



How can we inspect 'Human Factors' ?

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Why Bother?

(1) Seveso Directive general obligations of the ‘operator’

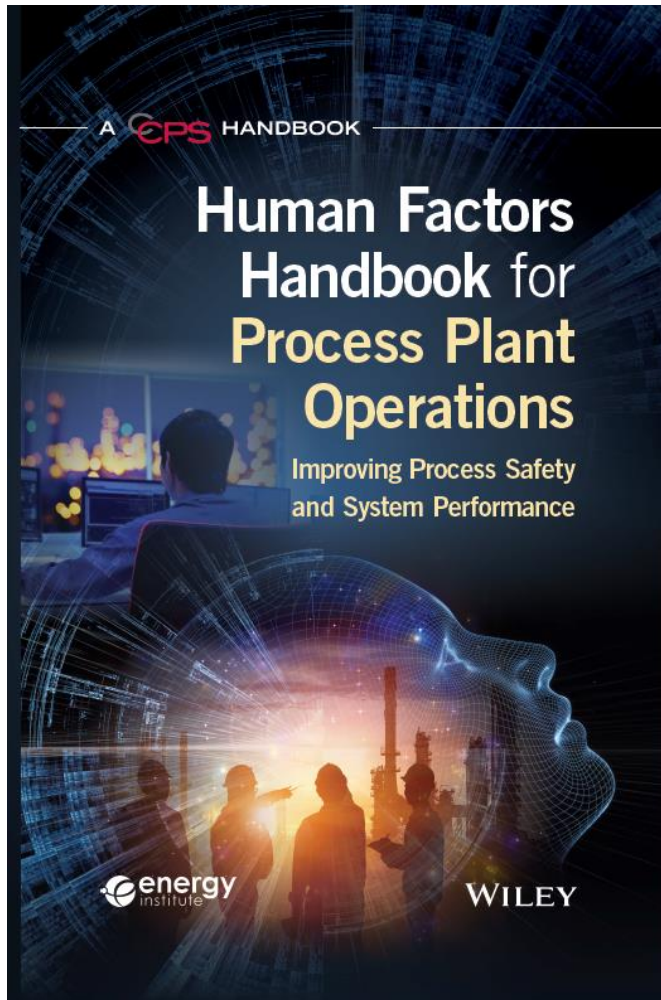
- the operator is obliged to take **all necessary measures** to prevent major accidents and to limit their consequences for human health and the environment
- the operator is required to **prove to the competent authority, at any time**, that the operator has taken all necessary measures as specified in this Directive

‘necessary measures’ include:

- Deploying a **Major Accident Prevention Policy / Safety Report**

The MAPP & Safety Report shall:

- ensure a **high level of protection of human health and the environment, and proportionate to the major-accident hazards**
- be implemented by appropriate means, structures and a **safety management system** in accordance with Annex [III](#)



26 Chapters, 435 pages

NEW BOOK from the CCPS (Published 2022)

together with the Energy Institute



With a Foreword by Professor Rhona Flin

“...This valuable handbook is definitely recommended reading for those striving to improve the safety and efficiency of process plant operations.”

Rhona Flin

Professor of Industrial Psychology
Aberdeen Business School
Robert Gordon University

CCPS Monograph:

Human Factors Primer for
Front Line Leaders



This monograph provides front line leaders in operating plants with human factors concepts and tools to support their decision-making. It complements and references *CCPS/EI Human Factors Handbook*.

Just published... May 2023

4 Sections - plus a Summary

5 Example case studies

26 pages

What do we mean by ‘Human Factors’?

Science

- Ergonomics
- Psychology
- Sociology
- Organisation, Management and Leadership

Practical Experience

- Learning from Incidents (incl. near & potential)
- Learning from normal operations
- **Learning culture: Psychological safety**

Principles and Concepts

- **To err is human**
- **Context drives behaviour**
- **Most errors stem from latent conditions**
- **Understanding errors helps prevent them**
- **How leaders respond to failure matters**

Tools and Techniques

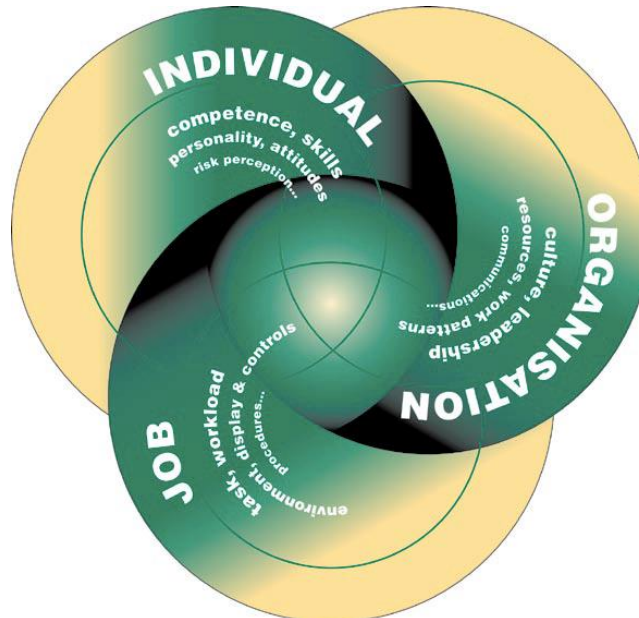
- Human Factors Engineering
- Operational Competence
- Task Planning & Error Management
- Procedures and other Job Aids
- Non-Technical Skills

What do we mean by ‘Human Factors’?

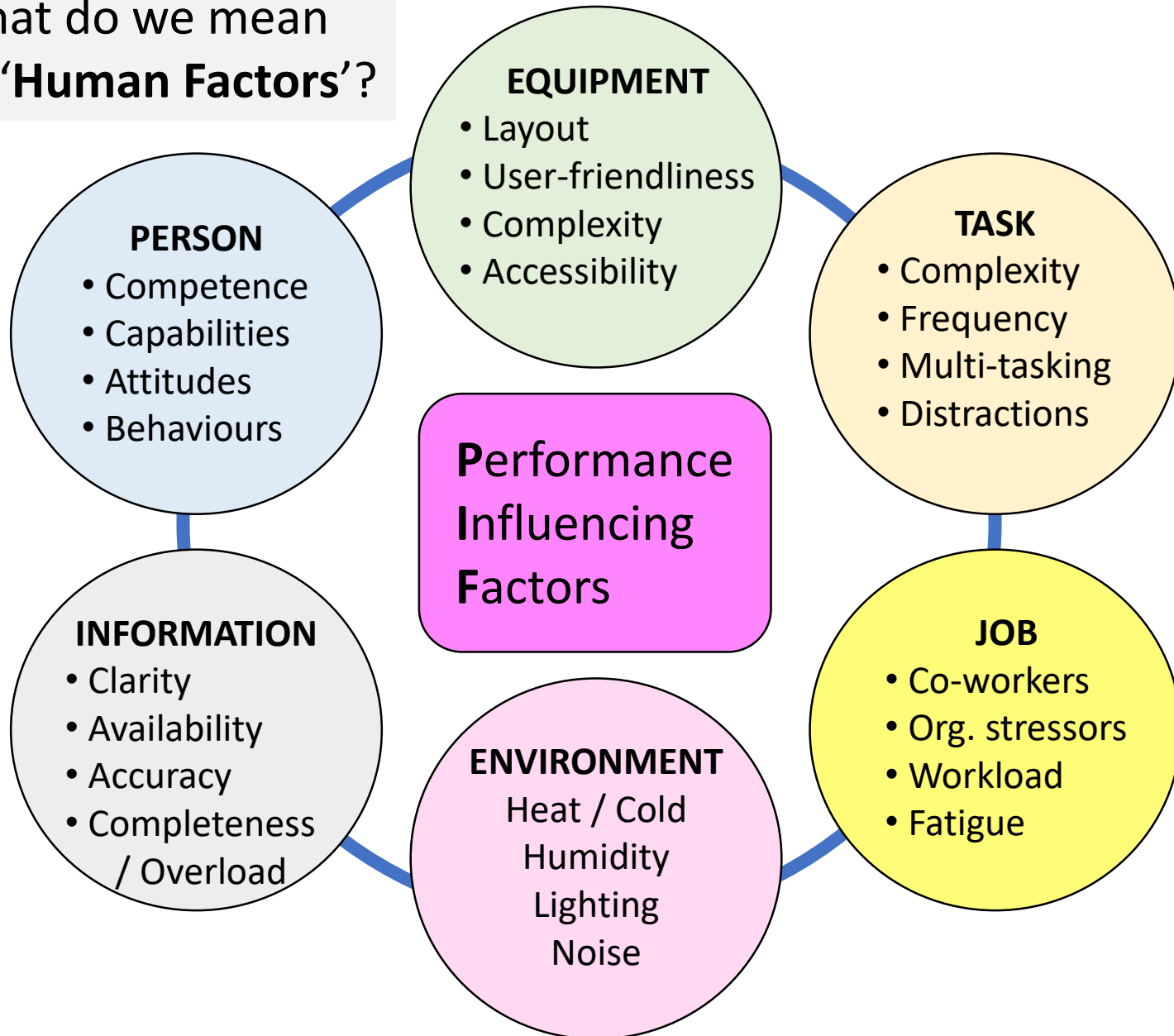
UK Health & Safety Executive:

‘Human Factors’ refers to **environmental**, **organisational** and **job** factors, and **human** and **individual** characteristics, which influence behaviour at work in a way which can affect health and safety’

HSG48: ‘Reducing error and influencing behaviour’ 2nd Ed. 1999



What do we mean by 'Human Factors'?





What does BAD look like?

INVESTIGATION REPORT

REFINERY EXPLOSION AND FIRE

(15 Killed, 180 Injured)

The CSB re



KEY ISSUES:

SAFETY CULTURE

REGULATORY OVERSIGHT

PROCESS SAFETY METRICS

HUMAN FACTORS

BP

TEXAS CITY, TEXAS

MARCH 23, 2005

What does BAD look like?

The CSB report on Texas City stated people were “set up to fail”:

The report cites Human Factors failures in all these aspects:

- **Instrumentation**
- **Competence**
- **Procedures**
- **Supervision**
- **Fatigue**

What does BAD look like?

The CSB report on Texas City stated people were “set up to fail”:

Instrumentation:

- “Raffinate tower level indicator incorrectly calibrated
- showing a declining level when it was actually overfilling”
- “Raffinate tower **high-level alarm was non-functional**”
- “Raffinate tower level sight glass dirty and unreadable”
- “The control board display did not provide adequate information on the imbalance of flows in and out of the tower to alert the operators to the dangerously high level”
- AND... “The blowdown drum **high-level alarm was non-functional**”

What does BAD look like?

The CSB report on Texas City stated people were “set up to fail”:

Instrumentation

Competence

- “Operator training program inadequate”
- “Training staff had been reduced from 28 to 8”
- “Simulators were unavailable for operators to practice handling abnormal situations”

What does BAD look like?

The CSB report on Texas City stated people were “set up to fail”:

Instrumentation

Competence

Procedures

- “Outdated and ineffective procedures”
- “Did not address recurring operational problems during start-up, leading the operators to believe that procedures could be altered or did not have to be followed”

What does BAD look like?

The CSB report on Texas City stated people were “set up to fail”:

Instrumentation

Competence

Procedures

Supervision

- “A lack of supervisory oversight and technically trained personnel during start-up”

What does BAD look like?

The CSB report on Texas City stated people were “set up to fail”:

Instrumentation

Competence

Procedures

Supervision

Fatigue

- “ISOM operators had worked 12-hour shifts for 29 or more consecutive days”

What does BAD look like?

The CSB report on Texas City stated people were “set up to fail”:

- Instrumentation
- Competence
- Procedures
- Supervision
- Fatigue

AND: the first reaction of senior leaders was to fire some of the people involved

‘BP fired some staff and disciplined others yesterday after admitting that "deeply disturbing" internal mistakes led to the Texas City refinery explosion’

The Guardian 17 May 2005



What does GOOD look like?

What does GOOD look like?

A 'safe' chemical plant will have well-managed Human Factors in at least these aspects:

- Plant instrumentation, control room design and Human System Interfaces
- Safety critical tasks
- Operational Competence and Non-Technical Skills
- Fatigue, Stress and Fitness to Work
- Task Planning
- Task Verification
- Procedures and other Job Aids
- Staffing and Supervision
- Psychologically Safe climate

What does GOOD look like?

Plant instrumentation and controls

- **Instrumentation** provides **all the safety critical information** about the process and plant condition, clearly, unambiguously and intuitively
- The **control room design** conforms to good human factors principles
e.g. ISO 11064
- The **Human System Interfaces** conform to good human factors principles
e.g. NUREG-0700
- AND the **integrity** of plant instrumentation and controls is **maintained systematically**
e.g. IEC 61508 / IEC 61511

What does GOOD look like?

Plant instrumentation and controls

Safety critical tasks

- are **identified** from Hazard Identification and Risk Assessment (HIRA) based on existing risk tools: e.g. HAZOP, Fault Trees, Bow Ties, SIL assessments, and existing Procedures, Safety Critical Equipment registers... etc...
- and **analysed** by:
 - ***Safety Critical Task Analysis*** (SCTA)
e.g based on Energy Institute '*Guidance On Human Factors Safety Critical Task Analysis*' 2nd Ed 2020
and
 - ***Difficulty, Importance and Frequency*** (DIF) Analysis
e.g. based on IAEA '*Systematic Approach to Training*' 2000

What does GOOD look like?

Plant instrumentation and controls
Safety critical tasks

Competence of all people performing safety critical tasks

- **Operational Competence** is managed effectively
e.g. based on: HSE RR086 *Competence assessment for the hazardous industries 2003*
- **Non-Technical Skills** are managed effectively, e.g. based on:

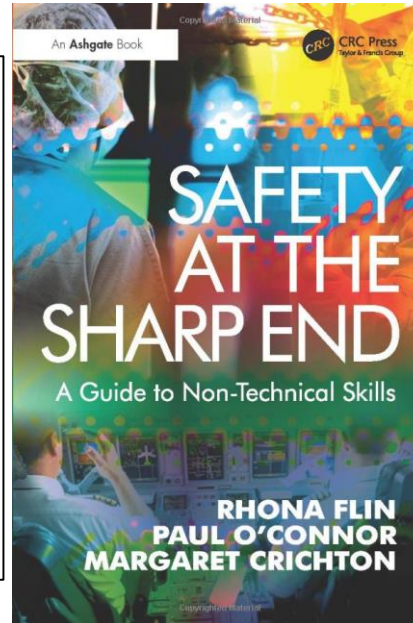
IOGP 501 *'Crew Resource Management for Well Operations Teams, 2014*

IOGP 502 *'Guidelines for implementing Well Operations Crew Resource Management training, 2014*

IOGP 503 *'Introducing behavioural markers of non-technical skills in oil and gas operations' 2018*

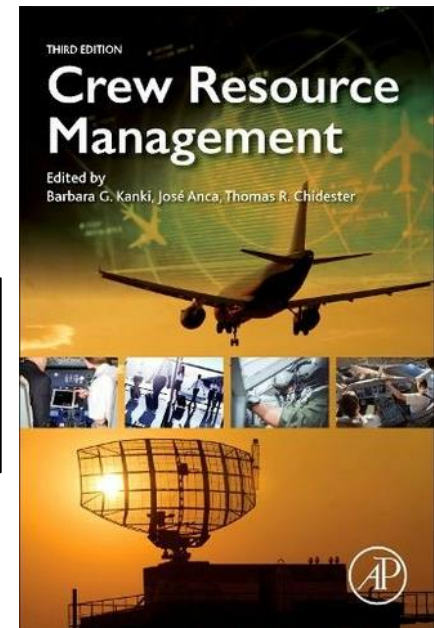
Non Technical Skills

- Situation Awareness
- Decision-Making
- Communication
- Team Working
- Leadership
- Managing Stress
- Coping with Fatigue



Crew Resource Management

>>> 'Threat and Error Management'



What does GOOD look like?

Plant instrumentation and controls

Safety critical tasks

Competence of all people performing safety critical tasks

For all people performing safety critical tasks:

- **Fatigue**

is managed effectively

e.g. based on UK Office of Rail and Road (ORR) '*Managing Rail Staff Fatigue*' 2012

- **Stress**

is managed effectively

e.g. based on UK National Health Service '*Guidance on prevention and management of stress at work*' 2022

- **Fitness to Work**

is managed effectively e.g. based on ORR '*Fitness for Work*' 2017

What does GOOD look like?

Plant instrumentation and controls

Safety critical tasks

Competence of all people performing safety critical tasks

Fatigue, Stress and Fitness to Work

Task Planning

- includes **Error Assessment** and '**Walk the Line**'
- is done together with the team performing the task
- scheduling is realistic
- distractions and interruptions are minimised

What does GOOD look like?

Plant instrumentation and controls

Safety critical tasks

Competence of all people performing safety critical tasks

Fatigue, Stress and Fitness to Work

Task Planning

Task Verification

- The level of **Task Verification** of each safety critical task is based on risk criticality
 - based on SCTA and DIF analysis

Task Verification

Task Risk Level	Tool	Application
Low	Self-checking	The individual thinks about the intended action, understands the expected outcomes before acting, and checks the intended results after the action
Medium	Peer-checking	This involves the individual self-checking and a peer checking for the individual at the same time
High	Independent verification	One individual, separated by distance and time from the action , confirms the conditions
High	Concurrent verification	Two operators working together use a step-by-step instruction with one taking the actions and the other verifying each step

What does GOOD look like?

Plant instrumentation and controls

Safety critical tasks

Competence of all people performing safety critical tasks

Fatigue, Stress and Fitness to Work

Task Planning

Task Verification

Procedures and other Job Aids

- **Procedures** are clear, correct, complete, concise and current
- **Other Job Aids**
are available and used depending on *Difficulty, Importance and Frequency* of the task:

These will include Permit to Work, Checklists, Step by Step Work Instruction, P&IDs, Photos, Diagrams...other...

What does GOOD look like?

Plant instrumentation and controls

Safety critical tasks

Competence of all people performing safety critical tasks

Fatigue, Stress and Fitness to Work

Task Planning

Task Verification

Procedures and other Job Aids

Staffing and Supervision

- **Staffing levels**, including **levels of supervisory support**, are managed effectively, e.g. based on Energy Institute '*Guidance on ensuring safe staffing levels*' 2021

What does GOOD look like?

Plant instrumentation and controls

Safety critical tasks

Competence of all people performing safety critical tasks

Fatigue, Stress and Fitness to Work

Task Planning

Task Verification

Procedures and other Job Aids

Staffing and Supervision

A Psychologically Safe climate

is maintained by **shift supervisors**, with active support from **leaders at all levels** exercising **Adaptive Leadership Practices**. This results in:

- Effective **Error Capture, Challenge and Correction**
- Active reporting of Near Miss Incidents and Potential Incidents – and effective analysis
- Active dialogue between workers, supervisors, engineers and managers about equipment, working practices, procedures and other job aids
- Frequent suggestions for improving the effectiveness of risk management – and effective analysis, implementation where practical, and effective feedback

Error capture and challenge

Error capture techniques include:

- Verbalizing activity – providing a step-by-step description of the activity
- Second person monitoring – having a person in a hands-off role observing the activity and the environment

Error challenge skills include:

- Providing timely, specific, non-judgmental feedback
- Active listening and providing detailed, relevant, positive feedback
- Reporting one's own errors without fear of repercussion

A Psychologically Safe climate

is maintained by **shift supervisors**,
with active support from **leaders at all levels**

exercising

Adaptive Leadership Practices

Three year Research Project at Cranfield University
to investigate *the influence of leadership on Process Safety*

Sponsor 

- **Fieldwork visits to three large High Hazard sites in Oil & Gas / Petrochemicals**
- **Interviewed 73 people at the ‘sharp end’ of Operations and Maintenance**
- **Analysed 194 documents relating to 117 Process Safety Incidents**

Cranfield University Research Project



SITE A

- Large petrochemicals complex in the Middle East
- **Had suffered a number of major incidents**



SITE B

- Onshore oil & gas production in Asia-Pacific
- **Had suffered a number of major incidents**



SITE C

- Offshore oil & gas production in Europe
- **No recent major incidents**
- **Recent award for process safety**

Cranfield University Research Project - FINDINGS

Two types of leadership

Administrative Leadership

'Command & Control'

planning, directing,
monitoring, controlling

Hierarchy

...Procedures & Compliance

...'*Work as Imagined*'



Adaptive Leadership

'Flexible'

listening, reflecting,
creating ideas, catalysing action

Supporting networks

...Mindful sensemaking

...'*Work as Done*'



PARADOX:
we need BOTH

Cranfield University Research Project

MAIN FINDING: need more **ADAPTIVE** leadership

1 Learning is inhibited by ‘Command & Control’ leadership

Learning needs a climate of ‘psychological safety’ – people must feel their ideas are valued, and that they won’t be blamed or ridiculed

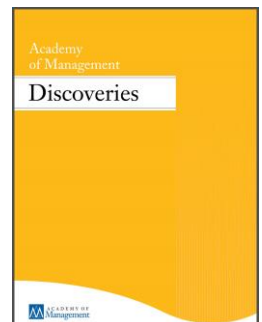
2 **Organizational Learning** needs a COMBINATION of

- Dialogue, reporting and reflection (**ADAPTIVE**) and
- Embedding changes (**ADMINISTRATIVE**)

Paper published December 2021:

Cowley, Denyer, Kutsch and Turnbull-James ‘Constructing safety: Reconciling Error Prevention and Error Management in Oil & Gas and Petrochemicals Operations’ *Academy of Management Discoveries*, Vol. 7, No. 4 Dec 2021

<https://journals.aom.org/doi/abs/10.5465/amd.2019.0190>



Cranfield University Research Project

PRACTICAL IMPLICATIONS

**Need to help leaders adopt more
ADAPTIVE Leadership Practices**

Adaptive Leadership

‘Flexible’

listening, reflecting,
creating ideas, catalysing action

Supporting networks

...Mindful sensemaking

...‘*Work as Done*’

to create a LEARNING CULTURE:

- A climate of psychological safety, so people want to report problems and share ideas
- Expert resources to identify underlying issues and improvements with real value
- AND effective ADMINISTRATIVE leadership practices - to embed the improvements

What does GOOD look like?

Plant instrumentation, control room design and Human System Interfaces

Safety critical tasks

Operational Competence and Non-Technical Skills

Fatigue, Stress and Fitness to Work

Task Planning

Task Verification

Procedures and other Job Aids

Staffing and Supervision

Psychologically Safe climate – from Adaptive Leadership Practices

- Effective Error Capture, Challenge and Correctionand reporting and dialogue

AND: the first **reaction of senior leaders** to a failure is to **care for the people involved** and to **support learning** how to avoid future related failures

How can inspectors use this to inspect Human Factors?

One idea: **10 Questions for Supervisors and Managers... Some suggestions:**

- 1 - What instrumentation enables your operators to monitor the plant?
- 2 - How do you assure the competence of your operators and technicians?
- 3 - How do you assure the health of your operators and technicians?
- 4 - How do you plan operations and maintenance work?
- 5 - How do you minimise the risk of errors occurring during operations and maintenance?
- 6 - What information do your operators and technicians use to guide their work?
- 7 - How do you assure that you have appropriate numbers of staff and supervision?
- 8 - How do your operators and technicians report problems or make suggestions?
- 9 - How do your operators and technicians avoid errors during their work?
- 10 - How do you engage with your operators and technicians?

How can inspectors use this to inspect Human Factors?

Another idea:

Nudge the managers...

... give them guidance about what GOOD looks like



Danke

Mulțumesc

Tack

Tak

Takk

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Köszönöm

Go raibh maith agat

Merci

Ačiū

Paldies

Hvala vam

Tānan

Dziękuję



Благодаря ти

Grazie

Obrigado

Thank you

Bedankt

Grazzi

Děkuji vám

Efharistó

Gracias



Kiitos

How can we inspect 'Human Factors' ?

BREAK-OUT SESSION

Suggested questions to discuss:

A - What do inspectors need to know about Human Factors?

B – What Human Factors guidance can we give inspectors?

C – What should be the main headings of a CIC on Human Factors?



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BACK UP

What is effective Teamwork?

Five core components:

1. **Leadership**
2. Mutual performance monitoring
3. **Backup behavior**
4. Adaptability
5. **Team orientation**

Three coordination mechanisms:

1. Shared mental models – of the plant, task, team members and how they interact
2. Closed-loop communication
3. **Mutual trust**

(Salas et al., 2005, 2020)

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Research by Captain Manfred Mueller - Head of Flight Safety, Lufthansa

Task Related Probability Of Errors MTBFs		
Prof. Bubb TU-Munich		
Category	Error probability	MTBF
Simple and regularly performed tasks at a low stress level.	$1 \cdot 10^{-3}$	~30 min
Complex, regularly performed tasks in a well known working environment at a low stress level.	$1 \cdot 10^{-2}$	~5 min
Complex tasks in unusual situations at a high stress level and / or time pressure.	$1 \cdot 10^{-1}$	~30 sec

Research by Captain Manfred Mueller - Head of Flight Safety, Lufthansa

Operational problems (delays / weather / technical problems...)

+

Human Error

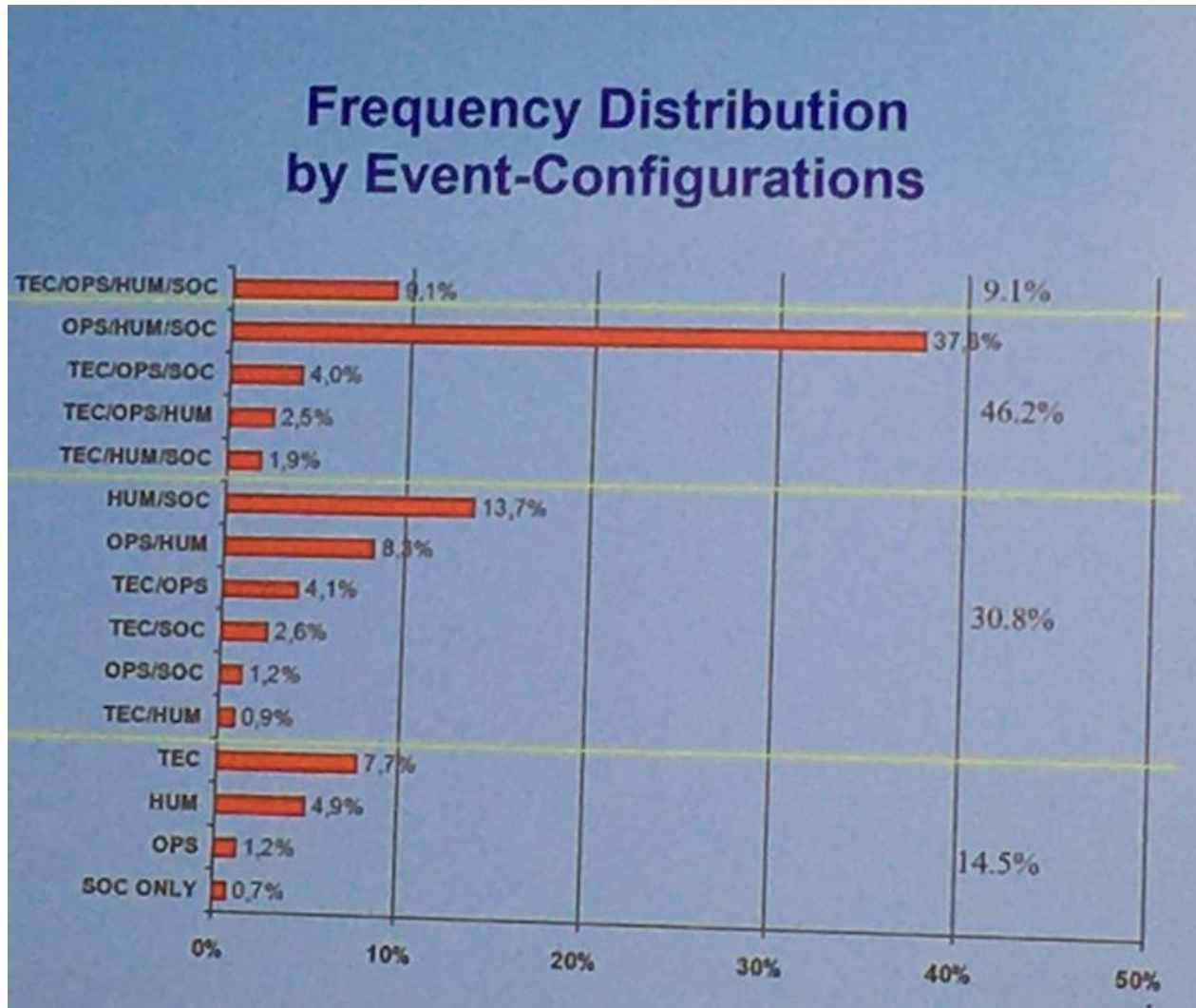
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Teamwork quality reduced by “social problems”

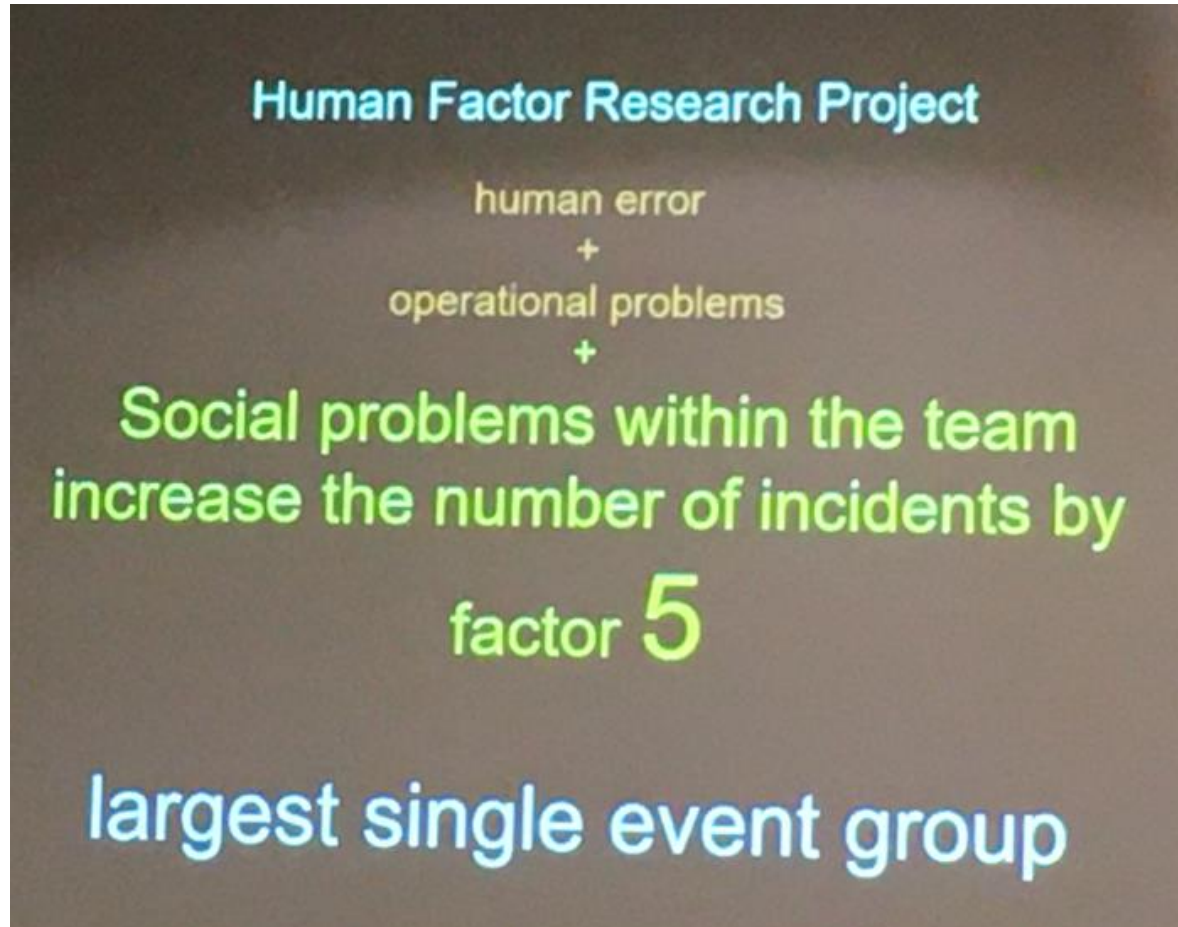
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37.8% of all safety related incidents

Research by Captain Manfred Mueller - Head of Flight Safety, Lufthansa



Research by Captain Manfred Mueller - Head of Flight Safety, Lufthansa



Research by Captain Manfred Mueller - Head of Flight Safety, Lufthansa

in 48% of all cases

- Necessary statements were not made, important information was not shared.
- Unclear concern was not addressed.
- Important information was incomplete, or was not heard correctly.

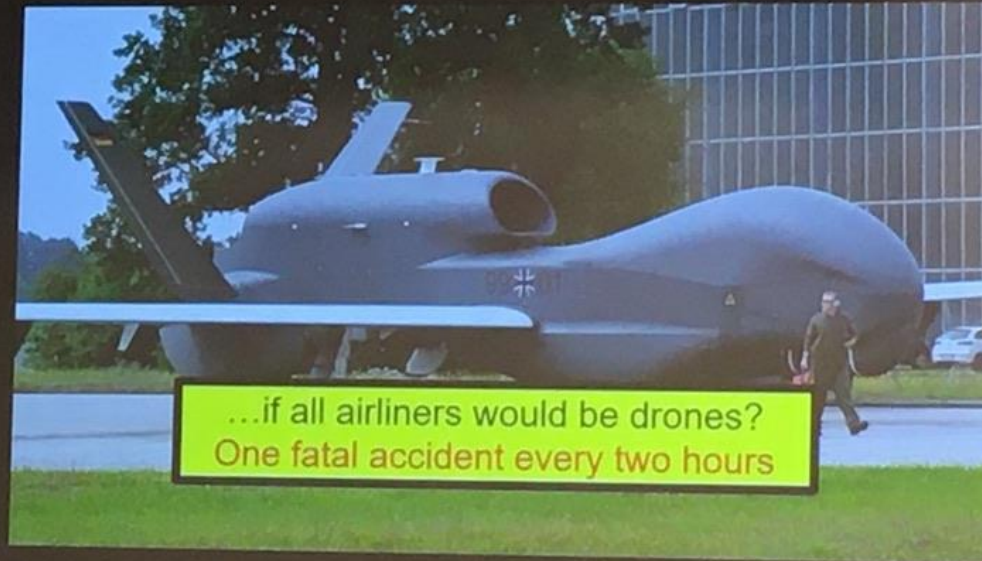
Research by Captain Manfred Mueller - Head of Flight Safety, Lufthansa

BUT... 😊

Social Competence

80% of all "Human Errors" in
complex situations can be handled
using
optimum social interaction.

Automation is NOT the answer... Good Teamwork is a MUCH BETTER answer!!



The drone Global Hawk flies autonomous, avoiding other traffic without problems...
(reliability $<10E-4$)



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MORE BACK UP

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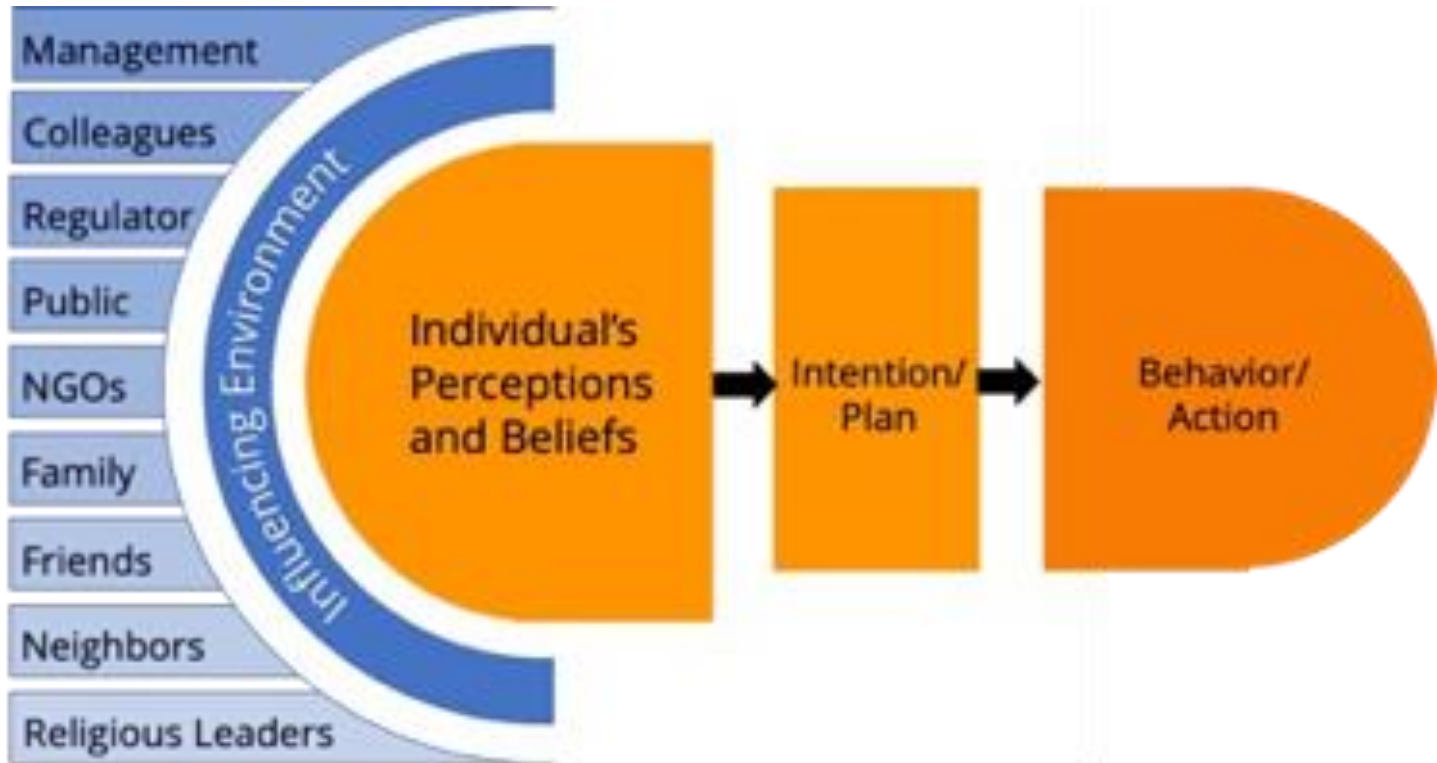
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Adapted from *Tripod Beta: Guidance on using Tripod Beta in the investigation and analysis of incidents, accidents and business losses* (Energy Institute, 2017)

Five INPO Human Factors Principles

- People are fallible, and **even the best people make mistakes**
- Error-likely situations are predictable, manageable, and preventable
- Individual behavior is influenced by **organizational processes and values**
- People achieve high levels of performance **largely because of the encouragement and reinforcement received from leaders, peers, and subordinates**
- Events can be avoided through an understanding of the reasons mistakes occur and application of the lessons learned from past events (or errors)



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