Trainer's manual

1. Based on EASA Part-145 Human Factors syllabus
2. Extensive background information on all contents
3. Plug n' play lesson plans for each topic

THIS IS

HUMAN FACTORS FOR AVIATION MAINTENANCE

Your all-in-one tool to assist you with your future task as a Human Factors Trainer in aviation maintenance

No. 1

"Best Aviation Crew Resource Management Firm 2023"

EU Business News

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Human Factors for Aviation Maintenance

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Dear Human Factors Trainer,

This manual is an easy-to-use tool for your future task as a Human Factors (also sometimes referred to as HF) Trainer in aviation maintenance.

The manual and its chapters follow the EASA syllabus for initial human factors training for aviation maintenance organisations. The lesson plans are designed in a way that, if followed as outlined, will fully cover the syllabus.

Throughout the manual, you'll see several references to pilots, aircrew, flight deck, cockpit, and general references to an aviation working environment. Human Factors have roots in aviation and Crew Resource Management and has been continuously developed since its early beginning in the 1970s. Since there is a cockpit voice recorder and a flight data recorder in all modern aircraft, accident investigations can be quite precise and include elements of human factors - not "just" technical issues. The causes of aviation accidents and incidents are hence easily documented. As accidents in the aviation industry is a matter of life and death, the impact of human factors is easily shown. So, whenever you encounter references to pilots, flight decks (cockpits) or other aviation references, you can easily replace the terms with the job functions or working environments that are "yours".

NaviMinds have taken all reasonable care in designing a manual and programme that is simple to use and yet proves the points in ways designed to create self-reflection in your trainees to maximise their learning.

The manual starts with an introductory chapter (Chapter 0) that describes the essence of the facilitator role and desired instructional techniques for facilitating human factors training. In addition to the introductory section, you will discover ten chapters.

Chapters 1-9 describe all the various elements of Human Factors subjects in accordance with the EASA Part 145 syllabus for engineering/maintenance initial human factors training.

These chapters are further divided into these sub-parts:

- The first part of each chapter contains background information that will provide you with the background knowledge needed to facilitate the subject.
- The second part of each chapter contains a lesson plan with trainer's notes. Each lesson plan is a tool designed to help you feel confident in facilitating the proposed lessons. The lesson plans are designed to let you use them completely as they are or take out the bits that you find relevant - either for the timeframe of a training course or considering the previous experience of your students.

We suggest you familiarise yourself with all the chapters and background information before using the lesson plans.

We wish you and your future students all the best of success and lots of inspiring training.

Kind regards

Anne G. Sølvsteen Knudsen

PowerPoint slide

Hand out to students

Show a video clip

Read boxed text out aloud

Please note that not all colours are applicable to all lesson plans

? A question mark indicates a question to ask your students

Regular text indicates an "action" for the trainer; such as show/read a slide, hand out a paper, describe or inform.

Italic text indicates additional advisory information for the trainer.

Text in boxes indicate optional exercises that can be used at the discretion of the trainer if time permits.

Indicates that it would be a good idea to write down your students' answers on a flip chart/whiteboard

This Trainer Manual is supplied as a PDF file. The files are "locked" and considered NaviMinds property. You are naturally welcome to use the NaviMinds logo on the documents for in-house training.

As our customer, you are always welcome to contact us at ask@naviminds.com if you have any questions regarding the material. We are always happy to share our thoughts with you.

Topic	Areas to be addressed
1) General/Introduction to Human Factors	• Need to address human factors • Statistics • Incidents
2) Safety culture/Organisational factors	• Not specified
3) Human error	• Error models and theories • Types of errors in maintenance tasks • Violations • Implications of errors • Avoiding and managing errors • Human reliability
4) Human Performance and Limitations	• Vision, hearing • Information processing • Attention and perception • Situational awareness • Memory • Claustrophobia and physical access • Motivation • Fitness/health • Stress and workload management • Fatigue • Alcohol, medication, drugs • Physical work • Repetitive tasks/complacency

5) Environment	• Peer pressure • Stressors • Time pressure and deadlines • Workload • Shift work • Noise and fumes • Illumination • Climate and temperature • Motion and temperature • Complex systems • Hazards in the workplace • Lack of manpower • Distractions and interruptions
6) Procedures, Information, Tools, and Practices	• Visual inspection • Work logging and recording • Procedure-practice/mismatch/norms • Technical documentation – access and quality • Critical maintenance tasks and error – capturing methods
7) Communication	• Shift/task handover • Cissemination of information • Cultural differences
8) Teamwork	• Responsibility • Management, supervision and leadership • Decision-making
9) Professionalism and Integrity	• Keeping up to date; currency • Error-provoking behaviour • Assertiveness
10) Organisation's Human Factors programme	• Not specified in this manual

INTRODUCTION TO HUMAN FACTORS

Human Factors - introduction and history

In aviation, we have developed safer and safer systems for decades. At the technical level, this is done via new and safe technology, and at the non-technical level (human interaction and interpersonal skills) via procedures and CRM/Human Factors training.

Crew Resource Management is a complete training programme initially designed to increase safety and minimise accidents in aviation caused by the crew. A series of fatal aviation accidents in the late 1970ies led to the development and later the implementation of CRM. Nowadays, the programme is mandatory worldwide, meaning that all flight crew (pilots and cabin crew) must attend a CRM course regularly.

The CRM training programme incorporates subjects such as communication and behaviours, leadership and management skills, decision-making, situational awareness, man/machine interface (automation), company culture, cultural differences, resilience development, stress, fatigue, information acquisition and processing spectrum of elements. CRM focuses on the non-technical (interpersonal skills) aspects and on gradually improving the understanding of these.

CRM was developed as a response to new insights into the causes of aircraft accidents, followed by introducing flight recorders and cockpit voice recorders into the flight decks of modern jet aircraft. Information gathered from these devices has suggested that many accidents result not from a technical malfunction of the aircraft or its systems, nor a failure of aircraft handling skills or a lack of technical knowledge on the part of the crew; it appears instead that they are caused by the inability of crews to respond appropriately to the situation in which they find themselves. For example, inadequate communication between crew members and other parties could lead to a loss of situational awareness, a breakdown in teamwork on the aircraft, and ultimately to, a wrong decision or series of decisions that result in a serious incident or a fatal accident.

Almost everyone in aviation knows that the worst aviation disaster to date happened in Tenerife in 1977 when two massive Jumbo jets collided on the runway. There were no technical failures with either aircraft, and they were both on the ground when the accident happened. Five hundred eighty-three people lost their lives. The Tenerife accident is still the worst aviation disaster the world has seen in terms of number of fatalities. During the investigation, the focus was drawn to the human factors that resulted in the accident. This includes the failure of the Captain to listen to his crew members. Another crucial factor was the lack of assertiveness from the First Officer and the Flight Engineer when they attempted to address their concerns. In brief, Human Factors are explained as the physiological limitations in performance and psychological factors. Human Factors played a vital role in the worst aviation disaster in history, and perhaps more importantly: our ignorance about these issues and their importance at the time.

While CRM's emphasis in its early years primarily focused on the cockpit crew and how they work as a team, later accident investigations have indicated the importance of looking wider at team effectiveness.

Human Factors for maintenance

Following a number of high-profile maintenance error events in the late 1980s and early 1990's considerable work was done in looking at the issue of human factors (HF) and human performance within aircraft maintenance. It appeared that the growing complexity of aircraft technologies, the prevalence of carrying out maintenance during the night and the impact of the increased pressure on the commercial needs of the operation all had the potential to create an environment where the potential for error could exist.

Below are mentioned a couple of famous maintenance error-related events/accidents that made their contribution toward the development and implementation towards human factors training for maintenance:

Accident

The accident involving Aloha flight 243 in April 1988 involved 18 feet of the upper cabin structure suddenly being ripped away in flight due to structural failure. The Boeing 737 involved in this accident had been examined, as required by US regulations, by two of the engineering inspectors. One inspector had 22 years of experience, and the other, the chief inspector, had 33 years of experience. Neither found any cracks in their inspection. However, the post-accident analysis determined there were over 240 cracks in the skin of this aircraft at the time of the inspection. The ensuing investigation identified many human-factors-related problems leading to failed inspections.

As a result of the Aloha accident, the US instigated a programme of research looking into the problems associated with human factors and aircraft maintenance, with particular emphasis on inspection.

Accident

On June 10th 1990, in the UK, a BAC1-11 (British Airways flight 5390) was climbing 17,300 feet on departure from Birmingham International Airport when the left windscreen, which had been replaced before flight, was blown out under the effects of cabin pressure when it overcame the retention of the securing bolts, 84 of which, out of a total of 90, were smaller than the specified diameter. The commander was sucked halfway out of the windscreen aperture and was restrained by cabin crew whilst the co-pilot flew the aircraft to a safe landing at Southampton Airport.

The Shift Maintenance Manager (SMM), short-handed on a night shift, had decided to carry out the windscreen replacement himself. He consulted the Maintenance Manual (MM) and concluded that it was a straightforward job. He decided to replace the old bolts and, taking one of the bolts with him (a 7D), he looked for replacements.

The storeman advised him that the job required 8Ds, but since there were not enough 8Ds, the SMM decided that 7Ds would do (since these had been in place previously). However, he used sight and touch to match the bolts and, erroneously, selected 8Cs instead, which were longer but thinner. He failed to notice that the countersink was lower than it should be once the bolts were in position. He completed the job himself and signed off, the procedures not requiring a pressure or duplicated check.

Several human factors contributed to this incident, including perceptual errors made by the SMM when identifying the replacement bolts, poor lighting in the store area, failure to wear spectacles, circadian effects, working practices, and possible organisational and design factors.

Research into examples like these eventually led to the introduction of HF training requirements for all maintenance staff at both an initial and continuation training level.

The need to address human factors in maintenance

As mentioned, the majority of concerns regarding aviation safety have been related to pilots and to the poor communication and decision-making on the flight deck that led to aircraft crashes. However, in recent years, attention has turned to human factors in maintenance. Aircraft engineers deal with a unique set of human factors challenges that can lead to maintenance errors.

It is vital to emphasise that when talking about human factors, we are not focusing on problems with the knowledge or technical skills of specific people involved. Instead, when incidents and accidents occur, people were let down by non-technical elements (or human factors), such as being victims of time pressure (perceived or real), visual illusions, lack of information and misunderstandings. Often, highly experienced engineers or senior people in an organisation make the mistakes. This is consistent with flight crews, where many accidents have happened because highly experienced people made mistakes.

Human factors play a role in most parts of a typical aircraft maintenance operation. Very often, work must be carried out under time pressure, in a noisy environment or outside in all types of weather – and tasks may take place working on high stands above the ground. Often, multiple interruptions during a task make it easier to forget things. Tools or spares may be unavailable and difficult to access, and procedures may be poorly written or hard to obtain. Furthermore, work often requires more than one shift, resulting in handovers from one engineer to another.

Statistics

The difference between the airline industry and other industries is that good accomplishments, as well as poor accomplishments, are exceptionally well documented.

When it comes to aircraft accidents and incidents, technical failures or weather hazards account for only 25% of the primary causes of accidents. In contrast, human factors-related causes account for the remaining 70 to 75% of accidents.

The famous "black box" on board a commercial aircraft documents every tiny bit of events leading up to any accident. And the effects of every word spoken are scrutinised by experts to take learning from the accident and to help identify primary causes.

When it comes to aircraft accidents and incidents, technical failures or weather hazards account for only 25% of the primary causes of accidents. In contrast, human factors-related causes account for the remaining 70 to 75 % of accidents. The rate of human error as the main factor in 75% of accidents has remained more or less constant over the last century. Simultaneously the number of accidents in aviation has fallen dramatically. But the fact remains: humans make errors. In 75% of cases – human error is still the main contributing factor to things going wrong, despite a decrease in the total amount of serious accidents.

But what are the statistics in aviation maintenance?

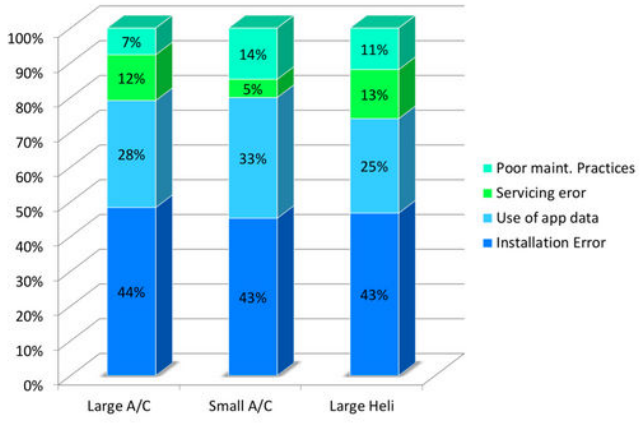
It may seem obvious that with the absence of voice and data recorders in the hangar, it may be harder to pinpoint primary causes in maintenance. Data must come from different sources, such as reporting and safety management systems (SMS). There are varying estimates of the proportion of aircraft accidents related to maintenance errors. Some studies found between 12 and 20% of accidents involve maintenance. Others have indicated that of all accidents with human error as a primary cause, a stickering 25% happened partly due to human error in maintenance.

The below table shows the numbers of of three different studies:

% of accidents	Source of data
12%	Worldwide study of 93 major accidents between 1959 and 1983
15%	IATA figures from 2008
20%	Boeing statistics on 232 commercial jet aircraft accidents

There is some evidence suggesting there has been an increase in maintenance-related aviation accidents. Boeing indicates maintenance errors as the primary cause in 6% of all accidents over the last twenty years, while this figure was 3.4% over the previous forty years. Similarly, the number of maintenance errors reported to the UK Civil Aviation Authority (CAA) has increased significantly over the past few years. Again, this may be related to an increased awareness of the importance of reporting errors.

We could debate the accuracy of these figures. For example, the increase is due to a better awareness of human factors and what causes accidents. In other words, engineers may now be reporting a human error today they might not have reported twenty years ago because of a more mature safety systems approach. There are several maintenance areas which are more prone to human factors errors. The figure below depicts some of these for different types of aircrafts.



From these figures, it can be seen that the most likely error type is 'incorrect installation'. Incorrect installation includes failure to fit all required components (e.g. seals or spacers), incorrect routing of electrical cables and incorrectly applied torque. The next highest is the use of approved data, or rather the probable lack of it. This includes properly using approved data such as the maintenance manual, service information or repair drawings. Poor maintenance practices are unwritten rules and workplace practices generally accepted as how work is done within an organisation.

Does human factors training work?

In December 2007, the Australian Safety Transport Bureau confirmed that Qantas mechanics had been pumping potentially fatal nitrogen, rather than oxygen, into passenger jet emergency oxygen tanks. As a result, almost 200 aircraft had to be checked for nitrogen contamination. This incident illustrates how human error in aviation maintenance can have expensive, and even fatal consequences. The aviation industry has long focused on human error as a cause of accidents and incidents; however, human error has often been equated to pilot error or human error in air traffic control. Yet, as the Qantas incident shows, human error can also easily occur in aircraft maintenance.

It is challenging to measure to what extent human factors training works. The same is the case for CRM training. We know that today flying is the safest it has ever been. 2017 was the safest year, with the least fatalities ever registered. At the same time, more flights took off and landed than ever before. However, how much of this success should be attributed to CRM and Human Factors training?

Sage Journals has published a survey in which they state the following:

Journal

"Since 1999, aircraft maintenance personnel in the European Union (EU) have been required to take human factors training. At that time the training was not compusary in the US.

Prior to 1999, the rates of maintenance-related error for the EU and the US were not statistically different. In the years following the implementation of mandatory human factors training in the EU, the difference in rates for the US and the EU became statistically significant. Our results suggest that human factors training may be very valuable in reducing maintenance-related error in aviation".

Sage Journals 2010

The data collected from the survey can be seen in the picture below:

Years	Mechanical *number*	*%*	Non-mechanical *number*	*%*	Total *Number of reports*
1991 - 1998	25	33	51	67	76
2000 - 2006	40	48	43	52	83
1991 - 1998	21	33	42	67	63
2000 - 2006	10	22	36	78	46

As an AME or AMT, the ability to tap a colleague as an available resource will help compensate for human factors performance errors involved in decision-making in aviation maintenance. Managing the resources will help ensure that all decisions and actions follow safe working practices and reduce the risk of an incident or accident.

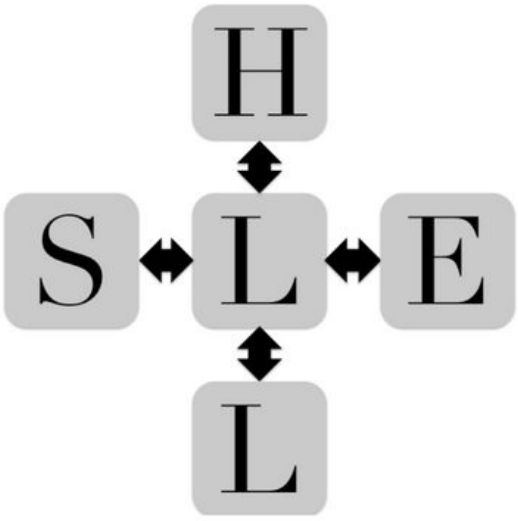
With the acceptance and understanding that humans make errors every day, it makes more sense to try and deal with the errors rather than try and eliminate them. This includes the ability to recognise when errors are present, to communicate observations and act accordingly. Throughout the years, several models have been developed to help conceptualise the complex systems in which humans operate. One of them is the Shell Model.

SHELL model of human factors

The SHELL model is intended to help facilitate a gradual understanding and comprehension of Human Factors. The model consists of 5 "building blocks" – each block contains the initial letter of its components – Software, Hardware, Environment, and Liveware, thus each block represents the components and complexities of Human Factors. The blocks must be carefully matched to avoid breakdowns and stress in the system.

This building block diagram does not cover the interfaces outside Human Factors (hardware-hardware, hardware-environment, software-hardware) and is only intended as a basic aid to understand Human Factors; below is a Shell model, which can be drawn on a whiteboard to illustrate.

Note that on the models to follow, the blocks all have rounded edges, indicating that they can change in size and shape depending on the situation.



A more detailed description of the components and their meanings follows on the following pages.

Software - the rules, procedures, written documents etc., which are part of the standard operating procedures.

Hardware - machines, equipment, controls, switched and surfaces, displays, the aircraft

Environment - the situation in which the L-H-S system must function, the social and economic climate, as well as the natural environment

Liveware - the humans - engineers and maintenance personnel, management and administration people, flight crews - within the system

Liveware (humans)

In the centre of the model is the person or the human being. It is not a coincidence that the person is placed in the centre – humans are the system's most critical and flexible component. Remember that in 75% of incidents and accidents, human error is the primary cause. However, of all the dimensions in the model, the human being is the least predictable and most susceptible to the effects of internal (hunger, fatigue, motivation etc.) and external (temperature, light, noise, workload, etc.) changes.

Human error is often seen as the negative consequence of the liveware dimension in this model.

As long as humans work in the system, removing the live-ware dimension would make no sense because we are an inevitable part of the system. However, humans are prone to making errors – regardless of how much training we get and how well we do when we are evaluated.

The fact is humans cannot be removed or replaced entirely by computer systems or computer-controlled devices, at least not at this point in time.

Liveware - Liveware (people and other people)

This is the interface between people. In this interface, we are concerned with leadership, cooperation, teamwork and personality interactions—all soft or social skills. As company culture, climate, and operational pressures affect human behaviour and performance, staff and management relationships are also included.

Earlier, it was assumed that if each team member was proficient, then these individuals put together would make up a proficient and effective team. However, the study of many accidents and teams has shown this is not always a correct assumption.

Many groups are involved in the operation of an aircraft; engineers, technicians, supervisors, management, flight crews, air traffic controllers, caterers and ground handlers. Group influences and individual cultures are strong and can play a significant role in determining behaviour and affecting performance. In brief, although these groups work toward a common goal – they are separate groups (separate cultures) within the system, not one team. Culture determines behaviour, and behaviour can affect human performance.

Liveware - Software (people and procedures, checklists, rules)

Software is the collective term which refers to all the laws, rules, regulations, orders, standard operating procedures, tech manuals, installation diagrams, customs and conventions and the usual way things are done. Software also refers to the computer-based programmes developed to operate automated systems.

To achieve a safe, effective operation between the liveware and software, it is essential to ensure that the software, particularly if it concerns rules and procedures, is capable of being implemented; that they are easy to understand, simple and easy to use. As systems in modern aircraft become more automated and complex, the issue of "man/machine" has become one of the most important aspects of Human Factors.

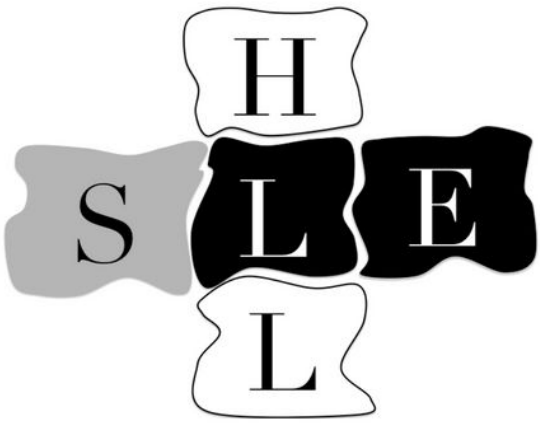
Liveware - Hardware (people and machine)

Another interactive component of the SHELL model is the interface between liveware and hardware. This interface is the one most commonly considered when speaking of human-machine systems. Examples are the seat design to fit the human body's sitting characteristics. Displays that match the symbology that the user is familiar with. For E.g. a warning light that typically is red has been fitted with a green cover. This could lead to confusion and failure to discover the warning if activated. It also refers to available equipment such as lighting, scaffolding and tools.

Hardware, for example, in Air Traffic Control, refers to the physical features within the controlling environment, especially those relating to the workstations. For example, the press-to-talk switch is a hardware component that interfaces with liveware. The switch will have been designed to meet a number of expectations, including the probability that when it is pressed, the controller has a live line to talk. Similarly, switches should have been positioned in locations that controllers in various situations can easily access, and the manipulation of equipment should not impede the reading of displayed information or other devices that might need to be used simultaneously.

The user may never be aware of a liveware-hardware deficiency, even where it finally leads to disaster. Designers must be alert when designing new systems, as liveware-hardware deficiencies could be a potential safety hazard.

Liveware - Environment (people and the environment)



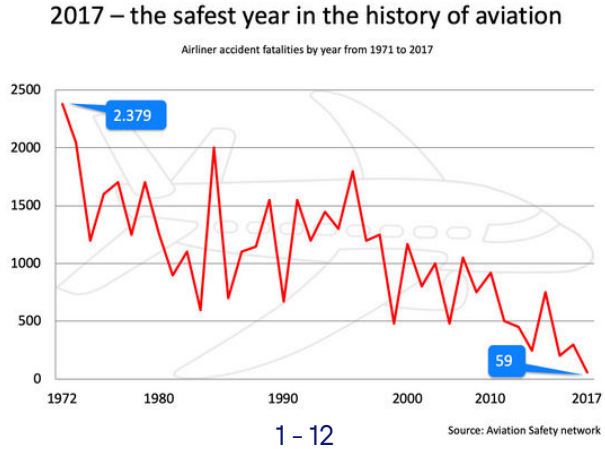
The liveware-environment interface refers to those interactions which may be out of the direct control of humans, namely the physical environment - temperature and weather.

Much of the human factor development in this area has been concerned with designing ways to protect people or the equipment and developing protective systems for lights, noise, and radiation. In the old days, the focus was on adapting humans to the environment; helmets, flying suits, oxygen masks, G-suits, etc. Later the trend was to reverse this process by adapting the environment to match human needs; pressurisation, air conditioning, soundproofing, suspension, etc.

Because it no longer takes several days to travel from Europe to, for instance, Australia, humans' body rhythm and sleep patterns are disturbed to a greater extent than earlier. We simply do not have time to adjust to time zone differences naturally.

A few more statistics

Air travel has been growing during the last 50 years. As a result, more and more aircraft find their way through a crowded sky. Despite this, air travel remains the safest way of travelling. The year 2017 was the safest in commercial aviation - ever. On average, you would have to get on a plane 1.4 million times (some statistics even suggest 2 million times) to risk being involved in a severe accident. And in 2017, there was only 0,37 accident per 1 million departures.



Summary

The “human factors” initiatives in the context of Part-145 are “safety and airworthiness” initiatives, the aim being to ensure that maintenance is conducted to ensure that aircraft are released to service in a safe condition. The organisation should have a safety management system in place (SMS), many of the elements of which will need to take into account human factors to be effective.

Human factors best practice should be seamlessly and invisibly integrated within existing company processes, such as training, quality management, occurrence reporting and investigation.

One of the basic underlying premises of human factors is that a team can and should perform better than two (or three) individuals. The aim is to ensure that 1+1>2, as opposed to 1+1=2. This phenomenon is often referred to as the “synergy effect”. Synergy can be defined as the sum of information held by individuals in a team flowing freely. Effective communication is necessary to ensure that the information required to achieve this is flowing at all times. And that team performance takes precedence over individual performance.

To be effective, team members must be able to talk to each other, listen to each other, share information and be assertive when required. In addition, managers should take particular responsibility for ensuring employees function effectively as a team. Lastly, human factors training is all about raising the issue of human error without pointing the finger of blame at any individual.

The lesson plans in NaviMinds´ MHFT Manual are designed to promote group participation and encourage feedback. Much effort has been put into creating engaging and varied lessons in content and approaches to appeal to various learning styles.

We have included numerous examples of group exercises that are fun and engaging and designed to help bridge theory into practice.

References

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12. Safety Management Systems to minimise risk, Amsterdam: 27-28 April.
13. Aviation safety network - statistics

INTRODUCTION TO HUMAN FACTORS

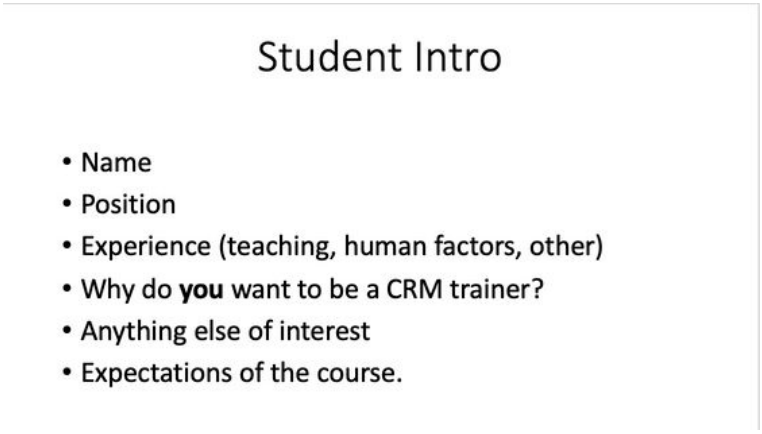
Topics covered in this lesson plan

History of human factors, Statistics, Incidents and accidents, Attitude, skills and knowledge, Need to address human factors, The aim of human factors training

Human factors training (slide header)

Welcome students and make a brief introduction to the human factors course. Then move to introduce the trainer/trainers:

Introduction



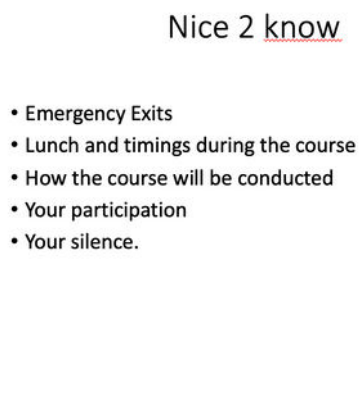
Trainer introduction: Firstly, introduce yourself according to the points on the slide. It is a good idea to make your own slide, writing down your name, position, your brief history. Getting auditory and visual information will help students remember who you are.

Student introduction: Secondly, ask students to introduce themselves according to the points on the slide. This is important, as it will give you clues as to how much human factors experience exists within the group.

A good tip is to take notes of students´ names, their seating position in the classroom and short points that help you memorise their backgrounds and experience. This is also a good time to hand out name cards to be completed if required.

Then tell students you have some practical information and show the following slide:

Nice to know



(The slide can, of course, be edited to contain the points which you find the most relevant).

Timings during the day: Tell them you aim for lessons of approx—50 minutes to an hour. Students should always be allowed to ask for a break if needed. Knowing this will help your students relax and get the most out of the course.

Smoking: Explain the smoking policies in the building. Where can people smoke? Escape routes: If students are unfamiliar with the surroundings, point out the emergency exits. That is professional in a safety-critical industry.

How the course will be conducted: A mix of theory, practical group exercises and video clips.

Your participation: Point out to students that you want them to participate. It is their course; their input and ideas are valuable to you and the group. The more they give - the more they will get out of it. Human Factors are a subject that allows for different viewpoints to emerge without being judged or leaving the room.

Your silence: This point is meant to help you, the trainer, remember to tell students that some exercises have a point to them. And that you would like them to be silent about these and not tell their colleagues who are coming on to the course at a later date what the exercises are about.

Feel free to create your own slide with the points applicable to the course. Other tips include sanitary facilities, lunch and refreshments, use of computers and wifi.

Programme for day 1

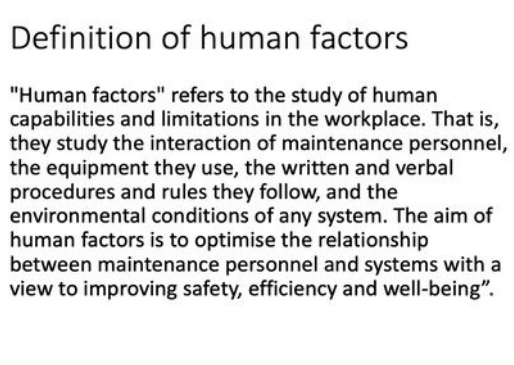
It is always a good idea to set the agenda before starting the course. This will give your students a good idea of what to expect. Display each of the required lessons on a slide – or make a hand-out that you can place on the tables for when students arrive.

? What is meant by human factors?

Generate a short discussion and listen to a few of your students' different inputs without judging.

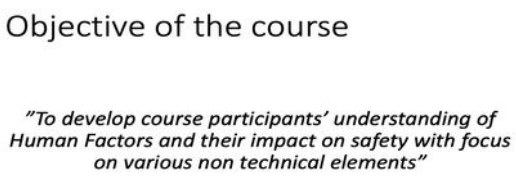
Then tell students that you will show them one definition of human factors:

Definition of human factors



Then show the overall objective of the course:

Objective of the course



What do you think is meant by non-technical elements?

List answers on the flip chart

Listen to students' input and prompt for several answers. Ensure you write the answers on a flip chart or whiteboard – you may need to show them later during this lesson.

Possible answers; include communication, the way we are, the way we act, the way we interact, stress, the working environment, our habits, leadership, culture, social skills, cognitive skills, and human traits.

Explain to students that you will show them a video clip of aviation history. Everything is well documented on the flight deck due to cockpit voice recordings and flight data recordings, making it easier to search for the root causes of accidents and incidents. Therefore, we will start with a short video that focuses on what happened on the flight deck. It helps illustrate why we focus on non-technical elements.

Tenerife disaster header

Before showing the following video – tell students that you will show them an 11-minute video clip of the world's worst aviation disaster to date. Five hundred eighty-three people were killed. The Tenerife accident is one of a few aviation accidents in the 1970ies that led to the implementation of Crew Resource Management training for the flight crew.

Instruct students to pay attention to the non-technical elements: Then show a video clip about the Tenerife Disaster (find one that suits your needs online):

Tenerife disaster full (11-minutes)

? From what you say what factors caused this accident?

Possible Answers: stress, time pressure, lack of equipment, language problems, cultural differences, weather, authority, poor leadership, poor communication, and insecurity.

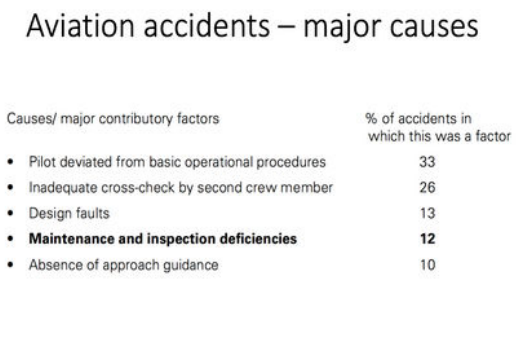
The Captain´s position within KLM Airlines and his attitude towards his colleagues are believed to have significantly contributed to the accident. The resources were available on the flight deck; however, the crew did not use them to their full potential. Other reasons include lack of equipment (no ground radar) and on-time performance. There were no technical faults with either aircraft – instead, it was concluded that human error was to blame.

Approximately 75-80% of aviation accidents have human error as a primary cause. Based on the extensive research, we have no reason to believe that this figure is different in other industries. So, this is why we are on a human factors course.

? How many of these accidents do you think have maintenance errors as a major or primary cause?

Allow students to ponder and comment on the question – then display the following PowerPoint slide:

Aviation accidents - major factors



From this, around 12% of accidents in aviation have maintenance and inspection deficiencies as primary causes. However, the number varies. Some studies suggest it might be less - other studies suggest it may be as much as up to 20%.

We now know why and when CRM (crew resource management) originated. Let's have a brief look at another video clip:

Aloha Airlines 243

This is one of a few accidents that led to the realisation of the need to address the human factor on a broader scale: namely in aviation maintenance.

? What factors could cause experienced engineers to miss these cracks in their inspections?

Listen to students' input – many answers will likely be non-technical elements (which underlines why we do human factors training).

The display the following slide:

An interesting fact

? The little holes you see what do they indicate?

The holes indicate that someone has identified that crack and stopped it from worsening.

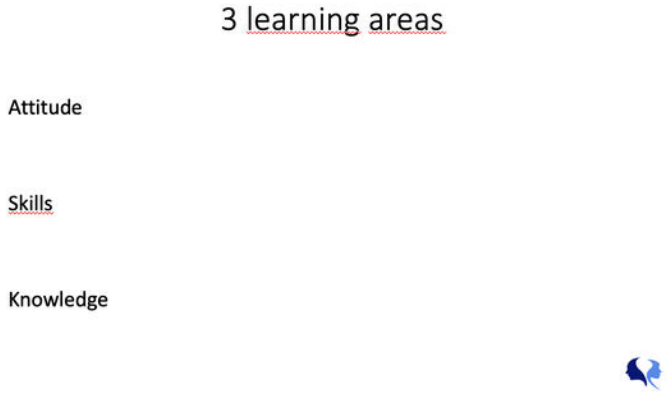
Then move on and tell students: Imagine that you won the lottery and you decided to start your independent maintenance organisation. You are now looking for your future staff.

? What qualities would you look for in the people you recruit?

List answers on the flip chart 

Make sure to prompt for several different answers. You must return to the input to this question at the end of the lesson. Then show the next slide:

3 learning areas



When we conduct training of any kind, whether online, classroom or other – we are concerned with developing one or more different learning areas – 3 areas in which humans can learn. Let's call them: knowledge, skills, and attitude.

? What is meant by knowledge – how would you define it?

Knowledge can be described as "what we know". It is the books we have read, the sense we make on a conscious level. This includes procedures. Compared to driving, it could be how well we know the road signs and traffic rules and how to operate the clutch and gears. However, this knowledge is not transformed into skills unless we practice it.

? What is meant by skills – how would you define it?

Skills can equally be compared to driving a car. However, the skills would be related to motoric (muscle memory). When they take their driving license, most people already know how to operate the clutch and gears. However, the first time in a car for most people proved rather challenging in terms of shifting gears – despite the knowledge. With practice, skills soon become an integrated part of our driving, and for most experienced drivers, the art of shifting gears has become second nature. This is a skill.

? What is an attitude – how would you define it?

Our attitude becomes evident in our verbal and non-verbal communication. It is what other people can observe and make sense of - and it influences how we communicate and react. Our attitude reveals how we feel about a person, issue, situation, job, or other.

? If you were to point to the most important learning area – which would it be and why?

Your students may argue that it is impossible to choose and that all three learning areas are essential. Just keep prompting and ask which one they would consider the least important – and which one they would consider the most important.

Then go back to the list you have made of the qualities they mentioned as ones they would look for in the people they would recruit. Then compare these to the three learning areas. Most of these qualities are likely attitudes that underpin how important attitudes are.

? If you think back on the Tenerife accident – do you think the accident happened because the Captain lacked knowledge and skills in how to fly an aircraft?

Again, it is likely that your student will point to areas such as; poor leadership, poor communication, arrogance, lack of listening, impatience, and aggressiveness – all non-technical or aspects closely tied in with attitude.

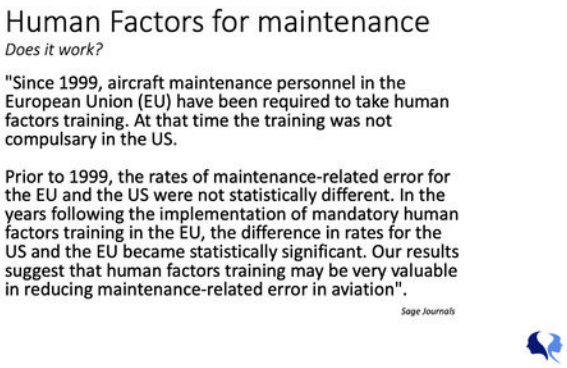
Conclude that human factors training is focused mainly on non-technical aspects or attitudes.

? Does human factors training work?

Listen to students' input. This is also a good time to ask for any previous experiences with human factors training your students may have. Human Factors training first became compulsory for maintenance staff in the EU in the year 2000. However, it took several years before the US followed suit.

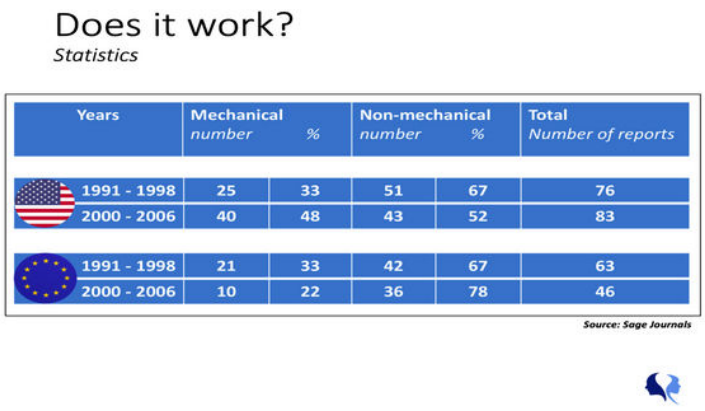
The text on the next slide is taken from a publication from Sage Journals. The publication describes a study conducted to compare the rates of maintenance-related errors in the EU and the US after the EU had implemented HF training. Show the text and allow students to read it at their own pace:

Human factors - does it work?



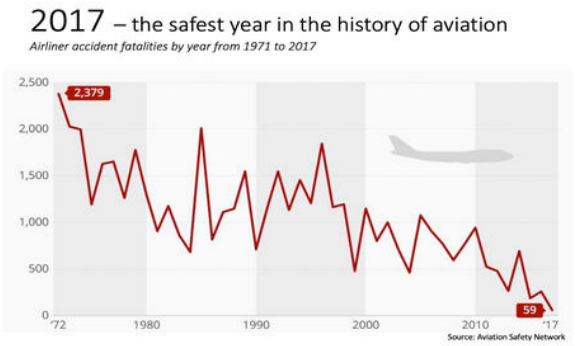
On the next slide, you will see the numbers for both the EU and the US before and after the implementation of human factors training in the EU:

Does it work - statistics



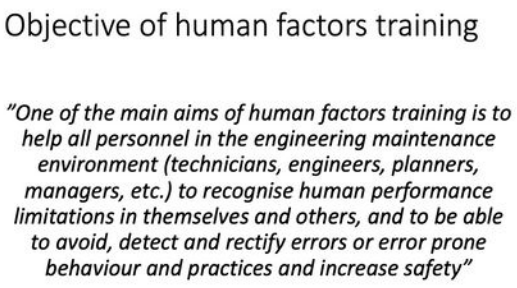
Based on these statistics, we have reason to believe that human factors training does have a positive impact. The next slide show number of fatalities in airliner accidents from 1972 through to 2017.

2017 - The safest year in aviation history



Elaborate and let students comment. Then move on to showing the overall objective of human factors training on the next PowerPoint slide:

Objective of human factors training



? How easy is it to change an attitude?

Finish the lesson by showing the next slide and reading the boxed text:

Brushing teeth

Read boxed text aloud

"Imagine that you read an article stating that changing your hand when brushing your teeth would be beneficial. So, if you are right-handed and normally brush your teeth with your right hand, imagine you are to do this with your left hand. You know from the article that it is good for you.

The first time, or the first couple of times you brush your teeth, you will grab your toothbrush consciously with your left hand and try it out. However, what happens the following day when you are in a hurry, a bit pressed for time? You rush into the bathroom; you quickly grab your toothbrush…."

? You grab your toothbrush with which hand?

Yes - you are likely to grab it with your right hand because this is what you usually do - this is your normal behavioural pattern, and it happens almost automatically. A trigger for relapse, in this case, would probably be a stressful situation, being in a hurry.

This "inbuilt human system" also works with other behavioural patterns. We must consciously work on it, repeat it and feel the benefits before we can claim that a change has happened. This is human factors in a nutshell. It is about becoming aware of our behaviours and actions, our brain and its limitations and accepting that it takes practice to change the things we want.