

Practising What We Preach

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1. Introduction

1.1 Abstract

Accident statistics have highlighted the importance of the human element in aviation safety. Human Factors (HF) has become a well established discipline in the aerospace industry, and most organisations publicly espouse concepts such as 'human centred design' and the use of technology to support the pilots task. In practice, HF still seems to be a peripheral concern in most manufacturers. Many words have been spoken and written on the subject, yet the issues and the messages seem to have remained strangely constant for some ten or even twenty years. Some progress has been made but, fundamentally, little appears to have actually changed in the design process of most organisations.

This paper will consider why many manufacturers outwardly pledge their allegiance, but privately seem to resist any real shift in working practices, to accommodate the 'human' element. It will be argued that the structure and business culture of the industry overall is unlikely to facilitate a solution to human factors issues, and that Regulation has a role to play in improving the 'human' aspects in safety.

1.2 Summary



- The human pilot forms the interface between many different parts of the aviation system, such as selection, training, licensing standards, flight deck design, flight time limitations, air traffic control, and operating procedures.
- If different parts of the system are not entirely compatible, this interface becomes strained, and may fail. This failure is known as 'pilot error' or, more recently, a 'human factors' issue.
- In general, the individual parts of the aviation system receive a great deal of attention, in terms of both management and regulation. The interfaces between them receive rather less, because they are difficult to quantify and have no clear ownership.
- Achievement of highly compatible interfaces may require individual areas to expand the boundaries of their task beyond its current definition. Ensuring the adequacy of the interface to the pilot, and through him, the interface to other areas, may not necessarily be defined as a program task in civil aircraft development.

- Cost recovery of such activities may be deferred and indirect.
- Business culture strongly favours meeting requirements as defined, and does not tolerate the costs of exceeding that task. Current trends are probably increasing this tendency, with separation of activities into cost centres, individual accountability against key measures, and direct recovery of costs.
- This could mean that business culture increasingly penalises the activities that are needed to address human factors issues in the aviation industry.
- Most companies - and individuals - will behave in the way that is most rewarding for them and their shareholders. Yet, it is not unknown for any industry to systematically penalise the very activities that it seeks to encourage. This may be the case in achievement of good 'human factors' design in some areas of civil aerospace.
- It is probably not realistic to hope that the general business culture will change in order to address the human factors issue. Therefore a different solution is needed. The JAA are considering how regulation can be best used to ensure a good interface with the pilot, in the important area of flight deck design. One possibility is the certification of the overall flight deck design, that will pay more specific regard to the human factors point of view. This would include a structured development process.

2. Human Factors in the Civil Aviation System

2.1 Who is Responsible?

The civil aviation system consists of all of the activities that contribute to civil air transport. It is large, complex, multidisciplinary and international. Describing the advent of complex engineering systems during the industrial revolution, Tenner (1995) describes a new phenomenon that was challenging the technical and legal minds of their day: *'the interaction of acceptable components could produce an unacceptable result'*.

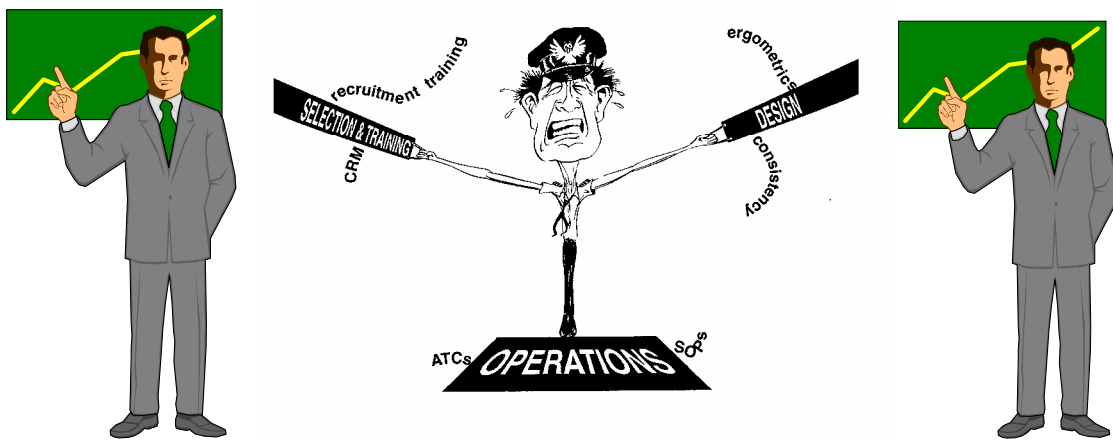
This could prove to be a fruitful line of thinking when approaching the human factors issues that have proved so elusive to date. Following an accident or incident, the first line of investigation is to determine the causal factors, and this often leads to ascertaining who is at fault: who is responsible. Providing that each component area has met its defined requirements, any responsibility for the event can be denied. The pilot, who must adjust and compensate for any shortfall in the compatibility between the interfacing areas is left, as it were, holding the baby; the verdict is pilot error.

2.2 Important Interfaces

From a Human Factors viewpoint, a safe flight could be seen as having three major contributory areas: Flight Deck Design, Operational Environment, and Pilot Preparation. Each of these areas has many aspects, and each of them has links to the other areas through that very special interface: the human pilot. The pilot forms the adaptable, flexible, thinking interface that can often compensate for minor incompatibilities or shortcomings between the contributory areas. However, this interfacing device has its own characteristics and limitations, and it cannot continue to compensate for an infinite degree of shortfall; beyond a certain point, the interface comes under strain. This has three major implications for each of the contributory areas:

- It must reach a minimum standard
- It must interface adequately with the characteristics of a human pilot
- It must not make excessive demands upon the other areas that interface with the pilot. For example, a flight deck design should not require a degree of pilot education or training beyond the level that the pilot population can absorb, and commercial industry is willing to support.

To some extent, it is possible for one area to compensate for increased demands or shortcomings in another area. If the Flight Deck design is made more complex, but the standards in training and selection are raised to 'link' up with it, then the pilot at the interface will not become strained. If, however, several different areas become more demanding with no compensation elsewhere, then the pilot interface will come under strain and eventually fail. The most common cause may be the commercial pressure that exists to minimise costs in almost every area of business operations.



The testing of other important interfaces, such as between avionic equipment, is usually defined as a programmed task and funded without question. This could be because they are in the domain of traditional engineering disciplines, which are usually the primary interest of individuals who manage manufacturing companies. It could be because the test criteria are more easily quantified. Alternatively, it may be that if an electronic or mechanical interface fails, the responsibility clearly lies with the manufacturer of the equipment. If a human interface fails there is always the possibility of blaming another party - the training, the operator or, most often, the crew.

2.3 Facilitators and Inhibitors

The extent to which these interfacing 'links' ensure compatibility between the contributory areas is influenced by many factors. Some of these factors encourage the 'links' to increase and strengthen, to explore the requirements for compatibility and seek effective matching; we can refer to these factors as 'facilitators'. Others influence them to decrease and withdraw into the protective shell of their individual areas; these we can refer to as 'inhibitors'. Table 1 lists some of the influences that could be viewed as 'facilitators' and 'inhibitors'. The left hand column, representing 'Facilitators', is really listing influences that facilitate a good 'human factors' interface between contributing areas. Notice that the right hand column headed 'Inhibitors' could almost as easily be headed 'Trends in Modern Industry'. The business culture, particularly in the light of recent trends towards subcontracting, separation into individual business units, and quantitative measurement of

performance indicators, is ideal for addressing technical, numerical, engineering based tasks, but poor for addressing the interfaces that can result in human factors problems.

Facilitators	Inhibitors
Adherence to the spirit of the requirements	Minimum compliance to 'letter of the law'
Staff in positions for long periods of time	Staff move on after two or three years
Staff concerned for long term outcome	Staff concerned for immediate outcome
Collective responsibility in the industry	Individual responsibility for contract task
Success measured by operational feedback	Success measured by immediate cost/ time
Delivery date dictated by time required	Demanding, fixed, delivery dates
Strong financial resources, money available	Financial resources tight, minimum costs
Costs attributed to the industry collectively	Costs attributed to separated business units
High staff levels of experience / expertise	Staff with minimum qualifications
Overall tasks completed by single company	Task divided between subcontractors
Preventative activities justified / resourced	Resources only for 'proven' need: 'fire fight'
'Judgements' independent of pressure	Commercial pressure on judgements
Select subcontractor by product quality	Select subcontractor by lowest bidder
Clear responsibility for issue	Issue shared among areas; (e.g. 'pilot error')
Issue is simple to define, bound, resolve	Issue is complex, unbounded, and difficult

Table 1: Facilitators and Inhibitors of achieving good 'human factors'

This table indicates that *the trends and practices in the modern aerospace business are pulling in directly the opposite direction to that required for improvement in the 'human factors' area.*

As each defined task is completed to the bare minimum required under contract, investment of time or resources in interfaces that are difficult to define and quantify will diminish. These are generally governed (if at all) by terms such as 'adequate' or 'satisfactory' that are subject to interpretation, and therefore possibly vulnerable to commercial pressure. This might most accurately be characterised as the '*dis - integration*' of the aerospace industry. This is not meant to imply decay, but rather the opposite of integration: it is organised in such a way as to work against its own stated objective of improving safety in the area of 'human factors'. This same phenomena observed within the individual organisations could be referred to as '*dis - organization*'. This does not imply lack of organisation or anarchy, which would most properly be called unorganised, but the systematic and structured organisational characteristics that work, often through the system of rewards, against the organisation achieving its own stated goals, such as safer product design.

The following paragraphs explore the mechanism by which this *dis - integration* and *dis - organization* might operate.

3. Goal Achievement Strategies

3.1 A Bit of Basic Psychology

In the 1950's, the behaviourist B. F. Skinner used animal research to establish some fairly basic but widely applicable principals of psychology. One of the principals that he proposed is so fundamental, so obvious, and so true, that it is often overlooked in the complexities of organisational analysis. It is this: *Behaviour that is rewarded is likely to be repeated.*

Most organisations believe that, in one form or another, they use reward to encourage employees for behaviour that will help the company to meet its goals. Hard work and good ideas get rewarded with praise, promotion and better pay. Unfortunately the 'carrot and stick' approach is not always as effective as we might hope.

3.2 Mysterious Failures

Many commercial companies spend a great deal of time and money trying to ascertain why their organisation is not as successful as they would like it to be. Management consultants are employed at fabulous rates, employees attend courses to learn about communication, motivation and leadership, the company reorganises and endless initiatives are born. Two years later, nothing has changed. Communications are still failing, resources are still misused, co-operation is lacking and improvement programs have petered out. The elusive 'can do' attitude has not materialised. The company hires a new team of consultants, and the cycle begins again.

3.3 What Goes Wrong?

One reason for these mysterious failures can be that the company is unwittingly punishing the very behaviour that it wants to encourage, and rewarding the behaviour that makes it fail.

It is not difficult to recognise some of these characteristics from almost any business organisation. Most people have, at some time, witnessed the frantic spending on needless items at the end of a financial year, to avoid having lower budgets next time. Hard workers may be given more to do and tougher targets, because they can be expected to deliver a good result. If they notice a 'time bomb' in their part of the process and report it, it will become 'their problem', and they will be expected to solve it; if they omit to report it, it will be 'someone else's problem' when the time bomb finally explodes later on. The net effect is that the employees may not always behave in a way that would help the company to achieve its objectives. They may behave in a diametrically opposite way, not because they are bad people who want their company to fail, but because they are normal people who want good outcomes for themselves. Their behaviour is not what the company wants or needs, but it is the behaviour the company rewards (Kent 1986).

This self defeating characteristic of the system can just as easily happen at the corporate or industry level. An increase in the durability and reliability of engine parts could cripple engine manufacturers, as the demand for spares and replacements dried up. New discoveries may be deliberately stifled by a scientific community with a vested interest in the existing technology. Software houses profit enormously from the 'maintenance' contracts to debug their products in service, or their follow on projects to

improve functionality or user friendliness. If their products were really 'right first time', they would lose money and might, in some cases, be pushed out of business.

The main point here is that 'free market' forces cannot always be trusted to achieve the results that are clearly desirable as an overall goal. The goal may be desirable to the world, or the industry as a whole, but it may not necessarily be desirable to those involved in the key decision making process. In a '*dis - integrated*' or '*dis - organised*' environment, the 'free market forces' will act in the opposite direction of the stated goal of the greater system.

3.4 Why Is This Relevant?

What is the reason for including this concept in a paper on Human Factors in aviation? The reason is this: An important objective of the aviation industry is to maintain or improve safety and it is widely agreed that addressing 'human factors' would play an important part in achieving this aim. *Unfortunately, a serious attempt to address these human factors issues would go directly against the principal interests of almost everybody involved in deciding what to do.*

4. The Consequences of Addressing 'Human Factors'

4.1 Consequences at the Corporate Level

Embrace 'Human Centred Design'	Continue with Traditional Engineering Approach
Identifies an issue that needs solving	There is no problem to solve
Accepts ownership of the 'unsolvable'	Someone else should solve this problem
Implies liability for human error	No liability accepted; not our responsibility
'Findings' may suggest restrictions	No nuisance 'findings'
Time/cost to address the unknown	No additional time/ cost required
Invites criticism for efforts	No activity; so nothing to criticise
Task structure may change; unknown way	Task structure continues in proven format
Internal organisation structure disrupted	No disruption
Untried knowledge; may fail to work	Use proven knowledge, predictable results
Failure not be obvious until in service	Use proven knowledge, no surprises
Failure could cause catastrophe	Not tried so won't fail
'Right first time' means no updates or follow on work after production	Updates and follow on work constitute large proportion of profit, and absorb staff 'slack'

Table 2: Negative corporate consequences of addressing human issues in design

The example above in Table 2 is based around the consequences of incorporating a full Human Factors program for a Design & Manufacture Organisation. Similar principles could be applied to companies in almost any part of the aerospace industry. Some of the entries may be genuine threats, and others wrongly 'perceived' as fears; in either case, if they are believed to be true they will influence decision making.

The leaders of the aerospace industry are not fools. They may sometimes avoid committing to solve this difficult issue, not because they do not recognise its existence or importance, but because there is too severe a penalty for such a course of action. Managing a major commercial aerospace company is not usually a career for altruists, and they are unlikely to receive many thanks for putting their company into an unnecessarily difficult position.

4.2 Consequences at the Individual Level

Every organisation consists of individuals, each with their own particular motivations and personal agenda. Each individual is able to influence the process and decisions made within the organisation in their own particular way. How would the prospect of embracing a 'Human Centred Design' be perceived by the main groups of individuals in, say, a manufacturers organisation? In most cases, the majority of employees - and managers - are technical people with no background in the 'human' disciplines. They may not want to be involved with messy 'human' issues, or to see decisions deferred to a group of people from a 'foreign' discipline that they distrust. They may envisage delays in starting early design work while the 'human factors' are explored and, having been explored, the resultant output may not be compatible with the favoured technology of the engineers. Test pilots may feel that their judgement is being seen as no longer sufficient.

Technical staff, marketing representatives and technically minded visitors from the Customer will often want the maximum 'cutting edge' technology on the product, whether it best supports day to day flying activities or not. This is particularly true if there is any chance that a rival manufacturer or operator is likely to use it. Project managers would dread the idea of having to wait for 'human' issues to be researched and resolved before basic decisions about the design could proceed. Even the Human Factors staff themselves may foresee an avalanche of contentious and difficult questions, for which they will be expected to have clear, immediate and easy answers. In the light of such perceptions, it is not difficult to see why resistance may be present.

4.3 Costs and Benefits

The manufacturer would have to fund any human factors effort that is directed at flight deck design, but the real benefits of it will be reaped by the aircraft operators, trainers, insurers, and maintainers. Only in the very long timeframe will it benefit the manufacturer themselves, and most are focused on short term goals. In all cases the returns will be difficult to quantify because crew related situations have multiple contributors. This may explain why the Military design world has long since progressed with Human Factors on a scale that the civil world, in most cases, has not done. In Military development, the same organisation - the MoD - pays for all aspects of the aviation system: design, development, selection, training, maintenance, operations, ATC, aerodromes. Therefore, they later reap the benefits of paying for good human factors effort in the design process, in reduced life cycle costs later on (e.g. the T800 engine 'designed for maintenance').

The benefits may not only be absent, but negative, because if their HF research effort leads to the conclusion that their sophisticated aircraft design actually needs a much

longer training program for safe operation, then it will prove more difficult to sell than a competitors product where no such pitfall has been 'discovered'.

This kind of research output may indeed be unwelcome. To challenge whether an automated flight deck design that has been built around contributions and feedback from Western Test Pilots, will *necessarily* be used and understood in the same way by Russian or Asian First Officers, is to open a fairly sizeable and expensive can of worms.

5. Conclusion

5.1 *Are We Doomed?*

We have already discussed three basic reasons why the aerospace industry may not unequivocally embrace the 'human factors' issue. These are:

- It would run directly counter to the aerospace business culture
- It would run directly counter to many corporate interests
- It would run directly counter to many individual interests

Recognising these difficulties are the first step on the road to overcoming them. It is not realistic to stand before the rising tide like King Canute, continually telling the technical world that human factors are jolly important and hoping that this message eventually weighs heavier than all of the influences to the contrary discussed above.

There is a need for action that will impose a minimum safety standard on the interfaces between aviation areas as well as the areas themselves. This does not imply that the Regulatory environment has been lacking in the past, but that dynamic changes are occurring in the industry and the Regulatory environment should now develop to meet these new challenges.

5.2 *Recommendations*

In conclusion, the industry seems unlikely to progress as far as we would wish in the improvement of human factors issues, without some minimal regulatory intervention. It is proposed that for flight deck design, some additional regulation should be introduced in certification, to ensure that proving the human interface becomes a defined task in the civil industry, in the same way that testing software, integration or structural strength are defined as tasks, and resourced as a necessary and integral part of development.

References

1. Tenner, E., *Why Things Bite Back*, Fourth Estate (1995)
2. Kent, R., *Managing People: 25 Steps to Improving Employee Performance*, Sidgwick & Jackson (1986)

