# 1.1 Introduction to Human Performance

## CAE's Vision

To be the worldwide partner of choice in Civil Aviation, Defense and Security, and Healthcare by revolutionizing our customers' training and critical operations with digitally immersive solutions to elevate safety, efficiency, and readiness.

CAE aims to provide training for the whole pilot life cycle. Whilst we already have many areas that cover the technical training, this human performance guide sets out the non-technical skills training that develops and integrates Crew Resource Management (CRM) training from Knowledge Skills and Attitude (KSA) at Airline Transport Pilot's License (ATPL) and Flight Training Organization (FTO) level, up to command and instructor levels within business, commercial, and helicopter aviation.

In the past, non-technical skills have often been referred to as 'soft skills', in comparison to 'hard skills' which are those required to do a task or job. However, this has created a misconception where 'hard' technical skills are seen in opposition or mutually exclusive to 'soft' non-technical skills. As a result of this misconception, soft skills are often seen as less important. To counteract this false impression, the preferred term has evolved to 'Human Skills' [i].

**Human Skills:** Human skills (sometimes called 'soft skills') are the non-technical skills that aren't traditionally taught as part of an education curriculum but that enable us to function at our optimum.[ii]

## Structure of the Human Performance Guide

This human performance guide provides advice and guidance for clients and instructors in any CAE program.  It is divided into 3 sections:

**Section 1.** *Introduction chapters:* basic concepts in behavioral psychology, learning sciences and aviation frameworks

- **1.1** Introduction
- **1.2** Basics of Human Behavior
- **1.3** Competency Based training and Assessment (CBTA)
- **1.4** Threat and Error Management (TEM)

**Section 2.** *Pilot competencies*: one chapter per ICAO competency, with hints and tips for empowering pilot skills in reference to the ICAO observable behaviors.

- **2.1** Application of Procedures and Knowledge
- **2.2** Communication
- **2.3** Flight Path Management- Automation
- **2.4** Flight Path Management- Manual
- **2.5** Leadership and Teamwork
- **2.6** Problem solving and Decision Making
- **2.7** Situational Awareness
- **2.8** Workload Management

**Section 3.** *Application chapters:* covering more in-depth concepts, with practical tips for functional use of the knowledge and skills.

- **3.1** Surprise, Startle, and resilience
- **3.2** Culture
- **3.3** Psychological Safety
- **3.4** Sensory Illusions
- **3.5** Leadership Command and Mentoring
- **3.6** Briefing and Debriefing

## Crew Resource Management

Crew Resource Management (CRM) is a flexible, systematic method for optimizing human performance in general, and increasing safety, by:

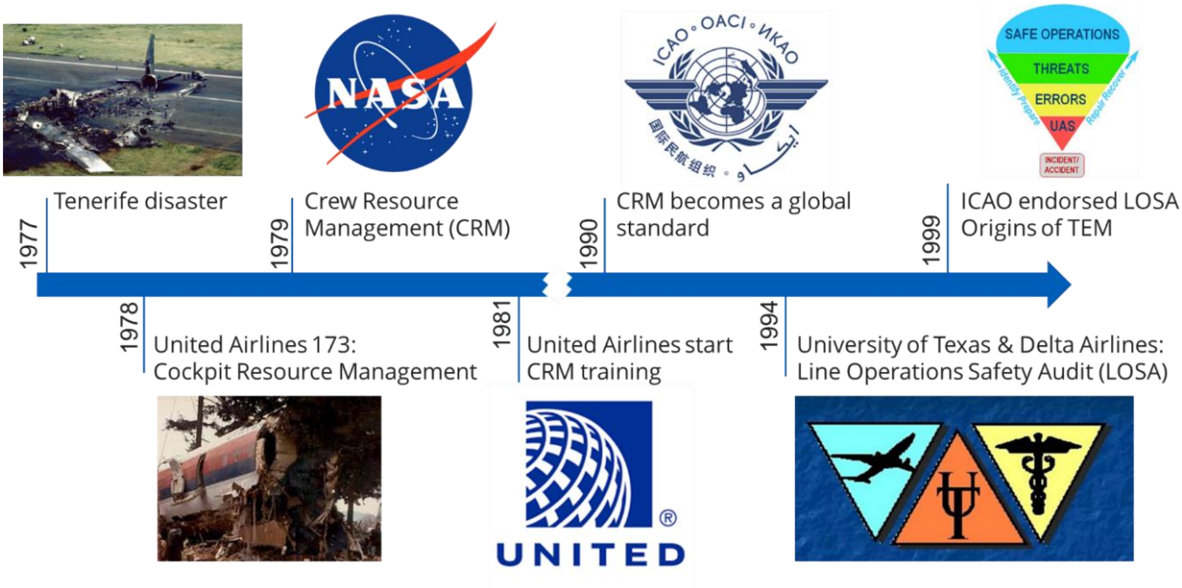
1. recognizing the inherent human factors that cause errors and the reluctance to report them,
2. recognizing that in complex, high-risk endeavors, teams rather than individuals are the most effective fundamental operating units, and
3. effectively mobilizing all available resources to reduce the adverse impacts of those human factors.

Aircraft accidents have played a key role in highlighting the need for a new tool to deal with the human errors that were cited as major causes:

- 1977 brought about one of the worst loss of life accidents when two Boeing 747s collided on a runway in Tenerife. That accident occurred in part because of a communications breakdown in the cockpit.
- In 1978, United Airline 173 crashed into the Portland suburbs when the aircraft ran out of fuel.  The crew had been distracted with a minor landing gear problem.

In 1979, the National Aeronautics and Space Administration (NASA) created a workshop entitled "Resource Management on the Flight Deck". This workshop was the culmination of research conducted by NASA in the early 1970s which identified the human error aspects of aviation accidents. After the NASA workshop, in 1981, United Airlines initiated the first CRM program. Conducted in a seminar-type setting, the United Airlines program and other first-generation programs used psychology as a foundation and were based on management training principles. Many of the courses were well received.

By the 1990s, CRM was a global standard in aviation, leading to more research in the field, which is still ongoing and developing today. Most of this research is founded in the 1994 University of Texas Human Factors Research Project (partnered with Delta Airlines) where they developed the Line Operations Safety Audit (LOSA).  In 1999, LOSA was endorsed by ICAO and then built upon with many elements including Threat and Error Management (TEM).




Since its first introduction, CRM has developed through 6 generations.

| | |
|---|---|
| **1st Gen** | Programs were focused on business management, and strategies were typically generalized and abstract. |
| **2nd Gen** | After 1985, CRM transitioned from "Cockpit" to "Crew" Resource Management. Topics expanded to distinct modules on decision-making, team building, and breaking error chains. |
| **3rd Gen** | Programs evolved to a much broader spectrum, integrating CRM into technical training. The flight crew concept was extended to other employee groups, including flight attendants and maintenance personnel. |
| **4th Gen** | Advanced Qualification Program (AQP) begins, allowing airlines to customize their training. Line Oriented Flight Training (LOFT) became an integral part. |
| **5th Gen** | Introduction of error management, recognizing that human error is inevitable and must be actively managed. |
| **6th Gen** | Further development into threat management, resulting in CRM skills being applied not only to avoid, trap, or mitigate errors, but also to identify threats within the work environment. The combination became known as Threat and Error Management (TEM). |

Rather than having the goal of eliminating error entirely, CRM provides tools to recognize errors, threats, and deficiencies, with a view to mitigating their effects to the best degree possible. This table was developed to provide a clear representation of CRM.

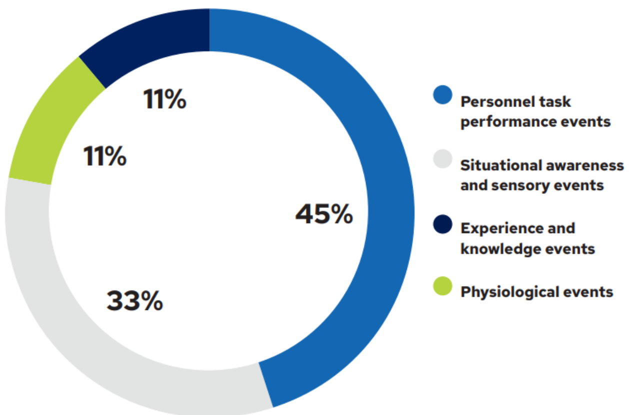
| **CRM is:** | **CRM is not:** |
|---|---|
| ▪ a comprehensive system for improving crew performance<br>▪ designed to address the entire crew population<br>▪ a system that can be extended to all forms of flight crew training<br>▪ an opportunity for individuals to examine their behavior and make decisions on how to improve cockpit teamwork<br>▪ designed to use the crew as the unit of training | ▪ a 'quick fix' that can be implemented overnight<br>▪ a training program administered to only a few specialized or 'fix-it' cases<br>▪ a system where crews are given specific prescription on how to work with others on the flight deck<br>▪ another form of individually centered crew training<br>▪ a passive lecture style classroom course<br>▪ an attempt by management to dictate cockpit behavior |

## Human Factors

***Human Factors*** is about people in their living and working situations; about their relationship with machines, with procedures and with the environment about them, and about their relationships with other people.[iii]

The EASA Annual Safety Review 2020 still showed a concerning number of human factors and human performance related accidents.

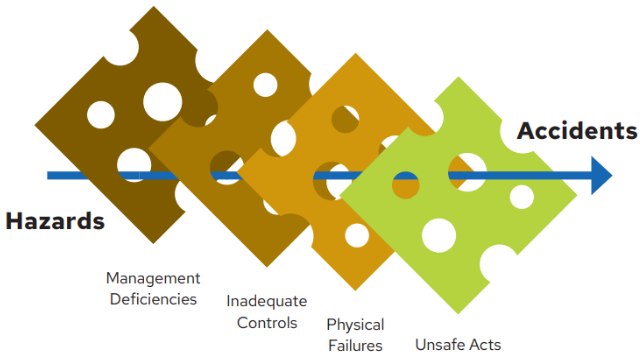
*"Approximately a quarter of commercial air transport large aeroplane accident and serious incident reports identify human factors (HF) or human performance (HP) issues."*.[iv]



This shows us that while aviation safety has increased in terms of the technological and mechanical aspects of flight, the human skills need to be improved.

Dr. James Reason developed the Reason, or "Swiss Cheese" Model in the late 1990s[v], to explain how systems components are like slices of cheese, each playing a role in the defense of the system. An accident will occur if we do not have sufficient mitigation for each of the four basic layers within this model.

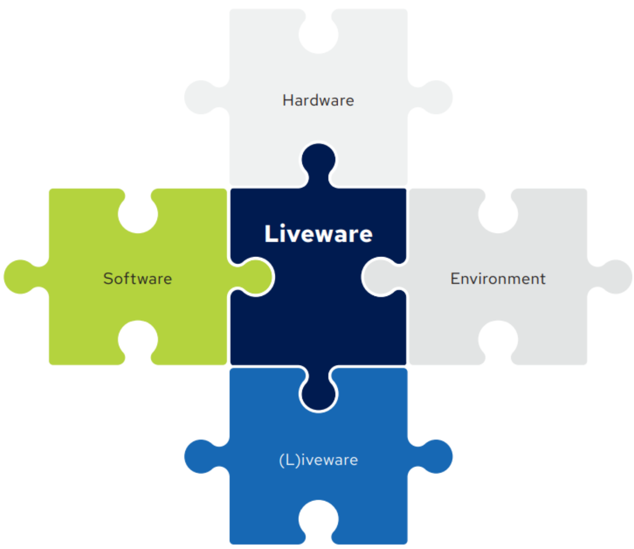
- Management deficiencies
- Inadequate controls
- Physical failures
- Unsafe acts




The holes in the layers of interventions represent imperfections that, if lined up with holes in subsequent layers, will, one-by-one, allow an error to pass through the system. Ultimately, if there are enough holes aligned, then an error will travel through and cause an undesired state where safety margins are degraded. This is where accidents and/or incidents occur.

## SHELL Model

Early in a pilot's career, understanding the interactions of human factors with CRM issues can be daunting. The SHELL model[vi] provides an easy way to classify interactions so we can better understand how to manage them.




The SHELL Model was developed by Elwyn Edwards in the early 1970s[vii] and subsequently adapted into a building block structure by Frank Hawkins in 1984[viii]. SHELL is derived from the names of the various building blocks which relate to the various components of a system.

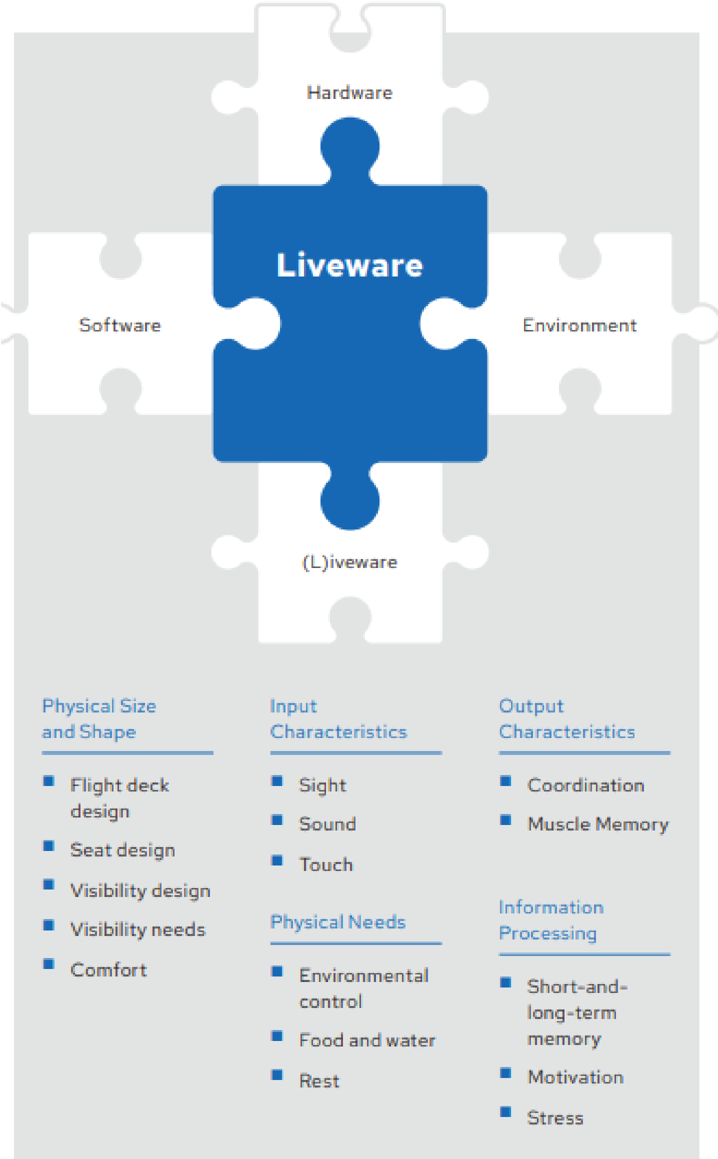
Each element must be lined up to fit into the central Liveware. If not, their mismatch describes a source of human / machine interface error.

### Central Liveware

In the center of the model, liveware represents the human operator component. It is considered the most flexible, and most critical point of the system. Yet it is also the most fallible and resistant to change or improvement. Central Liveware is constrained by several characteristics, each is associated with relevant scientific fields of study.

Humans collect and respond to information from the world around them through their senses. The efficiency and quality of this sensory perception can be affected by various physical, mental and/or biological factors. In turn this will affect the decisions based on the perceptions.

Human physical characteristics must be considered when designing equipment including body measurements and movements. The data for determining these design factors comes from the study of anthropometry, biomechanics, and ergonomics.




Elwyn Edwards (1972) and Frank Hawkins (1984)

***Ergonomics*** is a science-based discipline that brings together knowledge from other subjects such as anatomy and physiology, psychology, engineering, and statistics to ensure that designs complement the strengths and abilities of people and minimize the effects of their limitations.

### Liveware - Software Interface

The liveware-software (L-S) interface includes humans and the non-physical aspects of the system, such as procedures, manual and checklist layout, symbology, and computer programs. If the software is not designed well, the output may be negatively affected. However, this can be masked by a human's ability to compensate. L-S problems often contribute to accidents but are difficult to observe and consequently more difficult to resolve.

### Liveware – Environment Interface

The liveware-environment (L-E) interface was one of the earliest recognized in flying. Environmental tolerances, along with confined spaces and a boring or stressful working environment are known to affect performance and well-being. Initially, the measures taken all aimed at adapting the human to the environment, by designing such devices as helmets, flying suits, oxygen masks, and G-suits.  More recently this has been reversed by adapting the environment to match human requirements, for example pressurization, air-conditioning systems, and soundproofing.

Illusions and disorientation have been cited in many aviation accidents. Perceptual errors induced by environmental conditions such as illusions during approach and landing continue to challenge flight crews.

Today, new challenges have arisen, such as ozone concentrations, radiation hazards, disturbed biological rhythms and related sleep disturbance and deprivation.

### Liveware – Liveware Interface

The liveware-liveware (L-L) interface is that between the central Liveware component and the people who interact with it.  This can be internally between the crew, as well as external to the aircraft, the engineers, ground crew, air traffic controllers etc.…

Many incident and accident causes have been traced to the breakdown of teamwork, and therefore, Crew Resource Management becomes key to safety. This interface is managed through skills of leadership, crew co-operation, teamwork, and personality interactions. Corporate culture, corporate climate and company operating pressures can also significantly affect human performance.

### Liveware – Hardware Interface

The interface between central liveware and hardware (L-H) is also known as the human-machine interface. It includes such things as seat design, display designs, and information processing systems. Modern transport aircraft have used human-machine interface studies to improve the interaction between the pilots and the aircraft. Automation is the most common source of disconnects between the human and the system, and there is an entire chapter dedicated to automation in this guide.

## Summary

- Crew Resource Management was developed to focus on human skills alongside technical skills, to improve aviation safety
- Human factors are still causing aviation incidents and accidents.
- The Swiss Cheese model can help visualize how layers of protection are needed to prevent threats or errors slipping through to cause an accident.
- Interactions that must be considered within Human Factors can be simplified with the SHEL(L) model.

## Further Reading

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[ii] https://www.maxme.com.au/human-skills
[iii] ICAO Doc 9683 – Human Factors in Aviation – 1st Ed. 1998.
[iv] EASA Annual Aviation Safety Review. 2020. Available at : https://www.easa.europa.eu/sites/default/files/dfu/easa_asr_2020.pdf
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