TRANSFERRING HUMAN FACTORS EXPERIENCE FROM AVIATION TO OTHER DOMAINS

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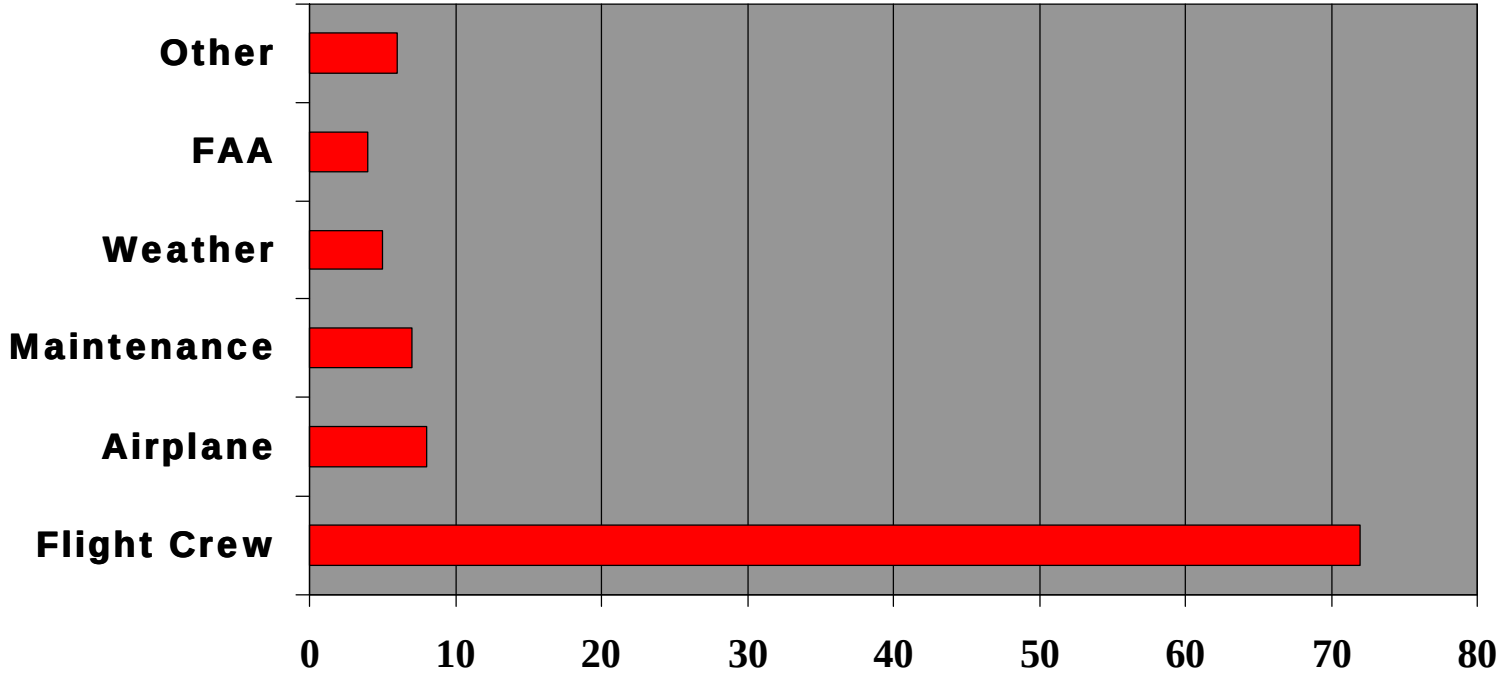
Why Teamwork Matters

- Most endeavours in socio-technical environments require teams to work together effectively
- Failures of teamwork in complex organizations can have deadly effects
  - NASA research found that more than 2/3 of air crashes involve human error, especially failures in teamwork
- Professional training has focused on technical not interpersonal skills

Primary Causes of Air Crashes (%)



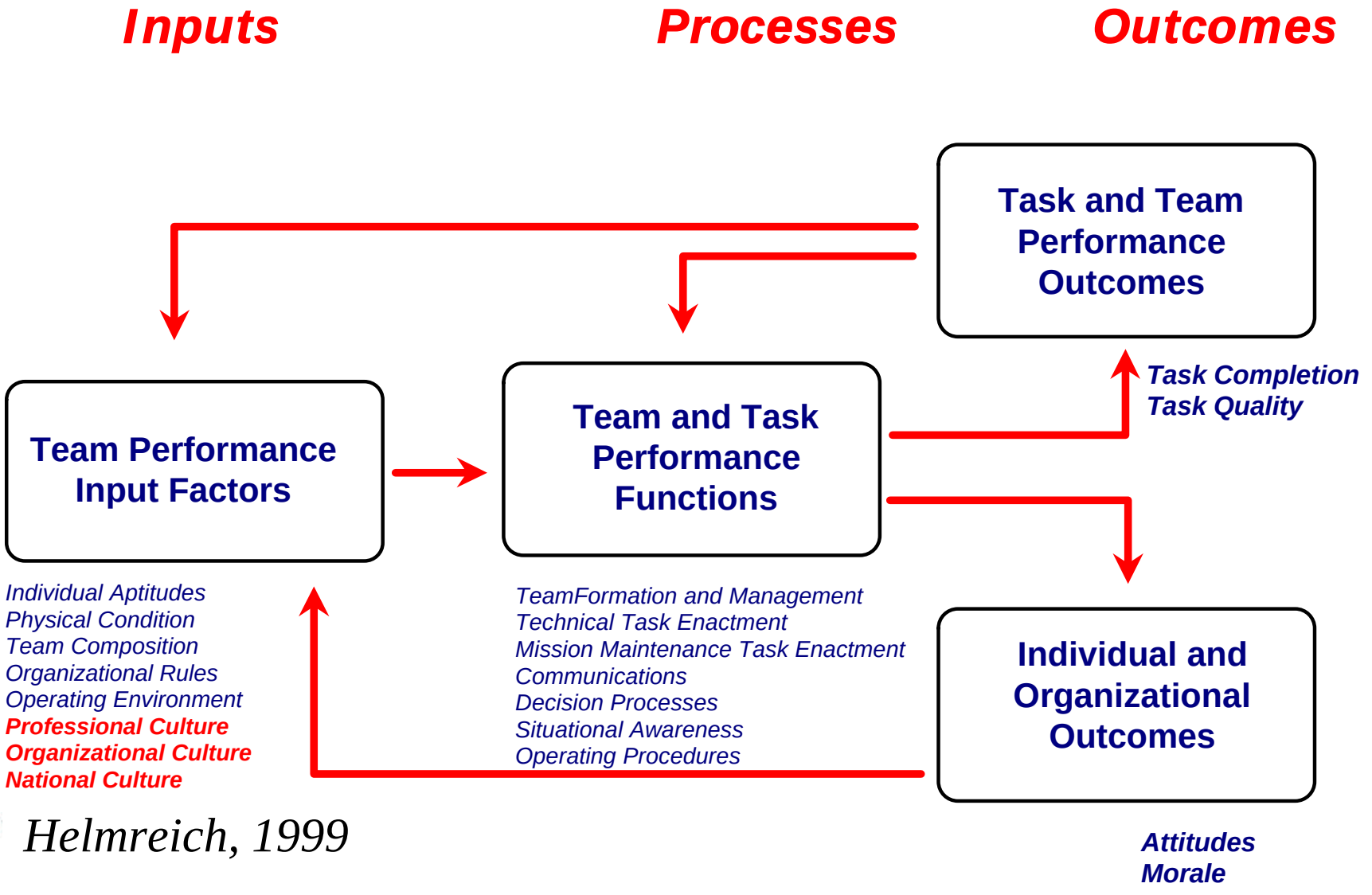
What Determines Team Performance?

- Three major elements
  - Inputs – characteristics and history of the team
  - Processes – what happens in the team
  - Outcomes – the results of team actions
- This results in an IPO (Input/Process/Outcomes) model
- The model is complex with multiple inputs, processes, and outcomes

The Critical Elements of Team Performance

- Inputs to team performance include culture, environment, resources, training, etc..
- Team processes have two critical aspects
  - The technical tasks
  - The interpersonal activities

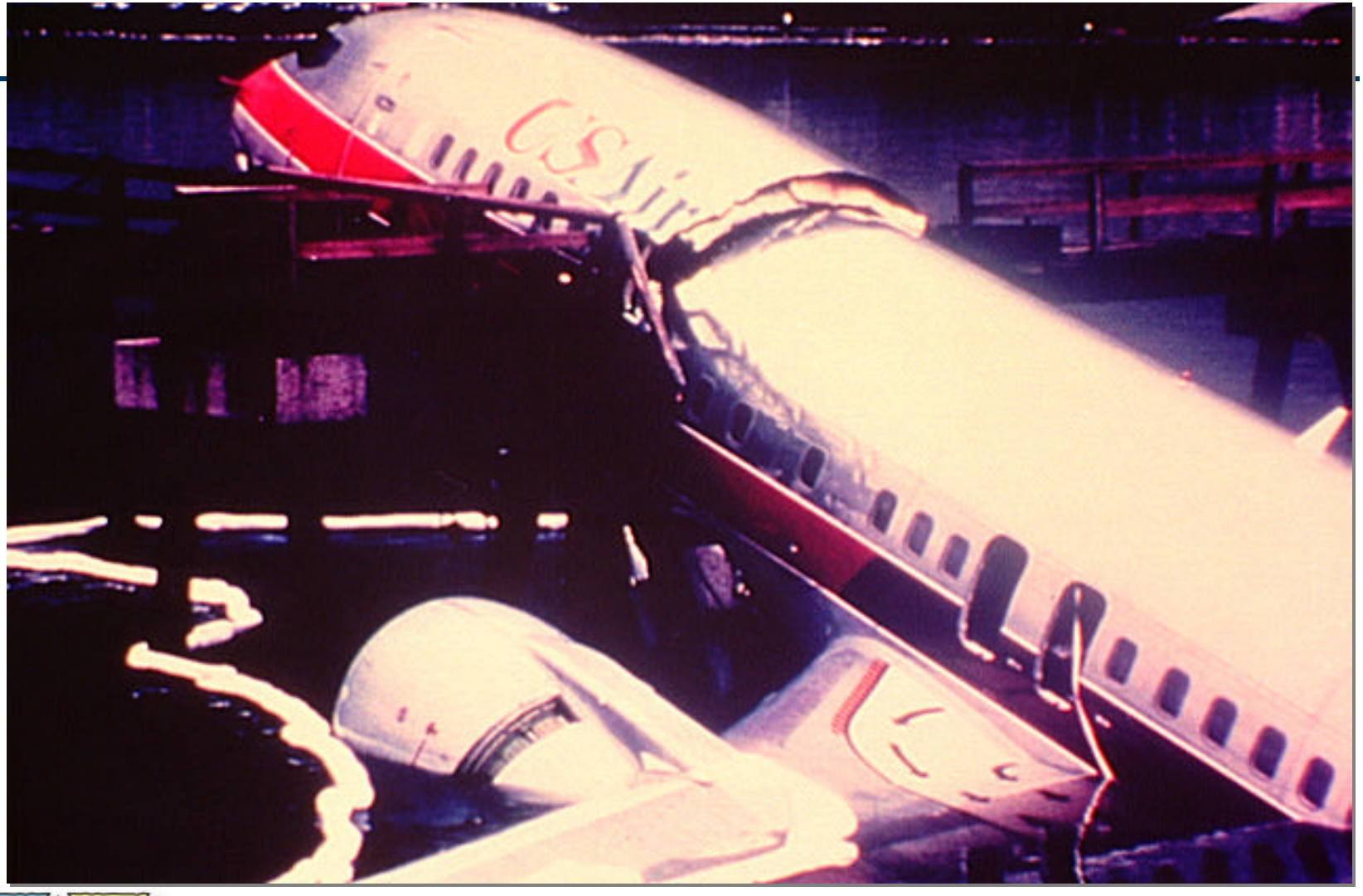
A Model of Team Performance



Helmreich, 1999

Errors Result from Human Limitations

- Limited memory capacity
- Limited processing capacity
  - multi-tasking capability
- Limits imposed by stressors
  - tunnel vision
- Limits imposed by fatigue and other physiological factors
- Team dynamics
- Cultural effects



Characteristics of Error

- Human error is ubiquitous and inevitable
- Errors increase the probability of incidents and accidents
- Error management strategies can reduce the severity of errors

Error-based Accidents and Incidents

- An aircraft runs out of fuel prior to landing
- A computerized aircraft flies into a mountain
- An aircraft lands at the wrong airport
- An aircraft lands in the wrong country

Addressing Threat and Error

Aviation's Strategy

- Training in teamwork and threat and error management (Crew Resource Management or CRM)
- Gathering data to understand threat and error
- Identifying and addressing systemic sources of threat and error in the culture

CRM as Organisational Strategy

- CRM originated in the early 1980's as response to 'pilot error' crashes
- CRM now required worldwide for flight crews
- CRM being applied in other domains
  - Maritime
  - Nuclear power plants
  - Medicine

CRM Training

- Effective CRM programmes are data driven
  - Based on survey and observational data from the organization
- Programmes are specific and practical
  - Deal in observable behaviors that have conceptual and empirical background
  - Avoid vague generalities
- CRM is ongoing and embedded in the organisational culture

Training Issues for CRM

- Human limitations as sources of error
- The nature of error and error management
- Expert decision making
- Conflict resolution
- Training in using specific behaviours as countermeasures against threat and error
  - Simulation
- Formal review of accidents and incidents
- Reinforcement for threat recognition and error management

Assessing Threat and Error Management

Observing Teams in Action

- The nature of teamwork in aviation was assessed by observing flight crews in action during line operations under normal and demanding conditions
  - Data collected by expert observers using systematic methodology
  - Observations strictly confidential, no jeopardy to crews
- Focus of observations
  - Threats and errors encountered and their management
  - Observable behaviors shown to be critical in managing threat and error
- Data collected on more than 4,000 flights of airlines in US and foreign airspace

Threat and Error

- **Latent systemic threats:** Conditions that increase risk and can induce error. These can, like pathogens, be long present before combining with local conditions to circumvent system defenses
  - Latent threats are hard to defend against, because they are not immediately visible

- **Culture as threat:** Cultures are input factors to team performance, and are also latent threats that can increase risk and the probability of error

- **Error:** Action or inaction that leads to a deviation from crew or organisational intentions or expectations

LOSA External Threat Results

- 72% of the flights had at least one external threat
- Two external threats per flight
- Most external threats on a flight = 17

- Most Frequent Threats for one airline
  - Adverse weather – 34% of the flights
  - ATC events or errors – 34%
  - Aircraft malfunctions – 15%

A Typology of Team Error

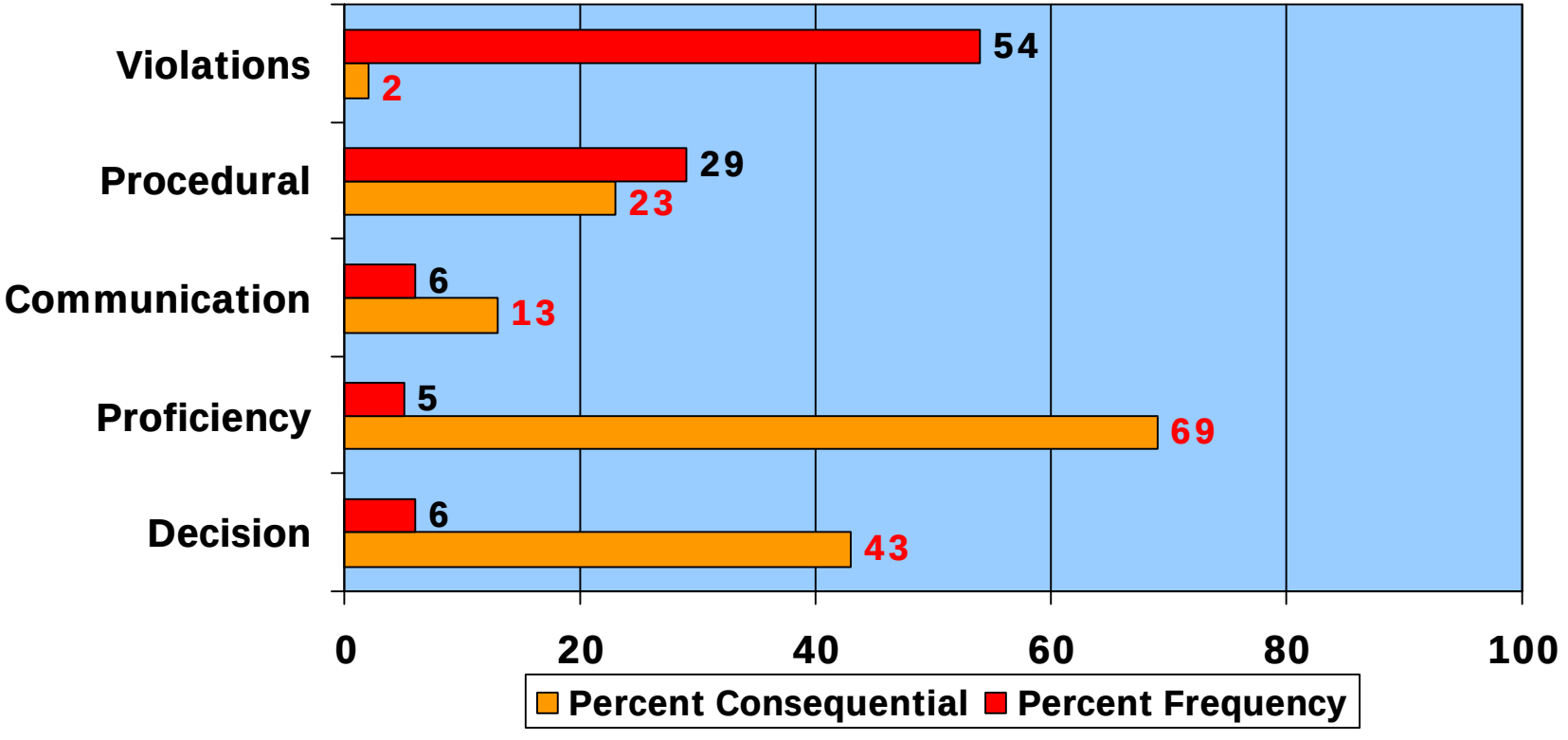
Typology derived from analysis of behavior observed under operating conditions. The typology covers all observed errors.

- Procedural – Followed procedures with wrong execution
  Example*) Wrong input into the flight management computer*
- Communication – Missing or incorrect information or misinterpretation
  Example*) Indirect speech by co-pilot does not alert captain to grave danger*
- Proficiency – Error due to a lack of knowledge or skill
  Example*) Inability to program automation or maneuver aircraft*
- Decision – Discretionary crew decision that unnecessarily increases risk
  Example*) Unnecessary navigation through adverse weather*
- Violations – intentional non-compliance with procedures or rules
  Example*) Performing a checklist from memory*

Flight Operations Error Results

- 68% of the crews committed at least one verifiable error
- From 0 to 14 errors per flight
- Averaged 2 errors per flight
- There were large differences in frequency and type of error associated with organizational culture

Error Frequencies and Consequences



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Using Error Data for Change

- Violations - **suggest poor procedures, weak leadership and/or a culture of non-compliance**
- Procedural errors **- may indicate poor workload management and/or poor procedures**
- Communications errors **- may reflect inadequate teamwork training (monitoring and challenging) or complacency**
- Proficiency errors **- suggest pressures to train and/or need for higher standards**
- Decision errors **- may indicate need for more training in expert decision making and risk assessment**

Organisational Culture

What Culture is and Does

- Culture is the values, beliefs, and behaviours that we share with other members of teams
  - Culture binds us together as a team
  - Culture provides cues and clues on how to behave in normal and novel situations

The importance of Culture at Work

- Culture influences how juniors relate to their seniors
- Culture influences how information is shared
- Culture influences attitudes regarding stress and personal capabilities
- Culture influences adherence to rules
- Culture influences interaction with technology

Organisational Culture and Safety

- Investigations of aviation accidents have shown organisational culture to be a precursor of disaster
  - Lack of safety concerns
  - Operational pressures
  - Poor leadership
  - Conflict with management
  - Negative organisational climate
- Organisational culture dictates policy toward training and standardisation
- Organisational culture has been identified as a factor in many air crashes

Organizational Climate

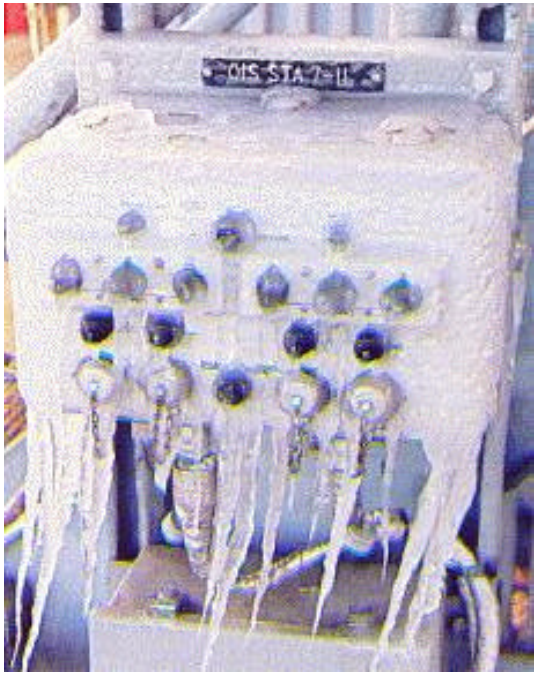
Questions used in research to determine perceptions of the quality of work life in an organisation

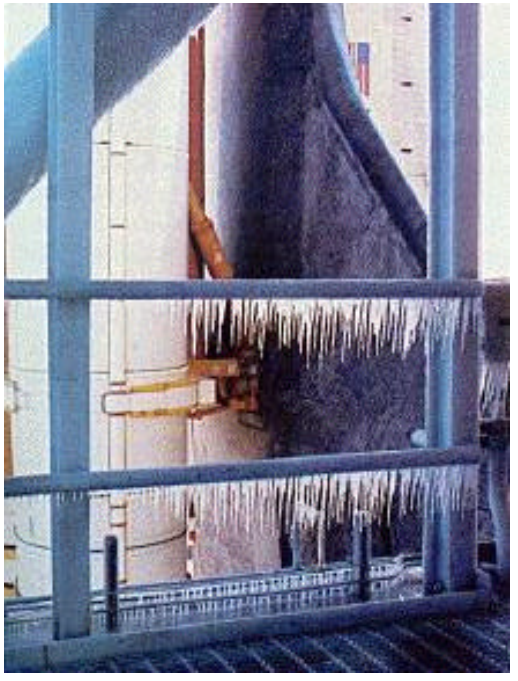
- I am proud to work for this organisation
- I like my job
- Working for this company is like being part of a large family
  - Southwest Airlines has highest measured climate
- Positive climate reflects harmony between subcultures
  - Better teamwork and safety awareness
  - But positive climate does not equate to zero errors


L59
L69
L79

The Challenger Launch Decision: An Organisational Accident

- Organisational pressure to launch
  - Press coverage – teacher in space
- Known history of hot gas blowing by o-ring seals on solid rocket motors
  - Awareness that seals less effective at low temperatures
- Engineer concerns over launch at below freezing over-ruled by management
  - Data showing temperature effects not considered
- The *normalisation of deviance* (Diane Vaughan)
  - History of successful launches at lower temperatures leads to changing standards and failure to acknowledge threat





Air Ontario Flight 1363 at Dryden: An Organisational Accident

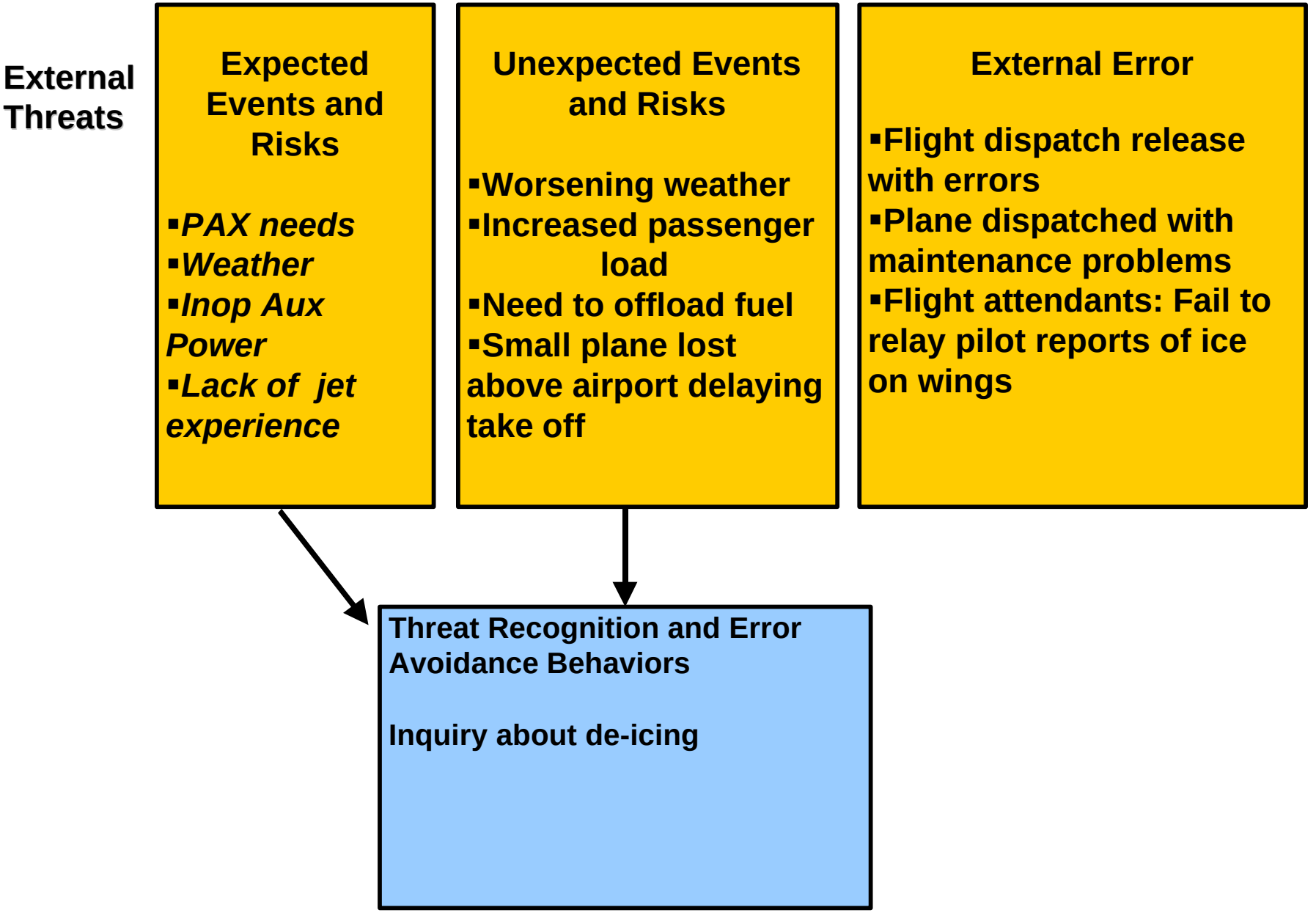
- Flight 1363 took off from Winnipeg on March 10, 1989. It was a used Fokker F-28 recently bought from a Turkish airline.
- Weather was deteriorating and it experienced delays due to de-icing.
- It flew to Dryden, Ontario then to Thunder Bay and back to Dryden.
- It taxied out then experienced additional delays because a small plane was lost, took off, stalled, and crashed.
- The plane crashed in woods off the end of the runway. The post-crash fire was so fierce that the voice and data recorders were destroyed.

Investigation

- Despite the relatively minor loss of life and identified cause, the largest investigation of an air crash to date was launched by a Royal Commission, headed by a justice of the Supreme Court.
  - Helmreich was human factors expert on commission
- A four volume report investigating all aspects of the Canadian aviation system resulted
- The root cause was the failure of the crew to de-ice before take off in heavy snow.

But…..

- Multiple overt threats and latent systemic factors were identified including
  - Regulatory factors
  - Organisational factors (Culture)
  - Environmental factors
  - Crew factors (Professional)


External Threats
Expected Events and Risks
▪PAX needs
▪Weather
▪Inop Aux Power
▪Lack of jet experience
Unexpected Events and Risks
▪Worsening weather
▪Increased passenger load
▪Need to offload fuel
▪Small plane lost above airport delaying take off
External Error
▪Flight dispatch release with errors
▪Plane dispatched with maintenance problems
▪Flight attendants: Fail to relay pilot reports of ice on wings
Threat Recognition and Error Avoidance Behaviors
Inquiry about de-icing

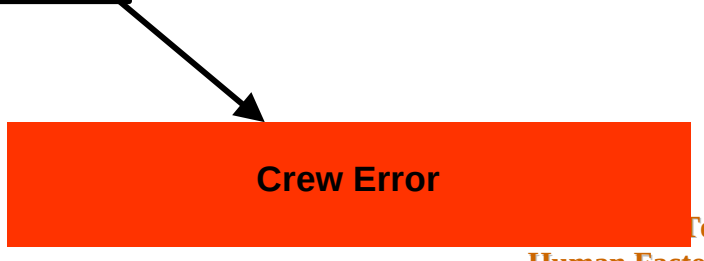
Flight Crew Error

- **Procedural** - fail to inspect wings for icing
- **Decision** – fail to de-ice after inquiry about facility
- **Decision** – taxi out in increasing snow
- **Decision** – fail to reassess after delay for small plane
- **Decision** – take off into storm without deicing

Latent Threats

Latent Systemic Threats

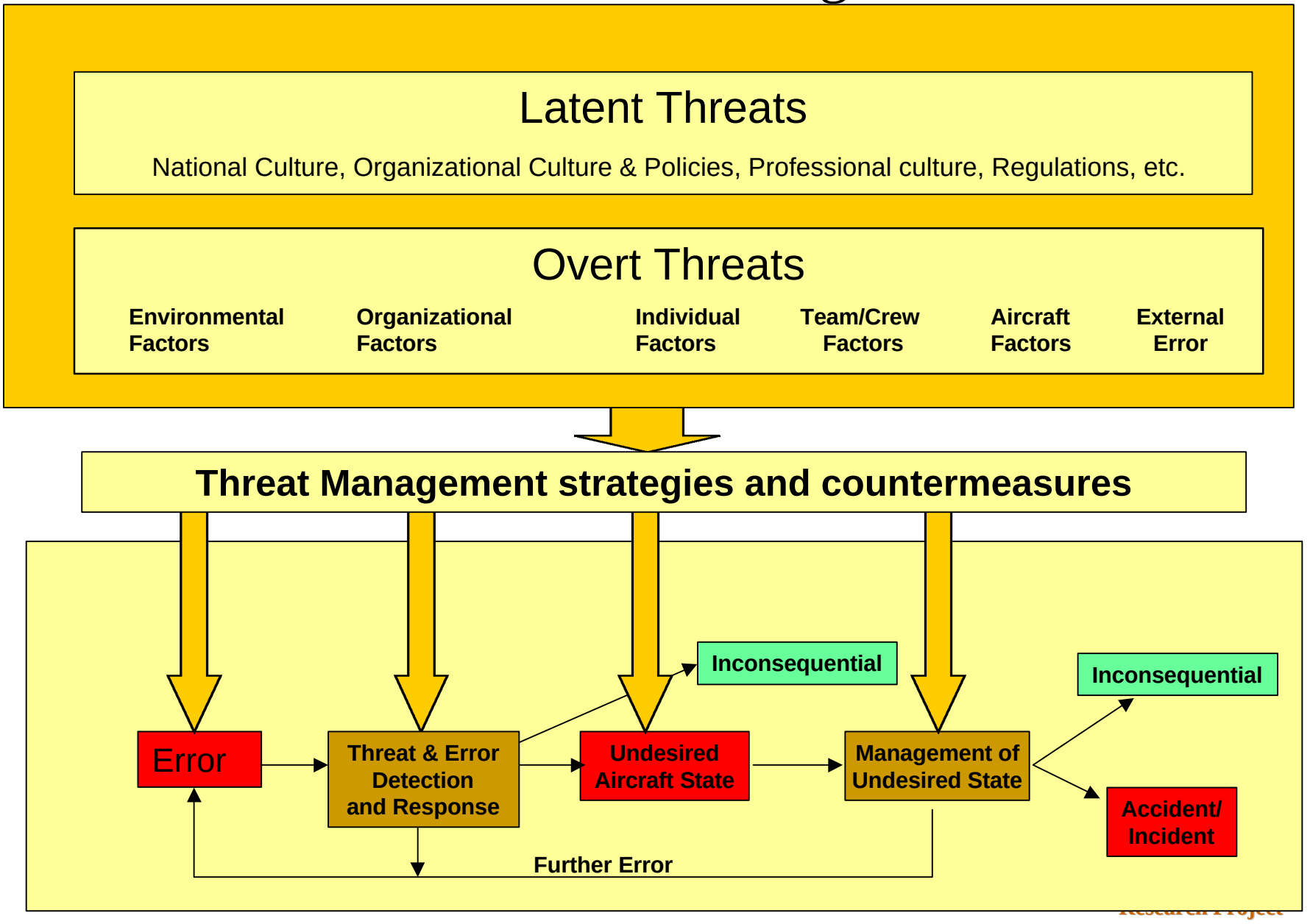
- **Regulator-Design that allows cold soaking of fuel**
- **Regulator: Failed to define de-icing requirements**
- **Regulator: Failure to audit jet program at Air Ontario**
- **Organization: No company manuals and Minimum Equipment List**
- **Organization: Practice of ignoring ice on wings**
- **Organization: Chief pilot the 'Iceman'**
- **Organization: Inconsistent training for jet operation**
- **Organization: Flight attendants trained not to alert pilots**
- **Individual: Capt. pressure to complete flight to get married**



The University of Texas Aviation Threat and Error Management Model (TEMM)

- The UT model has two parts
  - External threat and error that pose risk
  - Crew errors committed by those at the front line
- The model was derived empirically from observations of crew behavior in line operations
- It has also been applied to the analysis of accidents and incidents

The Threat and Error Management Model



CRM --Threat and Error Countermeasures

- Active leadership
- Threats and patient risks briefed
- Questions asked without hesitation
- Operational plans clearly communicated
- Decisions made, shared, and revisited
- Workload managed
- Others monitored for fatigue and stress
- Vigilance maintained
  - monitoring and challenging
- Debriefings conducted for learning

Evaluating Aviation's Experience

- The combination of CRM training, adequate data, and addressing systemic problems has enhanced safety
- It has not eliminated error, because that is an impossibility
- It has created effective error management

Transferring Aviation's Experience to Medicine

Diagnosing the OR

- We adapted two measures from aviation
  - the Operating Room Management Attitudes Questionnaire (ORMAQ) to assess attitudes and issues
  - the Operating Room Checklist (ORCL) to measure team behavior in the OR
- We gave the survey to anaesthetists, surgeons, residents, and nurses in 4 countries
- Items queried the organizational culture and attitudes about teamwork and communication
- Open-ended questions asked each person to indicate the biggest problem in the OR and what was needed to improve safety and morale

Medicine and Aviation are a Good Match

- Safety is super-ordinate goal
  - But cost cannot be ignored
- Teamwork is essential
- Risk varies from low to high
- Threat & error come from multiple sources
- Second guessing after adverse events
  - Public perception and litigation

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Training for Error Management

- Training programmes are being developed to deal with threat and error management in medicine

- The training has much in common with aviation CRM
  - But is based on data from the medical domain and recognizes cultural and context factors unique to medicine
  - Professional culture
  - Patient variability
  - Interface between disciplines and specialties

Risks and Barriers

- Overselling aviation programmes in other domains
  - Consultants promise quick fixes
- Failure to diagnose the culture and context
- Resistance to outsiders with solutions

Making the Transfer of Human Factors Work

Methods and Knowledge Transfer

- The common factors of teams dealing with technology and human limitations imply that training that enhances awareness of the sources of error and provides countermeasures will generalize
  - If it is presented in a relevant context
- The approach to gathering and interpreting data in a model of threat and error management will generalize
- Organisational strategies to address latent factors based on data will generalize

Building an Error Managing Organisation - a 6 Step Programme

① History – issues in this organisation

① Diagnosis

- data collection
- non-punitive error reporting system

① Organisational culture change

-clear standards

-acceptance of error but not violations of procedures

■ Training

- CRM as countermeasures

■ Feedback and reinforcement

- performance appraisal

■ Continuing training and assessment of organisation and people

- ongoing data collection & refresher training

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www.psy.utexas.edu/psy/helmreich/nasaut.htm