Human Factors
Integration in
Commercial Aviation

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Three Eras of Aviation Human Factors

Post WWII
- Deficiencies in cockpit layout
- Emphasis on training

The CRM Revolution
- Human Factors as a ‘hygiene factor’
- Avoiding error
- Advent of the Glass Cockpit and Automation

The Human Factors Integration (HFI) Era
- System wide, through life solutions
- Human Factors making a positive benefit

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Human Factors Integration (HFI)
The HFI Domains

- Organisational and Social
- Training
- Personnel
- System Safety
- Staffing
- Health Hazard
- HF Engineering

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Staffing

Issues

• How many people are required to operate and maintain the system?

Example HF Topics

• Staffing levels
• Workload
• Team organization
• Job specifications
Issues

• What are the aptitudes, experience and other characteristics required?

Example HF Topics

• Selection, recruitment and career development
• Qualifications and experience required
• Anthropometric characteristics (e.g. size, strength, eyesight)
Training

Issues

• How to develop and maintain the knowledge, skills and abilities to operate and maintain the system?

Example HF Topics

• Identifying requirements for new skills
• Training courses
• Requirements for specialist training facilities
• Individual and team training
• Skill maintenance (e.g. refresher courses, drills)
Issues

- How to integrate human characteristics into system design to optimise performance within the human/machine system

Example HF Topics

- Equipment design
- Workplace layout
- Maintenance access and ease of maintenance
- User interface design
- Function allocation
- Working environments (e.g. lighting, noise)
Health Hazards

Issues

- What are the short or long term hazards to health resulting from normal operation of the system?

Example HF Topics

Exposure to:
- Toxic materials
- Electric shock
- Mechanical injury
- Extreme heat/cold
- Electro-magnetic radiation
System Safety

Issues

• How to avoid the safety risks caused by operating or maintaining the system abnormally?

Example HF Topics

• Sources of human error
• Effects of misuse or abuse
• External and environmental hazards
Social and Organisational

Issues

• How to operate complex equipment safely and efficiently in large, diverse organisations

Example HF Topics

• Shared Situational Awareness
• Culture
• Organisational configurations
• Information sharing
5 Ms Model of Socio-Technical Systems
5 Ms

- (Hu)MAN
- MACHINE
- MISSION
- MANAGEMENT
- MEDIUM  Physical
  Social
5 Ms Model

What *can* be done

PHYSICAL MEDIUM

Management

Machine

Man

SOCIAL MEDIUM

What *should* be done

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For example, this includes:

- Anthropometric dimensions
- Cognitive and physical abilities
- Personality
- Training

The starting point for all human-centred design. The component in the system that cannot easily be modified.
For example, this includes:

- Controls
- Displays
- Automation
- Seating position
- Heating, lighting, ventilation *etc.*

All of these should be designed around the capabilities of the end user.
Mission

• The task that has to be done when the (hu) **MAN** and **MACHINE** come together

• The **MISSION** is tasked by the **MANAGEMENT**
Management

For example, this includes:

• Specifies and/or procures the **MACHINE**
• Selects and trains the (hu)**MAN**
• Tasks the **MISSION**, ensuring that the above factors are complimentary
• Ensures that all the above are possible within the demands of the **MEDIUM**
Medium

Two aspects:-

• Physical Medium

• Social Medium
Physical Medium (I)

The MACHINE should protect the (hu)MAN from the dangers imposed by the physical MEDIUM, e.g.

- Temperature
- Radiation
- Atmosphere
- Noise
Physical Medium (II)

The **MANAGEMENT** is responsible to ensure that the **MACHINE** provided protects the hu**(MAN)** from the physical environment when performing the prescribed task (**MISSION**)
Social Medium (I)

For example, this includes:

- Rules & norms of society
  - Criteria for performance of the hu(MAN)
  - Criteria for performance of the MACHINE
  - Criteria for performance of the MISSION
  - Criteria for performance of the MANAGEMENT

- Culture
The MANAGEMENT is responsible to ensure that the MACHINE provided, its hu(MAN) operators and the standard of task performance for the MISSION conform to the rules and norms imposed by the societal MEDIUM.
System Effects and Influences on the 5Ms
(hu)Man

Two Aspects:

• Positive (Primary) effects on the (hu)MAN
• Negative (Secondary) effects on (hu)MAN
Positive (Primary) Effects on the (hu)Man
Negative (Secondary) Effects on the (hu)Man
Mission

• **MISSION** is tasked by the **MANAGEMENT**
• It is a balance between
  • Performance
  • Safety
  • Efficiency (Cost)
• The **MISSION** needs to be monitored and analysed to assess and control risk (Safety **MANAGEMENT**)
  • LOSA (Line Oriented Safety Audits)
  • Incident Investigation
  • Error and Risk analysis (e.g. HET)
• MACHINE is specified by the MANAGEMENT
  • It supports the requirements of the mission (situation awareness) without imposing undue demands on the pilots (workload and fatigue)
  • Protects the crew from the physical environment
Machine

Physiological Stressors (Medium)

Requirements of the Mission

Flight Deck

Aviate

Navigate

Communicate

Manage

Training Requirement (hu)Man

Ability to perform the Mission
Management

Legislative Requirements

Cultural Context

Machine Certification
Crew Licensing
Operational Standards

Management

Within the Airline

Within the Aircraft (CRM)

(hu)Man Machine Mission

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Safety Management

Retrospective Measures (looking back)
• Accident Investigation
• Incident Investigation

Managing the current situation
• LOSA (Line Oriented Safety Audits)

Prospective Measures (anticipating problems)
• Error and Risk analysis (e.g. HET)
• Methodology aimed at predicting error on the flight deck
• Error is a product of
  • Design
  • Procedures (Training)
  • Task environment
• Paper describing the HET methodology won Royal Aeronautical Society Bronze Award and Hodgson prize, 2006
HET Methodology

- Task analysis of flight procedures
- Detailed examination of flight deck interfaces
- Apply HET analysis protocol
  - This predicts the error modes
- Collect low-level error data
  - This cross-validates the findings
HET Benefits

- Outperforms all other formal error prediction techniques (e.g. SHERPA)
  - Designed specifically for the flight deck
- Allows identification of design-related error
- Allows identification of procedure-induced error
  - Identifies requirements for revised procedures
  - Identifies requirements for revised training
- Can evaluate the error potential of revised procedures or flight deck interfaces before having an incident
The Relationship between Management and Culture (Social Medium)
Safety Culture

- Safety Culture refers to the behavioural and situational facets of an organisation
  - ‘what people do’
  - ‘what the organisation has’
- It is a sub-culture of
  - Organisational culture
  - National culture
Some dimensions of Safety Culture

Zohar (1980)

- Importance of safety training programmes
- Management attitudes towards safety
- Effects of safe conduct on promotion
- Level of risk at work place
- Effects of required work pace on safety
- Status of safety officer
- Effects of safe conduct on social status
- Status of safety committee
Ostrom et al. (1993)

- Safety awareness
- Teamwork
- Pride and commitment
- Excellence
- Honesty
- Communications

- Leadership and supervision
- Innovation
- Training
- Customer relations
- Procedure compliance
- Safety effectiveness
- Facilities
Safety Culture and Open systems

• Great deal of commonality in the characteristics of effective safety culture but all are internal to the organisation

• But

• ‘The environment places demands and constraints on the organisation in many ways. The total functioning of an organisation cannot be understood, therefore, without explicit consideration of these environmental demands and constraints’ (Schein, 1992).
Double-Loop Learning
(from Agyris)

The Organisation

Organisational Goals

Feedback

The Environment

The Organisation

Organisational Goals

Feedback
• ‘Most approaches to safety management attempt to lock the system down so that it does not generate new properties…. However, open systems are infinitely generative’ (Lintern, 2004).
Open Systems

- Closed systems
  - Exist independent of the environment and do not exchange energy with the environment
- Open Systems
  - Interact and exchange energy and resources with the environment
- Organisations are selectively open in that they interact with their environment but also need boundaries in order to exist
Some organisations are more open than others.
Ripple Model
(Morley and Harris, 2006)

• Ripple Model extends beyond the organisation to the Regulator, Government and Society

• Contains three (almost antagonistic) dimensions inherent in all the levels of the model
  • Concerns
  • Influences
  • Actions
Concerns

• Drive an individual to accept or reject safe working practices as a result of the prevailing culture
• Operate at an emotive (or affective) level
• Only drive safety behaviour to a relatively small degree as a result of the influences of other factors
Influences refer to those factors that underpin the ability to actually act in the desired (safe) manner.
• Actions are the behaviours themselves that have either a positive or negative impact upon safety
• Descriptions of what constitutes good safety management fall into this category
Ripple Model
(Morley and Harris, 2006)

Conscious
The needs for safety of the individual

Influences
Factors that influence the methods to satisfy needs

Failures
Results of inappropriate actions

Actions
Behaviours that influence safety
Concerns

• **At line worker level**
  • Personal health and safety
  • Job security
  • Job satisfaction and well-being

• **Middle management**
  • Meeting targets (including safety targets)
  • Controlling finances

• **Senior management**
  • Meeting organisational and shareholder goals
  • Maintaining stability
  • Assuring the financial health of the organisation
  • Potential for criminal and civil liability in the event of an accident
  • Maintaining the organisation’s relationship with the regulator and the public
Concerns

• **Regulator**
  • Demonstrating control of the level of risk in its industry
  • Responding to the economic and regulatory agenda set down by government
  • Balancing conflicting safety demands of the public while allowing industry to operate in a cost effective manner

• **Government**
  • Maintaining the stability of the government
  • Being responsive to the concerns of society
  • Promoting national economic growth
Influences

- **Line workers**
  - Attitudes toward safety
  - The skills and knowledge to deal with safety issues
  - The motivation to employ safe working practices
  - The workforce’s sense of ownership and empowerment

- **Middle management**
  - Supervisory style
  - Technical, knowledge and ability
  - Leadership and communication skills
  - Access to senior management
  - Level of autonomy and empowerment afforded to it
Influences

- **Senior management**
  - Response to public pressures
  - Social and economic imperatives
  - The regulator

- **Regulator**
  - Amount of power granted to it by government
  - Regulatory culture present in the industry

- **Government**
  - National culture
  - Public perception of risk
  - Economic imperatives
**Actions**

- **Line Worker**
  - Working in a safe manner
  - Being vigilant for new operating hazards
  - Participating in safety initiatives
  - Communicating safety issues to others

- **Middle Management**
  - Communicating information up and down the organisation
  - Encouraging and monitoring safe working practices
  - Scheduling work appropriately

- **Senior Management**
  - Determining organisational values & goals to promote safety
Actions

• **Regulator**
  - Setting, monitoring and enforcing industry-wide standards
  - Sharing safety information
  - Integrating initiatives across the industry

• **Government**
  - Providing a clear mandate to the regulator (with the required legislative power)
  - Responding to society’s safety concerns
Concerns, Influences and Actions

- The manner in which safety concerns are responded to (actions) often reflects the position in the organisation (or society).
- It is influenced by other (higher) positions in the organisation (or society).
- The dimensions of concerns, influences and actions are not completely independent.
  - An action from one level may serve to act as an influence at another level.
• A high level of concern for safety coupled with appropriate influences for promoting safety should lead to appropriate and effective safety actions

• However, a high level of concern for safety associated with a low level of influence may result in ineffective or inappropriate safety actions being taken

• Similarly, a low level of concern for safety associated with high levels of influence may result in potentially effective safety initiatives being ignored or only complied with in part
Where Safety Culture meets National Culture
National Differences in Accident Rates

- The safety culture of an organisation is a product of wider, extra-organisational factors so National culture will have a profound effect on safety
- There are vastly differing accident rates between regions
  - Africa and Asia tend to have a higher rate than Western Europe, North America or Australasia
- Collectivist cultures and those exhibiting a high level of uncertainty avoidance also exhibit higher accident rates

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Cultural Differences in Organisational Structures

• High Power-Distance Cultures
  • Tall organisational pyramids
  • Centralised decision structures
  • Many supervisory personnel
• Information is constrained and controlled by the hierarchy and there is resistance to change
Cultural Differences in Organisational Structures

- Low Power-Distance Cultures
  - Flat organisational structures
  - Relatively few supervisory personnel
  - Subordinates expect to be consulted
  - Open discussion by all personnel
  - Greater autonomy of action

- Many aspects of these low PD cultures are also desirable aspects of safety culture
Human Factors Analysis Classification System

- Organizational Influences
  - Resource management
  - Organizational climate
  - Organizational process

- Unsafe Supervision
  - Inadequate supervision
  - Planned inadequate operations
  - Failed to correct a known problem
  - Supervisory violation

- Preconditions for unsafe acts
  - Adverse mental states
  - Adverse physiological states
  - Physical/mental limitation
  - Crew resource management
  - Personal readiness
  - Physical environment
  - Technology environment

- Unsafe acts of operators
  - Decision errors
  - Skill-based errors
  - Perceptual errors
  - Violations
Human Factors Analysis Classification System

Factors more likely to be implicated in accidents in high PD and high UA cultures

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Conclusions

• You cannot study one part of any system without knowing where it fits in
• You will not get safety, performance or efficiency gains without considering how all parts of the system fit together
• You cannot consider just the human-machine system – you need to consider the wider socio-technical system
Conclusions

• Safety culture cannot be considered to begin and end at the boundaries of an organisation
• Safety concerns may be universal and the required effective safety actions may also be similar but influences determining safety practices will differ
• All organisations are selectively open systems and are becoming more open with time - safety culture must be considered in the same manner
Many Thanks

Questions?