take this into account. That boils down to the staff running the day-to-day operation. It is they who are tasked with maintaining the delicate balance between the commercial requirements of the company and the safe rostering of crews to complete that job.

So, after a number of prolonged and intensive meetings, the 3rd Edition of CAP 371 evolved and became effective on May 1, 1990. It introduced more restrictions than the previous document and all 240 U.K. air operator certificate (AOC) holders received formal approval to the revised schemes they had submitted by the effective date. The mechanics of checking that many schemes and chasing up the required amendments, involved some six people working full time for about three months.

Meanwhile, the JAA's Operations Committee set up an FTL study group to commence work by looking at and adapting CAP 371 3rd Edition, this probably being the most up-to-date scheme in the world at that time. Again, two separate study groups were involved, the helicopter being addressed by the helicopter operations study group and the fixed-wing study group comprising, in theory but never in practice, five national authorities and five experts from industry and unions. I cannot remember any single full meeting of the study group being limited to 10 people. It was more often than not around the 20-24 mark, illustrating the importance that is attached to this subject.

The first chairman was from Switzerland. The first five full meetings were completed and we got absolutely nowhere. The operators, for example, were looking for 1,200 flying hours a year and the pilots' union representatives were looking for 720 flying hours a year. Neither would move and over a period of time both sides became more entrenched. In addition, it was evident that the authority members themselves also had a wide divergence of opinion based on the current legislation in their own particular countries. One of the major items of divergence between the authorities was the implementation of standby rules. For example, standby in the United Kingdom is limited to 12 hours maximum and after six hours of standby the crew member is considered to have started a flight duty period (FDP). In several other European countries, up to 24 hours standby is possible, which can then be followed by a full FDP without counting the standby hours undertaken prior to the FDP.

After the first few meetings the chairman decided, quite rightly in my opinion, that no progress was likely to be made and that the authority-only members should get together and move forward. The authority members then commenced a further series of meetings and eventually produced a Draft Document No. 9 that was presented to the reconvened full study group. After taking note of some 40 points of interpretation or clarification, the document was refined and Draft Document 10 was produced. At about this time the chairman retired, a new chairman was appointed and a message came down to the study group from the JAA Ops Committee that a less complicated FTL scheme was required. So it was back to the drawing board after a year's work.

We went through the whole process again over the next year or so. Again, no agreement could be reached in the full study group so the new chairman was persuaded to follow the same route as before with the authority members deciding on the scheme. We looked at the Dutch scheme first, quickly followed by the German scheme with occasional references back to the previous Document 10 scheme.

Meanwhile, the European Commission had set up a Joint Aviation Committee under their chairmanship comprising representatives from both operators and unions. Again, no agreement that satisfied all sides could be reached and they decided to await the outcome of the JAA FTL Study Group.

Now that our initial deliberations, relating solely to flight deck crew, are concluded, first indications are that neither side is happy with the end result.

To give you some further idea of the wide divergence of opinion between crews and operators, some pilot representatives suggested that two-pilot operations be limited to a maximum of nine hours flight time, while some operators' representatives want 13 hours. Currently, pending the results of medical research, 11 hours is proposed.

Union representatives also suggest maximum FDP for two pilots should be two hours (for the 0700-1159 best time of start) whereas some operators have suggested 15 hours with up to three sectors. Document 19 had settled on a maximum of two sectors best start time and 14 hours duty.

This has been the theme throughout, with operators proposing extensions and the unions proposing the opposite, with both sides unwilling to give way. Our job has been to produce a scheme that is safe, and I believe we have done this. What remains to be seen is what role the EC will now play.

An EC representative has attended all our meetings as an observer and I believe he is keen to obtain the acceptance by the Joint Committee for Aviation of the JAA draft Document 19. If this can be achieved (perhaps with some modifications, since the EC's job primarily is to consider the competition and social aspects as well as safety), then the scheme will be presented by the commission to the EC Council of Ministers. It could then, following consultation, be made into a regulation applicable to all 12 EC member states.

Our concern in the United Kingdom is that the EC should not take a JAA draft document, prior to the comprehensive national consultations, and prematurely turn it into legislation. It is important that we ensure an appropriate level of consultation with all operators prior to the legislation taking effect. At present, probably three quarters of U.K. operators remain unaware of the draft proposals and the future implications.

The following are the salient points of the JAA fixed- and rotary-wing schemes:

Maximum Flying Hours

JAA Helicopter	JAA Airplane
90 hrs/28 days	100 hrs/calendar month
800 hrs/365 days	or
	100 hrs/28 days
	900 hrs/calendar year

Capt. Russ Williams

Daily Flying Hour Limit

	JAA Helicopter	JAA Airplane
Single Pilot	7 hrs/day	-
Two Pilots	8 hrs/day	*11hrs/day
All Pilots	21-24 hrs/3 days 35 hrs/7 days 270 hrs/3 x 28 days	

* Research work being undertaken.

Minimum Rest

JAA Helicopter	JAA Airplane
As long as the preceding duty or 12 hours, whichever is the greater.	As long as preceding duty or 11 hrs, whichever is the greater. If more than 4 time zones crossed minimum rest is as long as preceding duty or 14 hrs, whichever is the greater.

Maximum Duty Hours

(Flight Duty Hours)

JAA Helicopter	JAA Airplane
60 hrs/7 days	60 hrs/7 days
	100 hrs/14 days
200 hrs/28 day	1,800 hrs/calendar year

Standby

JAA Helicopter	JAA Airplane	
	Notification	Max stby
Max 12 hrs Counts as half on the day and toward cumulative	Less than 1 hr	Counts as full duty
	1 hr	12 hrs
	4 hrs	18 hrs
	6 hrs	24 hrs
	Counts as half towards cumulative totals only (nothing on the day)	

Maximum Flight Duty Hours

	JAA Helicopter	JAA Airplane
Single Pilot	10 hrs/day	10 hrs/day
Two Pilots	12 hrs/day	14 hrs/day
Extension by Commander's Discretion	Max 3 hrs plus 1 hr flying	Max 2 hrs (3 hrs with augumented crew)

Commander's Discretion

	JAA Helicopter	JAA Airplane
FDP Extension	Max 3 hrs FDP plus 1 hr flying. (All prior to departure if required.)	Max 2 hrs but 3 hrs with augmented crew. (All prior to departure if required.)
Reduction or rest	Down to minimum of 10 hrs or, if preceding duty was 8 hrs or less, 9 hrs at accom-modation.	May reduce a rest period by a maximum of 2 hrs but to not less than 11 hrs.
	If reduction more than 1 hr, report required.	If discretion used, report required.

Earlies/Lates/Nights

JAA Helicopter	JAA Airplane
Limits duties in 0100-0659 L (Except at remote sites).	Limits duties in 0100-0659 L. If 3 or more duties within this time band within 7 days, 36 hrs rest must be increased to 48 hrs within 7 days.

Split Duty

JAA Helicopter	JAA Airplane
2-10 hrs split can extend FDP by half total split (excluding post/pre-flight duty).	3-10.59 hrs split can extend by half. If break 8 hrs of which 6 hrs falls between 2200-0600, can extend by $1^1/_2$ (excluding post/pre-flight duty).

Days Off

JAA Helicopter	JAA Airplane
Single day off lasts a minimum of 32 hrs 2 consecutive and 3 total in any 14 days	36 hrs rest within any 7 consecutive days or 60 hrs within 10 consecutive days.
Average of 8 days off in 28 days averaged over 3 x 28 day periods.	7 calendar days (0000-2400) in any calendar month and 24 calendar days in any calendar quarter with at least 50% being taken at home base.

I believe it is essential when assessing this, or any other, FTL scheme that the assessment is made on the total package. It is always easy to pick a particular aspect, pose a scenario and show that the limits set or rules made, do not logically apply. One can never write a set of rules to cover every single type of operation and both operators and unions have fallen into this trap.

Finally, there is one aspect that has not been touched on so far and that is the method of implementation and monitoring to be employed across Europe. It is likely that the EC will chair a committee to deal with FTL matters, to offer advance on implementation and to consider any variations for which an operator may wish to apply. It would be far more appropriate for the JAA to carry out this task, as they will for the whole range of safety regulation. The EC can monitor the JAA process and raise with JAA any issues if, and when, they feel that their objectives are not being met. In my experience, operators and crews alike will be very keen to have the regulatory authorities work together to ensure even-handed and consistent treatment on FTL matters — the level playing field. Currently, there are inconsistencies throughout Europe on the levels of monitoring and this will need to be resolved and standardized. Reporting procedures will need to be established and any variations granted will have to be made available to any operator who wishes to make use of it. In the long term, a central computer databank will need to be established to record variations. These are all aspects that remain outstanding, so there is still a great deal of work to do.

Stress: Underlying Factor to Interruptions of Judgment

Gisèle Richardson
Richardson Management Associates Ltd.

Stress is directly related to safety: *it predisposes to interruptions of judgment*. Like me, you are probably tired of hearing that 80-something percent of aviation accidents are caused by human error. And yet it is so. Most of the people who make these errors are normally competent. The mystery is that each one manages, in his own peculiar way, to confuse himself at critical moments. The question is always: Why does a properly trained pilot or mechanic who has performed the procedure correctly hundreds of times suddenly does not do it correctly? These moments of inattention and poor judgment are frequently related to what we call, generically, "stress." The reduction of such errors depends on increased self-knowledge for each individual. That is to say, no recipes can be applied across a company or across the industry to correct the situation. Each individual has to address his own vulnerability to errors of judgment, and unless the industry finds better ways to help its people to do so, five years from now we will be deploring the fact that 80-something percent of aviation accidents are caused by human error!

Stress affects safety and that is a primary concern. But its noxious effects are much more far-reaching and much more pervasive in our life. It is a killjoy. It is the root of family quarrels. It stands in the way of cooperation, of giving and getting support from our colleagues, of closer relationships with our spouses or children or friends. It has a direct bearing on our health and our longevity. Clearly, it is of great importance. That being so, why is it such a recurrent subject? Why is it never settled? Why are there so many approaches dealing with it? Why do so few of them work? I believe that the lack of solid solutions is due to the fact that the aviation industry has largely confined itself to trying to cure the symptoms rather than uprooting the cause and that we have largely addressed the resulting behaviors rather than their wellsprings.

First, stress is pervasive. It is an inherent aspect of life. It cannot be avoided. A recent advertisement for an American book claimed: "This book leads to the complete elimination of all stress." Well, the complete elimination of all stress is rigor mortis. So, resign yourself to stress as a constant life companion — that is not so bad when you consider the alternative!

Second, the only thorough way to attack stress is to understand its wellsprings in our personality. Stress is the outcome of ordinary unavoidable life events. People are promoted, demoted, they lose their jobs, children are born, they leave home, couples are married, they quarrel, they divorce, drivers cut you off on a highway, drivers do not start immediately when the traffic light turns green, people overextend themselves financially, employers are unstable, etc. So, life places constant demands on us. These demands allow us to grow and to learn and to be challenged but they also sometimes come at the wrong time, they may be demands that we should have preferred to live without. But positive or negative, they require us to accommodate and to adapt.

Why are these life events relevant? What do they have in common with stress in the cockpit, with making tough decision calls under pressure, with sound and timely responses to technical failure, with sharing cockpit space and decisions with colleagues you don't like or respect? Well, all are stressors and they require us to adapt. Now, the question that is really interesting is why do some people cope with stress better than others. We all know that some people do go through life more easily than others. The questions for each one of us is: Can I make myself more like them? Can I increase my own resistance to stress?

Is There a Stress-proof Personality?

Many years ago, two doctors called Holmes and Rahe quantified certain common events in life that are stressful. They gave a weight in points to each one of these events. And what they found is that anyone who rated above a certain cumulative number of points had an 80-percent chance of having a serious illness in the next year. And they focused a great deal on the 80 percent who became ill. What about the 20 percent who do not get sick? What is their magic? What do they know that the others do not know?

Several years ago, a group of psychologists got together and said: "We know all about sick people, but what do we know about healthy people? We never see any." So, they selected a group of 268 young men whom they had tested and found to be better adjusted emotionally than the average population and they followed them for 35 years. They followed them in a way that would skew the process as little as possible, and the outcome of their work was published as a book at the end of that period. Three pieces of their conclusions are particularly thought-provoking. First, these healthy men did not have fewer reverses or tragedies in their lives than did the control group. The difference was the way in which they reacted to problems and crises — they dealt with them and moved on. That is to say, a measure of our mental health is our way of responding to problems, not the absence of problems in our life.

Second, they found that the group under study was much more likely to make use of difficult experiences to grow. "Much," they said in a graceful metaphor, "as the means by which an oyster, confronted with a grain of sand, creates a pearl."

And finally, they concluded that the members of this healthy population had a view of life that led them to seek their own goals while helping others reach theirs, where a less well-adjusted person's life would consist of trying to make points at others' expense, making more enemies than friends, frustrating their own desires and undermining the support that they can get in their environment. So, there is such a thing as a stress-immune personality.

Here are some more ideas about what shape that personality takes and how it can help us change our psychological habits. Vaillant, who wrote the report on this experiment, says, in effect, that stress-proof personalities deal with difficult situations more elegantly. They are generous rather than judgmental, they are helpful rather than competitive. They have good relationships, they remain confident even in the darker periods of their life.

Another man, Flannery, from the Harvard Medical School, writes:

I became interested in stress as a result of some personal experiences and observations. One Saturday evening, after I had myself spent a frazzling day working with stressed-out people in a walk-in clinic, I turned to a nurse who was also working there and I said to her, 'Everybody and his brother went through here today.'

She said, 'You know better than that, some people never come here.'

I started to wonder what these people are like. So I set about developing a research project to see whether I could find some of the characteristics of people who cope effectively.

He concluded that those who were sick the least had effective ways of dealing with problems. They tended to have a sense of personal control of their lives. No machos here — they tended to ask for help when they needed it. Stressed persons were more likely to be passive in the face of problems or — likely in aviation — "to carry their cross alone." (The latter, by the way, is truer for men than it is for women. Many men do not know how to use their friends. A man's wife may be dying of cancer or a couple may be on the verge of divorce, but rarely does a man ease his pain by talking about it with his friends. Rarely does he take the opportunity to see that other people also have transitory dark nights of the soul and that he is not alone.)

Harvard's Flannery found that stress-proof persons have a sense of commitment and a sense of meaningful participation in life. This may range from a strong desire to be a good parent, to improving professional competence, to being involved in a community activity. But, in any case, it is some commitment that has personal significance for them. This is a lesson for people who have devoted all of their energies to their work alone, and who find retirement a very devastating experience if work is the only meaningful commitment they have made in their life.

The Harvard study also reported that stress-resistant persons were more likely to have some form of active relaxation, and were more likely to exercise. Also very important was that they tend to seek people to be actively and emphatically engaged with them. In other words, they have a more positive view about life and they are more optimistic about themselves and about others.

Can We Use This Information to Improve Safety and Well-being?

With so much information available about the stress-proof person, why are most of us are not more so? Well, people cannot change. Everybody knows that. We hear it in every language from the time we are children: "Chassez le naturel et il revient au galop." "Quien nace redondo no se enquadra." "You can't teach an old dog new tricks." "The leopard can't change its spots."

If that is the case, where is hope? "People can't change" is a lie, of course. It is a very persistent lie because it is so convenient; it is a convenient cop-out for the incompetent change agent. It is a convenient cop-out for the person who does not want to change.

One day, one of my colleagues was doing some counseling with the wife of a pilot who slept around a great deal and at some point, we asked to see the husband. He came in — handsome, charismatic and definitely star quality. So, he sits down, shrugs his shoulders and says: 'Is it my fault that I was born so handsome?'

How can he change his looks! Hard to detect any desire for change there! What is true is that no one can make any one else change, as husbands and wives soon learn if they are at all smart. But, it is also true that each one of us can change ourselves if we want to, and that we can be helpful to others who want to change.

Our experience with aviation is that most people want to improve their relationships, their attitudes, their comfort with themselves and with others and their self-confidence. A pilot or a mechanic or a manager never has said, "Above all, don't teach me how to be happier." A person does not wake up in the morning and say, "How can I go to work and screw up my relationships today?"

Some people would like to change but they do not know how. An increase in safety depends on tapping into that desire and using it as a catalyst. More than that, it is our duty and our responsibility to take charge of the changes that we need to make for our own sakes so that we can live this too-short life as fully as we can, as well as the changes that we need to make for the sake of people who surround us at work and at home.

Self-knowledge Is the Most Underestimated Requirement for Safety

Self-knowledge is the road to change, is the best inoculation against stress and is the most underestimated requirement for safety. Of course, we all have some degree of self-knowledge; most people know what is troubling them.

Some people have a very dim view of personal evolution programs where people spend several days and come out with a report card that tells them what kind of personality they have. The poor person already knows that he is difficult. He knows that he is damaging his relationships by his anger; he knows that he cuts himself off from the support available in his family and from his co-workers, he knows that he has arranged his life so that he is basically alone. The unassertive person does not need to go to a course to be informed that he is a wimp; he already knows that he avoids conflict, is easily intimidated and does not stand up for himself or his people as well as he should. They do not need that information; the information that they need is how to make the changes beyond transitory mechanical changes — the harsh man can change himself to smile and appear to listen to others, but when the pressure increases, he will revert to his old self unless he has had new learning that changes his attitude.

Self-knowledge at a Much More Fundamental Level

Self-knowledge does not just include, "What kind of a person am I today?" but much more important, "How did I get to be this way?" Somewhere in our life, we all exercise choices in our way of being. Your brothers and sisters may be very different from you. Why? All of you had the same father, same mother and same environment. Why do you react differently to the same situation? Why did you develop different psychological habits?

Think of your own department. A new procedure is brought in that affects every one equally. Even before the procedure is announced, you know that one pilot will predictably see it as a glass half full, while another will predictably see it as a glass half empty. One will accept the procedure and move on, and one will complain about it to anyone who will listen. Why?

Neither of these men is discovering reality. Each one is creating reality to fit his personal view of the world. Neither half-full nor half-empty is right or wrong, but how the person interprets it will have a critical effect on the way he will react and the level of comfort he experiences and the level of stress or comfort he emanates for the people who surround him.

So, an essential part of self-knowledge and the key to changing our ways of stressing ourselves is to learn, "How do I create reality? What is peculiar about the way that I see the world?"

Here is a simple example. Imagine a weekly pilots' meeting. One of the pilots makes a suggestion for improvement in some of the department's procedures. The first chief pilot, (let's call him Robert), says, "Hey, that's a good idea. We can do that." He feels excited at the prospect of improvement.

Chief pilot number two, (Albert), in the same circumstances, following a suggestion from one of the guys, says to himself, "Oh, why didn't I think of that? What's the matter with me anyway? I am the boss, I should be thinking about these things," and he feels inadequate and guilty. While he is churning, he is out of touch with what is happening around him.

Chief pilot number three, (Herbert), learns the same suggestion and he says to himself, "The idiot is trying to undermine me. He is always trying to make a fool of me. I'll fix him." And he is filled with feelings of anger and mistrust and isolation. Circumstances are the same, but the responses different. Why?

Each Person Designs a Psychological Map of the World

Each reaction is based on each individual chief pilot's construct of reality. Each has learned to think of himself, to think of others and to think about life. Each one is creating his own reality. Now, we generally believe that when we have a reaction following an event, that our reaction is generated by the event.

Most of the time, those of us who are functioning well, make meaning from what we can call a "clear part" of our head — a part of our brain where we are connected with reality, where we see what's actually going on, where we are conscious of ourselves, conscious of others, and where we can respond and react appropriately and effectively. That is the part of us that is self-correcting, and where we notice the impact of our words and behavior on others and on the goal we are pursuing.

If I do something really weird, I will notice the reaction around me and I review my behavior and my conclusions. Unfortunately, we all have a contaminated part as well and when it is dominant, we are not dealing with reality as others see it — we are dealing with reality according to some old construct that we formed early in life. This contamination is the cause of our being — all of us — normal neurotics.

Robert, then, the first chief pilot, at the time the suggestion was made by his pilot, was in the "clear" part of his head. He was dealing with the task at hand. He may, in fact, see that the other guy is trying to make points at his expense. But he is able to sort out the two aspects. He sees the value of the suggestion on the one hand; he sees the pilot's inappropriate attitude on the other — and he deals with them separately.

Albert and Herbert are both in "contamination." They are seeing reality based on old conclusions that are now blind spots for them. Albert, who berates himself and feels inferior and inadequate may be a very competent chief pilot. People around him may see him as hardworking, trustworthy and fair, but when he is hooked, he is never satisfied with himself. When he is in that spot, his underlying motto is: "No matter what I do, it is never good enough." He says, with an unconscious smile, "Oh, yes, I know that I am my own worst enemy." People say he lacks self-confidence. (Of course! How could it be otherwise, when he is constantly getting on his own case and undermining himself?) And some feeling of sadness or inadequacy or guilt will be his frequent companion. In other words, these will be his favorite bad feelings.

Herbert’s view of the world is different. His underlying motto is “You can’t trust anybody. If you want anything done right, you’ve got to do it yourself.” Anger and frustration are his favorite bad feelings. He spends a good part of his day in a state of unnecessary alertness, looking for others’ mistakes, trying to foresee some attack or betrayal. He is always right, he is a blamer. You will think I am joking but I worked with a pilot who actually said to me: “If it weren’t for my wife, I’d have a perfectly happy marriage!” So, poor Herbert is unable to trust even when trust is clearly justified. Like Albert, at heart he really does not like himself very much — and yet, the single most important source of stress is our unwillingness to like and respect ourselves. It is all the more insidious because it goes largely unnoticed. The person who is a tough critic of himself has been doing it so long and so consistently that he thinks it is natural.

Now, through this glass that each has created, each colors the events, large and small, that make up his day. When he is functioning well, he is in the “clear part” of his head. When he is hooked, he will respond in a way that is predictably, typically and recognizably his. If Robert’s wife tells him that she is unhappy, he listens and tries, jointly with her, to find a solution. If Albert’s wife is unhappy, he blames himself as though he alone were responsible for her happiness. If Herbert’s wife is unhappy, he blames her and says to her: “I’m perfectly happy. If you are unhappy, there must be something wrong with your attitude. Just change your attitude, and everything will be all right.”

Contaminated thinking can kill good judgment; when a pilot is hooked, he is out of touch with what’s going on around him and is no more likely to deal effectively with an evolving situation in the cockpit than he can, at home, notice a note of distress in his son’s voice at home or other events to which it would behoove him to pay attention.

Who, Me?

You may be asking yourself, “What does this contaminated thinking have to do with me? I am always in the rational part of my head: clear, objective, logical.” Well, if you really believe that we can explore whether you should be in the *Guinness Book of Records* or in the doctor’s office.

When you are in a good spot, you will be spending a lot of time with Robert. And yet we all have something of Albert and something of Herbert. Even Robert has something of Albert or Herbert. So, for all of us, some of our thinking, some of the time is at least self-limiting, at worst, it is hurtful to ourselves or to others.

Contaminated Thinking and Interruptions of Judgment

You can readily see the effect of contaminated thinking in operational situations and how these hooks explain a pilot’s reluctance to execute an appropriate go-around, explain subtle resistance to information or explain overt or covert power struggles in and out of the cockpit. If a pilot is hooked when he makes mistakes, part of his attention will be directed internally. Perhaps he is berating himself, perhaps he is fantasizing what the other guy is thinking about his mistakes; perhaps he is remembering another mistake that he made last week or the week before; and of course, he is momentarily indulging in his habitual favorite bad feeling. These momentary lapses, short-lived though they may be, are part of the explanation of the sequence of mistakes that too often precede an accident, with each error leading to more internal focus at the expense of the attention that should be paid to surrounding events in the present. No pilot is a safe pilot when he is hooked.

Sigmund Freud, Here We Come

How do we develop this contamination, these blind spots? It all goes back to our childhood.

The child is the father of the man.

As an adult, you know that comfort and control are closely related. A sense of control is an essential part of stress-proofing. We have all said, at some time or other, "Tell me what's going on. I'd rather have bad news than no news at all." Our belief is, "If I know what's going on, I can at least take care of myself."

This outlook is not one that we developed as adults. It is born with us, and at a very young age, we already begin looking for patterns, looking for predictability, looking for meaning that will give us a sense of control. Out of this premature desire for understanding — premature, because the child is not yet in a position to process information accurately — we draw some conclusions, and these conclusions accompany us through life, coloring the meaning we give to our experience, and enriching or impoverishing our life. These conclusions deal with three areas:

Conclusions about me — "What kind of a person am I? Am I good, am I bad, am I smart?"

Conclusions about others — "Are they trustworthy? Are they fair? Do they care for me?"

Conclusions about life — "Is it a hostile or a hospitable place?"

The difficulty we have coping and the amount of stress we endure, will largely depend on the depth and pervasiveness of our inaccurate early conclusions, which are triggered by daily events and move us into contaminated — i.e., inappropriate, inaccurate — assessments of a situation.

Our Beliefs and Our Attitudes

Robert believes that most people are decent and that they, like him, are doing the best they can with what they have. He is confident in his ability to cope with life's challenges, he is resilient in the face of difficulties; he respects himself and, in doing so, he is able to have a sense of community with others; he believes he is basically likable and decent; he tends to trust and like others and he believes that the world is benevolent or at the very least, neutral. The world is largely a mirror that reflects one's own behavior: "If I'm aggressive, I invite resistance; if I'm passive, I invite others to control me; and if I'm generous and cooperative, I invite generosity and cooperation."

Contrast that with the two others. Albert feels pretty good about others. When he is hooked, he overestimates their strengths and puts himself down in relation to them; he reminds himself that they are smarter, more articulate, sexier, more competent, etc. "They are O.K., I'm not O.K.," he says and he worries a lot about his competence to deal with life, which he experiences as difficult.

When Herbert is hooked, his view of the world is "I'm O.K., they're not O.K." And for him, life is a struggle, trying to foresee what he needs to do to protect himself from attack and trying to get the job done in spite of the "turkeys" who surround him. For him, life is a hostile environment.

Each of these men, like each one of us, reaches these conclusions early in life and each might benefit from exploring why these views of the world made sense to him at that time — while they no longer serve him now. All of us have suffered imperfect parenting, no matter how loving and caring our parents were.

Consider an everyday example of parental betrayal. Have you ever seen a woman dunking a baby in a pool, saying, "Whee! Isn't this fun!" and completely ignoring the child's screams of paralyzing fear?

If you went to that woman and asked, "Madam, what are you doing?" it is unlikely that she would reply, "I'm psychologically traumatizing my son." She believes that she is helping him lose his fear of the water.

The child is saying to himself, "This is the woman who is supposed to look after me? And this is how she’s doing it? If I get out of here alive, I’ll make sure I’ll never put myself in this kind of situation again.” And for him, this is the beginning of distrust, counter-dependence, and a fear of counting on anyone but himself.

Whether or not we are ignorant of the causes, we suffer their consequences today. The person who feels excessively responsible for others in his family or work group may have lost a parent early in life, or may be the child of an alcoholic father and a depressive mother — he is used to taking care of others because he has done it all his life.

Those who have a history of physical or sexual abuse often cannot tolerate relaxation; they have to move and keep hurry up to not think about the unthinkable. Those deprived of nurturing relationships early in life may exhibit persistent and unrealistic suspicion of the motives of their colleagues.

We suffer the consequences of these early experiences in the meaning we give to daily events, unless and until we acknowledge them, explore them and put them to bed. To do so, is the only way I know to free ourselves to live in the real world with the real people who surround us rather than those we fantasize — real people, who, like us, are struggling with their difficulties as well as they can, and trying to improve their life and be happier.

How Can I Learn About My Psychological Map of the World?

How do we explore? Well, I am not suggesting a five-year, five-times-a-week psychoanalysis. There exist now theories and concepts and structures that enormously facilitate both learning and application. It is the responsibility of each person to seek them out; more than that, it is your duty to make use of these theories for yourself first of all, and for the people for whose safety you are responsible. It may be that the greatest barrier to change is our unwillingness to believe that these habits (1) can be identified and (2) can be modified; and our unwillingness to put some energy into mastering them.

Where do you start? Seek resources to help you find short cuts to your destination. Look for people who have ideas and methods that you can use.

Apart from that, there is much you can do on your own. Notice when you are hooked. Are you more like Albert or more like Herbert? How does this manifest itself in your thoughts and in your judgments of others and of yourself? What kinds of favorite bad feelings do you entertain? Under what circumstances are you more likely to get hooked? With what kind of people? Why? Look for patterns, they are a golden road to learning.

Ask yourself: Are you in reasonable control of your life? As you look at your job? Your family? Your finances? Your time? Your dependence on alcohol, tobacco, or other drugs? Your energy?

Assess your personal relationships: Are you getting and giving what you need? Do you have someone to turn to when things are going badly for you? Do you turn to that person when you need to?

Another way to learn is to start monitoring your internal dialogue: How do you talk to yourself? Is your appraisal of yourself objective or unrealistically critical? Are you your own worst enemy? Or, are you excessively harsh in your judgment of others? And if so, are you willing to do something about it?

In other words, an easy but uncommon way to get there is to be more willing to check yourself out, to allow yourself some introspection, to start noticing how you are feeling, what you are saying to yourself, to examine how you got there, and to avoid deliberately what many men too often do — get busy in order to stop having to think about what is going on.

Notice, too, that there is a greater likelihood of going off the track when external stressors are high (family problems, financial problems, etc.), or in the presence of fatigue, in times of chronological vulnerabilities such as the mid-life transition, around Christmas or other emotionally-charged holidays or anniversaries. Look for your own patterns — they are your "early warning system."

Has it ever struck you as odd that given that the majority of accidents are the outcome of human error, there is no pre-flight checklist required for pilot airworthiness? We give our clients the skeleton of such a checklist, a skeleton in that each person will need to modify it to suit himself. It is a checklist he can use before each flight to reflect on himself, to see whether he is, on that day, more vulnerable to error, and if so, to decide whether to share this information with his boss or with the guy in the other seat, and/or how to modify his workload that day.

Has it ever struck you as odd that very few of you provide human element training for your maintenance people? Maintenance really gets short-changed in this area. Do they have the same human problems as the rest of us? They deserve your support.

It is true that aviation has approached psychology very diffidently. The whole idea of introspection is counter-culture to much of the historical "pilot personality." Does this mean the situation is bleak? Fortunately, no. Some companies are doing it. Many are doing it thoroughly. They tell their friends, who tell their friends. That is one way change takes place — in small pockets that spread. Change is also accelerated when people take action and take responsibility to educate themselves and bring that information to other people.

Some human factors programs approach these issues far too superficially. They are teaching adding and subtracting to a population hungry for calculus; they underestimate pilots' and mechanics' abilities to assimilate such information and their desire for solid learning that will help them be the person they want to be. Unless we look at underlying causes of stress; unless we are prepared to seriously address them; and unless we focus on a broader range of causes rather than outcomes, aviation will make little progress in dealing with human error. And five years from now we will wringing our hands about the fact that 80-something percent of the aviation accidents result from human error.

Relative Incapacitation

CAPT. LORENZO SANTANDREU
Director of Operations
Air Europa

Accident rates for the worldwide commercial jet fleet in the past 30 years show a spectacular decline in the first 10 years followed by a leveling in the past two decades.

An analysis of the primary cause factors of hull loss accidents, during the same time period, shows that approximately 75 percent of the accidents were caused by cockpit crews thus, we can reach the following conclusions:

- Our efforts to continue reducing the accident rates are not very successful.
- We are far from our goal of improving the cockpit crew's performance.
- We probably need to look at the problem from a different perspective or apply a new philosophy.

In studies made by Lufthansa's Capt. Heino Caesar, human failures are divided into the following categories:

H1—Active Failures (aware) 25 percent.

H2—Passive Failures (unaware) 20 percent.

H3—Proficiency/Judgment Failures 50 percent.

H4—Crew Incapacitation 5 percent.

Capt. Lorenzo Santandreu

Crew incapacitation occurs when a flight crew member is unable to perform her/his duties due to physical/psychological reasons, a subtle or obvious incapacitation which requires take-over.

Let me remind you of the kind of incapacitation we are talking about.

At the beginning of the 1970s, studies carried out by United Airlines on airline pilot incapacitation led to the establishment of pilot incapacitation training. A few years later, the International Civil Aviation Organization (ICAO) recommended the inclusion of this training in the training in emergency procedures.

United Airlines defines crew incapacitation as "any physical or mental condition which renders a crew member incapable of performing normal operations or abnormal or emergency procedures. Incapacitation may be obvious, usually involving prolonged maximum loss of function; or subtle, usually transient and involving partial loss of function."

To detect subtle incapacitation, the "two-communication rule" was established.

The two-communication rule states that "flight crew members should have a high index of suspicion of subtle incapacitation any time a crew member does not respond appropriately to two verbal communications, or any time he does not respond appropriately to *any* verbal communication associated with a significant deviation from a standard operational procedure or a standard flight profile."

Subtle or obvious incapacitation that requires take-over account for 5 percent of the human failures. These types of incapacitation should be called "absolute incapacitation."

But what of the remaining 95 percent human failures? Can some of these include an element of incapacitation?

Apply this concept of incapacitation to a high jumper. If he suffers an obvious incapacitation when he intends to jump, he will fall in front of the cross-bar. If he suffers a subtle incapacitation, his concentration will be diverted from his task for a certain amount of time. In both instances, he will remain out of the jumping contest, during a short or long period of time.

Think now of a champion, an excellent athlete, able to jump a height of two meters and 30 centimeters when his jumping capacity is at 100 percent. If the cross-bar is set at a height of one meter, he will make a very easy jump and a lot of remaining capacity will still be left. But if the cross-bar is set at a height of two meters and 50 centimeters, he will fail in his jump even if his jumping capacity is at 100 percent. The cause of the failure will be his incapacity to jump two meters and 50 centimeters.

This other type of incapacitation should be called "relative incapacitation" because it happens whenever the demand exceeds the capacity, regardless of the absolute capacity of the individual. This happens either because of an increase in demand, or because of a decrease of capacity or, more frequently, a combination of both—demand increase and decrease of capacity.

There are many factors that can increase the demand of the crew during the flight. Several examples are below:

- Adverse weather conditions;
- Air traffic control (ATC) requirements and/or restrictions;
- Aircraft malfunctions;
- Emergencies;
- Low fuel reserves;
- hijacking;
- bomb threats;
- Lack of familiarity with route and/or airport; and,
- Inadequate crew resource management (CRM) techniques.

There are also many factors that can decrease the capacity of the crew. Several examples are below:

Reduced oxygen supply to the brain caused by:

- Cabin altitude;
- Smoking;
- Alcohol;
- Drugs;
- Cardiovascular problems;
- Self-medication for colds, insomnia, allergies, hypertension, vitamins, etc.; and,
- Too much food just prior to or during the flight.

Reduced glucose supply to the brain caused by:

- Hypoglycemia;
- Hyperglycemia;
- Food intake, type, quality; and,
- Time between meals.

Deficiencies in the perception of incoming information caused by:

- Visibility;
- Optical illusions;
- Seating too low or too high;
- Rain, snow and fog;
- Fantasy;
- Stress too high or too low;
- Inattention;
- Complacency;
- Frustration;
- Mental set;
- Deficient human-machine communication;
- Deficient communication between crew members; and,
- Deficient communication between aircraft and ATC.

Occupation of the limited capacity channel that transmits the information caused by:

- Personal and family preoccupations;
- Professional or industrial preoccupations; and,
- Other preoccupations.

Lack of sufficient or incorrect data stored in memory caused by:

- Information deficiencies;
- Training deficiencies; and,
- Insufficient experience.

Different kinds of stress caused by:

- Biological desynchronization;
- Sleep problems;
- Different kinds of fatigue;
- Health problems; and,
- Lack of cockpit resource management

The result of increasing the demand and/or reducing the capacity is a loss in remaining capacity that can lead to relative incapacitation during which the crew will be prone to committing errors.

Capt. Lorenzo Santandreu

The problem of relative incapacitation is that it usually is generated by factors that affect the entire crew at the same time. Crew relative incapacitation is especially dangerous, because it leads to the development of faulty crew performance that goes undetected or is not properly evaluated.

During the time that a crew is in relative incapacitation, they can commit errors or omit necessary actions that can cause an accident.

A good protection against crew relative incapacitation would be an instrument in the cockpit which I call RCI (Remaining Capacity Indicator), allowing the crew to be aware at all times of their capacity in relation with the workload!

With such an instrument (Figure 1) the crew would see if they have enough remaining capacity, if they are approaching a limit situation or if they are entering a situation of relative incapacitation! If they see that their remaining capacity is declining too much, they could take the necessary steps to increase their capacity and/or to decrease their workload.

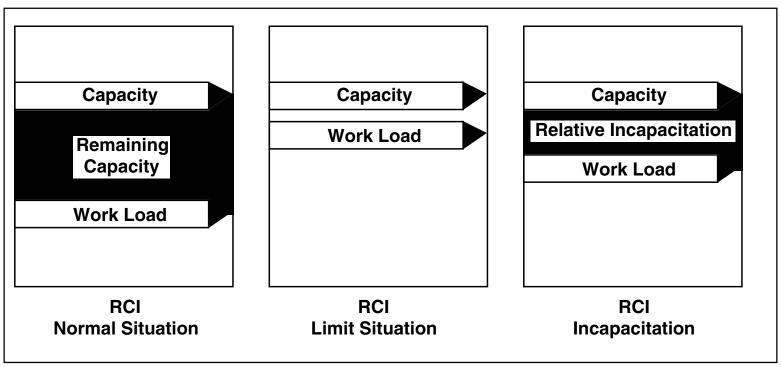

Figure 1

I have not yet discovered how to bring my idea to reality. I suspect it will take some time to come up with one. Until then, the pilot has only one solution: *Nosce te ipsum—Know Yourself.*

During his professional life, the pilot will have devoted almost 100 percent of his learning efforts to study the machine and other elements related to flight operations, and practically zero percent to study the human part of the system. As a result, he knows the operations and limitations of his aircraft a lot better than he does those of his own mind and body. The pilot shares this lack of knowledge with the aeronautical industry in general.

Before a flight departs, the fitness of the aircraft is checked by looking at the log book, making a visual inspection and carrying out the necessary tests and checks. If a defect appears that cannot be fixed before departure, a Minimum Equipment List (MEL) will determine if the flight is possible or not or if some kind of restrictions are necessary. Everybody in the industry agrees with this kind of behavior.

On the other hand, everybody also agrees that if a crew reports for a flight, that means that their capacity is at 100 percent. Moreover, everybody assumes that they still have the same capacity when, perhaps 12 or 14 hours later, they are carrying out a difficult night approach in marginal weather, in the early morning hours—perhaps after drinking five cups of coffee and smoking 30 or 40 cigarettes.

If man is the unknown part of the human-machine system it should be no surprise if he is the part that fails the most, and it should be no surprise that more than 70 percent of the accidents happen during only 6 percent of the flying time— precisely when the crossbar of the workload is higher in a normal flight, and when there is less remaining capacity in the crew.

To avoid relative incapacitations, the pilot needs the following:

- To be aware of the problem;
- To recognize the proximity of a limit situation;
- Recognizing and admitting that he has a reduction in capacity; and,

- Detecting the increase in workload.

To learn and use techniques that will:

- Increase capacity;
- Avoid or minimize reductions of capacity; and,
- To learn and use techniques to decrease workload.

Training in relative incapacitation must rest on a good background knowledge of human operations. Pilots must be trained to understand the operation and limitations of their minds and bodies and that this is just as important as the operation and limitations of their aircraft.

The timid approach made recently by some countries to require a very elemental knowledge of human factors to license new pilots is a first step toward the desired goal, but it is not enough. Some airlines are doing better with their training in human factors.

Important innovations in training such as cockpit resource management (CRM) and line-oriented flight training (LOFT) are excellent tools to help solve the problem of relative incapacitation, but they are not a panacea. They do not lessen the need for a more extended knowledge of human operations.

The industry has experts in human factors that can do the job of designing training to provide enough knowledge of human operations and limitations to the pilots and other personnel in the industry. But first, we have to be aware of the problem of relative incapacitation and admit that we need a change in our training philosophy. If not, we may continue treating symptoms instead of addressing the root cause of human failure: a lack of knowledge.

Judgment and Decision-making

CAPT. PETRUS KOOP
Division Manager, Flight Safety, Swissair

Decisions are an integral part of our day-to-day lives. A choice of alternatives is a prominent feature of our affluent and privileged society. Indeed, for many people, the freedom to make these choices offers concrete confirmation of the quality of their lives.

Making decisions is an attractive activity. It is stimulating. It is fun. It is a challenge, too, which is probably why many of us even like making decisions in our spare time and in the games we play.

Decisions are important. In society, the responsibility that goes with difficult decisions is treated with respect. We look upon political leaders and captains of industry as important people. And at least part of this importance is because they can have far-reaching effects.

For us, as flight crews, decisions are important for an additional reason. As it has been said by many flight crews

"Pilots are the only people in the company who make multi-million-dollar decisions in a split second."

It is true. The decisions we have to make in fractions of a second can save or lose the aircraft in our charge. More important, of course, these decisions will affect the fates of the many passengers whose lives are in our hands.

Anyone who is entrusted to make vital decisions of this kind has not gotten to that position by chance. All our flight-deck crews have years of rigorous selection and training behind them.

Thoroughness and care begin with initial selection. The flight training selection board uses a "paper-and-pencil" test to assess basic aptitude and intelligence. Spatial awareness and skilled coordination are also vital. There is a special apparatus to evaluate performance under pressure. And on the character side, the selectors will look for specific aspects of personality and the ability to work in a team. In fact, the whole individual will be tested and examined from head to toe.

For the candidates who are accepted, the next step is intensive training— countless hours in the classroom studying basic systems and procedures. It also includes hundreds of demanding training flights to acquire essential flying skills and navigation training, both visual and on instruments. All of this is preached and practiced time and time again.

Some of these activities are too dangerous to perform in a real aircraft. Engine failures, windshear, runway icing and countless other major problems can be replicated in a simulator with astonishing realism. Everything is practiced and practiced again, until it becomes almost second nature.

Pilot training is incredibly thorough and demanding. But one thing is sure. Anyone who has successfully completed it and takes a place in an airliner cockpit will feel more than prepared for the "moment of truth"—and will be ready to make those split-second decisions that really matter. Outstanding talent, comprehensive training, responsibility and discipline all add up to a decision-maker par excellence.

Yet year after year, dozens of accidents occur in civil aviation. And two out of every three of them are attributed directly to the behavior of the cockpit crew. Fifty percent of all airliner losses are attributed to a bad decision or bad judgment on the flight deck. Fifty percent.

How can this be? How can hand-picked, thoroughly-trained decision-makers come to make mistakes of this kind? To find the answer, we need to dig deep into the question. We need to ask ourselves: What actually happens inside us when we make a decision?

The brain is a highly sophisticated piece of equipment. And the processes that lead to a decision are very complex. But for our purposes, we can simplify them in a few basic steps.

The first step is perception. This is where we consciously take in the information we need. Next comes assessment, we put this information into context, and look at the possible options. In the third step, we choose one of these possibilities. This is the actual decision. And in the last step, the result, the decision and its consequences, are fed back into the system. After all, this expertise may well influence our future decisions.

For example, consider you are the father of a family, preparing for a weekend hike. You want to take the new video camera with you—the one you just got for your birthday. But the rucksack is not big enough for the camera and the family's rain gear.

The weather forecast predicts changes, perhaps with cloudiness. You listen to this information and take it in. This is your perception phase, as you start the decision-making activity.

You now put your initial perceptions into context. You do not see any clouds right now. And everyone knows that weather forecasters tend to be pessimistic in their predictions. You complete your assessment phase by concluding that the chance of rain is about 50-50.

Now comes the decision. You decide to take an optimistic view and pack the video camera. The rain gear is left in the cupboard. Of course, you will not know if you made the right decision until the end of the day. Say it does rain, and you get a little wet. The result of your decision is bound to have some kind of influence on your perception and your assessment the next time this situation arises. You will probably be a bit more cautious.

So much for the four decision-making phases. Leave the perception and result for now, and concentrate on the assessment and decision.

There is a widely-held belief in the aviation community that, in a situation such as aborting takeoff, the best aviators can make very fast decisions based on purely rational considerations.

In fact, these instant decisions are based on careful preparation—all the possible actions and all their possible consequences will have been thoroughly assessed beforehand. All the possible responses will have been talked through, played out and noted.

All these "canned decisions" will have been stored away, ready to be recalled at a moment's notice. So when the situation we have imagined actually occurs, the canned decision can be recalled and applied immediately. We seem to be very good at using and applying these decisions, even if they have been prepared by other people and not by ourselves.

But when we get into unusual or unexpected situations, it is a new ball game. Here, our abilities to assess and respond can be surprisingly limited. There may be no time to analyze a situation and come to a conclusion. The simplest of connections may be too much for our logic.

This is why, when we are under the pressure of time, we tend to aid our "reason" with a fair amount of "intuition." Our brains get support from our guts. There is no time to analyze all the details. We have to go for broader assessments. (Sometimes, "two and two is somewhere close to three" may be accurate enough to get us what we need.) When we are under the pressure of time, the first feasible solution may not be the ideal one, but it will often be the best.

In situations such as this, we are all likely to make mistakes. If we look into the cause of accidents and incidents in aviation, we come back time and again to four human characteristics that can seriously limit our powers of assessment and our ability to make decisions.

No. 1: Bounded Rationality

When it comes to making decisions, man is in a class of his own:

"There is no substitute for humans where judgment, improvisation and random intervention are required," says a project report by the European Space Agency (ESA).

We may not be totally logical about making decisions, even in very simple situations. But when it comes to deciding under pressure, man is excellent at drawing on past experience, deriving simple rules from it and applying them to the situation at hand. We even have a name for all of this. We call it "common sense."

Common sense is our ability to quickly analyze a situation and find a solution through our own intuition. It makes us more flexible (so far) than machines. It means we are still superior. And it means we are still an indispensable part of the decision-making process.

Some skeptics claim that common sense is not as common as we want to believe. If we look at the mountains of material on misjudgments and bad decisions, they seem to have a point. In fact, the optimists and the cynics are both right.

Whenever we are operating in a familiar environment, there is no reason why we should not use past experience as a guide. Common sense works. If it is a hot summer day and the thermometer shows it is below freezing, it is a safe bet that the thermometer is not working. We do not need an elaborate test apparatus; we can use our common sense.

But what happens when events lead us away from the territory we know so well? If the situation we are in is an unfamiliar one, our past experience will count for very little.

Remember the story of the servant who asked the king if they could be paid in grains of rice? The man just took a chessboard and asked for one grain in the first square, two in the second, four in the third and so on. Each square would have double the amount of the square before. A modest request, the king thought. So he agreed. Little did he suspect that, when they actually worked it out, all the rice in his kingdom was not enough to fill the six-by-four square.

What had happened? The king did not have the experience to see what his servant was demanding. And his common sense let him down.

If the king failed to analyze the situation, it was through carelessness. If we fail to do so in the cockpit, it is usually because of the pressure of time. This may be one explanation for the strange approach made by one of our long-haul crews to a destination we all know well.

It was night — in instrument meteorlogical conditions (IMC) at the end of a long and tiring flight. The crew of the widebody was in a fast-moving line-up. The workload was high—the approach routine alone was quite an effort. The crew turned into the localizer course at 265 knots. But the navigation computer did not turn into the instrument landing system (ILS). Instead, and quite unexpectedly, it aligned the aircraft parallel to the proper track, but far outside the localizer.

For the next few minutes, the situation was too much for the crew's logic and common sense. The raw navigation data from ground installations was simply ignored for a very long time.

It was the controller who realized the aircraft was not established on the localizer course. He tried to help the crew. He let them exceed the minimum sector altitude by 1,500 feet; and he allowed them to descend to 1,500 feet above threshold.

The autopilot now began a level-off at the preselected 1,500 feet. But this was overruled by the vertical speed. Rate of descent now increased to 2,900 feet per minute.

The ground proximity warning system (GPWS) sounded an alert for 10 seconds. The crew's reaction? They disengaged the autopilot and reduced the rate of descent slightly to 2,200 feet per minute. The flying pilot continued the approach far below the permitted radar minimum—in spite of the GPWS, the full-scale localizer deflection, the glide slope undershoot of more than two dots, and the verbal interventions of the assisting pilot.

Only when the localizer was crossed, clearly within the outer marker, at an intercept angle of more than 30 degrees, and with the aircraft at 702 feet radio altitude, was a go-around initiated by the assisting pilot.

The second approach was uneventful. Only then did the crew realize the extent of their navigation error. The explanation was simple. An error in the RNAV (area navigation) computer had guided the pilot more than one mile to the side of the localizer course.

The computer error had been enough to totally overload the human minds on the flight deck for a frightening length of time. The result had been a total breakdown in discipline. Flight rules had been broken and policies had been ignored. Even the last resort—GPWS—only triggered a response after a considerable delay.

Common sense is vital, but it does need support. Our policies and procedures are in place to help us keep within certain limits—limits within which our knowledge, our canned decisions, our experience and our intuition can be used to maximum effect. If we allow ourselves to wander outside these familiar limits, we will soon find ourselves in a no-man's land of unknown complexity. It is land where our common sense can let us down and safety can be seriously impaired.

Capt. Petrus Koop

No. 2: Conflict of Interest

Consider this anecdote from the Middle Ages. Our medieval donkey finds itself between two piles of straw. The piles look equally big and appetizing. Where should he go first? The poor old donkey cannot decide. He runs from one pile to the other, but does not actually eat from either. And he starves to death.

Maybe donkeys are a little smarter nowadays. But the old story still has some truth. In any decision-making situation, we will always feel drawn to the pleasanter option.

Deciding to go for a swim is a nice decision to make. Other situations can seem a lot less attractive. They may involve something unpleasant, like the traffic jam we can expect to meet if we drive our car during rush hour. We will try and avoid this, even if we have to make an elaborate detour.

But options can often seem attractive and unattractive at the same time. You want to go to the local sports event and see your favorite team play, but it also happens to be your spouse's birthday. Do you go to the match and make her or him unhappy? Or do you stay at home to celebrate and miss the game? We are torn between the two options.

The situations a flight crew member can find himself in may be much more complex. There may be a number of alternatives — with plus and minus for each one.

Take a difficult approach in marginal weather conditions. Getting the aircraft down safely is a challenge to professional abilities. After all, reaching the destination is part of the job. On the other hand, if the weather conditions really worsen they could compromise the safety of the flight.

The alternative is a go-around. That is the safer action. But a pilot may feel taking that action is a failure on his part. He may even see it as concrete proof of his own misjudgment.

In this kind of ambivalent situation, it is more difficult to make a definite decision. He may hesitate. He may not be able to make one at all. He may jump back and forth between one alternative and the other. Consider the surprising conclusion to the following flight:

The short-haul crew was flying a localizer approach. Visual ground contact was established during level-off at the minimum altitude. Then there was a change of controls. Now, on visual, the flying pilot descended below the 500-foot minimum.

Suddenly, the crew lost visual contact with the ground. At 260 feet a go-around was initiated and the aircraft began to climb away. At that moment, the EFAS (electronic flashing approach light system) came into view. The flying pilot changed his decision and called out "No! Landing!" The aircraft's nose was pushed down from 15 degrees attitude to zero. And the aircraft remained in landing configuration.

The autothrottle set go-around power, but was manually overriden. The crew continued the descent. At 144 feet, the assisting pilot called out, "no further descent, trees to the right." The nose was raised to an attitude of 11.5 degrees.

The aircraft was now 350 feet above the middle marker, and N.1 was at 85 percent. Again, the nose was lowered. After a steep dive, flare was initiated at V approach +20. The autothrottle system was still in go-around mode when the aircraft touched down.

Exactly how close this incident came to disaster may only be truly appreciated by the crew themselves. What is clear is that the unthinking "decision reversal" had pushed them into a dangerous area—an area where their common sense and their experience were no longer enough to guarantee the safety of the flight.

Here, too, the situation would never have occurred if the crew had kept to established procedures—in this case, continue a go-around after it has been initiated.

No. 3: Self-serving Bias

In any situation, our judgment will always be colored by our beliefs, values and expectations. We all tend towards an unrealistic kind of optimism, especially where we—ourselves—are concerned. As a result, we often underestimate the risks to which we are exposed.

Just think of smokers. "It won't happen to me," the smoker will think as he draws on his cigarette. He suppresses health-risk concerns to enjoy the moment. In the longer term his feeling of invulnerability may not be much protection against the less desirable effects of his habit.

We also tend to remember pleasant experiences and success, and forget our failures and disappointments, which means that we will always see the real enjoyment close at hand rather than the theoretical danger further away.

This self-serving bias is an understandable tendency in all of us. But it is also an influence that is carefully hidden from our consciousness. Because of this, it is hardly likely to improve our decision-making abilities. In aviation, misplaced optimism can have fatal results:

On the evening of April 4, 1986, a Westwind 2 (a twin-engine jet business aircraft) took off from Dallas, Texas to its home base in Teterboro, New Jersey. The flight had been delayed several hours, while its passengers finished their business negotiations.

The crew had ample time to prepare for the flight. The first general weather forecasts, a few hours before departure, had predicted storms enroute. But this did not seem to have worried the pilots. At least, they did not bother to obtain a more complete or updated weather report before they took off.

A few minutes after takeoff the captain contacted approach control radar. "Our radar is not doing very well," he reported. He asked for radar vectors to fly around the bad weather.

Seventeen minutes later, the Westwind had climbed to 37,000 feet. The crew called again: "Well off to the left they're still building, uh, there's topping out about 38, 39, but off to the right where we were just passing through there she's topping about 36 to 37."

The crew could see that the flight was gradually being surrounded by towering storm clouds. But the pilots still seemed optimistic. Then they changed radio frequency, but they did not tell the new controller about the problem with their weather radar. One minute later, in visual meteorlogical conditions (VMC) and at night, the crew was flying directly into a build-up as they reported: "Center, Westwind 50 Sierra Kilo need to get up."

The controller cleared them to flight level 290. He received no reply.

The aircraft flew into an active thunderstorm of maximum intensity. Its top was rising at 1,000 feet per minute. The crew lost control in the turbulence, and both engines failed. The aircraft crashed, vertically, into a field. Two experienced pilots and five senior executives lost their lives.

The captain had clearly felt that "it won't happen to me." He had obviously underestimated the severity of the weather. And, through a series of bad decisions, he had gotten himself into a situation where effective decisions could no longer be made.

No. 4: Group Think

Why is it that we often go along with other people's ideas? Why do we willingly and often unconsciously accept the "benevolent authority" of our superiors? Because we all have a basic desire—a need—for recognition and acceptance.

In some ways, our social adaptability is a positive thing. Grouping together can be a good way of dealing with less pleasant events in our lives. It is sometimes said that "a trouble shared is a trouble halved."

Capt. Petrus Koop

When it comes to teamwork in our day-to-day lives, falling in mentally behind the others in the group can be a dangerous thing. It means, of course, that we lose our independence of thought.

There is a name for this phenomenon: "group think." When group think takes over a team, vital safeguards are lost—mutual monitoring, control, criticism, and correction. The safety of redundancy is removed and collective error can take its place. And the dangerous individual illusion of "it won't happen to me" turns into the dangerous group illusion of "it can't happen to us," which is one of the reasons why it is not just individuals who make mistakes. Sometimes, it is the whole crew.

Perhaps the best demonstration of "group think" occurred on April 26, 1986. A team of skilled specialists was carrying out a test on a piece of high-technology equipment. The team was well-trained and highly experienced. Yet on this occasion they ignored the most elementary regulations and turned off warnings, even when the test had unexpectedly slipped into the danger zone.

The apparatus they were working on was a nuclear reactor—Chernobyl.

A feeling of overconfidence can just as easily take over the flight deck of a commercial airliner. As the following report shows:

Radar vectors to the ILS were planned for this highly sophisticated airliner. The crew expected no problems, so the pilot-in-command briefed his intention of testing some flight guidance switchings with flight director and autothrottle systems off. Radar turn-in was started and during the turn, slats and speedbrakes were extended to reduce speed. The planned test was made in a left turn with 12 degrees bank and one dot high.

In the meantime, the localizer had been overshot to the west; rate of descent was increased to minus 3,000 feet per minute; and speed was 230 knots. The crew now tried to intercept the localizer with a 10-degree intercept angle.

With a full localizer deviation to the left, half a dot below, glideslope and gear and flaps still up, a mountain triggered the GPWS "Pull up." Approach was continued with rate of descent reduced to 1,000 feet per minute and "pull up" was activated for at least 15 seconds.

About 25 seconds later the outer marker was passed on an angle of 20 degrees to the ILS, and 400 feet below the glideslope. The glideslope now showed full "flyup" with a rate of descent of 1,800 feet. The situation was finally resolved with a go-around initiated at 600 feet radio altimeter altitude and fully left of localizer.

This experienced and well-qualified crew had expected no problems with the approach. They even had radar support. They were unaware the feeling of invulnerability was gradually overcoming them. In carrying out their tests, crew members were no doubt acting with the best of intentions, and were convinced that what they were doing was fully correct.

But maybe the pilots were convinced of something else, too—that the policies and warning systems, such as the GPWS, were an unnecessary restriction in this particular situation.

These are the classic elements of group think. Gradually, unnoticed, the group-think mentality can lead our situation awareness away from the demands that every flight imposes, however normal they may seem. Failure is something we can hardly imagine. Yet paradoxically, it is closer than ever.

Summary

Freedom of choice is an integral part of the quality of our lives. And freedom of choice means decisions. As pilots, we find decision-making an attractive challenge. In fact, it is probably one of the main sources of our professional pride.

Some situations—such as a rejected takeoff or an engine failure in flight are clearly defined and foreseeable. Here, we can instantly call upon our canned decisions.

But in most cases, we need to analyze thoroughly the situation before we can decide what to do. For this, we need both time and information. Usually, in the air, we have too little of either. This is why we need to reinforce our rational thinking with experience and intuition — the things we usually call common sense.

Whatever methods or assistance we use, when it comes to making decisions, we must always remember our own human weaknesses:

- Bounded rationality. Common sense is man's great asset. But it can only function effectively in the narrow band of our own experience.

- Conflict of interest. If two courses of action seem equally attractive or unattractive, we will take much more time and effort to come to a decision.

- Self-serving bias. The "it won't happen to me" attitude can lead us to make silly and dangerous mistakes.

- Group think. The group can give us a comfortable feeling of belonging. But if "it won't happen to me" becomes "it won't happen to us," we will quickly lose the safety nets of mutual correction an control.

These weaknesses are in all of us. And we have to keep them under control. For this, we need external support. This help is readily available in our policies and procedures. These provide the guidelines to help us recognize the limits of our performance and keep within those bounds. If we do follow them, we will be far better able to process the information we receive and make a sound decision. In fact, breaking these policies and procedures, consciously or unconsciously, is the first sign that we are leaving the safety zone and entering a dangerous field.

Strict discipline is what we need to keep us within our own limits. And that includes the guidelines that are offered by company policies and procedures.

So let us make sure that discipline is there and each and every one of us practice it for safety's sake.

Integration of Ground ATC and Airborne Systems

Capt. Nils Brandt
Chief Technical Pilot, Lutfhansa German Airlines

Air transport can only satisfy the passenger when it reliably operates at the time the passenger wants.

The ever increasing demand for air transportation triggers the need for new air traffic control (ATC). More automation in the ATC system for strategic and dynamic traffic capacity control will allow the use of otherwise undetected capacity. The question is no longer: Is the glass cockpit better? Digital systems and glass cockpits couple the aircraft to ground-based systems. Successfully applied information compression in the cockpits, such as dark panel philosophies and information on demand, can be used in ground-based systems to relieve the controller from monitoring automated normal situations. In the denser traffic environment, indications about the surrounding traffic will help the aircrew to improve their situation awareness. This could more than compensate for decreasing "partyline effects."

Air Traffic in Germany

The air traffic situation in Germany shows increasing delays during the past few years, culminating in a statistical delay of more than 15 minutes for every fourth flight. German air traffic has 50-percent border-crossing (originating and terminating traffic) and 30-percent domestic traffic. Only 20 percent of the flights are overflying traffic.

Additionally, the former West German airspace consists of 65 sectors of civil and military enroute and approach control sectors in the upper and lower airspace. The average time to fly through a sector ranges from four minutes to 15 minutes; but in 11 sectors the duration is more than 10 minutes.

These parameters hinder the flexibility of ATC and the airline's goal to fly its optimum profile on schedule.

The increasing demand for air transport generated a renewal of ATC systems around the world. In Europe, the "ATC Harmonization and Integration Program" includes the implementation of advanced systems supported by extensive automation and enhanced data communication available with the aeronautical telecommunication network, Mode-S and satellites.

CATMAC (Cooperative Airtraffic Management Concept) is based on the recommendations of the Future Air Navigation System (FANS) Committee of the International Civil Aviation Organization (ICAO) and the Future European Air Traffic System (FEATS) concept developed by a working group of the ICAO European Air Navigation Planning Group (EANPG). The Aeronautical Telecommunication Network (ATN), currently being standardized by ICAO, will be used for the integration of CATMAC functions.

The functional diagram of CATMAC shows its main functions are:

- Strategic planning;
- Tactical planning;
- Short-term planning; and,
- Monitoring and control.

The introduction of CATMAC does not require any fundamental new system component. System components already defined and currently under development will be introduced gradually, increasing the efficiency and capacity of the ATC system stage-by-stage.

Data communication between ground and airborne systems is done primarily for the purposes of updating of flight plan information in the tactical and the short-term planning phase. Data linked voice will be used for the functions of monitoring and control.

A study showed that the air traffic control system need not become a restrictive factor in future air traffic development when based on the implementation of CATMAC.

After the U.S. National Aeronautical Space Administration (NASA)/Federal Aviation Administration (FAA) workshop in Europe in December 1988, it was understood that there could be a large gain in developing time for integrated ATC systems by using the airline automatic communications and recording system (ACARS) instead of waiting for a fully implemented Mode-S ATC dedicated system.

The following areas have to be considered:

- Reduction of coordinative work by automating coordination processes.
- Extended automated and improved conflict detection and resolution strategies.
- Improved coordination of planning and changes between ground and airborne systems.
- Integration of the potential and functions of the FMS into the ATS system.
- Infrastructure measures, including communications network simulator (CNS) and airspace organization.

CATMAC Operational Concept

Strategic Planning (in the month before a flight)

Flight schedules are negotiated at the flight plan conference, and the data are then stored in the DBE (Database Europe). In the future, this function will be performed by the CFMU

(Central Air Traffic Flow Management Unit) in Brussels. Request for changes to this contract are negotiated by the airline.

Tactical Planning (days and up to six hours before the flight)

This function will be performed by the supra-regional CFMU and is intended to prevent the vast exceeding of capacity such as overbookings for flights. This aims to reduce the necessity for extensive holding times. It should allocate acceptance rates over entry points or departure slots.

The CATMAC concept assigns a number of relevant ATC tasks to the aircraft:

- Exact calculation of the 4-D flight profile.
- Exact adherence to the profile.
- Automatic notification of deviation trends from the negotiated profile.
- Information about the performance possibilities of the aircraft for new negotiations.

For aircraft already in the air in the tactical planning phase, estimates over certain points, route alterations, altitude and speed restrictions are monitored. Information from this function will be routed to the FMP within the Regional Air Navigation Services.

Short-term Planning (under 45 minutes)

This should reduce the conflict probability early enough to carry out changes to the flight profile. The ground computer searches for resolution possibilities, mainly lateral and speed changes. The performance possibilities of the flight, needed to work out a resolution, are updated with the request. The resolution will be transmitted to the aircraft for the crew to evaluate. The crew has to accept or reject the proposal. With the push of the accept button the plan can be activated in the Flight Management Computer so the controller will know that it was accepted and will be followed.

Monitoring and Control (up to 15 minutes)

By now, most flights handed over to this phase should be conflict-free. Computers will have to assist the controller in detecting conflicts and preparing solutions. The computer can recognize airspace planning and separation conflicts considerably earlier than a human controller. If a flight path deviation is ordered, this is automatically downlinked by the FMS-Datalink Interface in the aircraft. Time and route changes are automatically inputted in the ground-based ATC computer. Traffic alert and collision-avoidance system (TCAS) is an inherent part of CATMAC, and, of course, TCAS maneuvers must also be communicated to the controllers.

The CATMAC concept is also valuable to aircraft without datalink because of the more precise data of the datalink-equipped aircraft. Information about profiles of non-equipped aircraft may be kept in databases updated by manual input. Information from the ground to the aircraft can be routed via gate printers as long as the aircraft is at the gate. The information by exception principle will keep the datastream to an acceptable level. So the philosophy of CATMAC is to improve the planning data to reduce potential conflict.

Handling the Flight at the Airport

An unused slot is gone forever! Pushback, taxi guidance and management must be accomplished so that minimum time is needed to board passengers as close as possible to takeoff. This also requires computer optimizing solutions. In Germany, one of the concepts is called TARMAC (Taxi Route Management Concept) and operated in concert with CATMAC.

Management of the Flight by the Airline (STAMAC)

Airlines need to keep to the schedule, to avoid endangering the negotiated slot. The less deviation from plan, the less strain there will be on the system and the less risk for further delays. Thus, airlines should have a station management concept with automated information to follow through and communicate when a flight schedule is joepardized, and propose solutions. Information requests to the ATC computer for alternate solutions should also be possible from the cockpit.

Possible Future Functions for ATC Datalink

Frequency change is the most repeated transmission. This could be automated and sent directly to the aircraft by datalink. Runway occupancy can also be reported by datalink-equipped aircraft, reporting every takeoff to the appropriate company in real time.

Cockpit Philosophy

Pilots have been working with automation for decades. A reliable and safe Category-III-B approach is only possible with the help of autopilots, with the crew in full command of the situation. In addition, cockpit design of large widebodies shows how information by exception can be used to keep the crew informed about the relevant parameters. Successfully applied philosophies like these can be transferred to the ATC ground system. Here again, automation must be used when the workload increases.

Is Flight Safety Increased or Reduced by Implementing Such Systems

ATC features prominently in crew reports and airline flight safety information. Near misses, wrong clearances and readbacks are the most reported causes. In a Lufthansa questionnaire conducted in 1988-89, flight deck crews reported collision risk as the largest risk factor group with 35 percent of all incidents.

The systems proposed here can help operators, crews and controllers in the following ways:

- Pilots will see the traffic and its status on the integrated navigation and traffic display. This improves their overall traffic situational awareness.

- The possibility of information ambiguity is reduced by digital information transfer instead of voice contacts.

- Computers will presort the traffic, thus decreasing the need for very short-term tactical controller actions.

- With a dark panel philosophy for the controller station we can reduce the information processing demand. The higher the workload, the more automation is needed to relieve the operator. The possibility must exist for the operator to increase or reduce the automation level and regulate his awareness level.

The symbology and phraseology used for ATC purposes are critical for safety, and should be developed on an international scale.

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Training and Examining Professional Pilots in a Field of Change

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The professional air transportation pilot bears a large part of the responsibility for operations safety. Charged with the task of ensuring a good safety level, civil aviation authorities try to make sure that new arrivals to the profession have the necessary personality, aptitude, training, attitude and health. Theoretical and practical examinations for the issuance of required licenses, together with medical examinations as well as recurrent training and checks, are the tools used to measure the new arrivals.

A crucial moment is the practical examination for the commercial pilot's license, particularly if it includes the instrument rating and multi-engine qualification. It is at this point, just before a pilot's entry into the air transport job market, that he or she must demonstrate the capability to operate safely under instrument flight rules (IFR). To obtain consistent results, civil aviation authorities usually specify a number of tasks or maneuvers in which competency is to be demonstrated, often with the specification of acceptable tolerances. Establishing and using such an examination guide is complicated by the large diversity of the candidates' training prior to taking the commercial pilot practical examinations. In addition, newly qualified pilots may be headed for different kinds of work, ranging from single-pilot IFR business aviation to work with small commercial operators and regional and major airlines. In many cases, it is not clear at the time of the examination in what direction the job market will force a new entrant.

My discussion is based on my experience as a designated pilot examiner for commercial pilot, type rating and instrument rating practical examinations in the Netherlands. Ongoing discussions about updating examination procedures have been accelerated by the International Civil Aviation Organization (ICAO) renewal of Annex One, and the move by the European Community (EC) toward mutual recognition of air crew licenses.

The Present Situation

Civil aviation in the Netherlands is supervised by the Rijksluchtvaartdienst (Directorate General of Civil Aviation), a department of the Ministry of Transport and Public Works. Aircrew licensing is one of the tasks performed by the Aeronautical Inspection Directorate.

The task of examining aircrews is entrusted to examination committees, composed of RLD (Netherlands Certification Authority) personnel and non-RLD examiners. The committee for the practical examination of professional pilots consists of about 200 persons. They are responsible for the commercial pilot license (CPL) and airline transport license (ATPL) practical examinations and for category, class or type ratings as well as agricultural and instructor qualifications. In addition, this group examines both professional and private pilots for the instrument rating.

Although there is a relatively large number of examiners, they work only part-time. Some are employed by commercial air transport operators, examining only within the scope of their operator’s training department. Other work for flight training companies are privately designated on the basis of experience and aptitude. Many of the latter category are recently retired professional pilots. Most, but not all of the examiners, hold flight instructor qualifications.

A form is provided to examiners designed to satisfy the requirements of the majority of practical examinations. As a consequence, a large number of notes and remarks are needed to indicate items applicable to different cases, such as type rating or instrument rating, and aircraft differences as they relate to engine-out procedures and systems differences.

Four groups of tasks are identified. Group I is concerned with knowledge of the aircraft and flight preparation, ground handling and pre-takeoff checks. All items in Group I are compulsory, but prior written examination may be used on approved courses for such items as knowledge of the aircraft and performance.

Group II deals with the departure phase, including engine failure in takeoff, and with general (instrument) flying such as steep turns and stalls. A number of optional tasks dealing with abnormal operations and emergency procedures is available for selection by examiners.

Group III focuses on instrument approaches, also divided between compulsory and optional tasks. Group III obviously is examined only in instrument ratings or if the candidate already holds an instrument rating.

Group IV consists of circuits and landings. This group is not examined for instrument ratings.

The form is not intended for use with such specialized examinations as agricultural operations, flight instructor qualification or helicopter pilots. Separate groups of examiners and separate procedures are used to deal with those cases.

Some Practical Problems

Getting the examination organized presents a number of difficulties. Examiners are scheduled approximately one week ahead of the examination. Because most are non-RLD, their availability is not guaranteed. Yet it is advisable to select those who have a good knowledge of the aircraft type or at least of the general class of aircraft involved. Because a safety pilot is used, it is not necessary for the examiners to be formally rated or otherwise qualified to fly the specific aircraft type or to be current.

Road traffic in the Netherlands is sufficiently congested that the distance between an examiner's home and the place of examination must also be taken into account.

Airspace congestion also presents a problem. RLD policy used to require instrument rating examinations and examinations of pilots already instrument rated to be given at Amsterdam's Schiphol Airport. The rationale was that candidates had to demonstrate their ability to operate in and out of a busy airport, mixing with heavy aircraft and to show they were able to handle the air traffic control (ATC) workload as well.

During the past decade, however, traffic load at Amsterdam has made such a policy impractical, with the exception of examinations on business jets. A growing number of examinations are therefore taking place at instrument landing systems (ILS)-equipped regional airports.

Weight and balance becomes an issue during many examinations because of rules requiring two examiners in addition to a safety pilot. While this ensures a balanced view of the candidate's performance and good feedback to the safety pilot who in most cases is the candidate's flight instructor — a single-engine aircraft or even a light twin can easily be overloaded with the fuel needed for the examination plus IFR reserves.

The combined limitations produce an examination with a scenario that is too predictable, especially in light-twin piston-powered types with their critical performance and simple systems. If a candidate has been trained at an approved school with a well-defined syllabus, it is easier to verify that the required proficiency has been achieved.

The Need for Change

Many of the factors mentioned above combine to make an unsatisfactory situation. Many candidates who enter the professional pilot world by the "self-improvement" route have not passed through a selection process and do not receive the same training as airline pilots, flight academy graduates and business jet pilots. The latter groups have access to well-organized ground courses on aircraft types and avionics, along with operating and ATC procedures. They can use simulators for a large number of training tasks including those situations that are too risky to perform in the aircraft. When all of this has been accomplished, they generally fly for a period as a copilot with an employer who provides them with recurrent training under the supervision of experienced captains.

None of this is available to the self-improver. Such a pilot may have to go into single pilot IFR operations with the legal minimum of preparation. Excluding this group from the profession, however, is not a good solution. Time and again, self-improvers have shown they can be highly motivated and highly proficient pilots.

It is regrettable that under the present circumstances the practical examination must be limited in scope and duration without a clear focus on the operational environment facing the newly qualified pilot.

The Wider Picture

ICAO's Annex One, personnel licensing, now in its eighth edition, introduces a change in type rating requirements. The well-known limit of 5,700-kg maximum takeoff mass no longer exists. A type rating must now be held to fly an aircraft type whose airworthiness certification requires it to be flown by a crew of two pilots or more. Copilots in such aircraft must also be type-rated although states may issue a copilot-only rating.

ICAO allows aircraft certificated for single pilot operation to be flown by holders of class ratings (single-engine land (SEL), multi-engine land (MEL), single-engine sea (SES), multi-engine sea (MES).

Another significant change to Annex One restricts the privileges of a CPL holder in commercial air transportation. The CPL holder may act as pilot-in-command only in aircraft certificated for single-pilot operation. An ATPL is required to operate in command of a multi-crew type in commercial air transportation, regardless of the aircraft’s weight. States have (as is often the case with ICAO rules) the option of making either stricter versions or issuing waivers, e.g., for training, testing and ferrying.

The Eighth Edition of Annex One was published in 1989 and gives countries until 1994 to adapt their own regulations (or publish their differences).

The European Commission (EC) has outlined procedures that should lead to mutual recognition of civil aircrew licenses by member states. This is necessary to give European Economic Community (EEC) citizens equal access to jobs in all member states.

An EC directive is not law, but it requires that member states amend their own laws, regulations and procedures in such a way that the intent of the directive is fulfilled.

European civil aviation departments are thus not only engaged in aligning themselves with the new provisions of ICAO Annex One, but are also in the process of complying with the EC directive.

In order to prevent diverging interpretations among European states of ICAO’s new personnel licensing rules and of the EC Directive on Mutual Recognition, a common interpretation for all member states is being formulated. Such a common interpretation will facilitate the integration of European aviation activities without the added burden of conflicting rules and licensing standards.

While this is a welcome development, there are inevitably some aspects that need to be watched. The composition of working groups that are charged with developing recommendations, is generally dominated by persons whose main interest and experience, whether as regulators or as operators, is commercial air transportation. Too often, all others are seen as equivalent to the visual flight rules (VFR) pleasure flyer. The group consisting of business aviators, small commercial operators, and even private pilots who have upgraded themselves to CPL/IR (instrument rating) standards in pursuit of safety, are not well represented. We are fortunate in having, in this instance, a representative of the European Business Aircraft Association (EBAA) who is able and qualified to take part in the working group discussions.

Due to the focus on commercial air transportation, aspects of personnel licensing tend to become mixed with aspects of operating regulations. While the former are related to Annex One, the latter follow from Annex Six, Flight Operations.

Annex Six consists of three parts: Commercial Air Transportation (Part One), General Aviation (Part Two) and Helicopters (Part Three). Strict rules on crew complement and training, intended to safeguard the traveling public, belong in the Operating Rules for Commercial Air Transport and not in the rules on Personnel Licensing.

As is often the case in matters of European harmonization, there is a tendency to produce an amalgamation of the stricter parts of the various national regulations.

European Civil Aviation Conference (ECAC) proposals go into significantly more detail than the ICAO standards of Annex One. Type ratings are not only required for multicrew aircraft types but also for single-pilot multi-engine turbine aircraft and for single-pilot single-engine turbojets. Class ratings remain for other single-pilot aircraft but they are to be limited for single-engine turboprops and multi-engine piston-powered types to aircraft produced by the same manufacturer. This is supposed to ensure that no mistakes are made due to the different cockpit layout philosophies used by different manufacturers.

Type and class rating renewal checks will be much more extensive than is now the norm outside the airline world. Different parts of the checks may be spread over a three-month period.

ECAC proposals on multi-crew type ratings are also worthy of inspection. To obtain a multi-crew type rating a candidate must have had multi-crew training. To this rather obvious and sensible requirement, ECAC now requires that the ATPL theoretical examination must also have been passed, not only for the pilot-in-command in commercial air transportation (who must hold a full ATPL), but also for others, including copilots.

A beginning copilot on a multi-crew type must therefore have the knowledge required of a pilot-in-command in commercial air transportation. While this is acceptable if the copilot flies for an airline where the employer will want to ensure his promotability, there is no need for this with operators who come under the provisions of Annex Six, Part Two.

This is an example of a requirement that clearly belongs in the realm of Operating Regulations for Commercial Air Transportation and not in Personnel Licensing, if it must be adopted at all.

These changes, and others, will have repercussions in the training world. The ECAC foresees two different training concepts, existing side by side. Both are supposed to conform in syllabus and quality of instruction to future European standards.

The luxury of *ab-initio*-to-airline is represented by the Integrated Course (ATPL), with a minimum of 195 flying hours, taking from one to two years full time. This course will include multi-crew training and ATPL theoretical examination. If not sponsored by state or airline, this is an expensive way to enter the profession.

Another integrated course leads to the CPL/IR, to operate single-pilot, multi-engine aircraft. The minimum hours would be 150.

Self-improvers will have to follow the modular route. Several standard modules are proposed, and map out various career paths. Training establishments will have to be approved for each module they wish to offer. Because each module has a number of hours devoted to the specific training required, there is no longer any merit in flying unnecessary hours in simple aircraft, apart from the experience and enjoyment obtained. Some of the minimum-cost options of today will thus be unavailable in the future.

Some of the most probable modules include:

- Private pilot license (PPL) to a basic CPL, with CPL ground school and theoretical with flight instruction on a complex single-engine type. (four seats, variable pitch propeller, retracting undercarriage);

- CPL to CPL/ME/IR for those going into single-pilot IFR operations; and,

- Multi-crew plus ATP to prepare CPL/(ME)/IR holders for their first multi-crew type rating.

The Future Shape of the Practical Examination

In view of the ECAC's work, there is sufficient input to the local discussion on training and examining of professional pilots to project a view of the new situation.

The call for separate procedures and examination forms for single-pilot and multi-crew situations is likely to be honored fully. Each module or integrated course will necessarily have its own specific examination. Much closer correlation will exist between the proficiency items checked and the (additional) privileges obtained by the candidate upon completion of the course or module.

Flight training establishments will have to be much more explicit in formulating curriculum and syllabus content. Periodic checks on proficiency with regard to sharply defined parts of the training course will be necessary. Given the aim to achieve identical content and quality of training throughout Europe, it is to be expected that more extensive documentation and supervision will be involved. Some of the concepts of task analysis and syllabus definition may well be related to the material published by the U.S. Federal Aviation Administration with regard to the AQP (Advanced Qualification Program).

While the concepts are quite valuable, the administrative burden of such a program should not be underestimated. Howls of protest must have gone up in airline training departments in the United States at the amount of study and paperwork required to put and keep an AQP in operation.

Those responsible for European developments in this field will do well to limit such administrative burdens to a minimum, thus freeing money, time and energy for the task of instructing.

It will be advisable to make a clear distinction between the regulations for commercial air transportation (coming under Annex Six Part One) and for operators coming under Annex Six Part Two. Also, rather than being proud to state: "We are quite critical in the matter of approving simulators," even in the case where pilots of several other nations take credit for training on the machine, civil aviation inspectors might want to take a more benevolent look at less expensive flight training devices. After all, we were taught not to trust the seat of the pants but to fly by instruments, so why is this fixation on perfect motion systems necessary? A serious analysis of minimum cueing requirements might well turn up a large number of tasks and part tasks that can be perfectly covered with the aid of very simple equipment.

All this is not meant to be specifically critical of the authorities in one nation. Undoubtedly, many, if not most, of the aspects will be familiar to examiners in other European states. As we make progress towards more unified standards and procedures, we should keep all lines of communication open. The "not invented here" syndrome was never more harmful than today. If we take care to listen to each other and protect the interest of all pilot categories, a well-balanced set of new regulations and procedures will be developed. Commercial pilot proficiency will be of the same level in all participating European states, facilitating the free movement of personnel. Examiners will be able to define examination scenarios with a much closer correlation to the purpose of the training module and the pilot privileges associated with it.

Flight safety can only benefit.

Congestion: Is There a Solution?

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Congestion: Is there a solution? The question is either very easy to answer, or very difficult.

The easy answer is: "On the technical level, and with unlimited money, yes."

The difficult answer is: "On the political level, who knows?"

In recent years, the implications of the explosion in air travel, and the inadequacies of the infrastructure, have become apparent even to those outside the industry. Politicians and the public have become interested. Radar is still not much of a vote catcher, but there is at least a better chance now than in the past that investment in infrastructure will be made.

It is almost four years since the United Kingdom's Airline Users Committee pointed to what it saw as three failings in the United Kingdom's National Air Traffic Services. Its remarks could have been applied to the air traffic control (ATC) authorities of other countries, too. The failings were:

- Severe underestimates by forecasters;
- General failure to incur necessary capital expenditure; and,
- Failure to appreciate that flow management procedures between countries would demand a very large increase in the extent of communication.

The government forecasters were not the only ones who failed to foresee the traffic boom of the 1980s. The airline industry also failed to foresee it, and probably contributed to a false sense of security.

The current situation would be very much worse than it is, but for the effects of the Persian Gulf War and widespread industrial recession. But traffic growth will return (in fact, in the regional airline sector it did not really disappear) and, although we have been having a breathing space, the problems are still with us.

Boeing, in its latest traffic forecast, predicts a threefold increase in passenger traffic (expressed in passenger-miles) between 1990 and 2010. That represents an annual growth rate of 5.5 percent for 10 years, followed by 5 percent for a further 10 years. The company describes the events of 1991 as "a short-term deviation" from the long-term trend.

The International Air Transport Association's (IATA) 21st Technical Conference on the subject of congestion, held in Montreal in 1987, was a turning point in the general awareness of the capacity problem; it evoked unprecedented interest from government agencies, airport operators and others outside the airline industry. It also spawned the Air Transport Action Group, which is working hard to spread that awareness.

Average Size of Aircraft

There is no doubt that an increase in the average size of aircraft would ease congestion simply by carrying more passengers on fewer flights. Some might argue that this is an inevitable trend.

The trouble is, it is incompatible with a competitive environment, which is what the European Economic Community (EEC) is striving toward in the single market. The fiercer the competition, the more the airlines go for high frequency. But to preserve their profits in times of slumping revenue yield, they need to operate those frequencies with smaller aircraft, not larger.

Evidence of this trend comes from Fokker. Only about a year ago, in its plans to develop a family of small jets based on the successful Fokker 100 (a 100-seater), the company suggested a 130-seat stretched version, to be followed at a later date by an 80-seat shortened version.

Then Fokker consulted airlines in the second half of 1991. The strong message it got was: "We want a 70-seater, and we want it soon." That attitude in the marketplace does not augur well for larger aircraft.

Indeed, Sir Colin Marshall of British Airways recently drew attention to the way in which the average number of seats per flight between London and Paris has declined in recent years. I think the same would be true between Amsterdam and London.

If we look at the densest airline routes within Europe, we find that the busiest, both in frequency and in number of seats, is London-Paris. Average seat capacity per flight is 156. (This and subsequent figures are based on one week in November 1991.)

Leaving aside the second busiest route in frequency terms—Monte Carlo-Nice, with only four seats per flight—we find the following in the top 20 routes (see also Appendix 1):

- Dublin-London at fifth, with 113 seats;
- Brussels-London in ninth place, with 117; and,
- Berlin-Düsseldorf in 12th place with 108.

These figures are lower than you might expect, given the number of Airbus A310s and Boeing 757s that are seen at our airports.

The figures back up the point that more competition means smaller aircraft. The three routes in Europe with the largest aircraft (230 or more seats on average) are all French domestic routes, a market in which inter-airline competition is negligible.

There are those who would like to solve congestion by raising average aircraft size. This is a threat to corporate aircraft operators who need slots at major airports. It is also a threat to regional carriers with turboprop and small jet aircraft who see their prime function as the feeding of hubs.

The threat comes partly from governments who want to see passenger traffic on routes of under 400 miles diverted to railways. Such policies attract environmentalist support, and may be seen as a convenient way of avoiding ATC investment in favor of already heavily subsidized railway systems.

Though trains can undoubtedly take traffic from airlines (look at the Paris-Lyon route when the TGV service began) they are not sufficiently flexible to do so on a large scale. Market research by Airbus Industrie has thrown doubt on their ability to divert traffic in this way.

A more serious threat to operators of smaller aircraft comes from charging policies. Eurocontrol is moving towards the concept of an enroute navigation charge per movement, rather than one based on gross weight. Some airport operators are also moving this way.

The logic is self-evident. The cost of handling a Falcon or a Saab 340 is not much different from that of handling a Boeing 747 or an Ilyushin Il-76. The airway and runway capacities needed are not so much different either.

Small aircraft are under threat in other ways. Duesseldorf Airport, to take just one example, plans to restrict aircraft under 40 tons gross weight.

Clearly, you can solve congestion problems piecemeal with rules and regulations, but you may shift the problem somewhere else. You will certainly develop an air transport system that does not serve the community as well as it should.

The following is an example of how airport and enroute charges affect different aircraft types. It is based on notional seating capacity, and on charges levied in French airports/airspace in 1988 for flights from Paris to the two destinations shown. The figures may be a little out of date, but the point is that treatment at present is fairly evenhanded between the airliner types, if not the corporate jet.

Airport Capacity

Airport capacity breaks down into three main areas. (Each of them separate, but—do not forget—all links in one chain.) They are:

- Runway/taxiway capacity;
- Passenger terminal capacity; and,
- Landside access capacity.

With regard to the first two, here are just one or two encouraging developments:

- Check-in terminals that allow the agent of any airline to configure a common-user, check-in terminal to his or her own company's standard;
- Smart cards to get you through passport control—just introduced for Dutch citizens at Schiphol, but perhaps a sign of things to come;
- The automated ticket and boarding pass (here is a case where the airlines took a long time to get their act together and agree on a standard); and,
- Constantly improving rail services to get you to and from the airport quickly.

One negative point: The EEC must resolve remaining doubts about passport requirements for intra-community travel. At the moment, it looks as though airports will have to reconfigure their terminals to provide an international channel, a domestic channel and an intra-European channel that is duty-free but does not have customs and immigration, except that some member countries such as the United Kingdom may still require passports and some countries may remove the passport requirement sooner than others.

Customs controls are due to end on Jan. 1, 1993, and passport controls two years later. But the Schengen group of countries within the EEC plans to take passport controls off in early 1993.

The airports have said for years they need time to remodel their terminals, but at the 11th hour they are still in the dark about exactly what is needed. It is a mess.

Runway Capacity

In terms of runway capacity, be aware of work in progress in the United States, for example, in the areas of independent approaches to closely-spaced parallel runways, approaches to converging runways, development of radars with a high data-refresh rate for accurate surveillance of final approach and automated aids to approach sequencing.

Consider too, why declared runway capacity is typically lower in Europe than in the United States? There is certainly a cautious attitude in some quarters, which may be a good thing.

To quote from the deputy controller of the U.K.’s National Air Traffic Services, a couple of years ago: “I would counsel caution on the operational acceptability and safety of such operating modes as simultaneous use of cross runways, and even in some circumstances of simultaneous parallel operations. Theoretical studies are very different from real aircraft operating at separation minima for 16 hours a day in a crowded environment.”

The following are the highest and lowest runway capacities among airports studied in the IATA/SRI study of European airport capacity:

Single:	Parallel:	Converging/ Intersecting:
Gatwick 41	Munich 274	Zürich 60
Stansted 20	Palma 30	Lisbon 22

The possibility that smaller aircraft may get regulated or priced out of busy airports need not be the case. Regional airliners have individual characteristics that distinguish them from the larger aircraft with which they mix at airports. At some U.S. airports, procedures are available that harness these characteristics. Europe has been very slow to follow the U.S. example.

With a few exceptions, regional airliners are not short takeoff and landing (STOL) aircraft; but they can operate from quite short runways. They can also execute steep approaches of up to 6 degrees. London City Airport, its runway recently lengthened to 1,199 meters, is an example of an airport built specially for these aricraft; in fact, it cannot be used by most jet types (the BAe 146 is the exception).

Turboprops can achieve a steeper climb gradient in the initial departure stages, and can turn off the center line early. In other words, they can break quickly out of the big jets’ departure pattern, and free it up for the next takeoff.

The concept of separate approach and landing system (SALS) owes much to the work done by de Havilland Canada when it had an excellent STOL airliner, the Dash 7, to market.

Zürich Airport has recently carried out trials of SALS, and the results are now being analyzed. In these trials, a separate approach procedure for regional aircraft was established to runway 28. At a point 8.1 nautical miles (nm) from touchdown, and at a height of 6,000 feet, the aircraft enters a 6-degree glideslope. Two miles from touchdown, the glideslope flattens to a more normal 3.5 degrees. Its approach is independent of traffic on other runways.

The steep glideslope capability of regional airliners may be utilized in other ways. For example, where parallel runways are closer together than 1,525 meters, fully independent procedures are not permitted, and an element of diagonal horizontal separation must be introduced. But suppose that a heavy aircraft, say a Boeing 747, is approaching on one runway, and a light turboprop on the other; and suppose that the turboprop remains higher than the Boeing 747, concluding its approach with a 6-degree glideslope. It may well be safe to reduce the horizontal separation between the two.

Wake turbulence is a big problem, of course. Like the sonic boom, it is something we have to live with, at least until we can learn to modify the laws of physics. But by plotting and forecasting wake vortices, we may be able to predict them sufficiently well to be able to reduce separation.

In this connection, there is research taking place at Frankfurt Airport, where the airside congestion problem is particularly bad, and where the main parallel runways are only 518 meters apart. The minimum separation for wake turbulence protection on staggered approaches is 2.5 nm.

The turbulence (vortex pattern) is influenced not only by aircraft type and weight, but also by wind and atmospheric stability. Researchers at Frankfurt have studied the movement and decay of vortices during the landings of more than 1,000 medium and heavy aircraft, using an array of anemometers, including a laser doppler anemometer.

The aim of this work, which has so far been funded largely by the airport authority and Lufthansa, is to develop a wake vortex prediction system. The researchers say that it will become practicable to predict the vortex pattern 20 to 30 minutes before the aircraft producing them lands.

The result, it is hoped, will be a reduction in separation standards. Following a validation process this year, involving real-time simulation, the system is due to be in place next year, and fully operational in 1995.

Closely allied to the vortex prediction system is Frankfurt's COMPAS, an automated approach sequencing tool for controllers. Approach sequencing systems have been studied for many years on both sides of the Atlantic, but are only now beginning to find their way into active ATC units. I believe I am correct in saying that COMPAS is the only one in Europe. The United Kingdom did a lot of work in this area many years ago, but abandoned it, because the computer in those days was not very good at beating an experienced approach controller at his or her own game, but chiefly because the problem did not seem pressing.

Concrete, Bricks and Mortar

May will see the opening of Munich's second airport—the first major airport to be opened on a green-field site in Europe since Paris-Charles de Gaulle almost 20 years ago. Unfortunately it does represent a net capacity increase, because Munich's existing airport at Riem will close the day the new one opens.

Given today's environmental pressures, there is not much prospect for more airports like that in Europe. What about existing ones?

Experience shows that those airports with space to grow, and farsighted enough to provide for expansion and implement their plans ahead of demand, have an enormous commercial advantage.

Amsterdam-Schiphol is a case in point. Paris-Charles de Gaulle is another. These two airports are investing heavily to keep abreast of demand. Aeroports de Paris plans to invest Fr3.2 billion ($600 million) this year, much of it at Charles de Gaulle Airport. At Schiphol, the investment program involves $2 billion during 10 years.

Elsewhere, the situation is less happy. One of the airports giving most cause for concern is

Madrid-Barajas. When IATA conducted its capacity study, it noted that no master plan for Madrid-Barajas was in existence, and that it would have a 50-percent capacity shortfall by 1995.

This still appears to be the situation. A "pre-master plan" proposes comprehensive redevelopment of Barajas and the adjacent military base, but (as of mid-February) no decisions appear to have been made. Spain has a newly formed airports and ATC agency, which, one hopes, will be able to give matters some added impetus.

The IATA study found that 11 out of 27 major European airports would be out of capacity by 1995 if nothing were done. Some of them are doing something: Frankfurt, which was the worst placed after Madrid, has an enormous capacity enhancement program, with a new terminal under construction. But even with planned improvements, IATA still put eight of the airports as short of capacity by the year 2000. That study was made before the events of 1991. But even if the problem has been postponed, it has not gone away.

The effects of commercial and economic policy on airport congestion cannot be ignored. Last year the British government removed long-standing controls on airline access to London's Heathrow Airport, which had effectively excluded charter airlines and some important scheduled airlines, including American and United.

The immediate result was a rush to transfer from Gatwick to Heathrow. The lesson is that where you have an airport, such as Heathrow, with a huge range of destinations to offer, it will prove a honeypot and the airlines will swarm in if they can, however bad the congestion.

Slot allocation is an important topic. For now note that the EC has been looking at an allocation system, and trying to reconcile the need to ration slots in some way with the need to let competition develop and let start-up carriers gain a toehold.

The U.S. philosophy of trading slots for money is not popular in Europe, where the view prevails that a slot is in some way public property to benefit the public interest. The outcome of the EC's deliberations is supposedly imminent, but the show will run a little longer yet.

ATC Structure

Communications shortcomings are a worldwide problem, yet without good communications, and good data interchange, no airspace infrastructure can function properly.

Banks can transfer money around the world at lightning speed; a terminal on a check-in desk in Tokyo can constantly update a computer file on a departure control system in New York or Frankfurt. Yet many ATC units around the world operate with indifferent telephone lines, and some controllers are reduced to talking to each other via high-frequency (HF) radio mobile frequencies intended for air-to-ground use. All this at a time when a carrier such as Singapore Airlines can introduce satellite telephone service for its passengers.

We see overloaded very-high-frequency (VHF) channels, bad HF links, and an AFTN (aeronautical fixed telecommunications network) that is equipped, in many parts of the world, with low-speed teletype circuits, circuits that should be there but are not, and even (I am told) Morse code links.

The advent of NADIN (North American Data Interchange Network) in the United States has applied modern digital high-speed communications technology to the AFTN. It must be well over 10 years since the International Civil Aviation Organization (ICAO) formulated the international equivalent, CIDIN (Common International Data Interchange Network). What happened to that? I believe, it is operating only in a limited area of Europe.

Datalinks

I once saw a demonstration of a datalink for ATC use. Remarkably, it was given by the Decca

Navigator Co. at the Farnborough Air Show about 25 years ago.

It is symptomatic of the neglect of the airspace system during the intervening years that the datalinks now being used in some ATC programs were developed commercially by the airlines for their own operational traffic by Société Internationale de Télécommunications Aeronautiques (SITA), Aeronautical Radio Inc. (ARINC) and Air Canada's own system.

Unlike some systems used by European control authorities, these three systems are compatible. Apparently, that is what commercial expediency does for you.

Mode S secondary radar will be the basis for an operational air-ground datalink, and the European Civil Aviation Conference (ECAC) objective is to upgrade monopulse radars to Mode S during the period 1995-2000.

It is clear that Europe's fragmented airspace system, with its 44 enroute ATC centers (compared with 20 in the United States), is at the root of the area's airspace problems. These 44 centers are operating 22 systems, not necessarily compatible with each other. According to 1988 figures, one of these centers handled more than a million flights in that year; three handled between 600,000 and a million; and 17 handled between 300,000 and 600,000.

Not long ago, the task of welding together these diverse ATC systems, all planned and developed in virtual isolation from each other, seemed a hopeless one. Now, thanks to the great political awakening, the ECAC countries have acted, and have put the task of restructuring the system in the hands of the European Organization for Safety of Air Navigation (Eurocontrol), which acts as project manager.

How much easier it might have been if Eurocontrol had been allowed, when it was first established, to assume its originally intended role as supra-national control authority. But in those days, political priorities were elsewhere, and some countries, the United Kingdom and France in particular, would not surrender airspace sovereignty.

That is history. At the moment, we still do not have universal agreement about how to go about setting up an international control system.

ECAC's approach boils down to coordination and harmonization of the existing national ATC systems. Before ECAC adopted its present policy, the Association of European Airlines (AEA), representing the flag carriers, called for establishment of a single international control authority in Europe. The EC has taken up a similar standpoint.

The ECAC ministers concluded that such an approach would be impracticable, not least because of the urgency of the situation. Thus a rift has developed between the EC and ECAC. It remains to be seen whether this rift has any practical significance.

It looks to me as though the ECAC/Eurocontrol plan of action has these advantages:

- It is backed by greater ATC expertise;
- It represents the whole of Europe, including the former Warsaw Pact countries, and not just the EC;
- It is probably the most practical plan for the relatively short term; and
- It is already up and running, albeit at an early stage.

ECAC objectives for the European ATC system are the following:

1993 (onward) Optimize route network and airspace structure.

1995 Deadline for comprehensive radar coverage throughout the area.

1995 Deadline for implementation of five-nautical mile (nm) enroute separation in high-density areas; 10-nm separation elsewhere.

1995 Deadline for harmonizing ATC systems in high-density areas, deadline 1998 elsewhere. Begin the process of integration.

1998 Deadline for automatic data transfer between air traffic control centers (ATCC).

1998 Begin implementation of Mode S-based datalink in central areas.

Denmark's director of civil aviation, Val Eggers, who is playing a leading role in getting the ECAC/Eurocontrol effort going, has suggested that the two opposing EC/ECAC strategies may come together, probably at the point when ECAC formulates an all-new ATC system for the next century. We may get a single system in the end.

Meanwhile, we soldier on with a fragmented airspace. A practical problem is the way in which longitudinal separation standards vary from one flight information region (FIR) to another. In northern Europe, five to 10 nm is the norm.

As you go south, the separation becomes greater, and 30 or 60 nm may be applied in southern Europe and the Mediterranean area.

While the reasons—notably lack of radar, particularly secondary radar—may be understandable, the effect is not acceptable. Take a busy route across Europe from northwest to southeast. Other things being equal, its capacity is obviously determined by the segment with the most restrictive separation standard. The main directional traffic flow in Europe is aligned in this way.

Lack of radar may be due simply to a lack of money, and here we come back again to political priorities. There are a few hopeful signs. The Greek government, in whose airspace some restrictive separation has been applied, has signed up with Thomson CSF for a major radar modernization program, and this is now under way.

Satellites

The work of ICAO's FANS (Future Air Navigation System) Committee, and its endorsement by the 1991 ICAO assembly, has secured a place for satellites in aviation.

Airlines—perhaps corporate operators, too—that use oceanic routes are beginning to experience the effects of congestion. United Airlines' Pacific routes are suffering already. It seems likely that the Asia/Pacific region, with its vast over-water distances and its high traffic growth, will also become a problem area.

With no radar cover practicable in oceanic areas, separation standards are very conservative. As a result, preferred slots, flight levels and routings are not always available, and an economic penalty results.

There are great hopes that automatic dependent surveillance (ADS) will do for the oceans what radar is doing for the more populated land areas. ADS involves the extraction of position and altitude information from the onboard navigation system, and its transmission by satellite datalink to the relative ATCC. There, the information can be displayed to the controller on a display somewhat resembling a radar plan-position indicator.

ADS offers the prospect of frequent, automatic position reporting, without intervention (unless needed) by the flight crew. Ultimately, direct voice communications between controller and pilot will be possible, and HF radio will become a thing of the past. The potential benefits of ADS include reduced separation standards, that will lead to less congestion, and to ready availability of the most economic routing and flight level.

You are in mid-Atlantic and you want a change of flight level. How long does it take to process that request now? (One U.S. Federal Aviation Administration official said recently that it takes 15 minutes on average just to establish HF radio contact.) Imagine, in the future, a direct voice contact with the controller, who sees conflicting traffic on the ADS display. He or she switches the ADS display up to a high refresh rate and steers you around the traffic just as with radar.

That scenario remains in the future. But ADS is being evaluated now in the multinational Pacific Engineering Trials program. What has made it possible to get even this far, and do so economically, is the existence of the communications satellites, operated by International Maritime Satelleite (Inmarsat), and the datalinks, operated by ARINC in the United States and SITA in Europe.

Oceanic control does concern corporate operators, though not regional airlines. In the future ADS may become a surveillance medium in such areas as the Mediterranean, Africa, and even farther afield.

It will never be a substitute for radar. But look at all the places where there is no radar, and all the places where there probably never will be radar because of the areas to be covered and the investment needed. ADS may not be a great anti-congestion aid in Europe, but in the future and elsewhere in the world—not just in oceanic areas—it could be.

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Can You Afford Not to Do Crew Resource Management?

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In the recessionary and highly competitive atmosphere of today, economics dictate that aircraft operators reduce costs wherever possible. Only the lean and mean will survive. Especially impacted are the smaller aircraft operators. Regrettably, in many instances, the first target for cuts is training; and under further scrutiny, the need for crew resource management (CRM) is questioned. Yet, that very action may impair the development of personnel and increase the risk of a costly flying error.

CRM encompasses training in the flight deck management and utilization of crew, technology and information.

Can you afford not to do CRM?

The Need

From Greek mythology we learn that Icarus ignored his father's warning by flying too close to the sun. As a result, the wax that held his feathered wings together melted, and Icarus fell to his death in the sea. In 1896, Otto Lilienthal made the wrong decision to demonstrate a glider in blustery wind conditions to a crowd of eager onlookers. The glider stalled into the ground, and Lilienthal died the following day.

In 1940, it was calculated that 75 percent of aviation accidents had human performance as a contributing factor. Some 35 years later, the International Air Transport Association (IATA) determined similar findings, and today, a quick assessment of the recent air accidents reveals little has changed.

From a scan of the history of aviation, it is clear that airframes and engines have improved dramatically in performance since the advent of flight. But has the human element shown parallel advances?

The answer is an emphatic "No!" and it is apparent that there is an urgent need to learn more about the subject of reducing human performance-related errors.

The general public and insurers have also noted the need, and aviation authorities around the world are on the brink of introducing legislation to require CRM training as a part of a pilot's essential education.

CRM Availability

Since the introduction of CRM, it has been researched and developed into a family of courses having varying lengths and contents. In the United Kingdom, there are four main companies that teach the subject on a commercial basis, while in Europe, the list of training organizations is correspondingly small, and predominantly confined to the main carriers.

The Benefits

In determining the benefits of CRM training, a department's objective should be carefully considered. If you require that a crew member needs to change a behavior pattern, then it should be realized that a short course will not achieve the desired outcome. Ideally, behavioral training should be taught at the flying or maintenance school phase, and then periodically reinforced. This is likely to be beyond the financial means of the smaller operators. However, a short course will allow a candidate to achieve an awareness of pertinent topics, and, as Dr. Clayton Foushee noted in his research, that is the thrust of most CRM training today. Indeed, that is also likely to be the direction of legislation in the aviation industry.

As recently as October 1991, Dr. Giselle Weisman remarked that although CRM was popular, it had not achieved the desired outcomes. According to research conducted by Helmrich et. al. (1989), in a sample of almost 1,500 persons who had attended CRM training, approximately 72 percent indicated that the training was either "very" or "extremely" useful. However, only about 44 percent of the same respondents felt that their behavior would undergo a "large" or "moderate" change on the flight deck.

An in-depth examination of the commercial courses available is likely to reveal that they are constructed for generic audiences, and they do not necessarily address the major human factors problems experienced by a pilot from a specific organization.

The results, therefore, appear to have questionable benefit for the money-conscious operator, especially considering that the cost of sending crew members to a program may exceed $3,000 per person.

There is clearly a need for CRM. But, for it to be more effective, new techniques and information must be utilized.

It must be recognized that *we* must make the changes on the flight deck, through appropriate CRM education, or laws will mandate changes for us. Those changes might be more expensive than if we had used effort and innovation at the start.

In-house Training

As a result of the preponderance of human factor-related accidents, and the corresponding legislative thrust, the need for CRM has been established. For the cost-conscious operator, consider in-house training. Capt. Harry Orlady (1985) revealed at the Ohio State University Symposium on Aviation Psychology that "there is no reason that relatively brief seminars or workshops, developed by in-house personnel and, if necessary, supplemented by outside help, could not also accomplish a great deal."

There are three advantages to "homegrown" courses: potential cost savings, ability to address the organization's problems and the ability for follow-up action.

Cost Savings

Assuming a dedicated instructor's salary of $60,000 per year, it will only require the training of 20 crew members to recover the costs. If existing personnel are used in the instruction role, the savings are greater. Another alternative is to pool resources with another corporate or regional operator.

Address the Problem

Conducting your own training allows unit problems to be addressed directly, and department objectives to be pursued. An internal instructor is likely to have a detailed knowledge of the students, and therefore the instruction can be applied to suit the needs. I have had the privilege to conduct CRM courses in six countries, spanning Africa, the Far East and North America, and the training emphasis has varied in each location. In these venues, I have been confronted with major cultural philosophies that respect elders to the extent that they are assumed to be correct and should not be questioned, tribal concerns over the status of individuals, performance effects as a result of religious beliefs, and the clashing of egos in an operation where two captains frequently fly together. Each problem should be approached in a different way, and I believe that the inhouse program facilitates this.

As a current consideration, Western Europe is heading towards integration, and stronger relationships with Eastern Europe. As a result, more carriers and corporations will be involved in joint ventures. Indeed, we are already seeing the integration of the ex-East and West German aviation bodies and the development of joint interest aviation projects in the Commonwealth of Independent States (the former Soviet Union). What problems will arise as a result of integrating crews from very different cultures? Is this an example of a need for a specific type of CRM?

Follow-up

Attendance at a commercially available CRM course is invariably a one-time affair with little or no post-course review. An internal instructor can continue to advise crew members, assess crew performance and can make adjustments and improvements in course content in response to those evaluations.

Guidance for the Syllabus

How do you prepare a training syllabus?

As recently as February 1992, a spokesman from a major European carrier indicated that they are still "feeling their way" with regard to course content, and it is apparent that aviation authorities are only able to provide general guidance.

However, you should initially consider proposed legislation from your authorities and then review the International Civil Aviation Organization (ICAO) recommendations that are described in the *Human Factors Digests*. A determination of departmental objectives on training and an evaluation of weaknesses may give pointers to course content. As indicated earlier, if long-term behavior changes are required, they can only be achieved through long-term training, preferably conducted at the beginning of the aviation career. Alternatively, if the objective is to increase crew awareness, a short course might be appropriate.

An examination of air accidents findings reveals source suggestions for a syllabus. In the spring 1979 issue of *Flight Crew* magazine, Arnold Reiner suggested that management should stress the fallibility of humans and train for it. Following the Air Florida crash in Washington, D.C., 10 years ago, the U.S. National Transportation Safety Board (NTSB) recommended that pilot training programs should include instruction in command decision, resource management, role performance and assertiveness. John Lauber, Ph.D., member, NTSB, in a report of the Northwest Airlines Flight 255 accident at Detroit in 1987, advocated the value of teamwork as opposed to individual performance.

When planning a CRM syllabus, we should not be distracted from the fact that much of the content should relate to general management practices. The management styles utilized in the office are equally appropriate in the crew environment, as are the values of group decision-making, good communication and attention to sensitivities. It follows that commercially available management training models and exercises may be readily adapted to the aviation environment.

I make use of a decision-making exercise that provides indelible illustrations of human fallibility and group synergy.

For the department pioneer, there is the comforting thought that there are professionals in the CRM business who are willing to assist you in your cause. I have been amazed and encouraged by the maturity of CRM instructors who value aviation safety over commercial secrecy. Many are willing to exchange information, manuals, and experiences.

One area of CRM that is relatively unexplored is that of excellence in aviation. We tend to concentrate on the negative and forget examples of excellence that, if emulated, would lead to a safer flying environment.

A look at the achievements of Capt. Gordon Vette of Air New Zealand, in his quest to find a Cessna lost over the Pacific Ocean, proves examples of CRM rarely considered. Vette optimized his resources by seeking the assistance of a flight navigator traveling as a passenger, and provided new insight into levels of professional knowledge, teamwork, innovation and the way in which information should be processed. In particular, Vette's healthy skepticism about the accuracy of one source of essential information is an example of resource management that is a lesson to the too-trusting aviator.

In another example of excellence, one can mention the actions of a first officer on a flight from Denver, Colorado, to Boise, Idaho, following the incapacitation of the captain. After the captain was removed from the left seat, the first officer placed a cabin attendant in that seat, and briefed her on the use of the nose wheel steering, should it be required. In the meantime, he made optimum use of cabin crew, passengers and ground resources to care for the captain.

Conclusion

The history of air accidents clearly indicates a need for CRM. There are few commercial organizations that provide CRM training, and the success of those courses is by no means guaranteed. There is a need to develop new and better ways of imparting the subject, before legislation compels more expensive solutions.

In a recession-ridden environment, consider the advantages of conducting the training inhouse. This offers the potential to maximize training value while reducing costs and to even achieve a marketable commodity. To develop a course, resources might include ICAO and pending aviation authority recommendations, accident reports, management literature and CRM specialists. However, do not concentrate only on accidents and mistakes for your learning platform. Incorporate examples of excellence that can be copied.

To the question, "Can we afford not to do CRM?," the answer is a resounding "No!" Otto Lilienthal's last words were "Opfer müssen gebracht werden" (Sacrifices must be made). Yes, sacrifices of budget and sacrifices of numbers of personnel may be required, but ensure that those sacrifices do not extend to the disregard of CRM training!

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Airport Pricing Policies — What Can Be Done?

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Safety is a vital issue to airport management. It is an issue that is inextricably linked to another vital issue—airport pricing policies.

At AACI, we look closely at these links (at how different areas impact each other) to provide the most thorough and current analyses for optimal airport management. Born on Jan. 1, 1991, AACI brought together the experience and expertise of the previous two international airport associations, the Paris-based International Civil Airports Association (ICAA) and the Washington-based Airport Operators Council International (AOCI). AACI has a membership of more than 400 airports in 110 countries. These airports range from the largest in the world—Chicago, London, New York and others, handling many millions of passengers—to small regional airports primarily serving general aviation and short-haul services. The safety environments for these airports range from the crowded skies over Europe and North America to the harsh climatic conditions of the jungle and the desert in Africa and Asia. The AACI network also has to face security problems associated with regions and peoples in conflict.

AACI represents the global airport community and the many international organizations that influence air services, including the International Federation of Air Line Pilots Association (IFALPA) and the International Federation of Air Traffic Controllers' Associations

(IFATCA). From its Geneva headquarters, AACI interfaces with the International Civil Aviation Organization (ICAO), the International Air Transport Association (IATA), and many other governmental and non-governmental organizations.

Policies are developed on airport safety and pricing, among other things, by drawing on the expertise of our member airports, supported by AACI specialized committees and staff, including the chief of technical and security affairs in Geneva, Peter Wilkins, formerly director of safety and security at the British Airports Authority (BAA). By networking with related agencies and organizations, AACI acts as the "voice of airports" in coordinating and linking efforts to provide air transport that is secure, efficient, and compatible with the environment.

At first glance, the connection between airport safety and pricing may not be obvious. At most airports safety and pricing are covered by different departments, and might even be in different locations—with the safety department members in the operator's office somewhere under the terminal and finance on the 23rd floor of a downtown office building.

The key to this connection is flight safety. It is the single overriding concern of professional airport managers everywhere. It cannot be traded off against any other priority. Therefore, the issue in relation to airport charges is simply how to make sure that the way we charge does not threaten flight safety and supports improved safety wherever possible.

First, airport prices must be set so that they generate enough revenue to provide high-quality safety services. These services are not cheap. Consider a major airport. The airport manager may have to maintain up to 17,000 runway and taxiway lights. He may have to ensure the strength and stability of more than three million square meters of runways, taxiways and stands. He will have to provide twenty-four-hour fire coverage including six or more foam tenders, costing $700,000 or more. These services must be paid for, and a source of revenues is airport charges. Airport charges average only 3.5 percent of the airline operating costs, lower for long-haul traffic and higher on short routes. Given the range of facilities in place at many airports, these charges are surprisingly low. However, the same charges sometimes constitute more than 50 percent of the airport's total revenues, the other portion coming from the different commercial activities of an airport such as duty-free sales and rental of premises and land.

At a major European airport, operators typically pay around US$10 per passenger for services that include not only safety and security, but also the full-range of airfield, terminal and infrastructure access at the airport. Even at the busiest airports in the United States you can still land a private light aircraft for a few dollars. Airport mangers are under constant pressure from airlines to reduce fees, but the baseline is that they must have enough money to supply high-quality safety services.

It just will not do for revenues to be forced down where airports can provide only the minimum measures necessary to meet national and international specifications. To do so would both decrease the current trends of services and reduce the ability of airports to undertake research and development for future improvements.

Future increases are likely in both the quality and the cost of airport safety. New technological advances, such as microwave landing systems (MLS), and increased requirements for safety and security will bring benefits, but at a monetary cost. Enhanced airport security will impose additional costs on both airports and airlines. A major airport operator may spend $700,000 or more on research and development for new security equipment. Although airports will try to introduce these services as efficiently as possible, they are bound to have an impact on charges. In these circumstances, a continued expectation by aircraft operators that airport landing fees should fall would be unreasonable. It will be more productive to focus on managing increases as carefully as possible and to remove from airport charges, the charges that are related to air traffic control (ATC).

A particular problem is the purchase of safety equipment by developing countries. There is a generally held view by airlines and by the ICAO that airports in these countries should be required to charge them in the local currency, rather than in hard currencies. However, safety and security equipment, and technical services can only be bought from Europe, North America and Japan in convertible, hard currencies. Since there is an acute shortage of hard currency in many developing states, AACI and IATA have both agreed that hard currencies may be used for charging in these circumstances.

A second link between charges and safety is through specific charges for safety-related equipment and services. An example would be an additional charge for the use of runway lights, or baggage screening equipment. These services are vitally important and they must be paid for by their users. However, to charge separately, depending on whether the service is actually used on each flight, could encourage operators not to use safety facilities. Therefore, the airports tend to avoid this kind of discretionary charge. AACI supports ICAO's guidelines that state, "charges should not be imposed in such a way as to discourage the use of facilities and services necessary for safety."

So, although there is a runway lighting charge at Paris, operators cannot avoid it by attempting to land by torchlight. An important point: Airports are unlikely to make a profit from landing charges.

Another difficult issue is the question of airport security charges. AACI attaches the highest possible priority on airport security. We are closely and continually involved with other international organizations in developing security standards. We also push for the effective and universal implementation of those standards by airports, airlines, and states. These standards cover passenger, baggage, and staff search, airside and perimeter protection, and other anti-terrorist measures. They involve extremely large expenditures. Searching passengers and staff at large airports takes large amounts of money, for security personnel, equipment and accommodations. The areas required for these functions also take up valuable terminal space, and create the need to redevelop and expand terminal complexes. New equipment not only costs money, there is also the matter of costly research and development, which is carried out by many major airports.

AACI shares the view of IATA that terrorist measures are normally directed against the state. An airline, airport and passengers are the hapless victims. Therefore, states should meet the costs of security. Unfortunately, in many countries, this burden is unloaded onto the airlines or airport. Where airports have to provide security, they must recover the costs through airport charges.

In these circumstances, airport users may have to accept significant security charges. There is simply no alternative if an appropriate level of security is to be provided. Of course, security standards and the operational arrangements for meeting them should be discussed between states, airports and users. However, when it falls to airports to use their skills to provide security efficiently and effectively, users should be prepared to meet the full costs involved.

There are a host of other small detailed links between airport charges and safety that must be recognized and dealt with locally.

For example, at London's airports, there is a controversial system of peak surcharging. When the peak period is about to start, cost-conscious pilots want to get push-back clearance before the peak-passenger departure hour strikes. This could potentially cause distraction, aggravation and apron congestion—all bad for safety. But, there is a solution. The people at Heathrow have fixed their peak to start not at the time of push-back, but at the departure time scheduled in advance, so nothing is gained by hurrying.

Other issues arise at other airports but they all lead to the same messages:

- We all need the very best in security and safety.
- We are going to have to pay for it through airport charges.
- We need to make sure that our pricing policies can do the job properly.

Airport operators need to consult with users to work out the best ways of paying for safety. Nothing else is good enough for the traveling public and the aviation industry.

Harmonization of Rules — Is It Working?

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The International Federation of Airworthiness (IFA) has existed for more than 15 years. It currently has about 125 members — manufacturers, airlines, regulatory authorities, maintenance organizations, consultants and professional societies. It has a strong broadly-based international flavor and is positioned to become increasingly influential in airworthiness matters.

To this end, IFA has worked together with the Flight Safety Foundation (FSF) to sponsor jointly initiatives for the 1990s. Five "white papers" have been produced, they are:

Continuing Airworthiness Assurance

World Aviation Standards

Standardization of Airworthiness Records for Transfer of Aircraft

Improving Aviation Safety with Current Technology

Human Factors

This paper, "*Harmonization of Rules*," is based on *World Aviation Standards*.

General

The IFA immediate past president, Joe Sutter, vice president of Boeing and whom many of you will know as the father of the Boeing 747, has often been heard to say, when talking about harmonization, “We should stop worrying about the rules and worry more about airworthiness.”

It should be possible to travel by air anywhere in the world with the same level of safety and at a cost that is both competitive for the user and on a fair and level plain for the provider.

Background

Harmonization of course is not new. The International Standards for Commercial Air Transport was introduced by the provisions of Article 37 of the Convention on International Civil Aviation in Chicago in 1944. The International Civil Aviation Organization (ICAO) Annexes were developed for all main subjects, stating recommended practices and standards to be achieved by all contracting states. Of course, these annexes did not provide detailed codes of practice or operational rules. This was left to individual nations to establish through their own legislative process.

Only two nations developed their own codes: the United States through the U.S. Federal Aviation Administration (FAA) Federal Aviation Regulations (FAR) and the United Kingdom British Civil Airworthiness Requirements (BCAR). Other nations accepted one or other of these codes and modified them to suit their own requirements. Unfortunately, through the years differences appeared.

Winston Churchill is reputed to have once said that America and Great Britain were two great nations divided by a common language. It would be easy to blame all our problems on this old adage. However, it is not as simple as that, although I am sure that different cultures do influence the situation and have a bearing on the solution.

History

The rules that were developed after World War II were not “bad rules.” They were the best that fair and reasonable people could produce. They certainly produced a high level of safety in a rapidly developing industry. Unfortunately, it was this very development that brought into visibility the differences in the rules which had evolved.

After the war and certainly during the 1970s, British operators found that when purchasing aircraft from abroad or leasing them across borders they were faced with special conditions for certification, even on types with a long satisfactory history in their own country. Some of these were small, but many were not so small.

In the large transport aircraft many of the special conditions were embodiments of bulletin rework instead of inspection. Some of the decisions were a bit arbitrary. Airworthiness notices and air navigation orders (ANO), of course, had to be addressed. One item that always seemed farcical was the changing of seat belts because of buckle angle problems. It would be interesting to see if anyone can produce the original case for this and to inquire if the other 80 percent of the world’s aviation has experienced similar problems. In other words, was it a one-off which is no longer valid? Of course, the big bucks were spent when we had to go back to the manufacturers for substantiation of the original certification and the inevitable flight manual amendment to U.K. Civil Aviation Authority (CAA) rules.

Fatigue life is a very important issue with currently wide differences between FAA and the Joint Aviation Authority (JAA). If the harsher rule of a factor of five is adopted as the harmonized one, it could cut the life limit on aircraft components by 40 percent. Yet in spite of Airbus Industrie and the Boeing Company considering this unnecessary, the FAA/JAA working group is leaning toward adopting the most stringent standards.

The general aviation (GA) side of the business has been particularly hit by this process. Typically, the special bird-proof windscreen and structure requirements on executive jets have produced extra costs on new and used aircraft requiring U.K. certification. This requirement has spread from the FAR/Joint Airworthiness Requirements (JAR) 25 rules. The merits or otherwise of this can be argued by many learned and highly technical bodies (and often is). However, many believe that there is no clear evidence that bird strikes are any more catastrophic in the United Kingdom than any other country. Going from the sublime to the ridiculous, the FAA is considering changing the FAR 25 rule to require a windshield able to resist the impact of an eight-pound bird.

These special conditions later became national variants. These have now disappeared. We now have hidden national variants. It seems that when any authority looks at harmonization of standards it takes the most stringent requirements as the baseline and attempts to convince its partners that this must be safer. This is not necessarily so. Unfortunately, this view is not shared by the FAA and JAA. In most cases, it seems specialists from the FAA and the JAA are not willing to compromise their positions and adopt the most stringent standards as a "harmonized" standard.

The FAA and the JAA are not the only authority to think this way. At the IFA conference in Toulouse in November 1990, the delegate from the then Soviet Union reported that they had compared their rules with the FAA and found many similarities. However, when their own rules were more stringent they would of course adopt them.

The European Scene

Within Europe the countries in the JAA, the European Commission (EC) and Eurocontrol are all drawn from the European Civil Aviation Conference (ECAC) membership. The ECAC is a subordinate body of the ICAO, comprising 28 countries, all of which could join the JAA system although currently only 19 are involved. Twelve of these are in the European Economic Community (EEC). (See Appendix 1.)

The ECAC was conceived by the Council of Europe and was aimed at achieving the greatest possible degree of coordination in inter-European air transport. The ICAO was asked to undertake the task of arranging the original conference. The ECAC still works in close liaison with the ICAO and uses the services of the ICAO Secretariat. The ECAC has Economic, Technical and Facilitation Committees, and these have a number of working groups. The Technical Committee is of relevance to safety regulation and currently has groups on operations of aircraft, general aviation accidents, flight-crew licensing, accident investigation and off-shore helicopter operations. The ECAC has no executive power but useful cooperative work is done. Much of the technical safety work is now transferred to the JAA forum, including the work relating to the harmonization of flight-crew licenses.

JAA is an associated body of the ECAC. This status gives the JAA a recognized position internationally. There is careful collaboration and coordination of the technical work in the two bodies. The director generals (DGs) of the JAA board are those who have direct responsibility for the aviation authorities in their own countries with the exception of the United Kingdom. The fact that Parliament decided to set up the CAA in the United Kingdom, as an independent body means that the U.K. DTp director general has no responsibility for the CAA; the sponsoring department in DTp is the CAP (Civil Aviation Policy). In practice, this does not cause problems as DTp always consults CAA before commenting on JAA matters.

How Is this Funded?

The JAA committee have agreed to the principal of full cost recovery. However, most JAA countries are state funded and cost recovery is via a ticket tax or a levy.

It is proposed to charge for JAA services as used, which means that manufacturer and operators will foot the bill. This aspect of JAA is likely to be both political and controversial to industry. IFA support the philosophy that this activity should be government funded and that to give a worldwide level playing field, industry should not be charged.

Harmonization of Technical Requirements and Procedures

The JAA work started in the early 1970s and was then concerned only with cooperation on, and the acceptance of, airworthiness requirements for the certification of aircraft, products, engines and components. This was formalized in arrangements signed in 1979 by 11 countries. These were superseded by a Memorandum of Understanding in 1989 and, currently the Arrangements of Sept. 11, 1990 have now been signed by all 19 countries.

Since the early 1970s, the requirement activity has expanded to cover maintenance, operations and, through the ECAC, flight-crew licensing. The present position on JAR is shown in Appendix 2.

The process of harmonization has progressed over the years and in support of that progress, the EC issued Regulation No. 3922/91 making JAR the sole code for all EC countries.

The EC Regulation on the Harmonization of Technical Requirements and Procedures came into force on January, 1992. It adopted those JARs that were in force on that date and makes provision for the EC to submit proposals on further technical requirements and procedures to the council for inclusion in the regulations. It is expected that the commission will put forward new JARs when they are adopted by the JAA, but they are not committed to doing so. A very important item in the proposed regulations is that "national variants" are not allowed. This means that a state will not be able, unless it can persuade the majority of other states on safety grounds, to change a rule to be applicable only to them. This could create inflexibility particularly after an accident where it appears necessary to introduce a change. There is, however, provision for authorities to take immediate action and report the circumstances to the commission and other authorities subsequently.

This regulation does not include the mutual acceptance of pre-JAA certification aircraft until the JAA has developed jointly accepted standards for them. These aircraft will not be required to undergo recertification by the JAA to JARs, which may not be practically possible for a number of reasons. They will continue to operate on their respective registers. Should aircraft be transferred from one member state to another it will be up to the importing country to state its certification requirements (nothing new). It may be that the original certification standard is acceptable. However special conditions are bound to arise. It is hoped that alleviations will be given by the importing country where the appropriate JAR is less demanding.

Following various "unilateral" certifications of large airplanes to JAR-25 and "coordinated" national certifications by several countries, all applications for type certification are now being dealt with by the true joint process. Current certifications are shown in Appendix 3.

Maintenance

JAR-145 is now complete and approval of maintenance organizations is being carried out by the domestic authorities to JAA standards and procedures. The authorities will be subject to checks by an international "standardization" team. The approval should be accepted by all other JAA countries. A similar system is expected to be applied for operational supervision. It is in its early days and we have yet to see how effective JAR-145 is. The main complaint is with regard to charges.

Operations

It was decided that JAR-OPS should be based upon the structure of the updated Annex 6, but that it would be considerably more detailed in content. Like Annex 6, JAR-OPS will be a comprehensive document in 3 parts. Part 1 will cover all airplanes in Commercial Air Transport. JAR-OPS Part 2 will cover general aviation, apart from helicopters. JAR-OPS Part 3 will cover helicopters engaged in both commercial air transport and general aviation. Good progress is being made in completing these codes.

FAR-121 and FAR-91 were found totally unsuitable as a basis for structure. However, this may have created discord rather than harmony.

Appendix 4 shows the organization of the JAA (OPS).

JAR-65-Certifying Staff

This JAR is being tackled in three stages:

Stage 1.

Define the process by which certifying staff are qualified.

Certifying staff being those persons defined in JAR-145 and who will issue Release Certificates for aircraft or aircraft components. The process includes determination of the knowledge and experience requirements.

Stage 2.

Establish the means by which the Stage 1 process is controlled. This includes what, when and by whom examinations and tests will be conducted.

Stage 3.

Determine what document will be issued at the completion of Stage 2 and by whom. This is the point in time when it will be decided whether a formal license or Authorization of Approval will be issued and by whom.

This JAR is one that we await with some apprehension. So many anomalies currently exist between countries that the task of harmonization is extremely difficult.

The FAA says that it is licensing airmen to perform aircraft and power plant maintenance. CAA/JAA say they are merely giving authority to certify.

The FAA Aviation Rulemaking and Advisory Committee (ARAC)/FAR-65 Committee has arrived at a different definition of "avionics" to the JAR-65 working group. They do not include power generation and distribution. No doubt this will be sorted out but it just shows how easy differences occur.

Both authorities and industry have been working during the past 15 to 20 years on the task of unifying aviation legislation and hoping to arrive at a common code that could be acceptable to all. Much of this work is now being put to the test. It may be found wanting in many aspects but at least something has happened.

The development of JARs has progressed, and at present nine are in place, ranging from JAR-25 to JAR-145. Besides harmonization within Europe, work has started between FAA and JAA, to align various rules. This is between JAR/FAR-25 at present and will progress to other rules in the near future — not only the rules, but in interpretation of those rules. We are aware that FAA/JAA are trying to achieve more bilateral rules as well as bilateral agreement for acceptance of each other's standards without separate investigations by regulatory authorities.

The Situation in the United States

In the early days of the JAA development, the FAA appeared to take little notice of what was going on. Why should they? They had authority over the majority of the world's aircraft and operations within their own borders. There was no need to look further. There was certainly no urge to consider looking at what other nations were doing. As with the United Kingdom, CAA codes were developed by reasonable men looking for safety and although the results were different and were arrived at by a different process, they achieved essentially the same result.

The first formal harmonization exercise between the United States and Europe (United Kingdom and France) began in 1962 when supersonic transport projects were being developed on both sides of the Atlantic. A common committee known as FAUST (France, Anglo, United States Supersonic Transport) was established to develop common SST requirements. The U.S. project was canceled. The United Kingdom and France went ahead and developed SST Concorde.

Nothing much happened in the years between then and now about differences between codes. However, as JAA developed and became more visible in the rest of the world, the FAA began to take notice. One of the FAA problems is the time required to get a rule change through the Notice of Proposed Rule Making (NPRM) process. Statistics show that the average time is seven years. That is, of course, apart from the urgent safety ones that go through more quickly. To try and speed up this process, FAA's Tony Broderick set up the ARAC. At the present time this committee has about 58 members, many of them from consumer groups. They meet twice a year and act as a steering group. A goal of ARAC is to flush the pipelines of all the rulemaking activities that are there. There appears to be a real effort to apply a little better criteria to the whole process.

There are nine subcommittees that are working groups and these meet every two months. The areas they cover are roughly as follows:

- Air Traffic Control;
- Air Carrier Operations, Training & Qualifications;
- Transport Airplane and Engine;
- Rotor-craft;
- Emergency Evacuation and Crashworthiness;
- General Aviation Maintenance (This includes the FAR-65 Group);
- General Aviation Operations;
- General Aviation/Business Aviation; and,
- Documentation and Record Keeping. (There is no equivalent for this subject.)

The subject of aging aircraft is now included. This is a pretty formidable group in total and may be a bit unwieldy, but at least it is an effort in the right direction. These committees are advisory and are still in the definition stage. They do have JAA representation. The one that is making some real progress is the Evacuation and Crashworthiness Committee.

Cooperation Between Authorities

At present, the JAA and the FAA meet about once a year to plan cooperation activities between European and U.S. regulations and procedures: Extended-range twin (engine) operations (ETOPS), Master Minimum Equipment Lists (MMELs), and common Release Documentation (JAA Form One). Considerable progress has been made on these subjects in particular, the JAA Form One, which is now being phased in by the JAA nations. It is not yet accepted by the FAA.

Leasing of aircraft across borders is now receiving attention. This is the subject of one of the IFA/FSF Joint Initiatives that is important and is becoming increasingly so. IFA believes that this topic should be linked with the *Standardization of Airworthiness Records for Transfer of Aircraft*, yet another initiative.

JAA also comments on all FAA NPRMs and FAA does the same for the JAR Notices of Proposed Amendments (NPA). Where a JAR corresponds directly to an existing FAR, all amendments to the relevant FAR are considered for adoption into the JAR unchanged.

Both FAA and JAA have representatives on the other's committees and working groups.

Industry has expressed a total commitment to the need for the JAA process to match the changing world involving collaborative projects and increasing practice of cross-border exchange of aircraft. The FAA recently proposed a new harmonization initiative of a "cooperative and concurrent" concept on new certifications (a real breakthrough).

The whole JAA process has been achieved in a relatively short time and this is now gathering momentum. All JAA countries are committed to exploring closer links that, subject to parliamentary approvals, could ultimately lead to a single JAA regulatory authority.

The Australian Experience

Before looking at conclusions and solutions, it might be worthwhile to look at what has been going on in Australia.

For years, getting an airplane on the Australian register was looked upon as a task almost as difficult as getting on the British Register. Complaints about the bureaucratic procedures adopted by the CAA of Australia in certificating "first of type" aircraft led to the Yates Report, commissioned by the Australian CAA Board.

The Australian Bureau of Safety was able to identify very few occurrences that would have been prevented by certification by the CAA. The final recommendation was that Australia accepts JAA and FAA certification. In other words, both pre- and post-JAR aircraft will be issued with certification in Australia on the basis of certification in the country of origin.

Conclusions and Some Solutions

Research has revealed that a great deal of activity and a tremendous effort is being put into the task of common standards in airworthiness both in Europe and the United States. Inevitably different cultures will influence the interpretation of what is common. There is a tendency for authorities to defend their own positions and there is clear evidence that a great deal of holy water sprinkling takes place to maintain divine rights. I can actually understand and sympathize with these attitudes. However, I feel that this is not the time to dig in and fight. To refer again to Joe Sutter: "We should stop worrying about rules and worry about Airworthiness."

Incidentally, U.S. President George Bush, in his State of the Union message, declared a 90-day moratorium on new federal regulations that could hinder economic growth.

One cannot but be impressed by the activities and the progress made by the JAA. But if we are not careful, we could end up with the same unwieldy bureaucratic monster that the FAA is now desperately trying to escape.

I believe that airworthiness is a matter for professionals and there should be a minimum of governmental influence.

The simple solution, of course, would be to go the way of the Australians and accept each others' rules even though different. Bilateral agreements already exist in some parts of the world. There is certainly no clear evidence from accident statistics that either certification is less airworthy than the other.

The IFA believes that the world accident and incident data should be collected and combined into one database. The U.K. CAA is already moving in this direction. At the 1990 IFA Conference, at least four different authorities produced statistics that showed almost identical trends. The evidence from a common database should be looked at in relation to harmonizing rules.

If "Harmonization — Is It Working?" is changed to "Harmonization — Is It Working to Improve Airworthiness?," then I am not at all sure it is.

The goal for the 1990s should be to accelerate efforts toward the global harmonization of aviation standards, their interpretation and application. Objectives include:

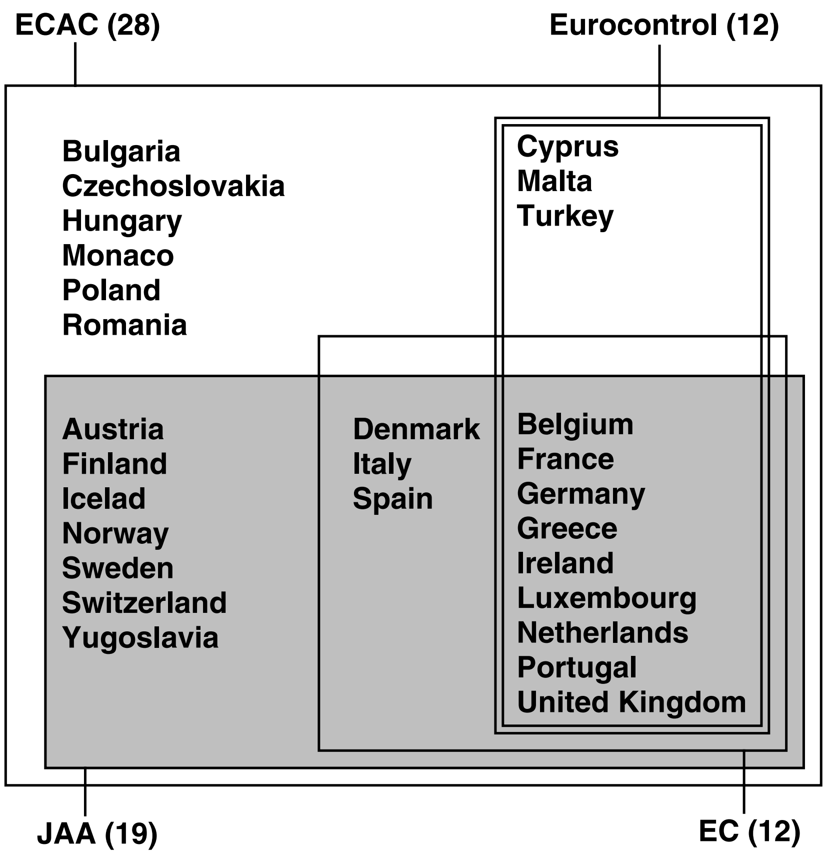
- Common build standards;
- Avoidance of redundant substantiation;
- Equitable certification baselines for derivative aircraft; and,
- Consistent levels of safest in design, continuing airworthiness, maintenance and operations.

Above all we must keep looking at what the data says. World experience on accidents, incidents, bird strikes, lightning and other subjects must be looked at continually.

There is a saying that a camel is a horse designed by committee. It may well be the time to look at all the camels designed by all these committees and get one independent working group to turn them back into horses.

Remember Joe Sutter's wise words, "Stop worrying about rules and worry about airworthiness."

Appendix 1



ECAC, EC, JAA/JAR and Eurocontrol

Appendix 2

Joint Aviation Requirements

Purpose	Code	Status
Large airplane design	(JAR-25)	Complete
All-weather operations	(JAR-AWO)	Complete
Engine design	(JAR-E)	Complete
Propeller design	(JAR-P)	Complete
Auxiliary power unit (APU) design	(JAR-APU)	Complete
Sailplanes and powered sailplanes	(JAR-22)	Complete
Very light airplane design	(JAR-VLA)	Complete
Maintenance organizations	(JAR-145)	Complete
Equipment	(JAR-TSO)	Complete
Light airplane (excluding commuters)	(JAR-23)}	Work complete
Commuter category airplanes	(JAR-23)}	To be started spring 1992
Helicopter design	(JAR-29)}	To be started in 1991
	(JAR-27)}	Preparatory work in hand
Certification procedures	(JAR-21)	In preparation
Operations (Commercial Air Transportation)	(JAR-OPS Parts 1 & 3)	In preparation
Operations maintenance	(JAR-OPS Parts 1 & 3 Chapter 7)	To be finalized
Operations (other Public Transport)	(JAR-OPS Part 2)	To be started in 1992
Certifying staff qualifications	(JAR-65(E))	In preparation
Recreational aircraft maintenance	(JAR-91)	Not started
Airworthiness directives	(JAR-39)	Not started

Appendix 3

Joint Certification to JAR-25

Aircraft:

Dornier Do 328
MD-11 (joint validation of the U.S. certification)
Airbus A-321
Airbus A-330 and 340
Saab SF-340-2000
Casa N235
BAe Jetstream 4100
Canadair CL-600-2B19 Regional Jet
Falcon 2000
Boeing 747-400F
Boeing 777
Tu-204 (RB211-535 engines)

Joint Certifications to JAR-E

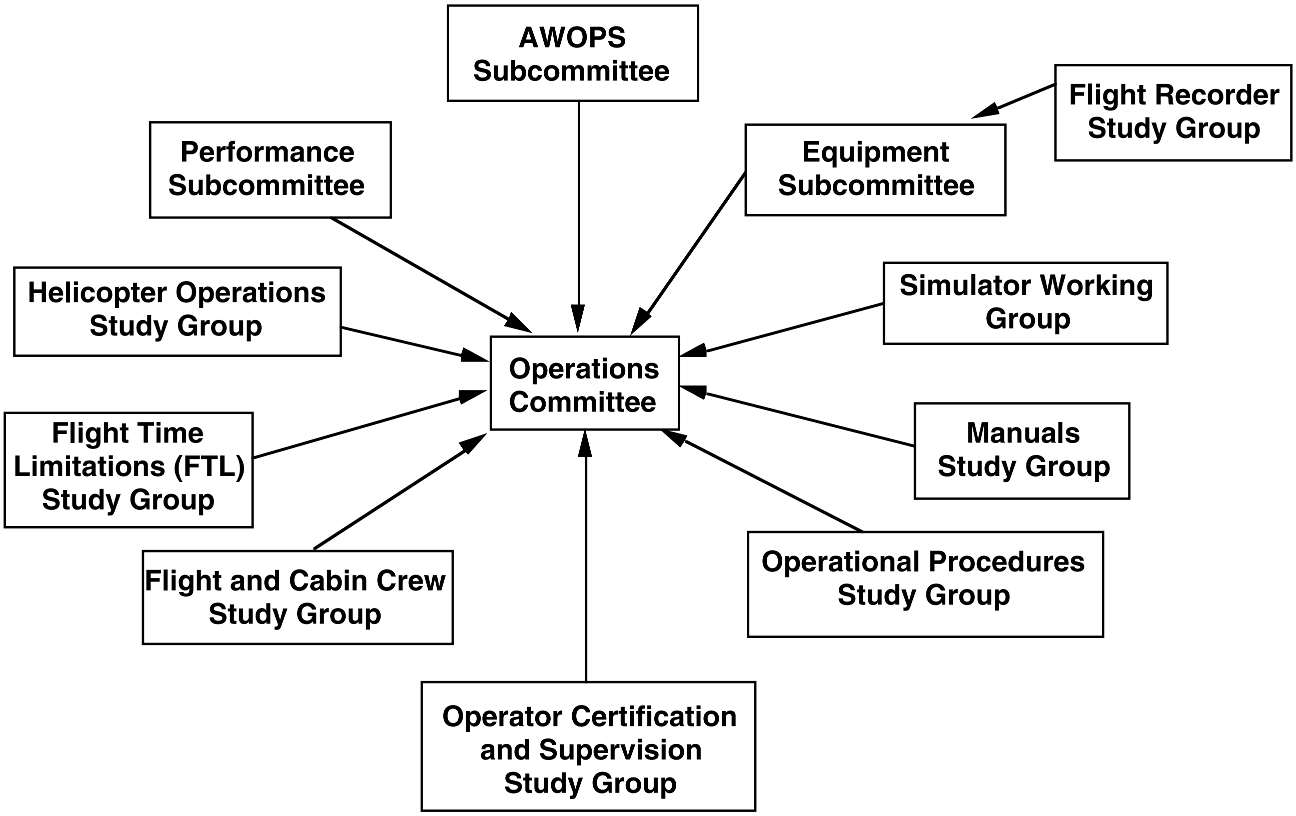
Engines:

RB 211-524L Trent 600, 700 and 800 series
PW-119
Allison GMA 2100
Williams FJ44

The Allison GMA 3007 turboprop version of the GMA 2100 is also likely to become a JAA certification

Appendix 4

JAA (OPS) Organization



Related JAA Groups

ETOPS WG, Flight Study Group, Cabin Safety WG, Manuals WG, MMEL/MEL WG

Safety Aspects of Increased Capacity of Airport and ATS

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Air traffic control (ATC) is safe or is at least not one of the major risk factors in air transport.

During the 18-year period from 1973-90, there were 543 fatal accidents affecting passenger flights in the world. Of these 543, 18 were collisions. The distribution of these 18 collisions between the various International Civil Aviation Organization (ICAO) regions closely matches traffic distribution as measured by 1989 ICAO statistics.

According to the annual safety analysis of *Flight International* these numbers are for passenger flights, excluding provoked accidents (highjackings, bombs).

A possible interpretation of this result is that, in regions of the world where the density of traffic is high (North America and Europe), the ATC system is able to reduce the risk to about the same levels as world regions with very low traffic density, but nearly no air traffic control.

Can this satisfactory degree of ATC safety be maintained when the volume of traffic increases. Can the traffic increase be accepted, because it is of paramount importance to maintain the level of safety? These questions are very important for those in charge of planning future ATC systems. To answer them one has to evaluate how the exposure to risk increases with the volume of traffic.

Maintaining High Safety Standards in the Turbulent '90s

	1989		1973-1990	
	Scheduled Passenger Flights (Million pass. x km)	percent	Collisions	Percent
- Europe	546 150	30.6	7	38.9
- Africa	40 710	2.2	1	5.5
- Middle East	47 830	2.7	0	0
- Asia and Pacific	319 720	17.9	1	5.5
- North America	744 180	41.7	7	38.9
- Latin America and Caribbean	87 440	4.9	2	11.1

Figure 1

Dr. Robert Machol, a professor of operational research and a chief scientist at the U.S. Federal Aviation Administration, has conducted a study on the global effectiveness of air traffic services.(1)

He compared the actual number of midair collisions (74) that occurred over the United States (all types of flights included) instrument flight rules (IFR) and visual flight rules (VFR) (2 IFR-IFR; 15 IFR-VFR; 57 VFR-VFR) during the period 1964-1972 with the theoretical number deduced from the mathematical formula below:

$$v = \frac{p^2 \bullet r \bullet V}{n \bullet A} \quad (2)$$

Graphic Unavailable

Figure 2

This formula was established based on aircraft flying in straight lines from departure to destination at their preferred altitude without looking outside. The comparison between the two figures indicates the effectiveness of organizing air traffic. The ratio varies 84-to-1 near airports to 32-to-1 for enroute low altitude. For enroute high altitude, the number of collisions (calculated or actual) is too low to be significant in their calculation. High altitude flight is very safe.

These results are not directly applicable to controlled airspace because the main components of the available data are VFR flights. Yet, surprisingly, the same formula applied in very different circumstances, such as the total passenger traffic over the entire world with the 18 collisions reported above, gives the same order of magnitude, i.e., between 10-to-1 and 100-to-1.

The conclusions are that ATC is essential and that the formula is reasonably representative of the exposure to risk that actually increases as the square of the traffic over a given area (see P^2).

It is expected that the traffic over Europe will double by the year 2000 and will increase three to four times by 2010.

According to the formula above, the exposure to risk will increase not twofold and threefold but by fourfold and ninefold, respectively.

Because the objective is to maintain the same satisfactory level of safety, the average number of operational errors per individual ATC problem (what I would call "elementary safety") has to decrease by twofold and threefold. The work of the air traffic controller and the pilot has to become more rigorous. While it is no doubt important to divide the airspace into more sectors to cope with traffic and to give better communications and better radar displays to the air traffic controllers, this is not sufficient. In the long term, their work methods have to be rethought.

The Eurocontrol program has been an outgrowth of member states and the European Civil Aviation Conference (ECAC).

In the short term (1994), when the national systems have not yet been upgraded and the European airspace not yet completely reorganized, the only solution will be better regulation of the traffic. This will allow more efficient use of available capacity without the risk of unexpected overload that could affect safety. The service will be provided by a Central Flow Management Unit, currently being built at Brussels for the benefit of the 28 ECAC states.

For enroute control, in the medium term (1995-2005), national ATC systems will become state of the art, thanks to national modernization programs stimulated and integrated by the European ATC Harmonisation and Integration Programme (EATCHIP). The capacity will increase as a result of improved radar coverage, improved communication and better airspace organization. The elementary safety will increase by the progressive sophistication of the controller work environment and of the associated "memory enhancement" tools exploiting the potential capability of modern data processing technology.

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Figure 3

For airport air traffic system (ATS)-interface, the harmonization started later and so is less advanced. But a program similar to EATCHIP is now being launched.

Graphic Unavailable

Figure 4

In the long term (after 2000-2005), the real challenge will be faced. Research is in progress to increase both capacity and elementary safety by close coupling of ground computers and airborne flight management systems. This will make it possible to predict precisely where each aircraft will be in the next 30 minutes whatever its flight regime will be — cruise, climb, descent. Powerful computer tools will exploit this capability and will separate the problem-free aircraft from others and will make sure that they remain problem-free. For the problem aircraft, these tools will assist the controller in predicting and solving the problems.

This research is being conducted in various quarters, not only in Europe but also elsewhere in the world. In Europe, it is a cooperative effort coordinated under the umbrella of the Studies, Tests and Applied Research (STAR) Programme of Eurocontrol; the best-known components of which are PHARE (Programme for Harmonized ATM Research in Eurocontrol), EASIE (European ATM and Mode S Implementation in Europe) and EATMS (European Air Traffic Management System). An outside view will also be provided by an ATLAS study being prepared by industry for the Commission of European Communities.

It is hoped these efforts will succeed in increasing capacity to match the demand, while maintaining the current high level of global safety.

References

(1) “Effectiveness of the Air Traffic Control System,” Robert E. Macchol, Northwestern University, *Journal of Ops. Res. Soc.*, Vol. 202, pp. 113-119. Pergamon Press Limited, 1979.

(2) A = surface of the zone (CONUS)
V = average speed
r = horizontal collision distance
1/n = vertical collision distance
P = number of aircraft over A

Detection of Low-altitude Windshear with Airborne Pulse Doppler Radar

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Low-altitude windshear is a major hazard to aviation. A variety of sensor technologies are now in development to provide an early warning for this hazard. Airborne pulse Doppler radar is the only sensor that can provide this early warning in all weather conditions with low false alarm rates. Pulse Doppler radar can predict the presence of dangerous windshear conditions by detecting a number of the unique features of its microburst sources. This analysis has led to the derivation of a new level of requirements for airborne weather radars to provide this increase in sensitivity for even dry microburst-generated windshear. In addition to sensitivity increases, the radar must also be able to discriminate between low relativity windshear and the down-looking radar clutter returns for a wide range of rural and urban environments. An Aeronautical Radio Inc. (ARINC) 708 compatible weather/windshear radar has been developed and flight tested with outstanding success. It can detect wet and dry microbursts with at least 45 seconds of warning time and provide real time displays in the cockpit. This modular radar design, with the potential to grow into an enhanced vision system, will be available for delivery in early 1993.

A new generation of airborne pulse Doppler radar technology is now available for the detection of low-altitude windshear. This radar technology combines advance-radar hardware architectures and sophisticated ground clutter-rejecting Doppler processing algorithms with affordable high-performance commercial parts and manufacturing processes. The result is a new forward-looking predictive windshear detection system that can provide between 45 and 90 seconds of warning to the presence of dangerous wet or dry microburst-generated windshear phenomena. Further, this capability is obtainable in a new generation of ARINC 708-compatible weather radars at prices comparable with existing designs.

The following is an overview of the key design issues and parameters that are guiding the development of the new windshear detection radar and a review of flight-test results of a prototype radar.

Windshear Detection Technology

Thunderstorms and microbursts create windshear hazards when there exists a strong downdraft at low altitudes that impacts the ground and creates a divergent radial wind flow. An aircraft attempting to transit this type of event at low altitude on approach or takeoff (see Figure 1) will initially encounter a strong headwind that will cause the aircraft to climb above the approach or departure path unless a reduction of power occurs.

As the aircraft enters the core of the microburst, however, the headwind diminishes rapidly and the aircraft is subjected to a strong

Graphic Unavailable

Figure 1

Graphic Unavailable

Figure 2. Severe Windshear Hazard Occurrence Probability

downdraft. On the far side of the microburst core, the aircraft suddenly encounters a strong tailwind. If power was significantly reduced on the near side to remain on the glidepath, the aircraft may stall and impact the ground before sufficient flying speed can be attained.

The conditions associated with this type of weather hazard have been mathematically combined into a hazard factor calculation [1] given by:

$$F = \frac{Va/c}{g} \bullet \frac{\Delta Wx}{\Delta x} + \frac{Wz}{Va/c}$$

Typically, indices greater than 0.1 are considered hazardous events and, unfortunately, constitute a significant percentage of observed microburst events (Figure 2).

The ability to detect reliably and classify these hazardous events with adequate warning time provides an increased degree of safety for aircraft operating in these weather conditions while offering the flight crew greater situational awareness and operational flexibility during approach and takeoff. Predictive warning times of at least 45 seconds are desired to allow the flight crew to assess the degree and extent of the hazard and then select the optimum avoidance maneuver. These accurate, long-range detections and classifications must also be accomplished with very low false alert rates and negligible missed events if the flight crew is to utilize confidently the sensor to obtain the safety and operational benefits.

Table 1
Low Altitude Windshear Hazard Detection Sensor

Sensors	Advantages	Issues
IR Radiometer	Low cost available hardware	Weather penetration
	Potential CAT detector Proof of principle linking Hazard to measurements	Lack of range determination
LIDAR	Narrow beam Unambiguous waveform Potential CAT detector	Higher risk technology High cost in production Weather penetration
X-Band Radar	Low life cycle cost	Detection in high clutter environment
	Excellent weather penetration Proven relationship to existing hazard Integrated with weather radar	

A variety of different onboard sensors have been proposed to detect this phenomena, including microwave and laser radars and radiometric techniques. The leading sensor candidates are summarized [2] in Table 1.

The infrared (IR) radiometer, though a potentially low-cost solution, has not adequately addressed the relationship between the sensed temperature differentials to a low false alarm rate hazard detection. In addition, the ability of IR radiation to penetrate through intervening weather is poor, reducing warning times and raising the probability of a missed hazard. An active laser radar (LIDAR) has the potential to detect windshear with low false alarm rates, but still suffers from poor weather penetration.

X-band radar, however, can directly measure the headwind and tailwind velocities associated with a microburst event in any navigable weather. Further, it can provide additional measurements of the microburst diameter and core rain intensity that can be used to refine hazard prediction and eliminate false alarms. This new function can also be incorporated into an enhanced weather radar without significant increases in cost or aircraft modifications. The only uncertainty associated with the X-band radar approach has been its ability to operate in the radar clutter environment surrounding many urban and suburban airports today. It will be shown later that these concerns have been eliminated.

Airborne Pulse Doppler Radar Windshear Detection

Microbursts and other complex thunderstorms that create windshear conditions provide a variety of features that can be directly or indirectly measured with a pulse Doppler radar. These features (see Figure 3) include the following:

- Near side and far side outflow velocities;
- Outflow rain intensities;
- Outflow extent in range;
- Core diameter and rain intensity; and,
- High altitude inflows.

The key to the successful detection of windshear phenomena with low false alarms and low missed-event rates is the detection of the far side outflow windfield. The presence of near and far side outflow is a key windshear discriminator from gust fronts and other windfield phenomena and is essential in the assessment

Graphic Unavailable

Figure 3. Key Detectable Features of a Microburst

of the windshear hazard factor. The radar must have sufficient effective radiated power to detect the outflow Doppler echoes through the rain associated with the microburst core. The radar must also have a sufficient sensitivity to detect the far side outflows over a wide range of reflectivities.

A challenge for any predictive windshear sensor is the dry microburst where the rain content of the outflow may be extremely low resulting in very low reflectivity. Figure 4 illustrates the cumulative probability of the outflow reflectivity for three different airports in the United States.

Reflectivities between 0 dBz are relatively rare except at Stapleton Airport in Denver, Colorado. When these dry microburst events are also correlated with their hazard factors, the probability of a missed event (due to a lack of sensitivity) to the minimum detectable microburst reflectivity can be computed. These

Graphic Unavailable

Figure 4. Microburst Outflow Reflectivity Probability

Graphic Unavailable

Figure 5. Probability of Hazard Detection

Graphic Unavailable

Figure 6. Correlation of F-Factor with Microburst Wind Divergence

Graphic Unavailable

Figure 7. Correlation of F-Factor with Wind Divergence Normalized by the Microburst Radius

comparisons are shown in Figure 5 for the same three cities.

In addition to measuring the different velocities between the near and far side outflows, it is also important to determine the extent of the divergent windfield to assess accurately the magnitude of the hazard. Figure 6 shows the correlation between divergent windfields and hazard factor.

Though a general trend is observable, the accuracy of the hazard prediction is poor. Figure 7, however, shows the correlation of hazard factor to differential wind velocity normalized by the extent of the divergent windfield resulting in a significant improvement in hazard prediction accuracy.

Another significant, but less important, element in the assessment of the microburst hazard is the effect of the microburst core. The core downflow imparts a vertical velocity component on the aircraft that must be included in the hazard prediction. This element cannot be directly measured with a Doppler radar due to the lack of a radial velocity component of the core. However, the magnitude of the downdraft term can be inferred from the measurement of the outflow velocity and the diameter of the core by utilizing an incompressible fluid approximation for the behavior of the core. The measurement of the microburst core is also an important element in the clutter processing and false alarm rejection that will be discussed later.

All of these measurable phenomena are sensitive to the noise limited detection capability of the radar. A comparison yardstick or performance index for windshear detection that normalizes the effects of range to the event, atmospheric attenuation and event reflectivity can be established to simplify this comparison. This performance index for a variety of different radar capabilities is plotted in Figure 8 against the minimum detectable outflow reflectivity and time to go before encountering the event.

The 20 dB improvement needed to provide warnings against very dry (-10 dBz) microburst conditions may be encountered at Stapleton Airport requires significant improvements in radar hardware and signal processing over the current generation of ARINC 708 radars. The magnitude of these improvements is beyond simple performance upgrades and has led to the conclusion that a new radar design is required.

Graphic Unavailable

Figure 8. Radar Performance Index Comparison

In addition to improvements in sensitivity, the radar must also have the ability to detect the low reflectivities and low velocities associated with dry microbursts in the presence

Graphic Unavailable

Figure 9. Windshear Detection Signal Processing Process

of often heavy urban background clutter. The ability to reject this clutter in both the mainbeam as well as the sidelobes is one of the key design criteria that also must be met with this radar.

Two important issues in the rejection of this clutter is the mainbeam look-down angle and the relative sidelobe levels of the radar antenna. The radar mainbeam must look-down the aircraft glide slope in search of the low altitude horizontal windshear and yet must not be depressed too severely to avoid signal saturation from near-range echoes. An additional problem is large second time around echoes (STAE) from terrain or cultural features beyond the runway. Sidelobe clutter returns are also of concern because they can arrive from any observation angle and be detected by the radar. Of particular concern are ground-moving objects (road traffic) detected through the radar sidelobes that will appear to be slow-moving targets in the mainbeam.

Fortunately, all of these design challenges can be met today with an X-band pulse Doppler radar. A pulse Doppler radar provides a range, angle and Doppler discrimination capability that uniquely allows the radar to not only detect windshear but reject the clutter from the main beam and sidelobes through a combination of spatial and spectral processing. This discrimination is generally accomplished in three steps:

- Signal conditioning and processing
- Target extraction
- Data processing

These elements are illustrated in Figure 9.

The signal conditioning and processing step is a combination of hardware design, initial signal processing and radar operation. After the radar signal is detected by the radar receiver and converted to digital information, it is processed using a Fast Fourier Transform (FFT) that separates the signal returns in any given range bin into its respective Doppler components. The result is a range-Doppler space map for every radar line of sight dwell. From these data, the microburst-generated low-altitude windshear echoes can be separated from mainbeam and sidelobe clutter and ground movers. The result of this automatic target extraction process is a windfield display ahead of the aircraft. By using color coding similar to weather map displays, the wind velocities ahead of the aircraft can be displayed.

To assist in the target extraction and hazard classification process, the radar utilizes a two-bar horizontal scan pattern. Initially, the radar performs a horizontal scan with the beam pointed approximately one beam width above the horizon to develop a higher altitude profile of the weather and to search for microburst downdraft cores or virga. A second horizontal scan is then performed with the beam pointed down the glideslope to detect the low-altitude windshear. For each scan, a set of range Doppler space maps are generated providing a range/angle/altitude/velocity profile of the weather in front of the aircraft. The resulting maps are then subjected to a pixel-based target extraction process whereby wind velocities and rain intensities are compared with data in adjacent range/Doppler/angle/altitude bins to develop target extent, and velocity features that can be classified as false alarms, ground movers and windfields.

Graphic Unavailable

Figure 10. Windshear Radar Block Diagram

These clean upper and lower bar windfield maps along with upper and lower bar rain intensity maps are utilized by the hazard classifier data processing algorithms to develop an unambiguous hazard factor map display without false alarms or other confusing clutter. This type of hazard map display will allow the pilot to assess immediately the magnitude, time to go and the extent of the hazard and to plan an appropriate avoidance maneuver. This display could be provided continuously on approach or takeoff on a dedicated weather radar display or as a "pop-up" display on an electronic flight information system (EFIS) or other multifunction display, when a hazard threshold is crossed.

Technology Development Status

An X-band pulse Doppler windshear weather radar with the capabilities described above was developed and flight demonstrated by the Westinghouse Electric Corp. in 1991. This radar was designed to be a new generation of weather radar with windshear capability for the air transport market.

The new radar design is based on a modular architecture whereby the principal hardware functions (transmitter, receiver, processor, etc.) are segregated into separate air transportation radio (ATR) size modules and packaged together in a standard ARINC 708 size 1/8 ATR modular concept unit (MCU) chassis. This modular approach allows the utilization of a common set of commercial radar modules across a larger product line than weather/windshear radar alone. A block diagram of the radar is shown in Figure 10 and an illustration of the transceiver package is shown in Figure 11.

Utilizing this design approach, a pair of radar prototypes was designed and fabricated in early 1991 and entered into an extensive flight-test program onboard a company-owned BAC 111 airliner testbed in the summer of 1991. In August 1991, the aircraft was deployed to Orlando, Florida, for a series of windshear detection flight tests. During a week of flight testing, more than 100 microburst events were detected. Signal and data processed in the radar processor was displayed in real time in the cockpit as well as at a variety of special crew stations in the main

Graphic Unavailable

Figure 11. Modular Radar Packaging

cabin. These flights were coordinated with a Massachusetts Institute of Technology (MIT) Lincoln Laboratory ground-based Terminal Doppler Weather Radar (TDWR) located at the Orlando International Airport. All TDWAR reported events were detected with no missed events or false alarms.

The microburst conditions encountered in Orlando were generally of the very wet variety (up to 50 dBz). However, it provided a unique opportunity to examine the more complex interiors of thunderstorms along with isolated microbursts to gain a better understanding of the horizontal and vertical wind profiles of real events at close range. Several dryer events estimated to be between 0 and +5 dBz were observed at long ranges confirming the radar's ability to detect even dryer events with at least 30 seconds of warning time.

In September 1991, this prototype was installed onboard a Continental Airlines A-300 Airbus in support of Continental's predictive windshear system evaluation program. This system operated in revenue service through the winter of 1991-92 with more than 2,000 flight hours.

Production models of this weather/windshear radar are now in development with initial certification as an ARINC 708 weather radar anticipated by the end of 1992 and full certification as a predictive windshear system by mid-1993. An additional feature of this new commercial pulse Doppler radar technology is its easy growth into an enhanced vision radar sensor. This approach takes advantage of the modular radar architecture, powerful radar signal and data processing capability and a planned in-growth in the core transceiver design that will allow the basic predictive windshear radar to be enhanced, with additional features such as forward-looking ground proximity warning (terrain avoidance), high resolution imaging of airport runways in all weather along the flight vector, and ground obstacle detection during approach, landing and taxi. The core radar system is also designed to accept raw video inputs from other sensors such as forward-looking infrared (FLIR) systems (and millimeter wave radars) and provide sensor data fusion and common display and graphics overlay processing.

This radar represents a new era in affordable commercial sensor systems that capitalize on previously developed technology and algorithms from military sensor systems. This new generation of sensors will provide an unprecedented level of information and situational awareness for the cockpit crew resulting in substantial improvements in aviation safety.

References

1. R. L. Bowles, "Windshear Detection and Avoidance: Airborne Systems Survey," 29th IEEE Conference on Decision and Control, Honolulu, Hawaii, Dec. 5-7, 1990.

2. B. D. Mathews, "Considerations of X-Band Radar For Airborne Windshear Forward Looking Detection and Avoidance," AEEC Technology Assessment Group, Denver, Colorado, July 10, 1991.

U.S. Aerial Application Flying and Safety For Calendar Years 1952-1990

by
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Background

The term "private flying" was used in the 1930s in the United States to refer to all non-airline civil flying, including personal flying, charter and fixed-base operations as well as to planes used by commercial organizations.

Before World War II there were about 10,000 aircraft engaged in private flying, logging about 1.9 million hours in 1939. Of those, only a few thousand hours were logged in aerial application. After the war, the total hours for private flying increased to 9.7 million in 1946, a 409-percent increase from 1939. Commercial operations involving aircraft for dusting, seeding and related crop control also expanded greatly.

In the late 1940s and the early 1950s, aerial application was a part of commercial operations. Thus, aerial application statistics were not reported separately until the then Civil Aeronautics Administration (CAA) conducted annual surveys to compile information of all categories involving commercial operations.

Table 1
Aerial Application Flight Time and Acres of Farmland Treated
Calendar Years 1952-1990

Year	Flight Hours	Aircraft	Acres Treated (000)	Acres/ Per Hour	Acres Treated as Percent of Total
1952	707,277	NA	37,421	52 (@)	3.1
1953	722,318	NA	39,396	55 (@)	3.2
1954	672,226	4,210	36,900	54 (@)	3.1
1955	851,960	4,360	50,157	59 (@)	4.2
1956	802,500	NA	51,938	65 (@)	4.4
1960	889,100	5,130	51,078	58 (@)	4.3
1970	1,520,000	5,455	98,800	65 (@)	9.7
1980	2,063,000	5,788	143,069	70 (@)	13.8
1990	2,227,641	7,032	150,900	70 (@)	16.0

(@) Survey estimates.
(*) Assumption based on estimates of previous surveys.
Source: *Statistical Abstract of the United States*, Department of Commerce and FAA *Statistical Handbook of Aviation*, 1952-1990.

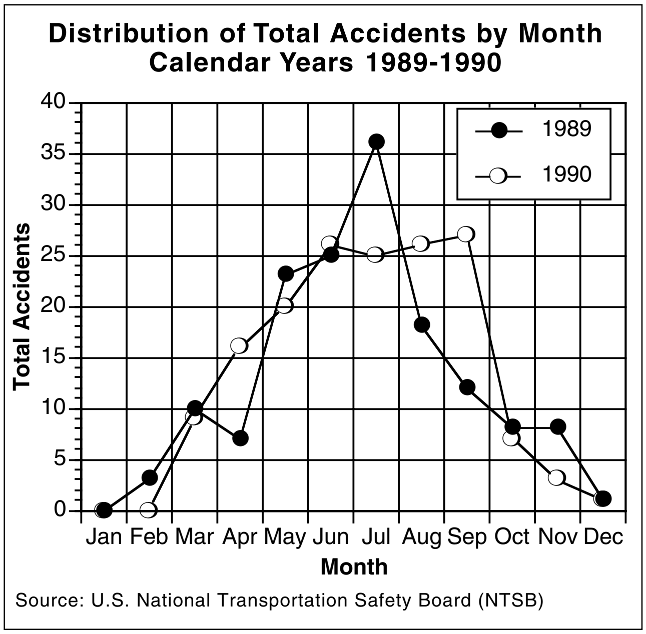

Figure 1

Context of Aerial Application

The annual general aviation survey started by the CAA in 1952 was continued by the U.S. Federal Aviation Agency (FAA). The survey methods, however, were changed from time to time as well as the definition of aerial application. In the 1950s, the FAA said that "aerial application represents the use of aircraft as a moving elevated platform from which chemical or seeds may be distributed over land or crops." In its 1966 edition of the *Statistical Handbook of Aviation*, the FAA reported that "aerial application in agriculture consists of those activities that involved the discharge of materials from aircraft inflight and a miscellaneous collection of minor activities that do not require the distribution of any materials." In 1975, the FAA redefined aerial application as "any use of an aircraft for work purposes which concerns the production of foods, fibers, and health control in which the aircraft is used instead of farm implements or ground vehicles for the particular task accomplished. This includes operations, the distribution of chemicals or seeds in agriculture, reforestation or insect control."

It is not known if the definition changes had any effect on the comparability of data compiled from the annual survey. This analysis, however, is based on the data available; data for 1958 are missing. In a trend analysis, such missing data do not seriously affect the overall analysis.

Growth of Aerial Application

U.S. farms have changed greatly during the past 40 years. In 1950, there were 6.6 million farms in the United States with an average of 213 acres per farm, according to U.S. Department of Agriculture (USDA) figures. The CAA survey showed that in 1954 about 4,210 aircraft were used for aerial application, logging 672,266 hours and treating 36,960,000 acres of farmland, accounting for only 3.1 percent of total farmland acreage. The use of aircraft for aerial application grew rapidly. As shown in Table 1 (page 119), aircraft hours flown increased from 707,277 hours in 1952 to 899,100 hours in 1960. They increased to 1,520,000 hours in 1970, to

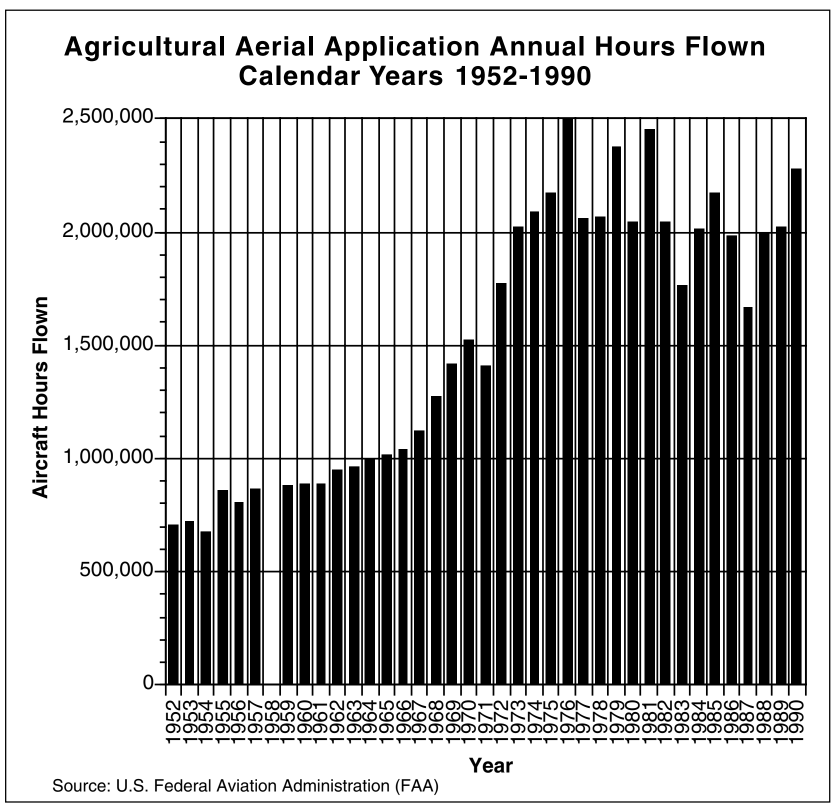

Figure 2

2,063,000 hours in 1980 and to 2,227,641 hours in 1990. It is estimated that 150 million acres, or 16 percent, of total farmland were treated by aircraft. The USDA also reported that the number of farms in the United States and the size of the average farm have changed dramatically over the years. In 1950, there were 5,648,000 farms in the United States with an average of 213 acres per farm. In 1960, the number of farms decreased to 3,963,000, a decline of 30 percent, while the size of an average farm increased to 297 acres (an increase of 39 percent). The trend continued into the 1970s and 1980s. In 1990 the

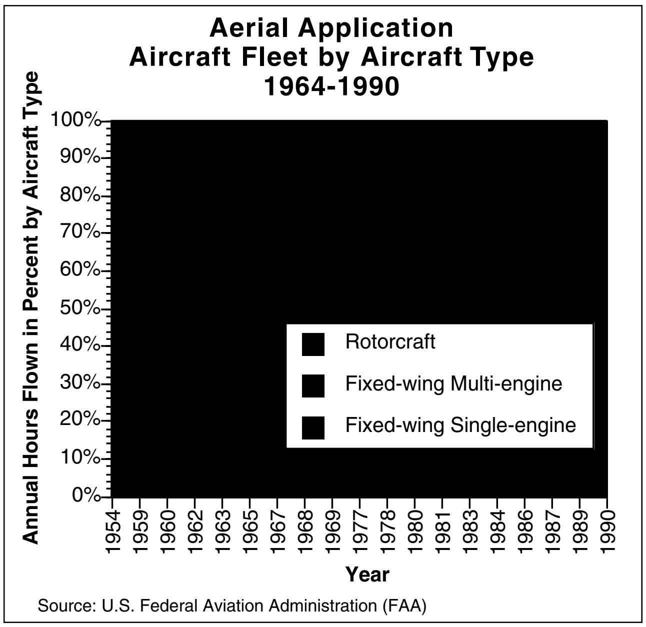

Figure 3

number of farms decreased to 2.1 million with an average of 461 acres per farm. The size of farms owned by corporations were much bigger. In 1990 the average was 1,700 acres per corporation-owned farm. As farm sizes increase, the use of aircraft for aerial application could become more demanding.

Characteristics of Aerial Application

Aerial application is a seasonal operation. Operations begin in late winter or early spring continue through summer. The seasonal characteristics of aerial application can be derived from the monthly distribution of total

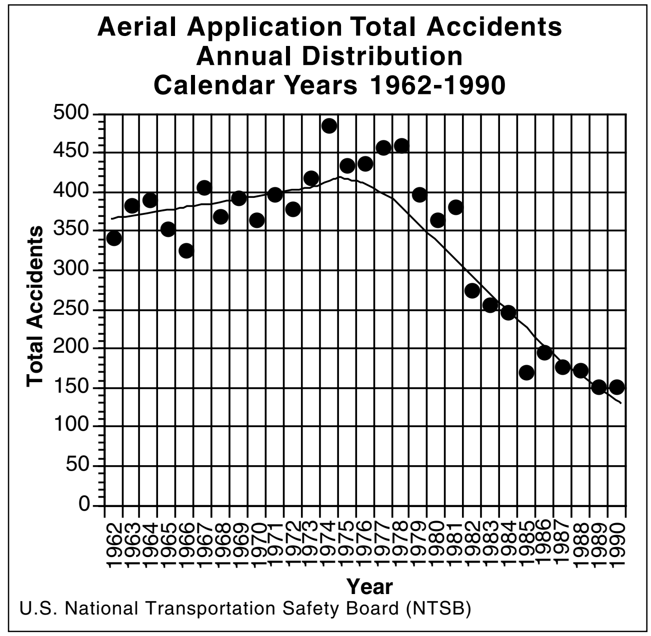

Figure 4

accidents and fatal accidents. Figure 1 (page 120) shows the monthly distribution of total accidents for calendar years 1989 and 1990. Note that the monthly accident distribution peaks in the months of June, July and August. There were no accidents in the month of January.

Flight time

Figure 2 (page 120) shows the annual growth of aircraft hours flown since 1952. It

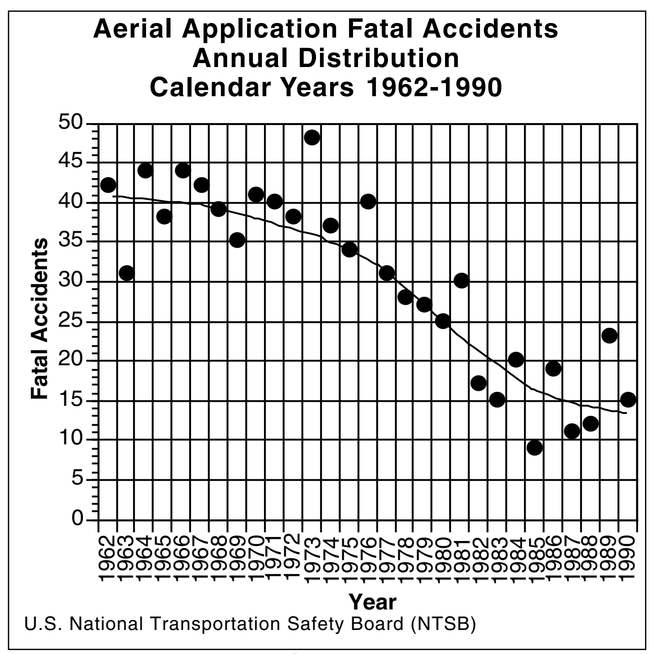

Figure 5

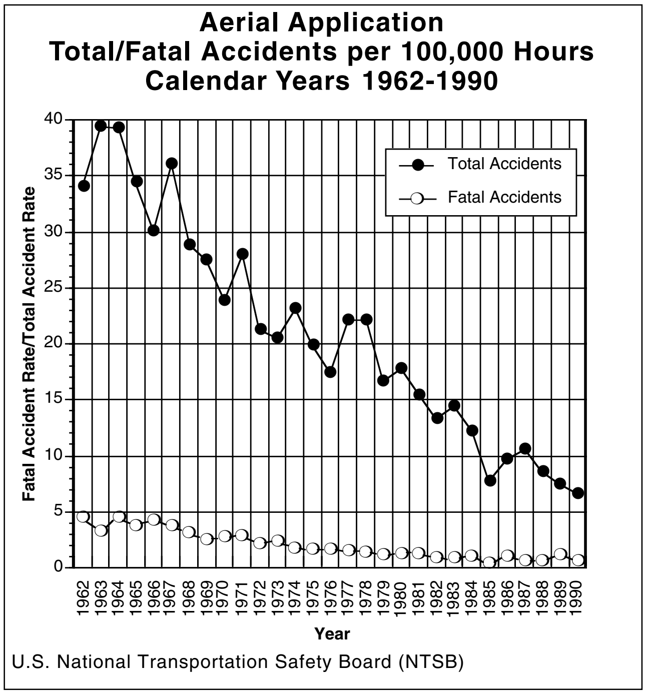

Figure 6

appears that aerial application operations grew until 1981. Since then the annual hours flown for aerial application have been fluctuating around two million hours. Figure 3 (page 121) shows the aircraft most used for aerial application are fixed-wing, single piston-engine aircraft, although the use of rotorcraft has also been growing.

Accidents and Trend

Safety information relating to aerial application was not reported separately from other commercial operations until 1962. Figures 4 and 5 (page 121) show the annual accident and fatal accident distribution for the past 30 years. Note that in the first 20 years total accidents fluctuated between 320 and 450 and that the annual number of fatal accidents fluctuated between 31 and 48. In the 1980s, total accidents dropped from 378 in 1981 to 272 in 1983 and down to 150 in 1990. Fatal accidents also dropped from 30 in 1981 to 11 in 1987 and up to 14 in 1990.

Although the annual frequency of total accidents and fatal accidents did not show a down trend before 1980, the total accidents and fatal accidents in terms of flight hours did show gradual improvement every year as shown in Figure 6.

Analysis of Accidents

Analysis of accidents involving aerial application flying by cause/factor for the period 1980-1988 is shown in Table 2. About 70 percent of the accidents involved pilot error; 35-40 percent involved terrain and 30 percent involved powerplant. Weather was cited as cause/factor in less than 17 percent of the accidents.♦

Table 2
Broad Cause/Factor Assignments in All Accidents
Aerial Application Flying
Calendar Years 1980-1988

	1980-1984		1985		1988	
Broad Cause/Factor	**Mean**	**Percent**	**No.**	**Percent**	**No.**	**Percent**
Pilot	212.4	69.9	116	69.5	118	69.0
Terrain	103.4	34.0	50	29.9	69	40.3
Powerplant	82.2	27.0	52	31.1	57	33.7
Weather	41.2	13.6	29	17.4	29	17.0
Personnel	25.0	8.2	10	6.0	18	10.5
Landing gear	14.4	4.7	5	3.0	7	4.1
Airport/airways/facilities	12.6	4.1	6	3.6	42	24.6
Rotorcraft	9.4	3.1	2	1.2	2	1.1
Airframe	7.4	2.4	3	1.8	7	4.1
Systems	3.4	1.1	1	.6	7	4.1
Instruments/equipment/accessories	3.0	1.0	1	.6	17	9.9
Number of Aircraft	304.0		167		171	

The accidents, the cause/factors of which have not been identified, are not included in the statistics.

Source: U.S. National Transportation Safety Board (NTSB)

Reports Received at FSF Jerry Lederer Aviation Safety Library

Reports

Turbine Engine Diagnostics System Study/Barbara K. McQuiston and Ronald L. De Hoff. Atlantic City International Airport, NJ., U.S. Federal Aviation Administration Technical Center; Springfield, Va.: Available through the National Technical Information Service*, [1991]. Report No. DOT/FAA/CT-91/16, Contract No. DTFA01-87-C-000 14. vii, 36, A-47 p.; ill.

Key Words
1. Aircraft Gas-turbines — Evaluation.
2. Aircraft Gas-turbines — Testing.
3. Aircraft Gas-turbines — Blades — Testing.
4. Turbine Engine — Fault Detection.

Summary: This report presents the results of a system study for the Turbine Engine Diagnostics (TED) program. This research program's purpose was to develop a method of approach and prototype design for a system capable of predicting the failure of rotating parts in turbine engines. Systems Control Technology (SCT) used an innovative approach that assimilated data from multiple sources to determine trends in engine performance. The result of this study is a proposed system with a method of approach that minimizes the technical and financial risk of turbine engines while at the same time optimizing the safety factors needed to predict accurately component failures.

Study of the Engine Bird Ingestion Experience of the Boeing 737 Aircraft (October 1986-September 1989)/Peter W. Hovey, Donald A. Skinn and Joseph J. Wilson. Atlantic City International Airport, N.J., U.S. Federal Aviation Administration Technical Center; Springfield, Va.: Available through the National Technical Information Service*, [1991]. Report No. DOT/FAA/CT-90/28, Contract No. DTFA03-88-C-00024. xiv, 96, [86] p.; charts.

Key Words
1. Bird Pests.
2. Airplanes — Turbojet engines — Blades.
3. Aeronautics — United States — Accidents.
4. Boeing 737 (Jet transport).
5. Bird Ingestion.

Summary: In October 1986, the Federal Aviation Administration (FAA) Technical Center initiated a study to determine the numbers, weight, and species of birds ingested into medium and large inlet area turbofan engines, and to determine what damage, if any, results. Bird ingestion data were collected for the Boeing 737 model aircraft that use either the Pratt & Whitney JT8D medium inlet area turbo fan engine or the CFM International CFM56 large inlet area turbofan engine. This final report analyzes the entire three years of data collection extending from October 1986 through September 1989. [See FSF, *Airport Operations*, "Airports — Breeding Grounds for Birdstrikes," July/August, 1992]

Physiological Response of Birds to Approaching Aircraft/ S. Tomlinson ... [et al.]. Atlantic City International Airport, N.J., U.S. Federal Aviation Administration Technical Center; Springfield, Va.: Available through the National Technical Information Service*, [1991]. Report No. DOT/FAA/CT-90/28, Contract No. DTFA03-88-C-000041. vii, 91 p.; ill.

Key Words
1. Bird Pests.
2. Airplanes — Landing.
3. Aeronautics — Safety Measures.
4. Bird Heart Rate.

Summary: Laboratory and field test studies were conducted to measure the physiological response of captive wild birds to approaching aircraft during the takeoff roll of large passenger aircraft. Bird heart rate data were collected and used as a measure of physiological response to approaching aircraft. The laboratory study exposed birds to video scenes of aircraft during the takeoff roll. Equipment used to monitor the heart rate of the test birds included a harness fitted with an electrocardiogram (ECG) transmitter. The test birds included gulls and pigeons captured on or adjacent to Corpus Christi and San Antonio International Airports. A control sample of pigeons acclimated to airport sights and sounds was used to compare with pigeons not acclimated to airports. The video scenes of approaching aircraft caused a heart rate increase in the unacclimated pigeons several seconds sooner than the acclimated birds, and the unacclimated pigeons were more responsive to the sound, as well as to the sight, of approaching aircraft. The same methods and materials from the laboratory tests were used in the field test to measure bird response to standard-body and widebody aircraft during regularly scheduled departures from San Antonio International Airport. The 24 test birds were exposed to more than 100 aircraft departures during the test period, response data were collected, and a statistical analysis of the collected data was conducted. The analysis showed that birds exposed to the widebody aircraft experienced statistically higher maximum heart rates on the average than standard-body aircraft. [Modified executive summary June 2, 1992]

Aircraft Fire Safety: Papers Presented at the Propulsion and Energetics Panel 73rd Symposium, held in Sintra, Portugal, 22-26 May 1989. North Atlantic Treaty Organization, Advisory Group for Aerospace Research and Development (AGARD), Propulsion and Energetics Panel. Symposium (1989: Sintra, Portugal); Neuilly Sur Seine, France. AGARD conference proceedings no.467, 1989. 1 v. (various pagings): ill.

<u>Key Words</u>

1. Aeronautics — Accidents — Congresses.
2. Airplanes — Fires and Fire Prevention — Congresses.
3. Fire extinction — Congresses.

Summary: The 73rd meeting of the Propulsion and Energetics Panel on Aircraft Fire Safety was composed of eight sessions with each session's papers focusing on an issue central to fire hazards in aircraft safety. Session I gives a Review of Fire-Related Aircraft Accidents in four papers; session II presents six papers on Fire Safety Standards and Research Programs; session III presents nine papers related to Aircraft Internal Fires; session IV has two papers on Aircraft External Fires; session V gives three papers on Fire Safety of Military Weapon Systems; session VI presents eight papers on Fire Hardening by Advanced Materials and Structural Design; session VII presents three papers on Passenger Behavior in Emergency Situations; and, finally, session VIII covers Passenger Protective Equipment in four papers. These 39 papers provide a comprehensive coverage of fire hazards in aircraft safety. Furthermore, the results of these studies can be adapted to improving the crash survivability of both civilian and military transport.

Aircraft Accident/Incident Summary Report: Midair Collision Involving Lycoming Air Services Piper Aerostar PA60 and Sun Company Aviation Department Bell 412, Merion, Pa., U.S. April 4, 1991. National Transportation Safety Board (NTSB). Washington, D.C.: National Transportation Safety Board; Springfield, Va.: Available through the National Technical Information Service*, 1991. 26 p.; ill.

<u>Key Words</u>

1. Aeronautics — Pennsylvania — Merion — Accidents.
2. Piper Airplanes — Accidents.
3. Bell Helicopter — Accidents.

Summary: On April 4, 1991, at about 1210 hours, a Lycoming Air Services Piper Aerostar, PA-60, N3645D, while maneuvering for a landing at Philadelphia International Airport (PIA) collided with a Sun Company Aviation Department Bell helicopter model 412SP, N78S.

While on approach, the captain of the Piper Aerostar reported that the nose landing gear position light had not illuminated to show that the nose gear was in the down and locked position.

As the helicopter departed from PIA, the pilots overheard the communications regarding the possible unsafe nose-gear indication on the Piper Aerostar and offered to visually inspect the aircraft's nose landing gear. The Aerostar captain accepted this offer and both aircraft maneuvered to 1,100 feet at a constant speed of 125 knots for visual confirmation of the nose-gear position. While prior attempts at visual inspection by both the flight tower and the helicopter indicated the nose gear to be in the down position, the captain reported he could tell the gear was down but could not tell if it was in the locked position.

A collision between the two aircraft occured while the helicopter flew under and behind the Aerostar for a close inspection of the nose gear. The collision occurred when the leading edge of the helicopter's rotor blade struck the underside, nose gear and right main gear tires of the Aerostar.

According to the National Transportation Safety Board (NTSB) accident report, both aircraft were rendered uncontrollable were destroyed upon impact with the ground. The flight crews aboard both aircraft and the passenger aboard the Aerostar were fatally injured. Two persons on the ground were fatally injured by debris and another was seriously injured by fire. Two others received minor injuries.

The NTSB determined that the probable causes of this accident were the poor judgment by the airplane captain to permit the inflight inspection after he had determined to the best of his ability that the nose-gear was fully extended, the poor judgment of the helicopter captain to conduct the inspection and the failure of the helicopter flight crew to maintain safe separation.

As a result of its investigation, the NTSB made three Class II, Priority Action recommendations (A-91-91 through A-91-93) to the FAA, and reiterated Safety Recommendation A-90-136. Additionally, NTSB made the safety recommendation A-91-94 concerning inflight inspections of other aircraft or other close proximity maneuvers. [Modified accident summary report]

Aircraft Accident Report: Fuel Farm Fire at Stapleton International Airport Denver, Colo., U.S., Nov. 25, 1990/National Transportation Safety Board (NTSB). Washington, D.C. National Transportation Safety Board; Springfield, VA: Available through the National Technical Information Service*, 1991. vi, 71 p.: ill.

Key Words
1. Aeronautics — Colorado — Denver — Accidents.
2. Aeronautics — Accidents.

Summary: On Sunday, Nov. 25, 1990 a fire erupted at a fuel storage and dispensing facility near Stapleton International Airport in Denver, Colorado, and burned for about 48 hours. The fuel storage facility, referred to as a fuel farm, was jointly operated by United Airlines and Continental Airlines.

Firefighting efforts included 634 firefighters, 47 fire units, 56 million gallons of water and 28,000 gallons of foam concentrate. Of the 5,185,000 gallons of fuel stored on the farm, about three million gallons were either consumed by the fire or lost due to leakage from the tanks. United Airlines estimated the damage was between $15 million and $20 million; furthermore, United Airlines' flight operations were disrupted because of the lack of fuel to prepare aircraft for flight. No injuries or fatalities occurred as a result of the fire.

According to NTSB, the probable cause of the fire was the failure of AMR Combs (the independent contractor operating United Airlines' part of the fuel farm) to detect loose motor bolts that permitted the motor of motor/pump Unit 3 to become misaligned, resulting in damage to the pump and subsequent leakage and ignition of fuel. Moreover, NTSB cites AMR Combs for its failure to properly train its em-

ployees to inspect and maintain the fuel pump equipment, and the city and county of Denver for failing to oversee the fuel storage facility in accordance with its airport certification manual.

As a result of its investigation, the NTSB made six class II Priority Action safety recommendations (A-91-95 through A-91-100) to the Federal Aviation Administration and one class II Priority Action safety recommendation each to AMR Combs, the National Fire Protection Association, the Airport Operators Council International, Inc. and American Association of Airport Executives. [Modified accident summary report]♦

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Accident/Incident Briefs

This information is intended to provide an awareness of problem areas through which such occurrences may be prevented in the future. Accident/incident briefs are based upon preliminary information from government agencies, aviation organizations, press information and other sources. This information may not be entirely accurate.

Air Carrier

Open Water Drain Valve Creates Risky Ice Chunk

Boeing 737-400: No damage. No injuries.

After the aircraft had climbed to cruise altitude and was about to begin the en route stage of the flight, the cabin crew reported that there was no potable water remaining and that the drain valve was open. The potable water system had been drained the previous evening for overnight cold weather parking. The fluid was replenished before departure while the aircraft was being de-iced after freezing fog conditions. The water draining from the potable drain valve may have been unnoticed because the de-icing fluid also was draining off the aircraft.

Approximately 40 gallons of water was lost. After completing the overseas flight, a large sheet of ice (three feet long, one foot wide and six inches thick) was found attached to the aircraft fuselage just aft of the forward potable water drain hole that was situated below the passenger entry door. Although there was no damage to engine fan or cowl, possible engine damage could have been sustained if the sheet had detached in flight.

Poor Lineup Leads to Landing Surprise

Boeing 747-212B. Minor damage. No injuries.

The Boeing 747-212B was on an instrument landing system (ILS) approach to runway 16R in patchy fog. Weather conditions at the time were reported as RVR 2,000 meters, fog and wind 070 degrees at three knots.

The crew initially prepared for an ILS to runway 16L, but later requested 16R because of the proximity to the terminal. Approach control cleared the flight to 16R about 15 miles from the airport. As the flight descended, ground and airport lighting was intermittently visible in patchy ground fog.

As the flight passed over the approach lights, the captain reported that the lights were partially obscured by the developing fog. Descending closer to the runway, the first officer, who was flying, and the captain reported only intermittent visual contact with the runway lights. A row of (what the crew interpreted to be the centerline) lights were sighted shortly before landing and the first officer realigned the aircraft with these lights.

Touchdown occurred firmly (two gs) on the runway with the aircraft angling slightly right to left, 450 feet from the threshold, with the right wing gear outboard tires on the left runway edge line. Runway width is 197 feet and runway edge lines are 90 feet from the centerline. The pavement edge measures 135 feet from the centerline. The left wing gear left the pavement about 800 feet beyond the threshold, arcing out to about 12 feet and then returning right until re-entering the pavement about 2,600 feet from the threshold.

The aircraft sustained minor damage as it crushed several runway edge lights during the excursion. After the aircraft taxied safely to the terminal, it was discovered that trailing edge flaps, the No. 4 flap canoe and a right landing gear door were damaged by flying debris and that the left inboard aileron was buckled.

The captain stated that shortly after touchdown he realized that the aircraft had landed on the left edge lights and applied hard right rudder to re-enter the runway and roll out on the centerline.

An investigation concluded that the incident resulted from flight crew fixation on limited light cues in patchy fog that obscured part of the approach and runway lights.

Botched Procedures Result In Mountain Crash

Fairchild SA227-III. Substantial damage. Two serious injuries. Nine minor injuries.

The daylight approach was made in zero visibility in snow showers. The flight had been cleared for a very-high-frequency-omnidirectional-range station/distance measuring equipment (VOR/DME-B) approach. The aircraft collided with the ground 100 feet in front of the VOR. It then struck the VOR and stopped a quarter mile beyond the initial point of impact on the north side of a mountain below the VOR station. A subsequent investigation concluded that while visibility was obscured and ceilings were low, improper instrument flight rules (IFR) procedures and poor copilot monitoring were the major factors causing the accident.

Hot Approach, Late Flare End in the Grass

BAe ATP. Substantial damage. No injuries.

The pilot of the BAe ATP scheduled (twin-turboprop) commuter was attempting a landing in a strong crosswind rated close to the maximum demonstrated for the aircraft. The aircraft touched down firmly in a flat attitude and bounced into the air. While attempting to complete the landings, a pitch oscillation rapidly developed which resulted in two additional bounces, each ending with a nose-first touchdown. On the fourth touchdown, again nose-first, the nose landing gear collapsed and the aircraft slid along the runway with the nose gear folded aft under the fuselage. The propeller tips disintegrated on contact with the runway and debris punctured the fuselage. The aircraft came to rest on grass adjacent to the runway. No one was injured and there was no fire.

An investigation concluded that the accident was caused by the pilot's decision to fly an approach speed that exceeded that recommended in the operations manual, misjudgment of the landing flare and poor recovery from the subsequent bounce.

Corporate Executive

Rutted Runway Sends Aircraft into Snowbank

Piper PA-31. Substantial damage. No injuries.

The aircraft, with a pilot and five passengers on board, was departing for an early afternoon flight in the winter. It had snowed and the runway had been plowed.

The pilot attempted to take off during a moderate snow shower. He lost directional control during the ground run and the aircraft left the runway to the right. The aircraft's tail section struck a snowbank. The aircraft sustained substantial damage but there were no injuries to the pilot or the passengers, who deplaned safely after the aircraft came to rest.

A subsequent investigation concluded that the runway area chosen for the takeoff roll was unsuitable and that snow removal operations had been inadequate, leaving the runway with an uneven coating of snow. It was determined that the left mainwheel dragged in a windrow left by the snow plow during snow-clearing, and that the pilot was unable to maintain directional control.

Power Loss Dooms Light Twin

Beech 65/70 Queen Air. Aircraft destroyed. Six fatalities.

The light twin-engine aircraft rolled abruptly to the right shortly after liftoff. The right wing tip struck the ground and the aircraft cartwheeled, crashed and caught fire.

A subsequent investigation revealed that the right engine supercharger intermediate drive gear shaft had become worn and that one of its teeth had failed from fatigue, causing an out-of-mesh condition and resulting in a partial loss of engine power during takeoff. The investigation also determined that the aircraft's weight was 679 pounds over the limit. The pilot and five passengers were killed in the daylight accident.

Other General Aviation

Fuel Selector Goof Results In Emergency Landing

Cessna 140. Substantial Damage. No injuries.

The pilot and one passenger were on a local daylight pleasure flight. Before takeoff, the pilot placed the fuel selector in the center position to feed the engine from both tanks. After 40 minutes in the air, the engine misfired several times and lost power. Because he had been making right turns for several minutes, the pilot thought the fuel had been transferred to the right tank, so he turned the selector to the right. The engine resumed normal operation and the pilot leveled the wings and continued normal flight. The engine stopped a few minutes later and the pilot executed an emergency landing in a field with a firm but rough surface. The aircraft bounced and traveled 500 feet in the air before touching down near a ditch. The pilot applied brakes to avoid the ditch and the aircraft rolled over and came to rest on its back.

An investigation determined that although the pilot was qualified for the flight, he had little experience on this type of aircraft. Examination of the aircraft revealed that the left wing tank was half full, the right wing tank was empty and that the fuel selector was in the OFF position.

It was also determined that the fuel gauges mounted in the wings functioned properly and that on this type of aircraft, the fuel selector has only three positions: LEFT, RIGHT, and OFF. When the pilot selected the center position, he thought he had BOTH, but actually selected RIGHT. When the engine stopped, he automatically turned the selector to the right without looking at it, thus turning to the OFF position. The pilot owned another aircraft, a Cessna 180, which has a fuel selector with four positions — LEFT, BOTH, RIGHT and opposite BOTH, OFF.

Lack of Instrument Experience Brings Down King Air

Beech 90 King Air. Aircraft destroyed. Two fatalities.

The light twin-engine aircraft was cleared for a non-directional beacon (NDB) approach in instrument meteorological conditions (IMC). The aircraft came out of the cloud base in a vertical dive, impacted the ground and exploded and burned. A subsequent investigation found no structural or mechanical defects that would have caused the crash. The investigation concluded that weather and the pilot's lack of instrument experience where significant factors in the crash. The accident report noted that ceilings were low and visibility was obscured by snow during the daylight approach. It suggested that the pilot, due in part to lack of instrument experience, had become disoriented and suffered from vertigo.

Rotorcraft

Rich Mixture, Surprise Engine Failure Bring Helicopter Down

Hughes 269C: Aircraft destroyed. Two minor injuries.

The pilot was being flight tested for his commercial helicopter license by an airman examiner. At a height of approximately 1,500 feet, the examiner closed the throttle without warning to simulate an engine failure, having first selected a suitable forced landing location which he estimated was within autorotation distance. The rolling terrain was tree-covered but there were scattered clearings.

The commercial candidate had not been expecting the simulated emergency and did not have his hand on the collective pitch control lever. But he made a normal entry into an autorotation straight ahead. The main rotor rpm initially reduced to 390 rpm, the bottom of the green arc on the rotor tachometer. When the throttle was closed all the way, the engine stopped instead of remaining at idle rpm.

The examiner took control quickly and turned the helicopter into the wind and toward the clearing he had selected. He brought the rotor rpm into the middle of the green arc at approximately 450 rpm but attempts to start the engine were unsuccessful. The helicopter undershot and settled into small trees at the edge of the clearing that cushioned the landing and reduced the forward speed. However, the main rotor blades struck the ground and the helicopter stopped on its right side approximately

25 feet into the clearing. The aircraft was destroyed but the two occupants were able to exit with minor injuries.

The engine fuel flow adjustment was found to be over-rich and was determined by investigators to be the cause of the engine failure when the throttle was closed to simulate an engine failure. Other significant factors included the fact that it is more difficult for a pilot to judge glide distance during autorotation over rolling terrain than level terrain, and the examiner was determined to have misjudged that distance.

Engine Failure Sends Jetranger into Trees

Bell 206B Jetranger. Aircraft destroyed. Two fatalities.

The pilot of the helicopter and a passenger had embarked on a daylight return flight to home base about 16 miles away. The cool, clear weather was not a factor. After flying about five miles at an altitude of 400 feet AGL (above ground level), a puff of smoke was seen coming from the engine exhaust. The aircraft then descended rapidly until it struck trees and was destroyed in an intense post-crash fire. The pilot was highly experienced and familiar with the terrain.

The pilot flew the most direct route home, which took him over a ridge covered with tall trees. Within one mile of the crash site there were numerous landing sites where a safe autorotation landing could have been carried out.

An investigation determined that the engine had suffered a catastrophic failure in the compressor section, causing a sudden and complete loss of power. The damage to the compressor was consistent with a second stage stator vane failure. The accident report speculated that the failure could have been caused by fatigue, although that could not be proved conclusively.

The accident investigation report noted that when the engine failed the helicopter was at a low level over the heavily-wooded ridge, with no suitable landing sites within autorotational landing distance. The report noted that the choice of a higher altitude or a less direct route would have given the pilot time to find a suitable landing site. It said the pilot likely decided against those alternatives because of the short distance to be flown and no hint of engine problems. ♦