Human Factors in New Manufacturing

International Aerospace Quality Group (IAQG)

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Note:

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The intention of this document is to assist organizations with understanding the concept of Human Factors and is not intended to be a requirement, nor auditable.

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Executive Summary

The impact that errors caused by Human Factors have on the quality of products and services in the Aerospace industry is well documented and must be mitigated. In this context the definition of Human Factors is "A discipline that explains the underlying reasons for human errors."

Human factors are heavily considered when performing a root cause analysis leading our industry to change the way we train and develop our employees, be it in Design Engineering, Operations, and In Service. Human Factors are found in the performance of our daily jobs. They are considered when making decisions every day and are the cause for some of the most horrific accidents in aviation history. When an assembly operator is preoccupied with problems at home and fails to perform their job requirements properly they are endangering the lives of those people that use the products they work on. When a maintenance employee is not properly trained and fails to perform their duties per the requirements of the job, they are creating the possibility of an accident that can cost human lives. These are some examples of Human Factors playing a key role in the Quality of products. In order to address these situations, industry must evolve into considering these factors during all the phases of our products, from initial design, into manufacturing and in our maintenance, repair and overhaul activities.

Human Factors are already an important consideration during the design phase of our products. For example, Boeing Wichita hired their first Human Factors professional in the early fifties. This work in the area of human factors maintained a traditional focus, concentrating on product usability. Their work was to build the customer's human specifications into the product design, building a product that would be easier to use and to maintain. The regulatory agencies have also recognized the need to address Human Factors when conducting training for repair stations. Human Factors is not directly covered by the FAA in the Code of Federal regulations (CFR's), however, the Human Factors Training Program assists repair stations in designing and implementing their own training on this subject which is highly encouraged by the FAA. The EASA requirements are currently detailed only in the maintenance regulations EASA Part 145 but there are discussions taking place to introduce Human Factors into the Design and Production regulatory requirements. There is no timeline for this change but EASA has said that they would actively support its inclusion by organizations.

In the late seventies and early eighties, manufacturing found itself faced with a re-emphasized need to increase productivity to stay in business. To meet this demand, companies began implementing new technology modernization programs, causing the workplace to be in a state of rapid change. These changes called for a new approach in the way companies planned for new technology and in how they utilized their human resources. Due to these rapid changes in technology and the need to train the workforce to meet these challenges, some organizations recognised Human Factors as the cause of defects and non-conformance and began to implement Human Factors programs. These programs were designed to make everyone aware of the effect that Human Factors had on the quality of our products and to put in place activities to mitigate the risks. However, the adoption of Human factors based error management programs was not widespread across the supply chain. The reduction in non-conformance and related safety issues through the adoption of Human Factors based Error Management programs is well documented and understood. Their implementation in manufacturing and production facilities throughout the Aerospace, Defence and Space Supply Chain is to be encouraged by the IAQG.
This paper will provide the reader with information on how to recognize the problems caused by human error and how to put steps in place to mitigate the risks and achieve the benefits of Human Factors based Error Management programs.

1.0 Introduction

This document has been written as guidance to the Aerospace, Defence and Space Supply Chain to support the implementation of Human Factors based Error Management Programs into manufacturing facilities.

Understanding Human Factors has long been recognized as critical to eliminating errors in aircraft maintenance. Regulations require that aircraft maintenance facilities implement Human Factors training and Error Management Systems. These awareness and error management programs are equally effective in the manufacturing environment. Using background and examples from the aircraft maintenance environment this paper shows how such programs can be implemented into new manufacturing facilities.

One small human error can have catastrophic consequenses. Understanding and managing/working with human factors on a daily basis is therefore a core responsibility of every manager and central to the reputation of the business. The analysis of human factors can help to ask the good questions, to support the organization and to enrich safety strategies. The objective of this document is to give guidelines so that Human Factors can become an integrated process at the organizational level (similar to lessons learned from all sectors that will be identified and taken into account for improvement).
As you read through this paper you will find valuable information on Human Factors and Error Management Programs. You will be taken on a journey that will show you the benefits of implementing a Human Factors based Error Management Program in a manufacturing organization. It will help you to understand and navigate through the regulatory requirements and will provide data on how to implement a program that will meet the needs of your business.

2.0 Definition of Human Factors

Human Factors is a discipline that explains the underlying reasons for human errors. It applies human capabilities, limitations, and behavior relevant to the design of tools, machines, process, systems, tasks, jobs, and environments for the purpose of increasing human performance, personnel situational awareness and organizational awareness to eliminate where possible, and to reduce the risk for human error in safe, efficient, and cost-effective operations.
There are four human factors principles in accident/incident prevention:

- Zero Accidents
- Incident Reporting
- Managing Human Factors
- Safe Execution

The same principles when applied to quality can be defined as:

- Zero Defects
- Anomaly / Non Conformance Reporting
- Managing Human Factors
- Correct Execution

The similarity is immediately obvious.

The first step is to define what the Human Factors are that may cause errors in the manufacturing process. These can be placed into 6 main categories:

- Ergonomics
- Equipment
- Culture
- Competence
- Environmental
- Feelings

Each one of these categories will be discussed extensively in this paper. (See Figure 1 below)

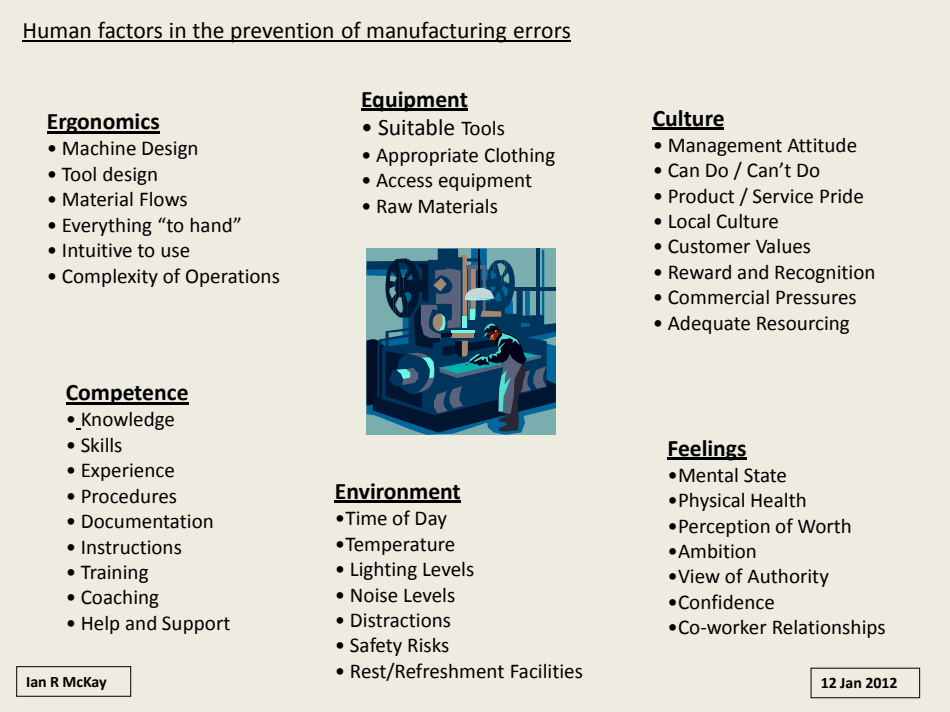


Figure 1

As we begin to understand Human Factors we will find how key it is to establish the right culture and in particular achieve management sponsorship for a Human Factors based Error Management Program. Roles and responsibilities must be clearly defined. These include Management, the Error Management Team, Supervision and the individual Operators. Supporting functions like QA and HR must also have their roles clearly defined, communicated and understood. Having clarity on who is doing what provides an environment that promotes success.

3.0 Human Factors Principles in Error Prevention

There are four Human factors principles that supplement a safety mission. These four principles capture the thinking behind an organization-unique approach to safety and accident prevention. They can equally

apply to quality and the prevention of defects and non-conformance in manufacturing and production. The four principles have been expressed below in terms of their application to Quality Management.

1. Zero defect and non-conformances principle is an indicator of operational/business capability.
2. Defect / Non-conformance reporting and PDCA is mandatory. (Unless mandated by regulation, for quality it must be mandated by organization policy – but its best encouraged as the right thing to do - see "Just Culture" below.)
3. Managing Human Factors is an individual, team and management responsibility. The Organization must recognize that the correct execution of work requires a responsible attitude, essential knowledge and skill for the job - and good leadership. (correct execution of work = quality as well as safety)
4. Correct execution requires a structured approach to plan and integrate quality into the work processes.

While the first three principles are self-explanatory, the fourth principle can be expanded upon from the organization perspective to better illustrate the responsibilities held at the individual and management levels. The prevention of defects and non-conformances caused by human error is the goal.

Responsibilities at the management level

The bullet points below are the management behaviors and best practices that have been seen to give the best results in reducing errors due to humans

- Constantly engage men and women under their jurisdiction and remind them that quality is integral and vital to mission success. The mission/task can be jeopardized when quality is compromised.
- Commit to the establishment of a robust management system that assures quality work processes and procedures. They must also commit to providing adequate and appropriate resources to ensure quality processes and products.
- Ensure, all activities are planned in such a manner as to avoid the generation of errors. This means anticipating and identifying potential causes of errors and eliminating them if possible, otherwise mitigating or minimizing the risks of occurrence.
- Ensure that staff are adequately trained and informed, and provided with adequate resources such as work area, publications, tools and equipment etc., to perform their tasks correctly.
- Provide an environment that promotes open reporting and treats people fairly.

Responsibilities at the team level

A work team environment embraces Team Excellence, whose teamwork produces additional safety nets in preventing errors.

Individuals in a work team must be aware of other team members who may be affected by their acts or omissions. Training and team working behaviors should be highlighted to promote a culture of quality and the prevention of errors and non-conformance.

Responsibilities at the Individual level

Every individual is personally responsible to perform their duties diligently and to exercise essential consideration for performing their work to ensure the quality of the product or service. A "Just Culture " or "no blame culture" environment must exist in order for every individual to feel comfortable reporting any mistakes they make (see Section 11.0). When a culture of no blame exist, employees are more inclined to

report mistakes than if a punitive environment is present. Statistics show that a large number of unsafe acts can be categorized as "honest mistakes" and should not be cause for punitive action. Even when a no blame environment exist it is imperative that if and when an act is uncovered that was caused by an individual that willfully engage in dangerous behaviors it must be dealt with in a consist and fair manner. It is these events that require a clearly defined approach in determining culpability (See figure 1 on page 20).

Every individual should ensure that they are competent to perform their assigned task correctly, effectively and safely. If they have any concerns they should be able to request support from their management to undertake appropriate training. They should be able to highlight issues with work instructions, environment, tooling or equipment deficiencies and ask for these to be remedied.

4.0 Classification of Errors

Errors are split into 3 categories:

Errors

- Skill-Based Errors: Errors which occur in the employee's execution of a routine, highly practiced task relating to procedure, training or proficiency and result in a non compliance situation (e.g., fail to prioritize attention, checklist error, negative habit, design errors, management decisions).
- Decision Errors: Errors which occur when the behaviors or actions of the employees proceed as intended yet the chosen plan proves inadequate to achieve the desired end-state and results in a non-compliance situation (e.g. exceeded ability, rule-based error, and inadequate / inappropriate procedure).
- Perceptual Errors: Errors which occur when an employee's sensory input is degraded and a decision is made based upon faulty information.

This is the majority of human error and should be treated as a learning opportunity. A minor remedial action ranging from re-training to counseling is probably appropriate. Repeated errors that are not addressed could be classified as Violations.

Violations

- Routine Violations: Violations which are a habitual action on the part of the operator, including overconfidence, and are tolerated by the governing authority.
- Exceptional Violations: Violations which are an isolated departure from authority, neither typical of the individual nor condoned by management.

5.0 Existing Human Factors Research

A large amount of Human Factors information is available. Many organization are dedicated to performing research on Human Factors with the intent of preventing the consequences of these mistakes in not only industry but everyday life. Organizations like Human Factor Reasearch Group are making a difference by providing training as well as an online forum where discussions can take place to address the problem of Human Factors and how they affect everyone. The FAA has a division dedicated to the research on Human Factors. They have HF research projects on Air Traffic Control/Technical Operations, Flightdeck/Maintenance/System Integration, NextGen - ATC/Tech Ops and NextGen - Air Ground Integration. A list of some of internet sites and books used for this paper is included at Appendix D.

Much of the available research is on managing Human Factors in order to improve safety but another by product of these improvements is a clear improvement of the quality of the product. As Human Factors are better understood and controlled the quality of the process as well as the product will improve.

6.0 Regulatory Agencies and Human Factors

The regulatory agencies have varying things to say about Human Factors in Error Management, from simple "encouragement" to mandatory requirements. Most regulatory agencies have been talking about including Human Factors in the regulations and this will happen in the near future. The FAA is conducting research on the effect of Human Factors in their many operations. These are covered further in Appendix B. In all cases, a Human Factors based Error Management program will be a positive factor in demonstrating compliance to regulations affecting aircraft manufacture. All the regulatory agencies recognize that as Human Factors risk is mitigated it also results in improved product quality.

7.0 Human Factors Based Error Management Programs

Program structure

A Human Factors Based Error Management Program will include:

- Program Implementation Plan
- Human Factors Maturity Model
- Error Management System (EMS)
- Safety and Quality Culture
- Policies and Processes
- Training Program
- Communications

The organization's Human Factors Training programs must reflect all parts.

Program Implementation Plan

Implementation of a Human Factors Program needs careful management. It is a change project that will impact many people in the organization. This needs to be recognised and planned for. The elements forming the structure of the program (e.g. the EMS) will need ongoing maintenance and support. Careful consideration needs to be given to assigning ongoing accountability within the organization.

The key events in an implementation plan would be:

- Gain sponsorship from senior management
- Establish a core team to manage implementation and support the organization in deployment
- Complete an awareness training of senior management – understanding the commitment required.
- Communicate the purpose and objectives for implementing an EMS.
- Negotiate and agree a "Just Culture"

- Train all employees in Human Factors and the EMS processes.
- Provide ongoing communications on errors investigated, root causes and the remedial actions
- Report errors prevented and improvements made, with benefits, to senior management.

Note that initially error visibility should significantly increase and this can be misinterpreted by senior management/regulators if not carefully explained. There has been no increase – they were already there but not known - a powerful argument for EMS and Human Factors.

Human Factors Maturity Model:

The Human factors Maturity Model can be used to plan and monitor the success of a Human factors program. The model is based on "Safety culture maturity model" written by Dr Mark Fleming, Chartered Psychologist and available thru Health and Safety Executive (ISBN 0 7176 1919 2).

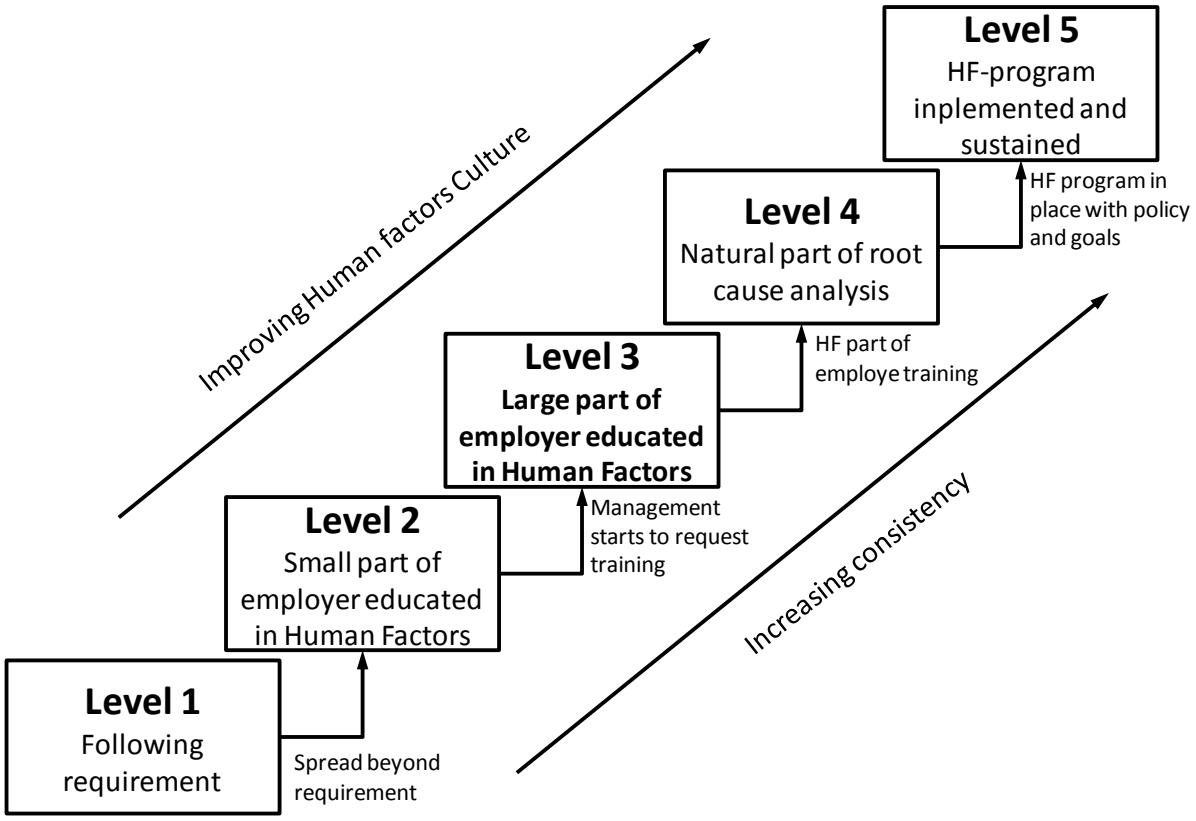


Figure 2

Typically for each level

- Level 1 Human Factors is not seen as a key area for improving KPI's, human error are accepted as root cause and in many cases seen as unavoidable.
- Level 2 The rate of human errors in the organization is at an average rate for the industry but Human Factors are seen as a key area for improving non-conformances. Management understand that human errors can be prevented and that human error as root cause will not solve the problem. Correct conditions are a prerequisite for being able to perform a proper job.
- Level 3 The rate of human errors in the organization is relativity low. Management understand that human errors can be prevented and that human error as root cause will not solve the problem. Correct conditions are a prerequisite for being able to perform a proper job.
- Level 4 The majority of staff in the organization is involved in the human factors program and taking personal responsibility for the conditions when performing work and communicate any deviations. A "just culture" is present.
- Level 5 Preventing human errors is part of the organization culture and human error is seen as a way to improve the process.

8.0 Error Management Systems (EMS)

Here is a brief explanation of a Human Factors based Error Management System.

The need for change:

Aviation safety investigations show that around 80 per cent of aircraft accidents are due to human factors. Recently the safety statistics have shown an increase in accidents where maintenance is considered to be a primary factor.

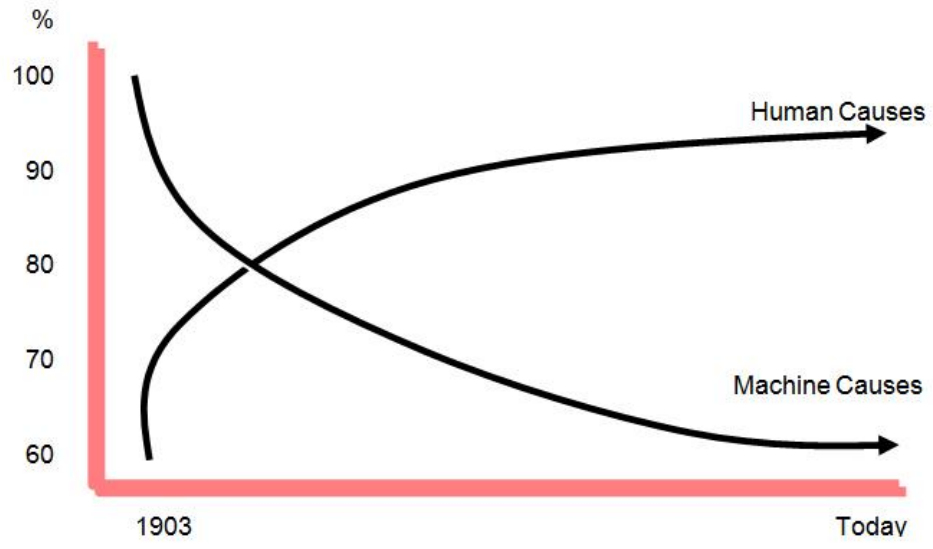


Figure 3

In response to these trends, the European Aviation Safety Agency (EASA) has set a goal of significantly reducing the number of accidents and aviation incidents. The EASA regulations Part 145 have become mandatory requirements for all certified maintenance operators. These rules include both error avoidance systems and Human Factors training for all employees.

In the manufacturing and production environment the same Human Factors are the cause of errors that lead to defects and non-conformance – Quality failures. These may only affect the Cost of Quality but in many cases will have safety implications for employees or end users of the product. The same error avoidance systems and Human factors training for employees as used in aircraft maintenance need to be adopted for manufacturing and production facilities. Although some organizations do this most in the Aerospace, defence and Space Supply Chain do not. Significant opportunity exists to reduce errors and therefore the cost of poor quality by understanding the Human Factors that are the root cause of most non-conformances and then addressing these in a systematic way - through an error management system - are significant.

Response to the need

To meet this requirement industry is introducing an Error Management System (EMS) into the Quality Management System with a focus on developing an error prevention culture. The EMS concept provides a process for measuring and responding to potential and actual events; the success of EMS is founded on the creation of an honest and open upwards-reporting procedure and a "Just Culture". Employees are able to raise safety concerns, report actual and near-miss errors and learning points will be shared across the whole business. EMS is designed to prevent human errors, procedural ambiguities and mismatches between required and actual practices that could lead to errors, such as those responsible for serious events like aircraft accidents. The EMS can also prevent errors that result in poor quality and impair the performance of the organization.

Just as a reminder, the common denominator associated with most accidents and near misses is people. The same is true of defects and product non-conformances. Through the recognition of the part played by Human Factors, providing relevant training in the subject and implementing EMS, errors can be reduced in the interactions between:

People:
- and other people eg: team communications
- and Systems/Processes
- and Environment
- and Machines/Equipment

An EMS must cover all departments whose work can affect airworthiness, aircraft safety and product quality. In fact it will involve everyone in the organization, including the management team. Training should start with the management team.

Getting below the waterline

The diagram below (Fig. 4) provides a visual representation of the ratio between serious safety related incidents, accidents, costly events and minor incidents.

- Fatal includes failure propagations, loss of life, loss of system, severe detrimental environmental effects...
- Non-Fatal includes loss of mission, temporary disabling injury, major damages...

For every one serious event the model shows there are approximately 40 additional costly events, and over 600 more minor events. By exposing near misses, the unreported and non-investigated errors, the number of all incidents including the serious and costly ones can be significantly reduced.

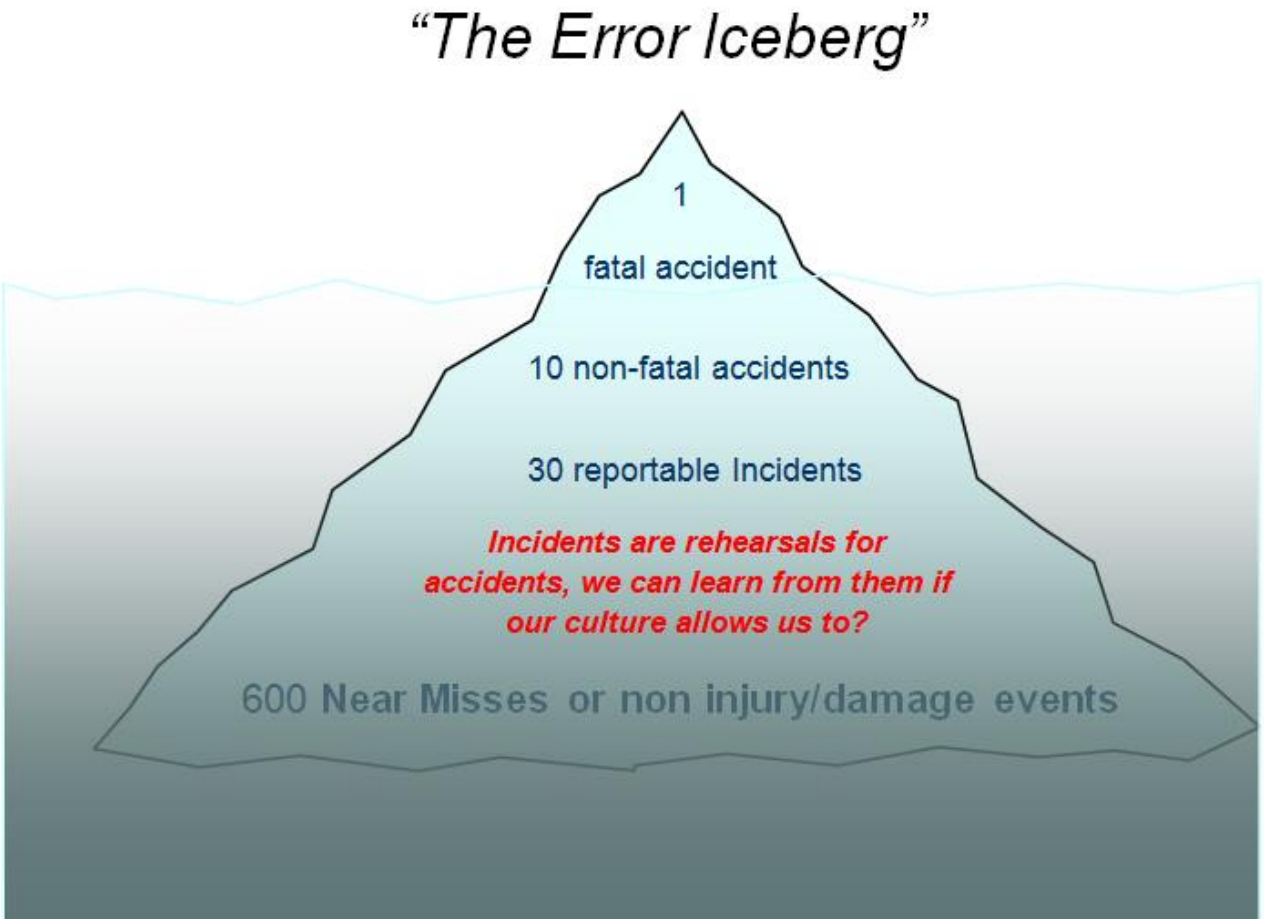


Figure 4

Note: Errors can take the form of **Events** or **Hazards**.

Events – are realised occurrences, which can be notified via a number of existing processes such as customer complaints, major quality failures, safety alerts, audit non-conformities and accidents.

Hazards – are potential occurrences, unsafe conditions, which could, if left unreported and un-addressed, lead to an error, near miss and possibly a non-conformance and/or safety concern.

If we can reduce the number of human errors within the workplace, by understanding the root cause, the possibility of a serious incident/accident resulting from manufacturing will also be reduced proportionally and the cost of poor quality will be reduced. Feedback is an essential part of the Error Management System, with regular communications being provided to all employees.

Follow-up actions for events and hazards

A number of people should be trained to carry out investigations on all Errors raised. Data resulting from occurrence reports and any resultant investigations should be recorded on a central EMS database. Over a period of time the EMS database will be used to identify patterns of causal or contributory factors that will determine error trends.

9.0 Standardized Cause Codes

Appendix C contains a recommended standard list of cause codes that organizations can use. The obvious benefit of adopting a standard list of cause codes is that the whole supply chain will be using the same codes so that when comparisons are made there is common understanding. Standard cause codes enables systematic search of potential risks and failures, and implementation of relevant risk mitigation e.g. conscious assessment about how safe each people feel before starting a sensitive operation, implementation of corrective actions thru the whole company.
The use of standard cause codes will also give industry leaders the opportunity to analyse data from the whole AS&D supply chain allowing generic corrective actions/improvements to be identified.

10.0 The Dirty Dozen

Originally the Dirty Dozen was born to be applied in Maintenance Human Factor studies and training, but, for the scope of this White Paper, it can be used to understand the causes that can generate Human Error in all activities (including design and manufacturing) performed on, or related to, an aircraft or an aircraft components. The Dirty Dozen is a list of twelve causes that, if not known and/or not managed properly, can generate Human Errors. It is important to know the dirty dozen, how to recognize their symptoms, and mainly how to avoid or contain errors produced by the dirty dozen; in this way the personnel can learn to prevent or manage them proactively in the future.

The twelve possible causes that can generate a Human Error identified in the “Dirty Dozen” are:

Fatigue:

This is considered the number one contributor to human error. It is insidious, and the person fails to realize just how much his/her judgment is impaired until it’s too late. Until it becomes extreme, a person may be unaware that he or she is fatigued. It is more easily recognized by another person or in the results of tasks being performed.
Fatigue seldom works alone but is a contributor to one or more of the other dirty dozen.
A person is said to be fatigued when a reduction or impairment in any of the following occurs: cognitive ability, decision-making, reaction time, coordination, speed, strength, and balance. Fatigue reduces alertness and often reduces a person’s ability to focus and hold attention on the task being performed.
Symptoms of fatigue may also include short-term memory problems, channelled concentration on unimportant issues while neglecting other factors that may be more important, and failure to maintain a situational overview.

Fatigue can be mental or physical in nature. Most common fatigue causes are: sleep deprivation, stress and overworking and Circadian Rhythm alteration (i.e. during first night shifts).

The mitigation strategy could be:

- Train the employees at all levels to recognise the fatigue symptoms in one's self and in others
- Train the employees at all levels to prevent fatigue causes (sleep at least 8 hours each day, eat properly and drink plenty of fluids, exercise regularly, etc.)
- Program the execution of complex tasks at the bottom of employee's Circadian Rhythms (i.e. at the beginning of the shift)
- Prefer to use teamwork especially during night shifts
- Minimise the length of time completing repetitive tasks (visual inspection etc) and consider rotation of tasks
- Reduce to minimum overtime
- Allow the employee to take a rest and to request a check of the job by a supervisor if he/she recognize a mental or physical fatigue symptom
- Train supervisors to encourage employees to raise a flag when they are fatigued and not judging them.
- Ensuring good ergonomics of the work areas (including temperature of workspace).
- Implementation of a Drug and Alcohol prevention program.

Lack of communication:

This is the failure to, or the lack of, information exchange between two or more people.
To prevent it the attention should be focused not only on how this happens, but also what safety net will prevent it.

The mitigation strategy could be:

- request and receive positive confirmation that the message (verbal or written) was, correctly, received.
- The use of standardrized terminology on instructions and communications
- promote the use of written communication with feed-back possibility by receiver
- standardize the meeting methodology for shift change (i.e. usage of a standard written module)
- provide the necessary information to the right people at the right time
- give people your full attention when listening
- expect people's full attention when talking
- arrange for translators when a language barrier exist.

Complacency:

This is where we become so self-satisfied in our activity or so familiar with a project that we lose awareness of dangers. Therefore some activities can become too familiar (i.e. repetitive tasks) and "rote memory" based so that every little change in the pattern can cause error.
It is sometimes called overconfidence and creeps in as we become more proficient at what we do.

The mitigation strategy could be:

- Encourage employees to participate in job rotation programs
- Train the employees to use and follow every time the applicable instruction to perform a work task
- Train the employees to be aware of the task/role: understand the purpose of work and what can happen if something goes wrong
- Train the employees to self-reviewing of the performed job
- Train the employees to sign only the activity they actually performed

- Train the employees to expect to find a fault/an error in the task performed
- Train the employees to remember the Murphy's law: "If anything can go wrong, it will go wrong"
- Implement continuous improvement initiatives to promote LEAN thinking and Poka Yoke concepts.

Lack of knowledge:

With constantly changing technology, this contributor to an error is more common than we think. Add to that the fact that the average human only retains about 20 percent of what they learn, unless they use it, often.

The mitigation strategy could be:

- Ensure that each employee (at all levels) is trained before starting to perform the activity (have a Training Program) and verify the training effectiveness (i.e. Tests, interview, etc..)
- Ensure that each employee is re-trained after an inactivity period (i.e. six months) or if new technology, new equipments/tools, new procedures/regulations are introduced in the workplace
- Establish a recurrent training program for all employees (at all levels)
- Establish a periodical assessment to find in time any training needs and use the results to improve your recurrent training program
- Allow all employees to request additional training/review and use these requests to improve your recurrent training program
- Involvement of subject matter expert and users in the design
- Research in the internet best practices, pitfalls in the topics
- Subject the design to input by peers, conduct peer review on design, product development and manufacturing phases of the product life cycle.
- Design away hazards such as Foreign Object Damage (FOD) and use of hazardous materials.

Distraction:

This is anything that takes your mind off the job at hand even for an instant. Our mind works much quicker than our hands, and thus we are always thinking ahead.
Any distraction can cause us to think we are further ahead than we actually are. This contributing factor is known to be responsible for at least 15 percent of all aviation accidents.

The mitigation strategy could be:

- Not having long tasks in the work instruction/job card (if possible split the single task in to more sub-tasks)
- Sign step by step the work performed in the work instruction/job card
- Mark as completed one step when the step is actually completed (not later, not before)
- Check the completion of the last 3 steps if you interrupt your work (lunch break, toilet, etc...)
- Keep your personal objects outside the work area (i.e. personal telephone)
- If a job has to be left unattended, leave a tag or flag it as uncompleted work and put a note on the work instruction/job card
- Assign/perform one single task (multitasking raises the distraction risk)
- Try to keep your mind free of your personal problems and be concentrated on your work.
- Not assign critical tasks to employees that have know personal problems that may affect their concentration/performance

- Respect of others to make sure that they are not distracted during the performance of their activities.
- Implementation of a Drug and Alcohol prevention program.

Lack of teamwork:

The larger an organization becomes, the more common this contributing factor is.
Because teamwork is constantly evolving and changing, it must be constantly worked on to prevent accidents from occurring. It is hard to gain and very easy to lose.
Causes of the lack of teamwork can be: roles and responsibilities not clear, decisions for the team made by one single person without the team's knowledge, problems and issues not addressed by the team members, lack of trust and respect and personal problems among the team members.

The mitigation strategy could be:

- Clarify the team goals, the roles in the team and the responsibility of each team member
- Have a standard method to take decision for the group that requires also team's knowledge
- Give the opportunity/instruction to all group members to raise problems at the correct level (also if possible outside the team)
- Monitoring the team performance, share the results with the team members and apply corrective actions if required (agreed and understood by all members)
- Provide training to the team leaders on Leadership Behaviors and multicultural aspects

Lack of resources:

A lack of resources can interfere with one's ability to complete a task. Furthermore the low quality of resources (i.e. tools, work instruction/job card, standard parts, etc.) can compromise the successful job completion and increase the empliyee's workload, stress, and fatigue. For example if the employee does not have the correct tool near the job area, he/she has to go away to find it and, when he/she comes back to restart working, there is an increased risk of forgetting something to do for the task being worked on.
The mitigation strategy could be:

- Be sure that all tools and parts required are available to the employee near the job area (i.e. usage of standard kit and tool kit)
- Check the quality of your work instruction/job card and be sure that it contains all the information the employee needs to complete the job (i.e. tools to be used, parts required, expected value and tolerances for dimensional check and for tightening, step by step sequence, etc..)
- Reduce the references on your technical documentation to a minimum and provide the information directly on the documentation.
- Train the employee that it is important to check the availability of all resources before starting a new job and that he/she has to stop the work if something is missing.
- All employees require adequate amount of time to complete their tasks. Time is a valuable resource that when not provide increases the risk of mistakes. Employees will feel rushed and mistakes can be made.
- The availability of sufficient manpower is a major factor for a task to be completed on time and with good quality.

Pressure:

Pressure to be on time is ever-present in the aviation industry.

We are very time-sensitive and many decisions are centerd around that fact. Over 64 percent of pressure-caused errors are caused by self-pressure.

The mitigation strategy could be:

- Be sure that the time assigned to the task is correct (especially if the employee knows it)
- Train the employee to recognize self-inducted pressure
- Assign to the employees an easy available entry point to raise pressure related problems
- Monitor the work progress and assign other resources if applicable
- Be sure that your employees know that the quality and safety is your/their first priority.
- Discourage incentive schemes for early delivery, shortage terms that would drive the wrong behavior.

Lack of assertiveness:

Assertiveness is the ability to express your feelings, opinions, beliefs and needs in a positive manner. Lack of assertiveness is failing to speak up when you think that something doesn't seem right, this has resulted in many fatal accidents. However, assertiveness also calls for listening to the views of others before making a decision. Assertiveness is that middle ground between being passive and aggressive.

The mitigation strategy could be:

- Promoting good and open communication among co-employees and among employees and their supervisors and management staff
- Develop relevant culture with an adapted model that allows people to raise a problem in an explicit manner without fear of repercussions. Have a simple system to allow the employees to raise a problem to management staff in a written manner (also anonymous).
- Train the employees to explain the possible consequences when they raise a problem and to give the possible solutions to the problem raised
- Give a feedback for each problem raised
- Train the supervisors and management staff to use a good communication method (i.e.: one problem at a time, have documentation and facts to back up the argument, give examples, request feedback, take into account employees opinion) that will allow employees to raise any problem without fear of repercussions

Stress:

Stress is the subconscious response to the demands placed upon a person. We all have some stress in our lives, and it is not all bad until it becomes excessive. The causes of stress are referred as "Stressors" and are classified as physical (Temperature, Noise, Lighting, Confined spaces), Psychological (Work-related, Financial problems, domestic problems, interpersonal problems) and Physiological (Poor physical condition, Proper meals, Lack of sleep, Conflicting shift schedules).

The mitigation strategy could be:

- Have a recurrent training schedule to refresh awareness of employees how to recognize overstress symptom and how to manage it (delegate workloads, give a priority to the tasks. Motivate and promote feedback and communication between employees. Act when you recognize factors of stress on colleagues.)

- Train supervisors and management staff to recognize acceptable workload on employees (not too low, not too high)
- Ensure proper planning of the work
- Have the option to use a back-up resource (a helper) if the workload increases too much on a employee
- Promote a healthy lifestyle and take into account the employee's personal problems before assigning a task
- Measure and report stress levels at the organizational level e.g. regular anonymous questionnaires and communicate the outcomes to employees

Lack of awareness:
Lack of awareness occurs when there is a lack of alertness and vigilance in observing that result in a failure to recognize all the consequences of an action. This usually occurs with very experienced persons who fail to reason out possible consequences to what may normally be a good practice.
Also information overload (without a priority) and many distractions factors can cause lack of awareness.

The mitigation strategy could be:

- Have a training program and a recurrent training program to explain to the employees the purpose of their work, process overview (to get a bigger picture), and what can happen if something goes wrong
- Use “lessons learned” cases during the initial and continuous training
- Train the employees to perform tasks as if it were the first time
- Train the employees to take a timeout, assess the distractions, and restart the task.Give to the employees only the necessary information to perform the task

Negative Norms:
Norms is short for “normal,” or the way things actually are done around an organization. Norms are unwritten rules followed or tolerated by the majority of a group. Negative norms are those that detract from an established safety/quality standard.

The mitigation strategy could be

- Train the supervisors, management staff to recognize if their employees use norms instead of standard procedures, evaluate it and, if the norms used are positive, transform them in to the standard procedure where applicable
- If negative norms used by employees were found, investigate to understand the root causes for the negative norms, explain to them the possible negative consequences and what the standard procedure is to be used and if possible, amend the standard procedure to prevent the negative norms
- Train the employees to use only approved procedures and work instruction
- Train the employees to report to their supervisors if the standard procedure or work instruction is ambiguous, incorrect or not applicable.

A good way to use the Dirty Dozen concept is understand how, and where, each of twelve causes may occur in own activity and apply the appropriate mitigation strategy .

Note: for the research were used following documents:

- "ATM Handbook Addendum Human Factor Chapter 14" (FAA document)
- "Avoid the dirty dozen with safety nets" by Gordon Dupont from AIRBEATMAGAZINE
- "Defeat the dirty dozen" a PIPELINE Performance Group presentation
- "Aviation Maintenance human factor (EASA 145)" Cap 716 Appendix H by CAA

11.0 Culture

Promoting a Human Factors " Culture"

Reporting is a crucial part of any Human Factors program and experience has shown that the quickest way to stem the flow of reporting is to treat people involved in incidents in an inappropriate or unfair manner. The root cause of errors is almost always the system, not the people and this must be remembered when asking people to report errors openly and honestly.

One way of guarding against this is to implement a "Just Culture" in your organization, introducing consistency and clarity in terms of Human Performance Management. Within organizations a Just or fair culture is attainable - given the right control processes that ensure timely, practical and targeted application of the agreed behaviors and procedures.

Without a healthy open reporting culture, the root cause of human errors may not be fully established and mistakes may not be learned from, which would allow them to be repeated. Only through open reporting and treating human error incidents as learning outcomes, will the organization gain in knowledge and experience on the HF causal relationship and become more proficient in preventing human error and strive towards achieving zero defects / zero non-conformances.

Just Culture

A 'Just Culture' refers to a way of thinking that promotes a questioning attitude, is resistant to complacency, is committed to excellence, and fosters both personal accountability and corporate self regulation in all matters. The principles of Just Culture have been developed in relation to safety management and proven to work if fully supported by the organization's management. Here the same principles are set out in relation to quality management and can be equally as successful. The key is remembering that we want management and all employees to lead improvements to the system to prevent future errors, not simply blame the people for making the errors.

James Reason stated the components of a safety culture include just reporting, learning and informed and flexible cultures. It is an atmosphere of trust in which people are encouraged for providing essential safety related information but they are also clear about where the line must be drawn between acceptable and unacceptable behavior. The same is true of a quality culture.

One of the prerequisites for a successful HF and Error Management System is that staff should feel that they can report occurrences and errors openly, without fear of punitive action. The reporting aspect may be accomplished by means of a confidential reporting scheme, but in order to investigate the occurrences, it is necessary to speak to the individuals involved. A completely blame-free approach is not the answer, since some actions are blatantly negligent and warrant punitive action. It is necessary to have a clear policy stating that staff will not be punished for genuine errors. Each company will need to decide what its policy

is concerning the 'grey' areas between error and negligence, where violations may have been committed but where punitive action may not be appropriate. The definition of this "Just Culture" policy should be agreed and supported by the Human Resources policies.

Some example wording and further guidance are given below:

Staff are encouraged to report quality concerns and errors, and to cooperate with investigation of incidents, the primary aim being to establish why the problem occurred and to fix it, and not to identify and punish the individual(s) concerned.

It is the company's policy that unpremeditated or inadvertent lapses should not incur any punitive action, but a breach of professionalism may do so.

In particularly serious cases it may be necessary to stand down (suspend) an individual pending investigation. This should not be interpreted as punitive action but, rather, as a precautionary measure.

As a guideline, individuals should not attract punitive action unless:

(a) The act was intended to cause deliberate harm or damage.
(b) The person concerned does not have a constructive attitude towards complying with mandatory operating procedures.
(c) The person concerned knowingly violated procedures that were readily available, workable, intelligible and correct.
(d) The person concerned has been involved previously in similar lapses.
(e) The person concerned has attempted to hide their lapse or part in an error or non-conformance.
(f) The act was the result of a substantial disregard for safety or quality.

This does not mean to say that individuals *will* incur punitive action if they meet one of the above conditions; each case will be considered on its merits.
"Substantial disregard", in item (f), means:

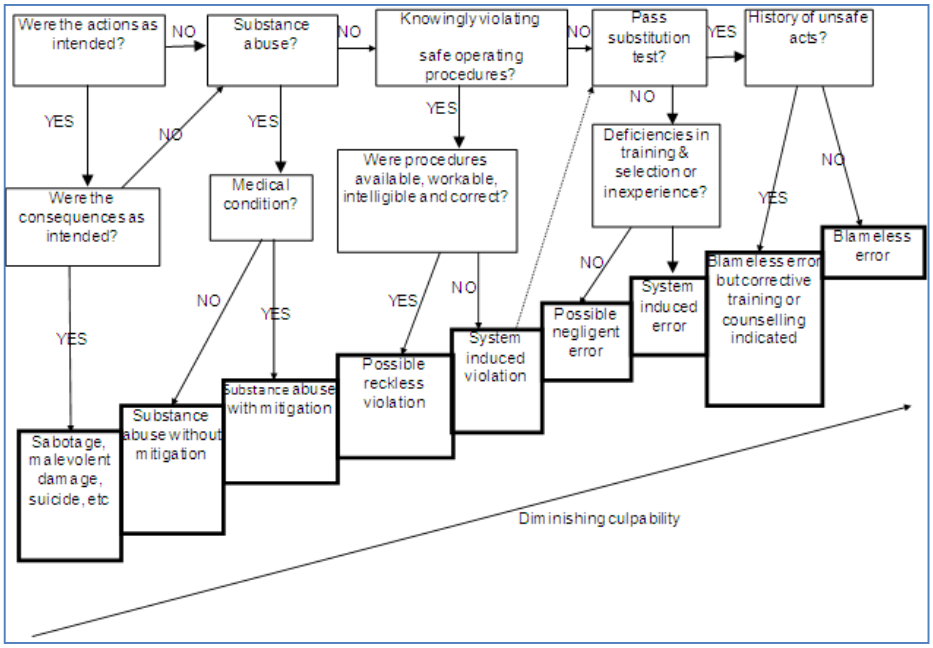
- In the case of a certification authorisation holder (e.g. licensed engineer or Certifying Staff) the act or failure to act was a substantial deviation from the degree of care, judgement and responsibility reasonably expected of such a person.
- In the case of a person holding no certification responsibility, the act or failure to act was a substantial deviation for the degree of care and diligence expected of a reasonable person in those circumstances.

The degree of culpability may vary depending on any mitigating circumstances that are identified as a result of an investigation. Attention should be paid to the adequacy of tools, equipment and the working environment, the clarity of relevant policies and procedures, the clarity of management or supervisory instructions, the competency of the individual to carry out the assigned task correctly and the availability of support or guidance.

If it is deemed appropriate to take action concerning an individual, this need not necessarily be punitive, nor should be considered as such. The action should always be whatever is appropriate to try to prevent a re-occurrence of the problem. Action may take the form of additional training, monitoring by a supervisor,

an interview with a manager to ensure that the individual is fully aware of the implications of their actions, etc. Only in the worst cases of negligence or malicious behavior would formal disciplinary action or dismissal be considered as appropriate action when considering errors causing quality failures. Where the error also has safety implications the organization's safety policies must also apply.
Note: an organization may wish to use Fig 1 as a guide when drawing up a disciplinary policy, whilst remembering what they are trying to achieve by ascertaining the degree of culpability - ie, to prevent a re-occurrence of that incident, not to establish blame or to mete out punishment for its own sake.

Figure 1 - A decision tree for determining the culpability of unsafe acts



The "substitution test" is good rule of thumb when illustrating where blame is inappropriate. If an incident occurs, ask yourself whether another similar individual (with the required skill, training and experience) in the same circumstances would have done anything different. If not, then blame is definitely inappropriate.

Management Commitment

Without the commitment and sponsorship of management the implementation of any change or improvement in an organization is unlikely to succeed. This is especially true of a Human Factors based error management program. The requirement for trust through application of a Just Culture and for transparency in the process of investigation and determination of error causes requires management at all levels to clearly express their commitment to the program.

In order to achieve commitment it is essential that managers are involved in the development and definition of the program from the outset. Management need to understand how the consideration of Human Factors as a cause of errors can lead to reduced waste and costs and improve overall quality performance if they are to provide proactive support. Examples from other organizations need to be cited

and the cost benefit case clearly set out. A senior manager should be appointed as program sponsor and the CEO should personally set out his support for the program. This should be done before any expectations of the workforce are communicated. Leadership by example is needed for a program that is essentially based on trust and openness.

Management culture is likely to be one of the most significant changes needed in order to implement a successful Human Factors based error management program. The workforce needs to be convinced that management will adopt the Just Culture that is needed and not seek to apportion blame to individuals. A proactive demonstration of this will be needed from management. It is unlikely that the workforce will be truly open in reporting errors and their causes unless managers visibly look for process and system improvements rather than culprits. Where appropriate, employee representatives should be engaged by management to establish agreed processes and standards of behavior in support of the program.
A Human Factors based error management program is not a short term initiative. It is intended to become part of the way the organization operates on a day to day basis the processes and the culture that supports them need to be continually supported and refreshed by management. Reward and recognition need to be used to highlight success and demonstrate management commitment.
If management show real commitment and belief the workforce will gradually become more confident that they can openly report and investigate not only actual errors but also the near misses that the error iceberg shows can deliver real benefit the performance of the organization.

Ethics

Ethics is a systematic and critical analysis of morality, of the moral factors that guide human conduct in a particular society or practice.

Issues and decisions involving ethics are encountered more commonly than most people think. Broadly speaking, there may be ethical concerns in every role that an individual can play in the different spheres of his/her life (i.e. as an individual, student, colleague, parent, professional, boss etc.). It is also not possible to "compartmentalize" roles as the decisions made in one area would inevitably affect other areas as well, either in the short or long-term, or both.

In addition, as one takes on more responsibilities and roles, one will face conflicting demands from other areas of life (e.g. family vs. work). Often, ethical issues may present themselves in the ordering of priorities. They may also be in the form of an omission or failure to act in a prompt manner, rather than a commission. Ethical dilemmas are also encountered by experienced professionals work on projects and with different organizations.

There are some general principles that if learned and understood can help employees, at all level, on increase their ethical behavior:

- **Honesty and Integrity**
  Base actions on a personal set of values. Follow the rules even when supervisors are not present.
- **Good Manners**
  Always show courtesy and respect toward others people
- **Accepts Advice, Supervision, Criticism**
  Have high self-esteem and do what is asked; accept criticism and use it to improve future performance

- **Dependability/ Follow Through**
  Work diligently to complete tasks, alert supervisor to problems or delays so there are no surprises about work not being done
- **Good Attendance/ On Time**
  Keep the mind on work (avoid external distraction); suggest improvement; be ready to begin work on time
- **Accuracy of Work/ No Waste**
  Be careful and avoid mistakes; if mistakes are made, correct the errors; be proud of work well done; hold high standards, always aim to complete all tasks Right First Time everytime
- **Pride & Productivity in Work**
  Show initiative; be ambitious; figure out how to get the job done; work as efficiently as possible to get the job well done.
- **Leadership:**
  Human being is a complex part in complex systems. System consisting of computer programs, workplace design, instructions referring further, training, **and organization** affect our ability to make decisions. People with different prerequisites such as knowledge and experience and other factors that affect is the family, peer pressure, lack of sleep, etc. In order to be more successful with the change process the leadership must take into consideration the Human element of the system that supports creating safe and high quality products

12.0 Policies, Procedures and Processes

A product safety and quality policy should identify the company policy regarding safety in enough detail to make it clear that safety is considered important, and to give clear messages to employees as to the company's policy concerning safety-related issues.

The policy should be published and made known to all employees and subcontracted staff. For the purpose of this document procedures fall into two categories: those telling you what you should do and those telling you how to do it.

One of the main factors contributing to incidents is failure to comply properly with procedures and follow the process. So why don't employees follow procedures? Is it a problem with the employees or with the procedures? Failure to comply with procedures and follow processes may be divided into two types:

- Failure to comply with good procedures and processes
- Failure to comply with bad procedures and processes

Ignoring for the present, the 'grey' area between the two, the general principle should be that:

- The former ought to be addressed by educating and training staff to comply with procedures, to resist pressure to cut corners, and to discipline staff when they fail to comply with good procedures.
- The latter should be addressed by improving the procedures such that they are accurate, appropriate, the best means of doing a task, easy to interpret, well presented, well designed, etc.

Research shows that the users of procedures often feel that they are 'written in stone' and they are not able to instigate changes, so they work around poor procedures rather than try to get them changed. The primary system causes of procedural non-compliance can be summarised under the following headings:

- Absence of a clear process for systematically developing optimised working practices ('best practice')
- Official procedures which are out of date and impractical and therefore lack credibility with the workforce
- Lack of a culture which develops ownership of procedures by a process of active participation in their development.
- Lack of communication channels in an organization to allow procedures to be frequently updated in line with organizational learning.

It is important to have a workable and trusted method for the staff to be able to highlight problems with procedures and to see those problems acted upon in the form of changes to the procedures.

Guidance material on the design and writing of procedures is provided in CAP 716 Aviation Maintenance Human Factors.

13.0 Communications and Awareness

Making a Business Case

Over the previous few years all the manufacturing improvement focus has been on the key processes and machine capability, therefore the non conformances due to human error have increased over the same time period. Little has been done to address the issues of Human Errors in the manufacturing processes. This focus as made the manufacturing equipment and processes more robust and capable, now the error capability of our people needs to be addressed.

A background of many years of manufacturing experience may have little or no significance when looking for the resolution of problems which only a thorough understanding of Human Factors can provide.

This is of special significance because, it has long been known that some manufacturing non-conformances are as a result of performance errors made by well trained, highly skilled and properly certificated individuals. The sources of some of these errors may be traced to poor equipment or procedure design or to inadequate training or operating instructions. The cost, both in human and financial terms, of less than optimum human performance has become so great that a makeshift or intuitive approach to Human Factors is no longer appropriate. Safety being the ultimate objective of all those involved in aviation, its logical follow up is to ensure a proper level of Human Factors
Knowledge throughout the industry. Human Factors program could impact the following KPI's; Complaints, Scrap, Rework and Audit non-conformances.

Human behavior and performance are cited as causal factors in the majority of Manufacturing non-conformances therefore in order to reduce the rate of or Cost of Non Quality in the business, Human Factors must be better understood and the knowledge more broadly applied.

Typical benefits for human factors initiatives can include:

Improve:

- Employee satisfaction, trust, & loyalty
- Health & Safety
- Productivity & work quality
- Customer satisfaction & commitment
- Sales & market share
- Repeat purchases
- Purchase recommendation
- Stock value
- Brand recognition

Reduce:

- Manufacturing Cost of Non Quality eg: Scrap and Rework costs
- Audit Non Conformances
- Accidents, injuries & illnesses
- Lost workdays
- Error rates
- Training time
- Absenteeism & staff turnover
- Need for redesign & recall
- Support & service costs
- Equipment damage
- Maintenance costs
- Insurance rates

Available Communication Channels

In any organization, communication is essential to ensure vital information is conveyed to all its stakeholders. Some organization have a process and specific department that is responsible for such activities, and in the Human Factors subject communication could be part of the information to be conducted through this media, however as minimum it is recommended that the following to be considered:

- Communication is to be divided into two major categories , external and internal:
  External communication where an organization communicate with external parties such as government, regulatory authorities , customers, suppliers , and the public.
  Internal communication is everything else that is happening within the organization.
- The organization has obligation to report incidences to its customers, to the relevant government organizations as well as to the regulatory authorities, and to ensure suppliers are aware of related issues to ensure compliance as well as prevent problems and to improve.
- Within the internal communication, training courses, awareness session, charts , figures , data, and relevant information for all employees to ensure compliance , effective controls , and improvements, moreover to document processes , procedures, reports, actions … etc.
- Direction of communication need to be well defined, such as :

- Downward communication , from management to lower level employees;
- Upward communications, from employees to their management;
- Lateral communication between employees as well as between departments;
- Multi Directional Communication, that is between all levels and departments.
- Media of communication can be written, verbal and pictorial, such as e-mails, magazines, personal letters, periodical newsletters, banners, video clips, or even mobile SMS.

Having stated the above and ensure effective communication channels, organizations are highly recommended to establish a documented human factors communications plan where well documented plan will help in:

- getting top chief executives and staff to support the program,
- setting priorities,
- providing day-to-day work a focus,
- providing a sense of order and control,
- protecting against last-minute demands from staff and members
- The plan should describe and document :
- objectives ,
- methods to accomplish stated objectives,
- intended audience,
- responsibilities,
- schedules,
- Key Performance Indicator's

When putting a Human Factors plan, the main elements should include the following:

- Objectives
- Scope: communication plan in the human factor aspects effecting the design, manufacturing and repair of aviation and aerospace equipment and systems.
- Audience: employees, customers, suppliers, public, government and regulatory authorities.
- List of subjects: training, meetings, procedures, policies, notifications, newsletters,
- Media of communication: e-mail, training classes, meetings (face to face & teleconference), intra net, banners, bulletin boards, Mobile SMS.
- Definitions
- Abbreviations
- Responsibilities: who should do what
- Communication s media : Meetings, Orientation, Training, E-mails, Banners, Charts, Intra-net , Reports
- Corrective Actions
- Preventive Actions
- Schedule
- Audits
- KPIs
- Lessons learned:
- Records & Forms:

14.0 Training

Human factors' training is part of a total system in managing human error, and discouraging procedural violations, in an organization. It is an essential part of this system aimed at individuals engaged in 'hands-on', support or management activities. Without proper training, other initiatives related to error management and safety improvement will probably not be effective in the long term. An integrated approach, linking human factors training with organizational safety management and error management initiatives, is essential.

Human factors training should not be something radically new - it covers basic safety principles and practices which should already be incorporated within a safety management and quality system, and how to ensure that work is carried out in a professional manner such that aircraft are released to service in a safe and airworthy condition.

Evidence from incidents and accidents shows that human error and Human Factors problems are not limited to 'hands-on' personnel, but may extend to planners, technical records staff, etc. In addition, it is often organizational decisions and policies made by managers that are at the root of some incidents (e.g. to ensure adequate resources). Senior management commitment to, and support of, the company human factors program is essential to the success of such programs. Staff need to be convinced of this commitment by management.

The objectives of Human Factors training, within a Human Factors and Error Management program, should be to:

- Improve Safety
- Improve Product Quality
- Decrease organizational exposure to risk
- Reduce errors
- Capture errors

The aim of Human Factors training should be to help achieve these objectives by means of:

- imparting knowledge on human factors and safety, and details of how the company human factors program works
- developing skills (where appropriate)
- influencing people's attitudes and
- influencing behavior

Training will not be successful in the long term unless what it teaches is supported within the organization on a day-to-day basis. The training should be a part of the total package of measures within an organization to assure safety and airworthiness.

The timing of Human Factors training with respect to the introduction and implementation of the key elements of the company human factors and error management program is important. The key people involved in the introduction of such a program should have received fairly comprehensive human factors training beforehand.

Organizations should have a mechanism for determining competence of staff, not just with respect to human factors, but for all areas (both technical and non-technical) in which staff are required to be competent.

Training structure

Human Factors Training combines different areas research and facts with the individuals understanding of it and how it affects ones everyday work.

Facts, exercises and discussion can be used during training courses.

Practical illustrations and examples should be used, especially accident and incident reports/root cause/corrective actions/action plans as well as successful proactive work.

There are different concepts of forming a Human Factors training program. Here are two examples:

SHEL-concept

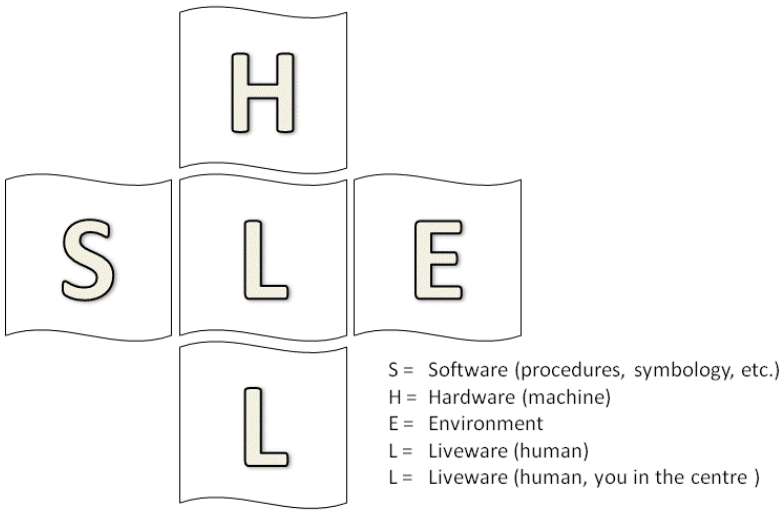


Figure 5

The SHELL concept was first developed by Edwards in 1972, with a modified diagram to illustrate the model developed by Hawkins in 1975. For those familiar with the long-established concept of ”man-machine-environment” (now referred to as ”human-machine-environment”), the following interpretations are suggested: liveware (human), hardware (machine) and software (procedures, symbology, etc.), environment (the situation in which the L-H-S system must function). This building block diagram does not cover the interfaces which are outside Human Factors (hardware-hardware; hardware-environment; software-hardware) and is only intended as a basic aid to understanding Human Factors.

Liveware. In the center of the model is a person, the most critical as well as the most flexible component in the system. Yet people are subject to considerable variations in performance and suffer many limitations, most of which are now predictable in general terms.

Liveware-Hardware. This interface is the one most commonly considered when speaking of human-machine systems: design of machine fitting to size characteristics of the human body, of displays to match the sensory and information processing characteristics of the user, of controls with proper movement, coding and location.

Liveware-Software. This encompasses humans and the non-physical aspects of the system such as procedures, manual and checklist layout, symbology and computer programs.

Liveware-Environment. The human-environment interface the next step from Liveware-hardware interface. Luminance, temperature, humidity, working environment, organization and peer pressure are important parts that affects you.
Liveware-Liveware. This is the interface between people. Communication, task- and shift-handover, relationships in groups, different generations working together are parts affecting you and your performance.

PEAR-concept

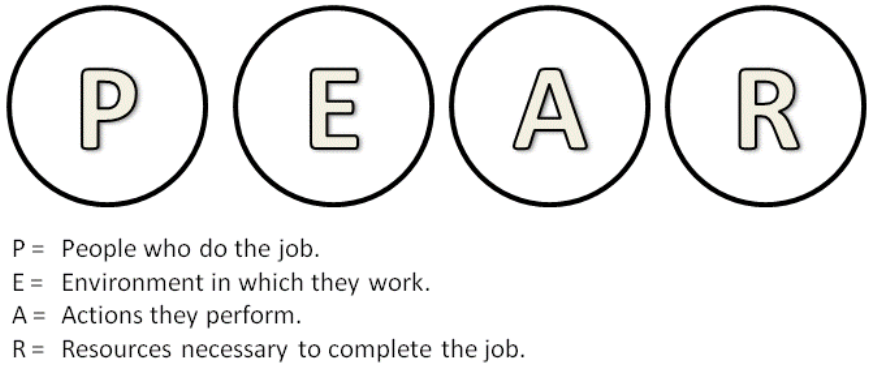


Figure 6

People Human Factors programs focus on the people who perform the work, and address physical, physiological, psychological and psychosocial factors. It must focus on individuals, their physical capabilities and the factors that affect them. It also should consider their mental state, cognitive capacity and conditions that may affect their interaction with others.

Environment: Physical and Organizational There are at least two environments in aerospace manufacturing to consider. There is the physical workplace in the shop or at the office. In addition, there is the organizational environment that exists within the company. A human factors program must pay attention to both environments.

Actions Successful human factors programs carefully analyze all the actions people must perform to complete a job efficiently and safely. Job task analysis is the standard human factors approach to identify the knowledge, skills and attitudes necessary to perform each task in a given job. This helps identify what instructions, tools and other resources are necessary.

Resources It is sometimes difficult to separate resources from the other elements of PEAR. In general, the characteristics of the people, environment and actions dictate the resources. Many resources are “hard”, such as lifts, tools, test equipment, computers, technical manuals and so forth. Other resources are “soft”. Examples include the number and qualifications of individual to complete a job, the amount of time allocated, and the level of communication among the crew, supervisors, vendors and others. Resources should be viewed (and defined) from a broad perspective. A resource is anything a person needs to get the job done. For example, protective clothing, a mobile phone, spare parts, can be resources. What is important to the “Resource” element in PEAR is focusing on identifying the need for additional resources.

Training Syllabus

The following training syllabus identifies the topics and subtopics to be addressed during the human factors training, EASA 145, CAP 719 Fundamental Human Factors Concepts.

In order to increase effectiveness and efficiency of your Human Factor courses it's very important planning, and personalizes it for your need. It can be accomplished with a good Human Factor syllabus preparation (to be inserted in your Human Factor Program)

The follow is an example of a Human Factor training course syllabus.

In the first column are listed most popular Human Factor topics.
The others column can be used to adapt and personalize the courses contents for all category of employees. For example you can use the cells to specify, with a "X", the topic to be treated during the course for each category of personnel, or you can specify the level of detail each topic will be treated for each category of employees.

In the cells there is a "R" for recommended topics and an "O" for optional topics

HUMAN FACTOR TRAINING	Managers & Supervisors	Operator	Inspector	Technicians production support	Certifying Staff
Introduction Introduction to the course	R	R	R	R	R
General The need to take human factors into account; Incidents attributable to human factors/human error; ‘Murphy's’ law	R	R	R	O	**R**
Error models and theories Implications of errors; Avoiding and managing errors; Human reliability	R	O	R	R	**R**
Human Performance and Limitations Vision; Hearing; Information processing; Attention and perception; Memory; Claustrophobia and physical access.	O	R	R	R	**R**

Social Psychology Responsibility: individual and group; Motivation and de-motivation; Peer pressure; 'Culture' issues; Team working; Management, supervision and leadership.	R	R	R	R	**R**
Factors Affecting Performance Fitness/health; Stress: domestic and work related; Time pressure and deadlines; Workload: overload and underload; Sleep and fatigue, shiftwork; Alcohol, medication, drug abuse.	R	R	R	O	**R**
Physical Environment Noise and fumes; Illumination; Climate and temperature; Motion and vibration; Working environment.	R	R	R	O	**R**
Tasks Physical work; Repetitive tasks; Visual inspection; Complex systems.	R	R	R	R	**R**
Communication Within and between teams; Work logging and recording; Keeping up to date, currency; Dissemination of information. Shift handover	R	R	R	R	**R**
Hazards in the Workplace Recognising and avoiding hazards; Dealing with emergencies.	R	O	O	O	**R**
Professionalism and integrity	R	R	R	R	**R**

15.0 Lessons Learned

It is important to monitor the various factors that determine the success of a Human Factors / Error Management program. The key learning areas shown in the figure below have been identified from experiences in the aircraft maintenance sector and from some of the organizations that have already deployed Human Factors into their manufacturing operations.

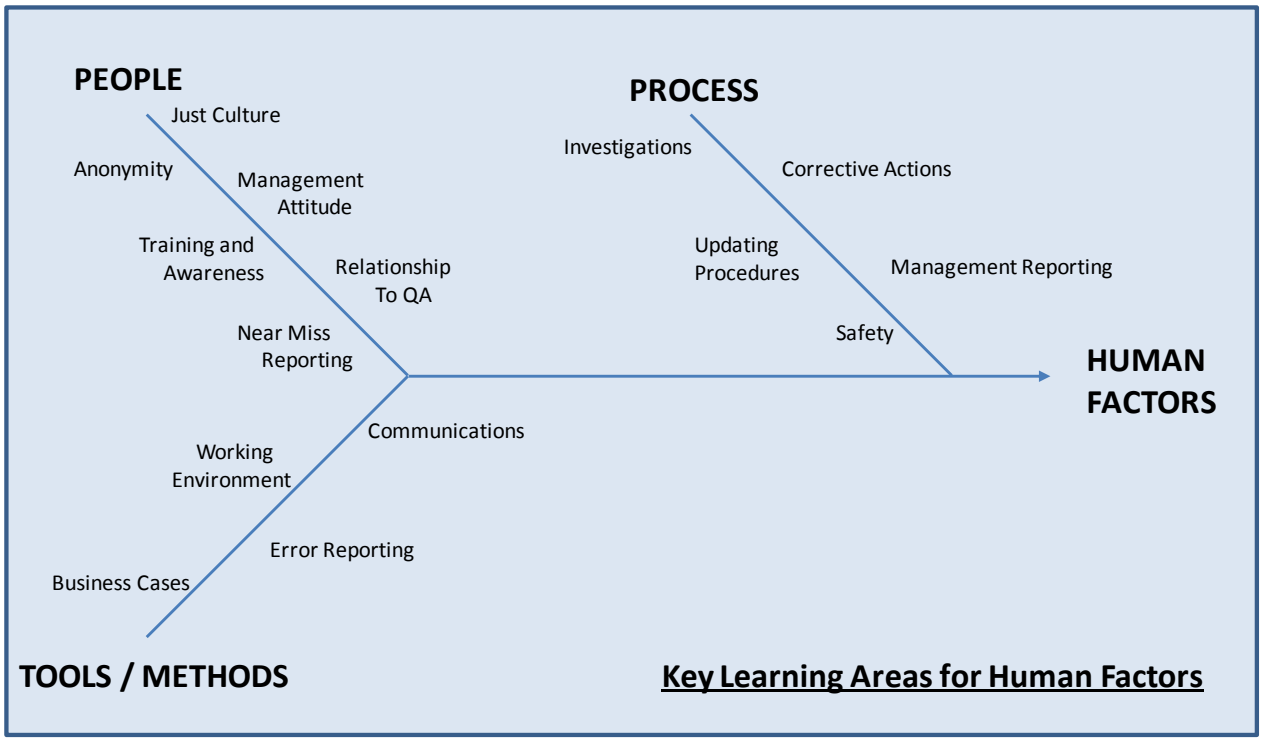


Figure 7

PEOPLE

Just Culture – Establishing a Just Culture needs to be done formally, in consultation with Human Resources and Trade Unions/Employee Representatives where appropriate. All organizations report that it is difficult to persuade the workforce that a Human Factors / Error Management program is about system improvement and not allocating blame. Safeguards against misuse of information must be transparent to all.

Anonymity – Linked to the Just Culture. The objective is to have open reporting where no-one is scared to say what happened. In certain circumstances the facility to report anonymously might be necessary, for example where personal issues are involved but it is essential that actions are always based on facts. The trust of the workforce can easily be lost.

Management Attitude –Examples of failure by management to support the program and adopt the Just Culture will soon circulate and damage any trust built up with the workforce. Examples of management showing a desire to listen to the workforce and enable improvements can have a surprisingly positive effect.

Training and Awareness – It is essential that the error management team are highly professional in everything they do. Issues with investigations, mishandled reports and lack of visibility of progress with actions, poor behaviors and similar problems will all de-motivate the workforce and reduce cooperation with the program. The workforce itself needs to clearly understand the purpose of the program and the process / procedures that are employed. Confusion or uncertainty on their part will also damage cooperation.

Relationship to QA – In some organizations the Human Factors / Error Management team has been created as part of the QA Department. Where the QA Department was seen as a checking or "policing" activity this proved a deterrent to the workforce reporting openly. It may be necessary to provide a separate reporting line for error management / human factors programs.

Near Miss Reporting – Many organizations find it hard to persuade the workforce to report near misses although these are the best source of preventative action. Near Miss reporting might best be considered for a later stage of maturity in the program.

PROCESS

Investigation – This is at the heart of Human Factors / Error Management programs. It is the basis for all decisions about the changes required and the benefits that reduced errors will bring. The facts must be ascertained, no assumptions made and the process conducted professionally. In the early stages of a program there can be an overwhelming number of reports to investigate. A process of prioritisation is essential and this should be visible to the workforce so that they are not de-motivated if things take longer than expected. Here communication is important to keep everyone aware of the situation. Rushed investigations leading to poor recommendations will damage the program.

Corrective Actions – Seeing positive actions come out of the Human Factors investigations helps to motivate the workforce to report errors and support a successful program. When management is seen to take notice and to make improvements this has an overall positive effect on the facility. Clearly lack of action or late/ ineffective actions have the opposite effect.

Updating Procedures – Where changes to processes and procedures are required as a result of the investigation it is important that the documentation is updated immediately. This will lock in the changes and provide a benchmark to monitor improvement against. It formally establishes that things are to be done differently in future and is visible evidence of improvement to stakeholders, including Customers and regulators.

Management Reporting – In the early stages of a Human factors / Error Management program the visibility of errors will inevitably increase. This can alarm senior management who wrongly perceive deterioration in compliance unless they are briefed about what to expect. Ongoing reporting should emphasise the improvements being made and not just the number of errors / investigations. Management should monitor the timeliness of the investigations and resulting actions. A measure of the workforce attitude to the program should be devised, perhaps as part of an annual employee survey. It is important to avoid falling into a numbers reporting format that will almost certainly leave a negative impression with everyone.

Safety - All errors carry a potential safety risk. This should be considered when allocating priority to investigations and improvements. Safety related actions will be more likely to get management and workforce support. It is also a good communications lever when trying to get the workforce to support the program. It isn't just about lower costs (and higher profits) for the business. However, badging the program as a safety activity but then focusing on costs will lead to scepticism.

TOOLS / METHODS

Communications – As with any change or improvement program, effective continuous engagement with the stakeholders is critical. A Human Factors / Error Management program is by its very nature dependent on the good will of the workforce. It is essential that all aspects are visible, transparent and regularly backed up by formal and informal communications. If this is not done then either apathy or mistrust will damage the outcome. It can be very hard to re-start a Human Factors program that has started badly. Similarly, if management see only extra work, more non-conformances and no evidence of benefit they will soon drop their support.

Working Environment – Improvement to the working environment can involve significant expenditure. It is essential that the investigation and decision making process recognises this and that the communications process clearly explains cost based decisions to the workforce. Expectation management is essential on all sides. The workforce has a right to expect essential improvements to be made but must respect that management have to decide priorities and that some less critical improvements may have to wait until funding is available. The Human Factors / Error Management team must manage communications around this important area.

Error Reporting – It is important that only factual reports, produced after thorough investigation are ever circulated. Management may want interim reports on some investigations; those involved may press for an informal update. Experience says that any information given out before the publication of the final report is likely to cause confusion, ill-considered action and disruption of relationships. There is a risk of breach of confidentiality. For this reason investigations and reporting need to be timely, allowing the team to deflect such requests.

Business Cases – All improvements and changes that have a cost attached to them need to justify that cost through the benefits they deliver. These benefits may be financial or they may be safety related or intangible benefits such as improved working relationships. Being able to clearly articulate the expected benefits and the priority they should have, showing the proposal against other investments the organization may be considering, will significantly improve management attitude towards the program. Using the organization's normal internal investment process will establish the proposed improvements as "business as usual" and contribute to their adoption.

EXAMPLE FROM an AEROSPACE Company X

Aerospace Company X has an inhouse Human Factors training program since 2006 for maintenance business area (BA) according to regulations. Production BA started Human Factors (HF) training in 2008 to raise the awareness of Human Error in production. Training in production BA started with product development and management and has later spread to all personnel.

Aerospace Company X choose to use two trained persons to form programs for different business areas, benefits with this was the close and near examples from their own organization. Everyone can apply to examples and exercises.

The HF program is part of the business plan and supported by management. All employees received HF training, from management to front end operators. Training for all employees creates understanding for human performance and limitations.

Some words from the organization:

"The Human Factor with its capabilities and limitations is a resource that we of course will develop in production. Together we will create the conditions necessary to be able to make the right decision first time."

"The Human Factor training is well received at [Aerospace Company X] and it develops continuously. Appropriate examples from our daily work are an important part of the training. "

"Today we understand the consequences of human factors and we are in a position where we understand how we can use our Human Factors program for taking proactive decisions".

16.0 Measuring Effectiveness of Human Factors Programs

Success Factors

Often quality costs are measured in costs for scrapped parts, customer satisfaction, number of non-conformances etc. Human factors measuring can be measured in different ways:

- Deployment of HF training (Number of employees; Number of hours/training)
- Establish metrics for a few Human Errors with clear connection to human behavior
- Start measurement of one or two internal n/c codes
- Attitudes and awareness before and after HF training.

Benefits

- Well trained instructors, or facilitators.
- Supported by management
- Topics should be related to the participants' organization and work where possible; too much unrelated theory should be avoided.
- Smaller groups, 5-15 persons, where the discussion is important part of the course
- With a well formed HF program there are several benefits:-
- Awareness of each employee in the organization.
- Detect problems earlier in the production chain
- Learning from slips, lapses and mistakes and near-misses

Improvement in Key Performance Indicator's (KPI's)

Skilled persons with awareness of how their human performance and limitations have effects on different Key Performance Indicator's such as:

- Punctuality
- Conformity
- Quality costs

Safety

Human factors training can affect people's attitude to personal safety. It encourages people to use the correct tools with right safety equipment. It also makes people aware of product safety. Professionalism and integrity makes people aware of what lack of quality costs for both the own company and also flight safety

Cost

Human factors program and Training has an initial cost that can be justified with an ROI analysis. Preparing training program, employees time spent on course costs money and hours of not producing. Is it then cost-effective to invest in a program?
Investing in human performance will help to reduce industry costs, and improve overall organizational performance by:

- improving system design, development & implementation processes and outcomes
- improving selection, recruitment, staffing
- improving work organization
- improving procedures and training
- improving system safety
- improving transition into operations and the social acceptance of changes

17.0 Conclusions

The most repeated learning point from organizations implementing a Human factors / Error Management program is that its success depends on the attitude of the management. They must be committed to see that real improvements in efficiency and waste reduction can be achieved in addition to preventing non-conformance. They must also be persuaded that the Just Culture approach will yield far more effective improvement than a "big stick / blame culture" approach. In this way there is more likelihood that they will support and enable the improvements expected by the workforce who in turn will improve their performance generally. A win-win situation for all the stakeholders in the organization. Top management must be committed and accountable to ensure the effectiveness of deploying a successful HF program even when the justification is reduced risk and cost avoidance.

All organizations are different. These learning points may or may not apply. They may be relevant but in a different way. If they are all considered at the outset and the key areas monitored from the start of the program there is every reason to expect a successful and sustainable Human factors / Error Management process to be achieved.

APPENDIX A: Safety Management Systems

SMS Definition

A Safety Management System (SMS) is a systematic approach to managing safety, including the necessary organizational structures, accountabilities, policies and procedures.[1]
A Safety Management System (SMS) is a business-like approach to safety. It is a systematic, precise and proactive process for managing safety risks. As with all management systems, a safety management system provides for goal setting, planning, and measuring performance. A safety management system is woven into the fabric of an organization. It becomes part of the culture; the way people do their jobs.[2]

SMS Background

The concept of "safety management" is becoming more and more prominent in the aviation sector. More specifically, the formal introduction of Safety Management Systems (SMS) is clearly found in the ICAO requirements, especially for Air Navigation Service Providers (ICAO Annex 11), aerodromes (ICAO Annex 14), operators involved in international air transport (ICAO Annex 6, Amdt. 30 to Part I), helicopter operators involved in international air transport (ICAO Annex 6, Amdt. 11 to Part III) and Maintenance Organizations (ICAO Annex 6, Amdt 30 to Part I).

In 2009, the ICAO Council agreed that the issue of an SMS Framework suitable for organizations responsible for type Design or Manufacture of aircraft should be re-examined in the future, particularly the application of a standard framework, in broad consultation with both States and industry. It decided that an applicability date of November 14, 2013 for the SMS provisions would allow sufficient time for States to establish corresponding regulations and for industry to implement them.[2]

SMS Design (Framework)

There is no globally harmonized standard for SMS, however the ICAO Safety Management Manual Doc 9859 provides generic guidance which has been unilaterally accepted by the aviation community.
ICAO Annex 6 Appendix 7 (framework for safety management systems) specifies the framework for the implementation and maintenance of a safety management system (SMS) by an operator or an approved maintenance organization, which includes four components and twelve elements representing the minimum requirements from SMS implementation:

1. Safety policy and objectives
    - 1.1 Management commitment and responsibility
    - 1.2 Safety accountabilities
    - 1.3 Appointment of key safety personnel
    - 1.4 Coordination of emergency response planning
    - 1.5 SMS documentation
2. Safety risk management
    - 2.1 Hazard identification
    - 2.2 Safety risk assessment and mitigation

[1] ICAO Doc 9859
[2] Find on web page address: http://www.paris.icao.int/news/200906_amendments_to_annexes_annex8.htm

3. Safety assurance
    3.1 Safety performance monitoring and measurement
    3.2 The management of change
    3.3 Continuous improvement of the SMS
4. Safety promotion
    4.1 Training and education
    4.2 Safety communication

While Annex 6 pertains to operators and maintenance organizations, Annex 8, pertaining to design and manufacturers will certainly use the same components in defining its SMS.

SMS Leading Countries

Transport Canada Civil Aviation (TCCA)
Transport Canada Civil Aviation (TCCA) leads the world in having safety management systems already in place and required by the Canadian regulations. For example, since 2005, SMS is required for Maintenance Organizations (Canadian Aviation Regulations Part V Subpart 73 - Division II). Details can be found on the following web page: http://www.tc.gc.ca/eng/civilaviation/standards/sms-menu-618.htm

Federal Office of Civil Aviation (FOCA)
In Europe, The Swiss Federal Office of Civil Aviation (FOCA) has also required the implementation of SMS for air traffic services, aerodromes, flight operators (aeroplanes and helicopters in commercial service, Commercial Air Transport - CAT) and Maintenance Organizations that hold a certificate in accordance with EASA Part 145 or EASA Part M, Subpart G. Details can be found on the following web page: http://www.bazl.admin.ch/experten/regulation/03086/03092/index.html?lang=en

European Aviation Safety Agency (EASA)
The Commission Regulation 1178/2011 (Flight Standards - Civil Aviation Aircrew) has been recently amended by the Commission Regulation (EU) 290/2012 of 30 March 2012, which addresses SMS in Annex VII: Part-ORA "Organization Requirements for Aircrew".
The EASA Rulemaking Program also comprises the introduction of Safety Management Systems (SMS) into Commission Regulation (EC) No 2042/2003 (Continuing Airworthiness, including Maintenance Organizations) and Commission Regulation (EC) No 1702/2003 (Initial Airworthiness, including Design and Production Organizations), which has been recently replaced by the Commission Regulation (EU) No 748/2012:

- Regulation 2042/2003 (Continuing Airworthiness): the SMS is not yet implemented but will be introduced through Rulemaking Task MDM.055. Terms of Reference ToR-MDM.055 Issue 1, published on 18 July 2011, indicates that SMS elements will be based on those developed for Flight Standards. The Notice of Proposed Amendment (NPA2013-01) was published on March 14, 2013 and is available in the EASA website at follow link: http://easa.europa.eu/rulemaking/notices-of-proposed-amendment-NPA.php.
  Opinion/Decision is scheduled on 2014
- Regulation 1702/2003 (Initial Airworthiness), replaced by the Regulation 748/2012: the SMS is not yet implemented but will be introduced through Rulemaking Task MDM.060 which has just started and proposed that all POAs as well as all DOAs implement a management system encompassing SMS (not only those designing/manufacturing aircraft, engines or propellers). The Notice of

Proposed Amendment (NPA) is schedule end 2012/ beginning 2013 with Opinion/Decision scheduled on 1st Quarter 2014 (Regulation one year later)

Federal Aviation Administration (FAA)
The FAA is considering the development of Safety Management System (SMS) regulations for entities for which the FAA has regulatory oversight responsibility.

After the withdrawal of the Advance Notice of Proposed Rulemaking (ANPRM) (74 FR 36414) that required certain 14 CFR Part 21, 119, 121, 125, 135, 141, 142, and 145 certificate holders, product manufacturers, applicants, and employers to develop and implement SMS, the FAA moved forward with individual SMS rulemakings addressing different types of aerospace product and service providers separately.

Key processes of a SMS

According to the Safety Management International Collaboration Group (SM ICG), the key processes of an efficient SMS are the following ones:

- Occurrence Reporting – a process for the acquisition of safety data;
- Hazard Identification – a method for identifying hazards related to your organization;
- Risk Management – a standard approach for assessing risks and for applying risk controls;
- Performance Measurement – management tools for analyzing whether the organization's safety goals are being achieved; and
- Quality/Safety Assurance – processes based on quality management principles that support continuous improvement of the organization's safety performance.

SMS in an Integrated Management System

ICAO recommends the integration of the SMS to others management system. Especially SMS could be integrated to Quality and EHS Management Systems in order to form an integrated management system and have:

- an integrated quality, environment, health and (occupational & aviation) safety policy,
- a common occurrence data reporting process,
- a common risk evaluation process.

It is also recommended to extend the SMS to the whole organization (Design, Manufacturing, Maintenance ...) as, for example, safety issues detected on products during maintenance activities are often linked to design or production problems.

SMS benefits for Design, Manufacturing and/or Maintenance Organizations

The main benefit of such systems is to have more feedback and reporting on small issues or unsafe acts (such as FOD ...) that could be hidden by the complexity of the organization (Heinrich Ratio / Iceberg Model). These issues are then managed by a systematic approach that will tackle the root causes and consequently will decrease the number of quality escapes or address safety issues before they lead to a costly incident or accident.

APPENDIX B – Regulatory Agencies and Human Factors

FAA (Federal Aviation Administration)

Human Factors is not directly covered in the Code of Federal regulations (CFR's). However, the Human Factors Training Program assists repair stations in designing and implementing their own training on this subject. The program follows the requirements outlined in the FAA's Flight Standards Handbook Bulletin for Airworthiness entitled "Guidance for Evaluation and Acceptance of Maintenance Human Factors Training Programs" (FAA Order 8300.10).

Other FAA guidance is detailed in FAA Order 9550.8 Human Factors Policy and on the FAA HF homepage http://www.hf.faa.gov/webtraining/index.htm.

The Bulletin explains that while human factors training is not a requirement of the CFRs, it is highly recommended. More importantly, however, if you are seeking or hold an EASA part 145 certification, the Maintenance Implementation Procedures Guidance (MIP-G) requires human factors to be included in a FAA-approved training program. Following is a preliminary research on FAA and its involvement of human factors requirements. Included are the links to the HF resources that the FAA provides, which far exceeds the requirements. Several sources state the ICAO requirements, and that the FAA does not require things at that level yet in regards to human factors programs.

Regulatory Guidance for Human Factors Programs in Industry
The FAA position on Human Factors *requirements* is slim. While the FAA focuses on research and guidance in human factors, there are a few requirements to review.

Current FAA Requirements related to Human Factors
The details of the FAA requirements can be found at the following web page http://www.faa.gov/aircraft/air_cert/design_approvals/human_factors/

1) Pilot Training requirements, operations manuals requirements, and various aircraft operations requirements can fall under the human factors umbrella. These include:

- Crew Duty-Rest requirements, details of which can be found on the following web page http://www.faa.gov/regulations_policies/rulemaking/recently_published/media/2120-AJ58-FinalRule.pdf
- Advanced Qualification Program (AQP) requirements for Cockpit Resource Management (CRM) Training , details of which can be found on the following web page http://www.faa.gov/training_testing/training/aqp/more/background/
- CRM requirements for ATP and Flight Engineer Practical Tests , details of which can be found on the following web page http://www.faa.gov/training_testing/testing/test_standards/media/faa-s-8081-21.pdf
- Medical considerations for self-assessment "fit to fly" and expired medical certificates, FAR Part 61

2) Approval of Flight Deck Systems in new aircraft designs (Aircraft Certification Service) , details of which can be found on the following web pages:

http://www.faa.gov/aircraft/air_cert/design_approvals/human_factors/hf-air/

http://www.designcopilot.com/sandbox/DCPLogin.aspx (require subscription) Main link: http://www.designcopilot.com

3) Internal FAA Order 9550.8 which creates the Human Factors Coordinating Committee, details of which can be found on the following web page:

http://www.hf.faa.gov/docs/hforder.htm
4) Internal System Safety Handbook (Chapter on Human Factors Principles) , details of which can be found on the following web page

http://www.faa.gov/regulations_policies/handbooks_manuals/aviation/risk_management/ss_handbook/media/chap17_1200.pdf

European Aviation Safety Agency (EASA)

The EASA requirements are detailed currently only in the maintenance regulations EASA Part 145; 145.A.30(e), AMC 145.A.30(e) paragraphs 6 through 11 and GM 145.A.30(e). This details the requirements for the organization and its staff, and also outlines the training program to meet the regulation. At this time EASA has no definite timeline to introduce HF into the Design or Production regulatory requirements but would actively support its inclusion by organizations. Furthermore, the introduction of the Safety Management System (SMS) during late 2012 / early 2013, will put further emphasis on HF.

Current activity within EASA is provided in the multidisciplinary field of Human Factors by means of the European Human Factors Advisory Group (EHFAG). This group acts as a source of human factors and safety management system expertise that regularly meets to discuss Human Factors issues to provide advice to EASA and the National Aviation Authorities (NAA's). This expertise is drawn from National Aviation Authorities (including the FAA), industry, and professional associations and Human Factors academia and science community.
Additional information can be found on the European Human Factors Advisory Group (EHFAG) web site:

http://www.easa.europa.eu/safety-and-research/european-human-factors-advisory-group-EHFAG.php

Asia Pacific

In general the Asian regulatory authorities follow the EASA and FAA guidance. The CAAC have now detailed HF requirements in CCAR-145, and also in Advisory Circular-145-05. The CAAS detail HF in SAR-145.

Defence

MAOS stands for Maintenance Approved Organization Scheme. It is the means by which the UK MOD will assess the competence of civilian organizations providing airworthiness support to military registered aircraft. The requirement for the scheme, which has been modelled on EC Regulation 2042/2003, is published in Defence Standard 05-130.
Defence Standard 05-130 will contain 4 main parts:

- Part 1 - Mil Part 145 - Maintenance Organizations.
- Part 2 - Mil Part M - Continuing Airworthiness Management.

- Part 3 - Mil Part 147 - Aircraft Maintenance Training Organizations.
- Part 4 - Mil Part 66 - Aircraft Maintenance Personnel.

Human Factor requirements mirror that of the EASA requirements and are detailed under Mil Part 145 (maintenance organizations).

Approvals will be possible under Mil Part 145 (maintenance organizations), Mil Part M (continuing airworthiness management organizations), and Mil Part 147 (training organizations).

EASA and the CAA do not formally recognize MAOS, however there has been extensive dialogue between the MAA and the CAA, and the CAA are aware of the MOD's intentions.
EASA regulation is applied directly to Military Flying in many other European countries.

Space

The Office of Commercial Space Transportation, or AST, has implemented minimal regulations regarding commercial space vehicles and human factors, which is limited to a few requirements regarding range safety, space vehicle design, and safety of crew and "participants." There is currently a moratorium on additional regulations, set by Congress, which has recently been extended to October 2013.

14 CFR Part 460. 15: Human Space Flight Requirements, Human Factors

An operator must take the precautions necessary to account for human factors that can affect a crew's ability to perform safety-critical roles, including in the following safety critical areas—
(a) Design and layout of displays and controls;
(b) Mission planning, which includes analysing tasks and allocating functions between humans and equipment.
(c) Restraint or stowage of all individuals and objects in a vehicle; and
(d) Vehicle operation, so that the vehicle will be operated in a manner that flight crew can withstand any physical stress factors, such as acceleration, vibration, and noise, further details of which can be found on the following web page:

http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=e11cee34fe5087a8cba8d252ec7327b3&rgn=div5&view=text&node=14:4.0.2.9.24&idno=14

Additional sections of Part 460 are marginally human performance related, and address training, skills and abilities of crew and participants, and range safety.

National Aeronautics and Space Administration

NASA policies are categorized into four main areas (in descending order of required compliance): NASA Procedural Requirements (NPRs), NASA Procedures and Guidelines (NPGs), NASA Endorsed Standards, and NASA Standards. NASA is currently reviewing all NPGs and consolidating/converting them into NPRs to remove ambiguity of compliance. All Human Factors documents fall within the 8000 series of file nomenclature; 8078 is Human Factors program management, 8600 is Operations, and 8700 is Safety and Mission Assurance. Health and fitness of crew falls under 8900. NASA documents regulate NASA activities, and NASA contractor activities. While these documents have proven to be good practice in industry, and

are referenced as such, they have no regulatory impact on any entity in industry which is not doing business with NASA. Most **NASA resources** used by industry in the Human Factors arena are research related. Here are a few research links for Human Factors plans, best practices and lessons learned, as they apply to space travel:

1) Human Research Program – Integrated Research Plan

This Integrated Research Plan (IRP) describes (1) HRP's approach and research activities that are intended to address the needs of human space exploration and serve HRP customers and (2) the method of integration for risk mitigation, further details of which can be found on the following web page

http://www.nasa.gov/pdf/651214main_hrp47065_revC_IRP.pdf

2) NASA Ames Research Center Human Systems Integration Division
- advances human-centered design and operations of complex aerospace systems through analysis, experimentation, and modelling of human performance and human-automation interaction to make dramatic improvements in safety, efficiency, and mission success, further details of which can be found on the following web page
http://human-factors.arc.nasa.gov/

3) Reusable Templates in Human Performance Modelling, further details of which can be found on the following web page

http://human-factors.arc.nasa.gov/publications/20051025120406_matessa_reusable_templates.pdf

NASA Procedural Requirements

1) NPR 8621.1A

NASA Procedural Requirements for Mishap Reporting, Investigating, and Recordkeeping requires Human Factors expertise on space mishap investigations as applicable, and outlines HF group leader responsibilities, further details of which can be found on the following web page

http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=8621&s=1B

2) NPR 8705.2B Human-Rating Requirements and Guidelines for Space Flight Systems

Defines and implements the additional processes, procedures, and requirements necessary to produce human-rated space systems that protect the safety of crew members and passengers on NASA space missions, further details of which can be found on the following web page

http://nodis3.gsfc.nasa.gov/npg_img/N_PR_8705_002B_/N_PR_8705_002B_.pdf

3) NPR 8715.3 NASA General Safety Program Requirements

Provides the basis for the NASA Safety Program and serves as a general framework to structure more specific and detailed requirements for NASA Headquarters, Programs, and Centers. Directed toward safety

requirements and to augment requirements for occupational health and environmental health of personnel and activities, further details of which can be found on the following web page:

http://nodis3.gsfc.nasa.gov/npg_img/N_PR_8715_003C_/N_PR_8715_003C_.pdf

4) NPR 8900.1 Health and Medical Requirements for Human Space Exploration
Applies to all space exploration activities involving crewmembers, and includes, but is not limited to, space systems, space suits, planetary habitats, planetary rovers, and surface vehicles, further details of which can be found on the following web page

http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=8900&s=1

NASA Standards

1) NASA-STD-3001, Volume 1

NASA Space Flight Human-System Standard, Volume 1: Crew Health, further details of which can be found on the following web page:

https://standards.nasa.gov/documents/viewdoc/3315622/3315622

2) NASA-STD-3001, Volume 2

NASA Space Flight Human-System Standard, Volume 2: Human Factors, Habitability, and Environmental Health, further details of which can be found on the following web page

https://standards.nasa.gov/documents/viewdoc/3315785/3315785

3) NASA/SP-2010-3407

Human Integration Design Handbook (HIDH), further details can be found on the following web page:
http://ston.jsc.nasa.gov/collections/TRS/_techrep/SP-2010-3407.pdf

APPENDIX C - Recommended Standardized Cause Codes

The IAQG People Capability team have determined the following as a recommended list of standard cause codes that could be used in an Error Management System:

D: Design Engineering

- D1: Ergonomics
  - D1-1: industrial design
  - D1-2: safety/survivability
  - D1-3: task sequence design
  - D1-4: work space design
- D2: Maintenance
  - D2-1: preventive maintenance
  - D2-2: sustaining engineering
- D3: Product design
  - D3-1: engineering drawing/detailed design
  - D3-2: material selection
  - D3-3: specifications
- D4: Design for production
  - D4-1 Manufacturability
  - D4-2 Inspectability
  - D4-3 Serviceability

P: People

- P1: Action error
  - P1-1: action
  - P1-2: inaction
- P2: Interpersonal behavior
- P3: Skills and knowledge
  - P3-1: decision process
  - P3-2: emotional factors
  - P3-3: physical capabilities and limitations
  - P3-4: task specific experience
  - P3-5: training
- P4: Values and attitudes
  - P4-1: values
  - P4-2: attitudes
  - P4-3: personal behaviors
- P5: Capabilities and Limitations
  - P5-1: decision process
  - P5-2: emotional factors
  - P5-3: physical capabilities and limitations
  - P5-4: task specific experience
  - P5-5: training

T: Team

- T1: Accepted group behavior (Norms)
  - T1-1: operational team behavior
  - T1-2: safety team behavior
- T2: Task performance

T2-1: change to task
T2-2: first time task
T2-3: infrequent task
T2-4: resources

T3: Team authority
T3-1: assertiveness/conflict resolution
T3-2: roles and responsibilities
T3-3: task briefings/walk downs
T3-4: team communication

T4: Team composition
T4-1: boundary crossing
T4-2: number of people
T4-3: skill mix

E: Environment

E1: Animal and florae interaction
E2: Facility interaction
E2-1 Temperature
E2-2 Lighting
E2-3 Noise
E2-4 Layout
E2-5 Air quality
E3: Hazardous materials
E4: Weather
E5: Peer pressure

O: Organization

O1: Communication systems
O1-1: verbal support information
O1-2: written support information
O2: Control systems
O2-1: material controls
O2-2: procedures
O2-3: process change controls
O2-4: schedule controls
O2-5: supervisory controls
O3: Culture and policies
O3-1: culture
O3-2: policies
O4: Training systems
O4-1: hardware system training
O4-2: leadership and team skills training
O4-3: software training
O4-4: task technical training
O5: Lack of infrastructure

This list is by no means exhaustive. It is a recommendation from the IAQG People Capability team for use internally by any organization wishing to implement an Error Management System. It will allow adequate analysis to be carried out and comparison with other organizations in the supply chain.

APPENDIX D – Existing Human Factors Studies

Web sites used to gather data for this paper. Other sites are available that provide information on Human Factors and Error Management

- Wikipedia Human factors and ergonomics
  http://en.wikipedia.org/wiki/Human_factors
- MedStar Health: Human Factors in Health Care
  http://medicalhumanfactors.net/
- Engineering Data Compendium of Human Perception and Performance
  http://www.dtic.mil/docs/citations/ADB345187
- Index of Non-Government Standards on Human Engineering...
  www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA436635
- Index of Government Standards on Human Engineering...
  http://www.researchgate.net/publication/235030891_Index_of_Government_Standards_on_Human_Engineering_Design_Criteria_Processes_and_Procedures._Version_1
- Humanics Ergonomics
  http://www.humanics-es.com/recc-ergonomics.htm#humanfactorsergonomics
- Joint Human Systems Integration
  http://www.manprint.army.mil/
- SKYbrary: Human Performance
  http://www.skybrary.aero/index.php/Category:Human_Factors

Books:

Dekker Sidney, 2006, The Field Guide to Understanding Human Error, Hampshire: Ashgate
Hawkins Frank H, 1987, Human Factors in Flight, Hampshire: Ashgate
Reason JT, 1990, Human Error, Cambridge University Press.Reason JT, 1997, Managing the Risks of Organizational Accidents, Ashgate Pub Co.
Reason JT, 2008, the human contribution - unsafe act, accidents and heroic recoveries, Ashgate Publishing Limited Dr Mark Fleming, 2001, Safety culture maturity model, Health and Safety Executive (ISBN 0 7176 1919 2).

Current FAA Guidance and Resources in Human Factors:

1) Human Factors Awareness web course. The most valuable pieces of this for our purposes are the Usability and Team Performance Modules, details of which can be found on the following web page
https://www.hf.faa.gov/HFPortalNew/Training.aspx
2) Human Factors monthly newsletter, internal and to industry
3) Civil Aeromedical Institute (CAMI) research, training courses, and publications available to industry, details of which can be found on the following web page
http://www.faa.gov/data_research/research/med_humanfacs/
4) FAA's Standard Practice Document on Human Factors (internal), details of which can be found on the following web page
https://www.hf.faa.gov/HFPortalNew/Uploads/supoladb/HF-STD-004%20-%20061209.doc
5) FAA Human Factors Research and Engineering Group resources, details of which can be found on the following web page
https://www.hf.faa.gov/HFPortalnew/
6) Maintenance Human Factors resources, details of which can be found on the following web page
https://hfskyway.faa.gov/HFSkyway/index.aspx
https://www.hf.faa.gov/HFGuide/

APPENDIX E - Glossary of Definitions, Acronyms & Terms

AMC	Acceptance means of compliance
ANPRM	Advance Notice of Proposed Rulemaking
AQP	Advanced Qualification Program
AS&D	Aerospace and Defence
AST	Office of Commercial Space Transportation
ATP	Acceptance Test Procedure
BA	Business Area
CAA	Civil Aviation Authority (UK)
CAAC	Civil Aviation Administration of China
CAAS	Civil Aviation Authority of Singapore
CAMI	Civil Aeromedical Institute
CAT	Commercial Air Transport
CCAR	China Civil Aviation Regulation
CEO	Chief Executive Officer
CFR	Code of Federal Regulation
CRM	Cockpit Resource Management
DOA	Design Organization Approval
EASA	European Aviation Safety Agency
EHFAG	European Human Factors Advisory Group
EMS	Error Management System
FAA	Federal Aviation Administration
FOCA	Federal Office of Civil Aviation (Swiss)
FOD	Foreign Object Damage
GM	Guidance Material
HR	Human Resources
HRP	Human Research Program
IAQG	International Aerospace Quality Group
ICAO	International Civil Aviation Organization
IRP	Integrated Research Plan
JAA	Joint Aviation Authorities
JAR	Joint Aviation Regulation
KPI	Key Performance Indicator
MAA	Military Aviation Authority
MAOS	Maintenance Approved Organization Scheme
MIP(G)	Maintenance Implementation Procedure (Guidance)
MOD	Ministry of Defence
NAA	National Aviation Authorities
NAA's	National Aviation Authorities
NPA	Notice of proposed Amendment
NPG	NASA Procedures and Guidelines
NPR	NASA Procedural Requirements
ORA	Organization Requirements for Aircrew
PCAP	People Capability
POA	Production Organization Approval
QA	Quality Assurance
SAR	Singapore Airworthiness Requirement
SM ICG	Safety Management International Collaboration Group
SMS	Safety Management System
TCCA	Transport Canada Civil Aviation

END OF DOCUMENT