Safety committee– Topic 1

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[1] This paper reflects the author's personal views and cannot be considered as the views of ICAO.

Strengthening International Standards on Human Factors in Aviation Operations

1. Background and Context

According to previous research, human error has consistently been recognized as a major contributor to many aviation accidents worldwide. Studies have shown that 70-80% of aviation accidents involve human performance failures.[2]

This type of error includes:

- "Violation (conscious failure to adhere to procedures or regulations)—performing a checklist from memory
- Procedural (followed procedures with wrong execution)—wrong entry into flight management computer
- Communications (missing or wrong information exchange or misinterpretation)—misunderstood altitude clearance
- Proficiency (error due to lack of knowledge or skill)—inability to progam automation
- Decision (decision that unnecessarily increases risk)—unnecessary navigation through adverse weather."[3]

Human error is a sign of systemic failure in training or culture, in work design, in workload organization, in regulatory compliance, or in regulatory oversight. With drastic changes in the pilot's working conditions, with increased flight hours and sometimes precarious contracts, the issue of human factors is becoming a growing threat to aviation safety. Additionally, there is a shortage of pilots as traffic continues to grow, making the questions of automation and the extension of the retirement age more acute and debated than ever before. Airlines need more pilots, but automation introduces new risks, from ergonomic concerns to training challenges. The pilots advocate for the possibility of working longer, but this poses new age-related risks.

Furthermore, human factors are often used as a means of defense in litigation following major aircraft disasters, which raises significant concerns for the aviation safety system: if the blame is put on the pilots, corrective actions of a more systemic nature can sometimes not be taken: "Although the pilot is often the last layer of defense, this limited approach to determining

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[2] Helmreich RL, Foushee HC. Why crew resource management? Empirical and theoretical bases of human factors training in aviation. In: Wiener E, Kanki B, Helmreich R, editors. Cockpit resource management. San Diego: Academic Press; 1993. pp. 3–45

[3] Helmreich RL, On error management: lessons from aviation, *BMJ (Clinical research ed.)*, *320*(7237), 781–785

probable causes does little to prevent similar accidents from occurring again and ensuring investigative findings matter."[4]

Figure 1.
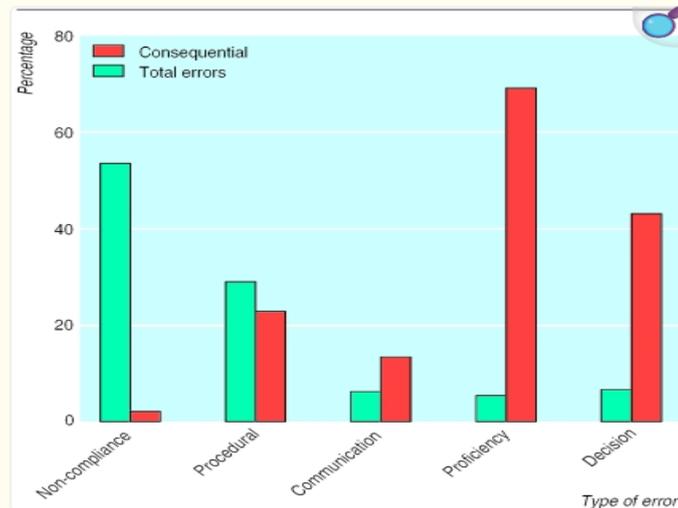
Percentage of each type of error and proportion classified as consequential (resulting in undesired aircraft states)

Helmreich RL, On error management: lessons from aviation, BMJ (Clinical research ed.), 320(7237), 781–785

The primary ICAO instruments include:

- Annex 1 (Personnel Licensing),
- Annex 6 (Operation of Aircraft),
- Annex 11 (Air Traffic Services),
- Annex 13 (Accident Investigation),
- Annex 19 (Safety Management),
- ICAO's Human Factors Training Manual (Doc 9683),
- IATA, ICAO and IFALPA's Fatigue Management Guide for Airline Operators.

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[4] Guido Perboli, Marco Gajetti, Stanislav Fedorov, Simona Lo Giudice, Natural Language Processing for the identification of Human factors in aviation accidents causes: An application to the SHEL methodology, Expert Systems with Applications, Volume 186, 2021

2. Key Issues

Training and Competency of Flight Crew

lead to an accident.

- **Accidents are systemic, not individual failures:** Accidents result from organizational and systemic failures, not just the mistakes of front-line operators.

- **Automation introduces new human factors risks:** Risks come from too much dependence on the automated systems, loss of experience and inappropriate reactions in cases of technical failures.

- **Ergonomics directly affects safety performance**.

- **Maintenance is a neglected but critical domain:** the failures in maintenance and inspection are a major and underestimated cause of aviation accidents.

- **Human factors training must be structured and profession-specific:** training in human factors should not be generic awareness content but rather competency-based and personalized to the specific operational context that applies to each group of personnel.

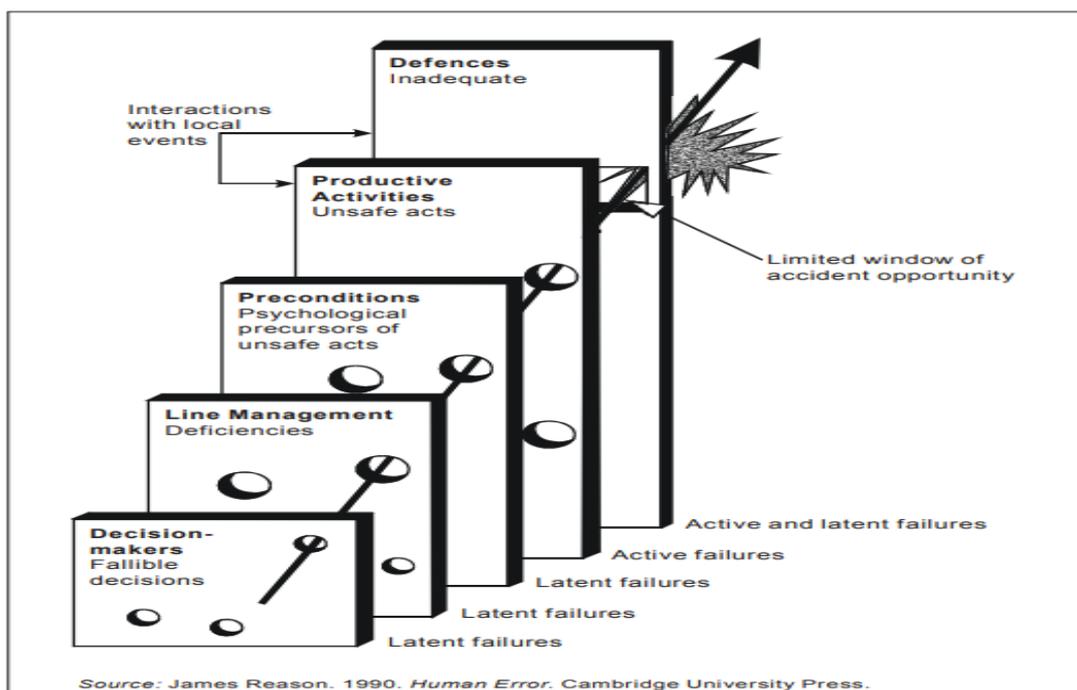- **Error cannot be eliminated, and systems must be designed to account for it**.

Figure 2-2. Human contribution to accidents in complex systems

ICAO, Human factors training manual, first edition, 1998, doc. 9683

Annex 1 to the Chicago Convention establishes minimum licensing requirements for pilots and other flight crew, and mandates that the applicant for a licence shall have received instruction on how to "recognize and manage threats and errors". Annex 1 nevertheless leaves significant discretion to individual states in designing training curricula and competency assessment

frameworks. Competency-Based Training and Assessment (CBTA), which focuses on demonstrated skills rather than hours-flown benchmarks, has been endorsed by ICAO in the 2006 version of PANS-TRG as a more effective approach, but adoption remains uneven globally.

CBTA consists mainly of performance-oriented training and assessment, with a focus on outcomes rather than predetermined training hours. During the 42nd ICAO Assembly, a working paper presented by the United States and co-sponsored by International Federation of Airline Pilots' Associations (IFALPA) advocated for:

> "Once pilots complete training and move into operations, there needs to be data collection processes for monitoring pilot performance to ensure training is effective. Therefore, it is recommended that the current hours in Annex 1 be maintained with the introduction of ICAO CBTA during the initial phase of training for a license, occurring in parallel with conventional training. Once sufficient data demonstrates CBTA effectiveness, then an additional training phase could be added and its effectiveness evaluated incrementally, over time."[5]
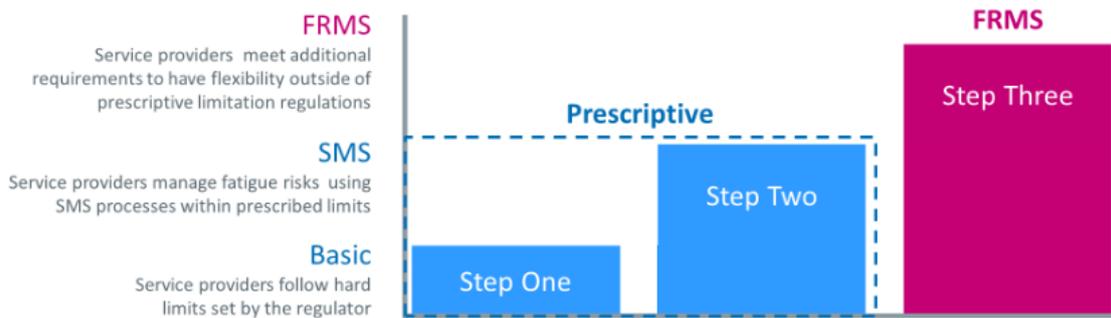
Fatigue Risk Management

Pilot fatigue is an important human factors risk in aviation. Traditional flight and duty time limitations are prescriptive rules (fixed maximum hours) that do not account for biological factors such as time of day, number of sleep periods, or cumulative fatigue. ICAO endorsed the development of science-based Fatigue Risk Management Systems (FRMS) in Annex 6, but FRMS remain optional and are implemented by relatively few operators globally.

States with more developed aviation industries tend to operate advanced FRMS and robust Crew Resource Management (CRM) training programs. However, many developing aviation markets continue to operate under prescriptive rest-period rules that do not take into account the scientific knowledge available on fatigue or circadian rhythm patterns.

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[5] ICAO, Agenda Item 25: Other issues to be considered by the Technical Commission, Supporting Enhancements in Pilot Competence Through Modification to ICAO Competency-Based Training and Assessment (CBTA), A42-WP/179.

In general, ICAO Standards and Recommended Practices (SARPs) in various Annexes support two distinct methods for managing fatigue:

1. a prescriptive approach that requires the Service Provider to comply with duty time limits defined by the State, while managing fatigue hazards using the SMS processes that are in place for managing safety hazards in general ; and

2. a performance-based approach that requires the Service Provider to implement a Fatigue Risk Management System (FRMS) that is approved by the State.

FRMS
Service providers meet additional requirements to have flexibility outside of prescriptive limitation regulations

SMS
Service providers manage fatigue risks using SMS processes within prescribed limits

Basic
Service providers follow hard limits set by the regulator

https://www.icao.int/safety/fatigue-management/fatigue-management-approaches

4.10   FATIGUE MANAGEMENT

Note.— Guidance on the development and implementation of fatigue management regulations is contained in the Manual for the Oversight of Fatigue Management Approaches *(Doc 9966).*

4.10.1   The State of the Operator shall establish regulations for the purpose of managing fatigue. These regulations shall be based upon scientific principles, knowledge and operational experience with the aim of ensuring that flight and cabin crew members are performing at an adequate level of alertness. Accordingly, the State of the Operator shall establish:

a)   prescriptive regulations for flight time, flight duty period, duty period limitations and rest period requirements; and

b)   where authorizing the operator to use a Fatigue Risk Management System (FRMS) to manage fatigue, FRMS regulations.

4.10.2   The State of the Operator shall require that the operator, in compliance with 4.10.1 and for the purposes of managing its fatigue-related safety risks, establish either:

a)   flight time, flight duty period, duty period limitations and rest period requirements that are within the prescriptive fatigue management regulations established by the State of the Operator; or

b)   a Fatigue Risk Management System (FRMS) in compliance with 4.10.6 for all operations; or

ICAO, Annex 6, Operation of Aircraft

A key challenge is whether ICAO should move toward making FRMS mandatory, and if so, how to ensure that states with limited regulatory capacity can implement them effectively.

Automation and Human-Machine Interaction

The growing automation in contemporary commercial aircraft opens up new dimensions of human factors risk. While automation reduces pilot workload in routine operations, it also creates risks of confusion, skill degradation, and over-reliance on automated systems. New crash investigations, involving a variety of aviation safety issues, have brought up the question of how prepared crews might be to deal with automated failures and recover from unsafe conditions
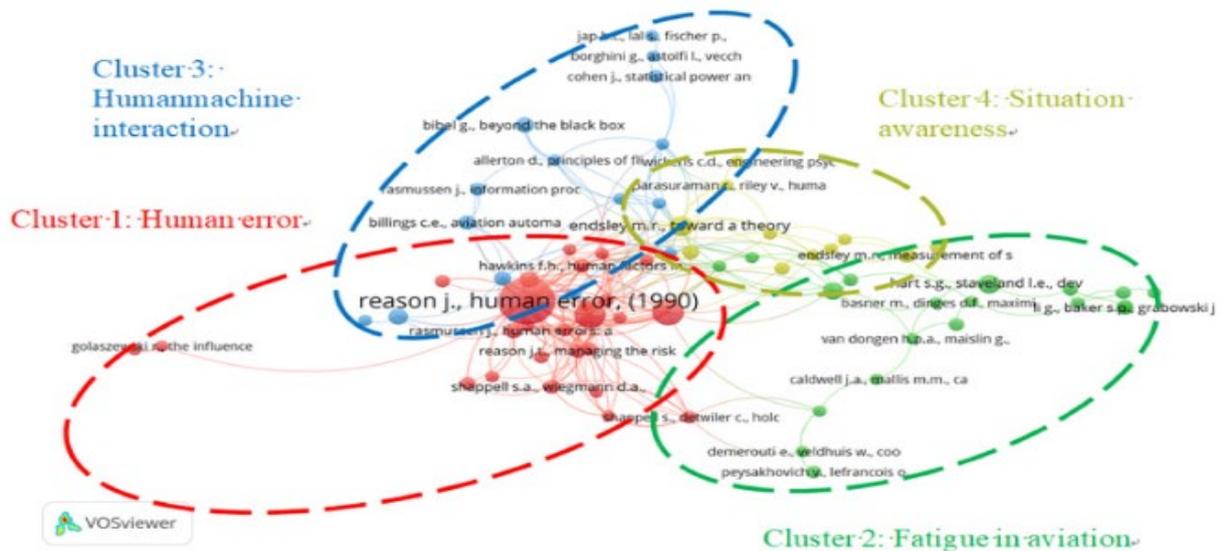
Elizabeth Amorkor Okine, Esmaeil Zarei, Brian J. Roggow, Naser Dehghan, "Evolution of human factors research in aviation safety: A systematic review and bibliometric analysis of the intellectual structure", Journal of Safety Science and Resilience, Volume 7, Issue 1, 2026.

3. Key Questions for Delegates

- Should ICAO impose Fatigue Risk Management Systems (FRMS) for all commercial operators?
- Over half of ICAO member states surveyed at the 42nd Assembly had not implemented CBTA. What is preventing adoption, and is the solution more time, more resources, or a fundamental rethinking of how ICAO standard-setting translates into national practice?
- As aircraft become more automated, pilots are spending less time flying manually and accident investigations have shown that crews struggle when automation fails. At

what point does increasing cockpit automation become a safety liability rather than an asset, and who bears responsibility for setting that boundary?

- Effective safety management depends on honest reporting of errors, yet in many states, punitive regulatory cultures discourage it. How can ICAO promote non-punitive safety reporting (known as 'just culture') regarding human factors, since the reporting of such errors invariably identifies a human cause of safety issues?