

PROGRESS AND TABOOS IN AIR SAFETY  
ORIENTATIONS OF RESEARCH IN HUMAN FACTORS IN AIR TRANSPORT

Jean Pinet  
President of Aeroformation

Abstract

Human factors are the discovery of the past decade. Their influence since the earliest days of aviation is certain, but it is only in contrast to recent technological progress in equipment that we realize that nothing fundamental has been accomplished in studying the adaptation of machine to man and vice-versa.

In fact, three quarters of civil aviation accidents involve what are cautiously referred to as "human factors", which groups various causes ranging from ergonomics to behaviour.

This recent awakening, which is tied to the need to constantly improve equipment use and productivity, has influenced the design and creation of ergonomic workplaces, primarily the cockpit, with adapted instrumentation, as for example in the A320. Efforts have also been made to introduce human factors into training, with programs like Line Oriented Flight Training (LOFT) and Crew Resource Management (CRM).

Massive research programs have been launched, primarily in the U.S.A.

But we are today in front of Man as Pilot or as Maintenance Technician at exactly the same point as we were nearly one hundred years ago before Aeronautical Technology : a complete scientific approach to human factors remains to be undertaken although some spectacular results like the A320 have emerged from pragmatic, experimental approaches.

Some experimental quantification has been achieved through ergonomic studies, with instant recognition. However, human behaviour remains the principal challenge and psychology today does not provide adequate measures. Research, scientific or pragmatic, to define quantitative parameters is mandatory in order to progress.

It is this new challenge to which a few organizations are producing innovative replies.

I. Need for such a research

How long are we going to keep hiding from ourselves the truth on the causes of aircraft accidents ?

Are we going to wait to attack the causes until inevitably it is known by the passengers community, from whom this truth is still disguised ? Do we have to provoke it to be forced to react ?

This truth is so obvious and upsetting in the objectivity of statistics that universally it provokes an incredulous and suspicious response. Do we believe our subconscious which refuses it or our logic which can only observe it ?

Copyright © 1992 by ICAS and AIAA. All rights reserved.

I cannot answer these questions on behalf of the aeronautical community, but I will try and show how we can react right now and how some people have already done so. The road to enlightenment is still long if you consider that the earliest reactions occurred two decades ago without any major result today.

What do statistics in air transport accidents tell us ? More than three-quarters of the accidents are due to the so-called "human factor". The statement is indisputable but difficult to accept.

Why this huge proportion of 75 % ?

In fact, the number of accidents per hours of flight has decreased in the last forty years thanks to technical and technological progress, mainly in manufacturing aircraft, their engines and their equipment. Their reliability and safety have increased considerably leading to this relative decrease in accidents. But the flying and maintenance of aircraft are entrusted to men and this is going to be so for a long time still. It seems clear that man is the weak link in the chain and this statement is difficult to admit. Man is questioned in the "human factor" which is only the expression of mistakes generally made by pilots or maintenance personnel. The reliability of equipment increasing rapidly whereas that of man does not change noticeably, statistics take into account this discrepancy and point to the weakness in man.

To recognize and analyze mistakes would allow progress in preventing accidents. However today anything concerning man is subjective and therefore subject to controversy and taboo. What is the state of things ?

II. Main obstacles

The enormous drag on the required objective study is the financial side of the consequences of an accident. It is normal and just that victims who have endured an aircraft accident to which they have not contributed, receive reasonable compensation, themselves or their beneficiaries.

It is therefore necessary to figure out who is going to pay : if possible but not necessarily always, those who are responsible for the accident. And there the hunt for a "guilty party" starts.

Yet, in terms of aircraft accidents, the analysis of hundreds of cases clearly shows that it can never be traced to one cause. The contrary has been found out and is now accepted by everyone : a chain of circumstances, failures and reactions lead to a catastrophe. Most of the time, the absence of just one of these conditions would have been enough to avoid the accident.

Thus a certain number of classes of causes have been determined, the combination of which can be fatal. One of them is of prime importance and therefore considered as the main cause. In 75 % of cases, it is the human factor, i.e. an erroneous selection, diagnosis, reaction, a misunderstanding in the crew, a lack of respect of procedures, a mismanagement of a situation etc. or any combination of these.

We used to talk of flightcrew's "fault". This notion of fault, implying a wilful breaking of rules, has been replaced by that of error, a more realistic concept suggesting a lesser responsibility.

The communities of players, mainly pilots and maintenance people, have reacted by pointing out they were not responsible for errors induced or aggravated by a bad man/machine interface. Fifteen years ago, this was still justified. Aircraft manufacturers worked with strict method on this famous interface. They brought spectacular improvements in the cockpits and in aircraft maintenance, except for one point I will discuss later.

Looking for who is going to pay, it was and still is the habit to turn first to the aircraft manufacturer and the airline as they usually are more solvent. This fact clouds the debate in looking for the actual causes as pilot or maintenance personnel are a priori subjectively considered as subject to the constraints of the aircraft and its operator. They are therefore considered as having a lesser responsibility in the accident than those who "imposed" a cockpit or a maintenance procedure. This accusation has even become an obvious fact since the manufacturer is automatically involved, if not indicted, in any aircraft accident. The manufacturer is presumed guilty.

All this has promoted the thesis of the "inevitable error", if not provoked, and therefore "excusable". This thesis is supported by some professional unions among others.

What the media mostly emphasize reflects this tendency and it is usual to see objective facts refused. A caricatural example is that of the A320 accident in Habsheim. Never in the entire aeronautical history had an accident got so many recordings, both visual and internal to the aircraft, or so many direct witnesses. The human error or rather the many human errors and their chain were proved, supported, obvious. In a staggering manner, the objective facts were pushed to the background to the benefit of irrational accusations echoed and amplified by the media : falsified recordings when everyone knows that this was impossible in the time available, conspiracy of the industrial lobby against the unfortunate captain, faults of the regulatory authorities, etc. Legal proceedings are continuing, initially fed by an administrative dispute irrelevant to the causes of the accident. The same legal proceedings opposed the publication of the content of the Cockpit Voice Recorder, which would tend to show that there is something to hide on the "human factor" side and that the pilot could be protected illogically by accusing the aircraft to the detriment of truth. This is not going to help

attack the real causes of the accident. In the meantime, the technical report has been issued with indisputable conclusions, based on observed facts. It has been ignored and criticized except by those whose judgment goes beyond irrational human reactions.

And yet, this irrational human reaction is involved in most of the 75 % of accident cases. Is there any way to solve the problem ?

Before leaving this chapter of confused and passionate search for responsibility in an accident, may I remind you of a suggestion made by Airbus Industrie, which could calm the debate. The Varsaw convention defining the compensation paid to victims is totally obsolete and gives a free hand to bounty hunters. The setting up of an international fund to provide decent compensations would make the search for the "guilty party" more serene as it often hides the search for who will pay. In this way, it would allow a greater objectivity in looking for the real causes of accidents.

### III. Ergonomy versus behaviour

Often as we have seen after analyzing them, accidents are due to more than one factor : weather forecast, traffic congestion, faulty equipment, etc... and most often the human factor. As we have also seen, the latter evokes the man/machine interface, i.e. the adaptation of the machine to its operator. This is usually called ergonomy.

Throughout the years, the cockpits, the essential interface between pilots and aircraft, and the aircraft handling qualities which are the second part of this interface, have improved rapidly to reach today an exceptional degree of adaptation to man in the universe of machines. Handling qualities have made a great leap forward as soon as it became possible to measure and quantify the human judgment which characterizes them. The advent of the "Cooper-Harper" scale in the sixties has been determining. It is still used today or has spawned efficient derivatives.

If the correct responses of an aircraft to the commands given by pilots are an obvious criterion of safety, pilots must have in the cockpit commands and controls allowing them to judge and act without ambiguity with a minimum of physical and mental effort. The implementation in the eighties of the two man crew on large transport aircraft, has compelled Airbus Industrie to imagine and implement techniques to measure the gestual and sensorial efficiency of commands and controls, and to quantify the tasks accomplished by pilots during the different flight phases, under different constraints, particularly in case of failures.

Improvements in ergonomy then went through a huge positive leap, helped by the massive introduction of digital techniques and equipment. In 12 years, we have seen successively the A300FFCC, the A310, the A320 and today the A340. It is the A310 which concretizes with, later, the B757 and B767 of Boeing and the MD80 of Douglas, the most important step in the evolution. The A320 with its "fly-by-wire" is but a derivative from the A310, just as the MD11 derives from the MD80 and the B777 from the B767.

It remains however that a cockpit cannot be designed for a given individual pilot and therefore all these cockpits have been designed, studied and developed by measuring the reactions and workloads of pilots, by testing them on dozens if not hundreds of pilots, as had never been done before. The result is that we now have cockpits truly adapted to the aircraft missions and to the majority of pilots flying it, with minimum workload, reduced probability of error, better diagnosis of critical situations and therefore increased safety.

Of course we cannot conclude that ergonomics is now perfect but, quantitatively, since measured, it comes close to the quality and reliability of technical equipment. It will be improved further thanks to measuring techniques and to powerful mathematical supports which will be more and more refined although probably at a lesser rhythm than in the last ten years.

In a word, ergonomics is now integrated in the current aeronautical evolution process with however an important exception, that of the Flight Management Computer. Its utilization has radically changed the flight management in the cockpit and all aircraft manufacturers without exception have adopted it... as virtually imposed by the equipment vendors, i.e. with an interface perhaps correct for manipulating it in an office but not ergonomic in a cockpit. The pilot/FMS dialogue imposes a long concentration on equipment, not adapted to the dynamic operation of an aircraft. Major improvements are required to make this interface more ergonomic.

#### IV. Emergence of behaviour

As early as the beginning of the eighties, manufacturers and airlines realized that this famous human factor comprised two major components: ergonomics and behaviour. For manufacturers, the main concern of design offices was the first component, the second was a source of problems for airlines. Whereas manufacturers used powerful measuring and calculating tools to control ergonomics, operators attempted to deal with behaviour through classical means derived from psychology and observation of work in the cockpit.

These classical means were simply based on educating pilots' behaviour through putting them in realistic difficult and often conflict situations, most of the time in flight simulators, to teach them how to communicate and work in harmony as a crew. However this method involved questioning individual behaviour and an interesting cultural phenomenon could then be observed, showing how difficult it is to admit that individual behaviour can be dangerous and must be educated. In the seventies and eighties, the only airlines to implement systems to deal with this problem were of Anglo-Saxon culture. No other airline from another culture did it before quite recently. In particular, very few of Latin, Arab or Indian culture approached the problem and then only recently and partially.

The program set up then was called Crew Resource Management (CRM) and the American FAA strongly encouraged it. As we are dealing with the education of a large and varied population, effects are

long to observe. Moreover as it concerns accident prevention, the positive effect is precisely the absence of event, something difficult to quantify. However it will be possible to judge by comparing relative effects between those airlines which practise CRM and those which don't. The number of accidents being after all low, we have to wait to measure it.

Even though manufacturers were oriented more toward measurable ergonomics, they were not indifferent to behaviour. Their training centers were directly in touch with individuals and their behaviour. Quite quickly, a few truths prevailed, even if they were opposed irrationally in the name of ideologies or more concretely in the name of the "search for a guilty party" already mentioned.

Thus the number of errors observed during training on new aircraft types tended to decrease, without disappearing however. Still the seriousness of consequences decreased. Of course the objective of training systems and methods is to correct errors and above all to teach how to see and correct them. Two experimental facts appeared clearly then and now : a well studied ergonomics limits the risk of error and its consequences, but also no pilot in the world is above making an error. In other words, errors will still happen in an ideal cockpit ; it is inherent to human nature. The issue for us, educators, was to correct behaviour with the imperfect weapons available to us, in the same way as airlines but with more emphasis on experimental observations and less on psychology.

#### V. How to correct behavioural problems

We have set up strict flight procedures and flight management, based on cockpit ergonomics and on a strict task sharing between pilots. We assess in training not only the pilot flying but also the pilot not flying so that the latter has to do his part correctly in the flight management.

In fact our approach is simple and based on an indisputable statement : whether a cockpit is ergonomic or not, safety increases if pilots are thorough in their tasks, i.e. if they apply procedures, respect task sharing, do cross checks, help each other and communicate. In other words if they are disciplined and cooperative.

Our experimental observation shows that most of the time, it is possible to reach good results during training but the effects can rapidly disappear later on, when people are no longer motivated by getting a type rating.

To try and act on a permanent motivation, we have introduced an education component, derived from the CRM, teaching pilots how to recognize a chain of errors leading to catastrophe and how to break it.

However education implies a permanent, long term action, touching all the players in air transport and requiring a concerted and coordinated action. Everyone is concerned, ab initio schools, airlines, manufacturers, regulatory authorities, and actions cannot be confined to a narrow national field.

In the aeronautical world, the USA are the only ones to have taken concerted and conscious measures, conducted by the FAA, in which most air transport players participate. This is not a small matter since this part of the world represents about half of the world activity in terms of air traffic. About 90 M \$ were spent in 1991 in studies which can be found perhaps too scattered. But have we got any right to criticize the only country which decided to attack the most important problem of flight safety ?

The rest of the world, Europe in particular, is nearly totally absent from all behaviour study whereas the USA try to issue regulations on it. We, in Europe, are still talking of the "man/machine interface". Obviously improvements are still required in ergonomics, in particular on the FMS. But the objective statistical data, facts, show how the part played by ergonomics in accidents decreases whereas that of behaviour remains constant.

We would tend to say that the solution is simple : pilots and maintenance personnel should be strict and disciplined. Automatically the number of accidents would decrease.

It is true that some individuals, even some cultures, should be educated in this perspective. Implementing such an education can only have a positive influence on the accident rates due to the human factor. Normal behaviour in pilots will lead to an early recognition of error and to an action correcting it, as abnormal behaviour could let the aggravating chain build up to an accident. But let's be realistic. Even the best pilot will make errors in the most ergonomic cockpit. He will be subject to personal problems distracting him from a strict discipline. The ideal man will never exist, nor the ideal aircraft.

#### VI. How to orientate the studies on human behaviour

As for the aircraft, it has been in existence for one century, progress has been fast and the present state of realizations is surprising. This has been made possible through the knowledge and control of "exact" sciences, those enabling us to measure and predict quantitatively. As we have seen, ergonomics has made a spectacular leap forward as soon as it became possible to measure tasks in the cockpit concretely and realistically.

As for behaviour, for 150 years psychology has been making essentially qualitative progress. Today behaviour cannot be measured, it is impossible to predict scientifically the probability of a certain attitude occurring in a pilot placed in certain circumstances. And yet if we want to decrease the 75 % of accidents caused by human factors, the qualitative approach of psychology is not sufficient by itself. It is naturally important in the absence of other means, CRM is here to prove it. We must carry on with it finding better means, by setting up world standards of education and training for pilots and maintenance personnel addressing this particular issue, bearing in mind what makes the problem more complex : normal behaviour is common, abnormal behaviour is the exception and therefore difficult

to address.

But at the same time, it is necessary to launch basic or specific research in pilots' behaviour in the cockpit and maintenance personnel's behaviour in the hangar or stopover.

Air transport accidents cost about one billion \$ a year to the world community, i.e. about 750 million \$ a year due to the human factor. If we consider the American effort of 90 million \$ a year, that of other communities being around 10 million \$ which mostly goes toward ergonomics, we can see how far from the goal we are in our fight against accidents.

It is high time for scientists and technicians to get to work to measure and predict the seemingly irrational human behaviour. How do we go about it ? This can be the subject of another paper.