14.0 MANAGING HUMAN FACTORS WITHIN A SAFETY MANAGEMENT SYSTEM

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INTRODUCTION

This paper discusses the work Shell Aircraft Ltd (SAL) has done in developing an aviation Safety Management System (SMS) and, in particular, aspects of managing Human Factors within the maintenance element of an aviation business that has developed an SMS. The same principles have also been applied in our model to manage and control the operational aspects of aviation.

It would be more correct to describe SAL's system as an Integrated Management System (IMS) because, apart from safety, our system was developed incorporating the ISO-9000 Quality Assurance model as the active tool to drive the elements of quality, health, safety and environment and complying fully with JAR-Ops-1/3.035 and JAR-145.

However, first it might be appropriate to explain why an oil company is involved in developing an SMS for aviation. SAL not only operates a London-based corporate fleet of aircraft for the Shell Group, but also provides an Aviation Advisory Service to the Shell Group around the world. The Advisory Service is required by the Corporate Management to assure the safety of its aviation support operations. A stated objective for SAL is to reduce Shell's world-wide aircraft accident rate. This requirement has for some time committed SAL to reduce the 1992 accident rate by 50% by the year 2000 and again by a further 50% by 2005.

The majority of flying for Shell is carried out by contracted aircraft operators. Therefore, to achieve a real reduction in the Group's accident rate SAL need to work with these aircraft operators, and our own in-house operations, to improve their safety performance. To aid our achieving this reduction SAL carry out periodic audits of all of contracted or in-house operations, which gives us a broad view of the status of the industry. It has enabled us to develop a number of safety initiatives which can be introduced into the operators systems where required. One such initiative is the aviation SMS.

SAL recognises that developing an aviation SMS is likely to take considerable research and development effort, much of which is the same for all aircraft operations. Therefore, where possible to avoid all the operators doing this work SAL, together with others, have worked on building the core knowledge which is available to share and develop with contracted aircraft operators.

The current aviation usage exposure to the Shell Group is approximately 70,000 flying hours per year of which some 50,000 are flown in helicopters. In many of our operations these hours are flown in the most hostile environments for aircraft operations. The aviation industry statistics identify that approximately 20% of accidents are related to technical or airworthiness failures and 80% to human factors. Generally, the accident rate relating to technical or airworthiness causes is reducing, but all of the investment in that area is addressing only 20% of the problem, whereas, the Human Factors accident rate is actually increasing world-wide. In reality, little is meaningfully being achieved to stop that rise; FAA and NTSB records identified 31 maintenance error induced accidents in 30 years with 5 happening in 1995. These statistics show that relevant to the flying hour levels the number of maintenance related incidents have doubled in the last ten years, and there is no evidence to show this trend is slowing.

Shell's accident record mirrors that of the industry although, over the last ten years, SAL has seen some improvement in the Shell Group accident rate. However, the reductions in the accident rate achieved to date are not enough to meet SAL's objective, hence the commitment to introduce an aviation SMS. The benefits of Safety Management Systems were recognised in the Cullen Report, which followed the Piper Alpha disaster. In that, oil industry companies were charged to demonstrate clearly that they and their supporting contractors had systematically examined every safety critical activity in their business and taken steps to manage the hazards identified. This required an analysis of the facilities and systems, the identification of latent hazards with the potential to cause harm and the measures taken to control them. This resulted in the production of a Safety Case which is a statement of fitness for safe operations; to systematically manage the hazards identified it was necessary to build a Safety Management System. Shell Aircraft drew from the experience the Shell Group has gained in developing Safety Cases and Safety Management Systems for off-shore and on-shore facilities whilst building an aviation specific SMS model.

Within Shell, all offshore facilities now have Safety Management Systems and the Shell Group has a declared requirement for all its direct contractors to have achieved the same status by the end of 1999. Aviation operators supporting Shell Group Companies fall into this category.

SAFETY CULTURE

It is SAL's view that the introduction of an SMS may require a culture change in the aircraft operator. Culture changes can only be achieved if the management openly demonstrate commitment to change to gets "buy-in" from the staff. The culture generally found in industry today is potentially a hindrance to the furtherment of safety, because deep down both staff and management believe they are safe enough. Aviation companies tend to accept the levels of incidents as being the price of doing business, and generally don't believe accidents can happen to them; in reality, if the industry chose to, it could be a lot safer. However, there is cost in effort, commitment and up-front investment.

This paper does not suggest that safety should be sought at any cost, because the price of addressing the extremely unlikely might be very high. Indeed, part of the development of an SMS requires the operator to establish what level of risk is acceptable. Therefore, it is essential in the objective setting for the Company to initially state what the SMS is trying to manage and to what level of risk. It will take time to change the culture of a company and management should be prepared for several years of repeated effort to achieve this. However, the potential rewards could be as much as an order of magnitude improvement in accident rate in ten years. The culture sought, needs to be based on a number of things:

- trust of the management by the staff,

- an open reporting culture,

- a communicative culture and, importantly,

- a Just Culture.

These elements could build the framework necessary for change but they can only be born out of management's demonstrated commitment to the prime objective of safer operations. To underpin the safety culture of the company, the systematic approach of a Safety Management System allows the company to review the business and aid the introduction of safety improvements.

Safety Management in Engineering

Safety management of engineering in aviation requires the company to consider why maintenance is done, for what benefit and to what standard; in its simplest term maintenance is the "management of actual and potential failures". If that premise is accepted, then engineers will recognise an SMS as the "maintenance programme" for the company's systems. Therefore, in the same way that operators and aircraft manufacturers design maintenance programmes to reduce the risk of failure to a predetermined level, the operator should design the SMS to reduce the risk of release of a potential hazard to acceptable and manageable levels.

THE SHELL AIRCRAFT SMS MODEL

Concept

The methodology SAL used to design an aviation SMS was to identify all the processes and subordinate activities carried out in the company's business, resulting in a Business Process Map (BPM). Each activity is then analysed to find those that are safety critical. Those activities are then further broken down to identify the tasks that are to be done, the competencies needed to do the tasks, the procedures that apply the required level of control and the hazards that exist in any task, for example, inflating a high pressure tyre. Using this approach of analysis of the business it is possible to identify all the hazards and the controls necessary to reduce the likelihood of the release of each hazard. In this context, "hazard" is defined as that which has the potential to cause harm, injury or damage.

Once a hazard is identified the operator should try where possible to either remove the hazard, reduce its potential, or at least manage that hazard. Hazards will always exist; however, it is controlling their potential to cause harm and reducing the damage caused when they are released that is important. For example flying itself is a hazard, as the aircraft in motion has both kinetic and potential energy. To remove this hazard requires the operator to stop flying, an unlikely scenario. Alternately, to reduce the hazard we are able to use "safer" aircraft, cut to a minimum the amount of flying being done, build in system redundancy, or improve the operating procedures.. However, ultimately the measure most often taken is to ensure that the hazard is managed in the best way possible through controls in place to maintain the hazard within safe operational criteria; steps such as effective procedures, training, quality assurance and supervision can mitigate the risk of hazard release.

The controls necessary are simply effective barriers which reduce to acceptable levels the likelihood of the release of the hazard. The controls identified in the SMS also need to ensure that suitable recovery measures are established to deal with the consequences of a release and return the situation to normal. Therefore, it can be seen that a safety management system does not propose safety at any price, but a structured approach to manage the risk of release of the hazards that could do the most harm to the company's staff, assets, customers or reputation, all of which are the key reasons for being in business.

Structure

The Model SMS SAL developed uses a custom designed computer software tool to manage the information, known as SAMS. However, the software tool in itself is not an SMS. The SMS is the structure of management for safety selected in the operator's company. Underpinning and describing that structure is a manual, which SAL consider to be the headline manual of the Company. This manual sets out the policies, objectives and mission statement; it also describes the methodology by which the SMS is enacted. In our model it also forms the Company Quality Manual based on ISO9002. However, to avoid unnecessarily increasing procedures or regulations, something the aviation industry does not need, the manual simply uses cross references to the Operations Manual, Maintenance Exposition and company procedures.

Our SMS manual is structured in five parts containing:

Part 1	Introduction - Policy - Standards - Quality Model - Business Process Map and methodology of application of the process.
Part 2	Is set out in three functional sections, Engineering, Operations and Company Management. These detail in the form of checklists a breakdown of the BPM into activities and tasks together with the competencies of staff and the procedural cross references the staff need to carry out the tasks. The output of the Part 2s is a listing of hazards pertaining to the various activities (interacting with Part 5); and the shortfalls against the required controls noted in any activity and task checklists feed into the remedial action plans (held in Part 4).
Part 3	Details the documents and manuals used in the company.
Part 4	Holds the remedial action plan; this is the health check of the operator, listing all the shortfalls and non-compliances currently extant in the company.
Part 5	Describes the Hazard Management, detailing from the output of Parts 2 what hazards exist in the Company and completes a risk analysis of each hazard. It also identifies what threats could release the hazard and what control barriers are in place or are needed to manage each hazard. This part also includes the escalation factors that might make the initial hazardous event worse if it is not controlled; it also identifies the consequences of releasing the hazard and if possible what recovery measures might restore the status quo. The output of Part 5 goes to Part 4 as remedial action plans to resolve shortfalls. Part 5 also forms a key part of the Safety Case.

CONTROL OF HUMAN FACTORS WITHIN AN SMS

Human Factor issues impact on operational and maintenance activities in many ways, and already much work has been done, both theoretically and practically, to better understand the problem and reduce its potential to cause harm. To date, the bulk of the work has focused on flight operations, which is probably correct given that the potential effects of error in that environment is greater. However, as yet work on engineering is only scratching the surface of human factors in the working environment. Addressing human factors within an SMS industry should start from a base line which recognises that aircraft maintenance is not benign. The act of intervention in the aircraft systems adds potential risk; this risk should be taken into account as part of the assessment of hazard management and risk reduction.

Wherever human error arises it is a potential hazard to safe operations and as such can be managed within the SMS. The hazard analysis process already described should identify the hazard, the threats that could release it and the control barriers necessary to control it. In the case of human error these are often soft barriers, such as effective procedures, compliant practice, communication and training. Soft barriers are less easy to manage than facilities and equipment and completed documentation, but nonetheless must be addressed in the analysis if the SMS is to be robust.

There is a shopping list of known problem areas that exposed the potential release of human error triggered incidents; these include:

- workplace environment
- poor hand over of work at shift change
- workload of individuals
- poor procedures

and

- non-compliant practice
- lack of supervisory oversight
- time pressures
- tooling/equipment availability
- night working

If viewed from the hazard potential viewpoint, measures can be taken to protect the company from any of these hazards. Experience to date has shown that most companies find it easier to address the hard barriers such as workplace lighting, quality assurance inspections on night shifts and tooling availability, whereas, other opportunities are largely ignored. For example, in an industry where pilots line checks for compliant practice are mandated, no such requirement has been introduce by the operators or the regulators for engineers. (Reference “On the Racing Line” Edwards 1996).

A strength of having a Safety Management System that systematically reviews the business and identifies the problems that the workforce face, is that it gives the management the structured opportunity to address the most significant issues before those problems become tomorrow’s accidents. A supporting structure of internal audits, safety meetings, toolbox (pre-job) briefings and, importantly, the line’s use of SMS checklists are all aids in keeping safe working in the engineers’ focus. These measures are operational tools for cross checking every aspect of the activities that the company undertakes. The feedback from such aid the management to address the most critical current problems.

Workplace Environment

The initial review of the activities a company undertakes identifies the locations that work will be carried out at and as part of that the hazards relating to that worksite. Supporting this, the process of structured safety audits by teams using the SMS checklists caters for the worksite to be reviewed on a regular basis and noted shortfalls to be logged in the remedial action plans. The environment can include working conditions, weather, lighting, equipment and tooling required to support any task.

Poor Handover of Work

Shift handovers have been a recognised problem for more than 30 years, although in that time little improvement has been achieved; neither has there been any Regulatory requirements introduced to reduce the problem. We consider that stronger disciplines in diary management are needed and that the handover log should be a historical record of the days work filled out as the day progressed, and not a list raised at the end of the shift from memory. The SMS review should identify shift or work handover as an essential control barrier

Workload of Individuals

As part of the process of risk identification time allocation for tasks, including preparation, should be considered when establishing control barriers. Normally, workload is not the initiator of an incident, but is frequently an escalation factor that allows the situation to deteriorate therefore, adequate manning levels are treated as required escalation control barriers. It is our view that a working hour limit for engineering shifts of 12 hours maximum should be imposed.

Poor Procedures

Any of us can put procedures or task cards in place, but it is the relevance of these and the engineers' compliance with them that really matters. Poor procedures lead engineers to lack respect for them which encourages the use non compliant, potentially dangerous practices. Procedures are often seen by maintenance staff as guidance material for the engineer to interpret, which is incorrect. They should be step by step instructions that should be literally applied. Part of the activity analysis process identifies procedures as control barriers. If procedures are to be effective, then they must be periodically reviewed; if nothing else procedures should be checked to see if they can actually be achieved as written, rather than needing interpretation for their intent. If it is a company procedure we are able to take direct action to resolve any ambiguity. If it is a manufacturers procedure then it is essential the manufacturers processes address the problem and allows for all of the industry to benefit from improved clarity. One positive aspect of reviewing procedures is that if done properly it will consolidate and reduce the number of procedures engineers need to consider when doing a task.

Non-Compliant Practice

Management cannot fix what it does not know is broken. Within aircraft engineering very little compliance monitoring or audit is carried out. Aircraft engineering is heavily populated with “can do” people, which usually manifests itself in a culture of their not telling management about the problems being faced and engineers using their ingenuity to overcome problems. Often when investigating incidents it is possible to see that the causal factors were not isolated one-off aberrations of the individual, but in reality are the systematic practice of the majority of staff. Such non-compliant practice is classified as a violation. (James Reason 1990) Within the aviation industry’s working environment, there is frequently little time available to read and use the procedures in task-cards, or maintenance procedures. It is common practice for maintenance staff to work from memory once he has done a task more than twice, possibly referring occasionally to the task card or procedure. If work is routinely done from memory it is only a matter of time before personal practice are introduced. These personal practices may differ between the staff and not meet the task design requirements and unintentionally may be unsafe.

Frequently management expect the maintenance staff to work from memory, calling it expediency to get the aircraft back in the air. If nothing goes wrong, the engineer may get praised, but if there is an incident he will be criticised. The SMS considers compliant practice an essential escalation control barrier. If the control is to be effective it needs to be routinely tested. A paper I presented in 1996 on Process and Practice Monitoring suggested that operators should monitor the practices of their engineers periodically using a similar approach to that used for pilots in the “Line Check.” This process, carried out by the immediate supervisor had the added benefit of reviewing a procedure for relevance and ability to be achieved as a literal instruction. Process and practice monitoring is not a trapping exercise; after all, engineers and technicians are not bad guys who set out to make mistakes or violate procedures. It is usually latent failures in the company systems and procedures that trap them into errors, believing they are optimising their efforts to get our aircraft back on line expediently.

Lack of Supervisory Oversight

In many aviation companies, cost related cutbacks have reduced manpower, which has resulted in staff supervision being a task that few Supervisors have time for. A percentage of the work which any supervisor should be doing is that of over-viewing their teams’ work, but in many operators this is no longer the case. The supervisor can give guidance, see shortfalls in resources, equipment, spares or tooling, maintain the shift log history, establish priorities and monitor the staff; these are all control barriers which an SMS would require to be in place. If we are to learn from the mistakes of others, it is necessary to avoid using the shift supervisor as just another pair of working hands. The supervisor is part of the safety net for his team and as such he cannot be his own safety net; nor should the industry accept his working without a safety net.

Time Pressures

Maintenance organizations in the aviation industry are struggling to maintain commercial advantage over their competitors; in fact the situation is worsening if anything, particularly where airline engineering has been established as a separate company. The SMS workplace audits should identify insufficient time allocations and feed this back through the remedial actions to the planners who can then allocate adequate time for the job.

Night Working

Night work is endemic in aviation and therefore cannot generally be avoided; the aircraft is an asset which must be optimally utilised to make the investment pay. Therefore, the control that an aviation SMS seeks is: a suitable environment, adequately lit, with working practices and procedures in place which are correct and mirror those used in the day shift carried out by staff who have not had excessive duty periods. The operator should have established quality assurance checks during night shifts to check the quality of the work produced including all those items listed.

Tooling/Equipment Availability

An SMS requires all the tasks being undertaken to be adequately resourced, and provision of equipment is a control barrier. If the tooling or equipment is unserviceable or unavailable then temporary injunctions to the task should be raised to warn that if the task has to be completed during the shortfall then special precautions should be applied. Shortfalls in equipment and tooling are areas where engineers are at their most inventive and learning from the mistakes of others identifies how essential these control barriers are.

POSITIVE SMS ACTIONS

Training

One of the key steps required in an SMS is provision of competent staff. The competencies required to maintain aircraft encompass basic knowledge, aircraft type courses, company procedures, and regulations. Additional competencies called for in an SMS would be workplace safety training, knowledge of quality assurance principles and human factors training. Engineering human factors training, initially based on the Crew Resource Management (CRM) training is still being developed, but has already been introduced into a number of companies. Those companies that have given the most consideration to human factors training are orienting their course material to engineering to ensure its relevance to engineers; when developed specifically for engineers the training is known as Maintenance Resource Management (MRM). The training should give the workforce, including management, an understanding of their interaction with others, situational awareness, decision making, physiological issues, communications, and the necessity of feedback.

Motivation

Management need to motivate the staff to be committed to the Safety Management System. Safety improvement needs to be understood, and believed in, and must be seen to have at least equality with commercial pressures. The perception that rewards arise from getting the job done by doing whatever needs to be done to get the aircraft back on line should be changed to emphasis on a safe working culture. The risk assessment which is part of the hazard analysis should identify what is acceptable. When engineers believe it expedient to cut corners (optimise the task) they are also likely to be adding unnecessary risk and that needs to be controlled. Therefore it is essential that the motivation and leadership given to staff correctly reflects that need for safety first.

Communication

As in all elements of business, the need to communicate the safety requirements and establish safety accountability within the staff is the key to success. Managing human factors safely in the business requires regular demonstrated and transmitted communication of the corporate commitment to safety. If the focus is not maintained as a clear requirement then other issues such as commercial pressure will replace safe thinking and safe working in the minds of the staff. It is necessary to accept that safe working is not instinctive for human beings; we have evolved by testing the barriers that limit us and by taking risks stepping outside those limits. Consider that bravery is commonly perceived as a positive attribute, whereas it could be assessed as somewhere between stupidity and enjoyment of risk.

Investigation

Most investigation processes employed by operators are focused on prime cause identification, rapid resolution and close out. However, these actions do not serve the company well. Investigation of near incidents, incidents and accidents should be carried out to identify the underlying causal factors (frequently latent failures) that allowed the incident to occur. Subsequent systematic actions should address the causal factors to remove the potential for recurrence. Currently, a review of the actions taken as the result of an investigation frequently result in the engineer being sacked. In reality unless the person had been malicious or deliberately violated the procedures, the action of firing the individual is a negative step. It will not encourage others to openly report near miss incidents nor will it remove the underlying causal factors. The management should consider if the engineer was really a bad worker with poor standards or just the unfortunate inheritor of an existing problem in the Company systems, and if he was a bad worker why had their supervisory and quality systems failed to identify it before the incident.

The analytical process of an SMS seeks to identify the potential latent failures in advance of incidents or accidents. However, in the real world it is recognised that not all problems will be avoided and therefore robust investigation processes are needed to underpin the SMS. The focus of an investigation should be to identify the underlying causal factors implicated in the incident and finding ways to resolve such problems.

Human factors related parts of a safety management culture should address near miss incidents. These near incidents are failures which, but for a control barrier, would have escalated into a more serious occurrence. It is recognised that there is a direct relationship between fatal accidents, serious incidents, minor incidents and near misses. The statistically proven pyramid with which most of us are familiar is just as relevant in aviation as other industries. Therefore, the controls identified in the development of an SMS can be enhanced by remedial actions raised from investigation and this can best be done by investigating the lower order incidents and thus potentially protect the company against damage to the assets, environment, customer/staff or reputation.

CONCLUSION

Developing an SMS in a company is a significant task, initially requiring a culture change in the workforce from management down. The investment in effort can result in significant reductions in the risks in the business and introduces better loss control measures in their systems. The systematic approach inevitably results in improvements in the human factors issues that lead to human error initiated incidents and accidents. As more companies develop these types of systems, there is an increasing potential for information exchange and learning from others. To achieve an effective SMS requires the involvement of the management, workforce, regulators and the customers. This interfacing helps to build a more positive relationship between these parties. The effort and investment that the development and introduction of SMS will be significant, but this can be recovered in time through the efficiencies gained and the reduction of accidents and incidents.

GLOSSARY OF SAFETY MANAGEMENT TERMS

Hazard An entity having the potential to cause harm, ill health or injury, damage to property, plant, products or the environment, production losses or increased liabilities.

Threat Something that could cause the release of a hazard

Risk The product of the probability that a specified undesired event will occur and the severity of the consequences.

Hazardous Event The first event resulting from the release of a hazard.

Barrier or Control Some kind of countermeasures such as procedures, system redundancy, competencies etc.

Escalation Factor A secondary threat that if not controlled with worsen the situation of the incident

Escalation Barrier Some kind of countermeasures such as procedures, system redundancy, competencies etc.

Consequence The result of the release of the hazard and any subsequent escalation’s.

Recovery measures Those actions required to return the status to normal.

Function Significant groups of business process within a business, e.g. Aircraft Engineering

Process Separate describable parts of a business, e.g. Maintain Aircraft.

Activity The sub-parts of a business process, e.g. Replace propeller

Task The sub-parts of an activity, e.g. Sling propeller for removal using overhead gantry.

Business Process Map A structured descriptor of all the processes and activities that form a function.

Procedure Detailed list of instruction and descriptions that enable a task to be carried out in a predictable and repeatable manner.

Process and Practice Monitoring A periodic review of the working practices used and compliance with a given procedure.

Safety Case. A statement of fitness of a single element of the business.

Incident An unplanned event or chain of events which has caused or could have caused injury, illness and /or damage (loss) to assets, revenue, the environment or third parties.

Abbreviations Used

SAL Shell Aircraft Ltd

SMS Safety Management System

IMS Integrated Management System

FAA Federal Aviation Administration

CAA Civil Aviation Authority

NTSB National Transport Safety Board

JAR Joint Airworthiness Requirements

BPM Business Process Map

ISO International Standards Organization

SAMS Shell Aircraft Management System

CRM Crew Resource Management

MRM Maintenance Resource Management

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James Reason Various Papers 1991 - 1996
Clark, Goulter & Edwards Safety Management Systems, (Shell Aircraft) 1995
C J Edwards On the Racing Line (Process and Practice Monitoring) 1996
Shell Group HSE Safety Management Systems 1994.