Human Factors

Module 1: Models and principles

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ICAO APAC AIG Workshop
15 August 2023 Singapore

Workshop modules

1. Models and principles
2. Evidence collection
3. Conducting interviews
4. Case study (Norfolk Island ditching)

Module 1: Models and principles

- What is human factors?
- The ATSB analysis model
- Some principles for investigating human factors
- The SHELL model

What is human factors?

- Human factors (ergonomics) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.
- Human factors is concerned with the application of what we know about people, their abilities, characteristics, and limitations to the design of equipment they use, environments in which they function, and jobs they perform.

(US Human Factors and Ergonomics Society)

What is human factors?

- A sciences that involves understanding and optimising the relationship between the human operator(s), technology and the environment. It encompasses:
  - psychology and cognitive science
  - ergonomics and anthropometry
  - physiology and biomechanics
  - medical factors
  - sociology
  - industrial and systems engineering
  - and other fields

Human performance

- Human performance: refers to how people perform their tasks; represents the human contribution to system performance
- Individual (or team) actions have a significant role to play in ensuring safety
- Accident and incident investigations need to identify and explain any individual actions that increase risk

Safety investigations

- Purpose is to enhance safety
- Use a ‘no blame’ or ‘just culture’ approach
- Aim to determine what, how, and why – in order to enhance safety (not just solving the puzzle)
- Look for contributing factors and other safety factors that increased risk
- Not an audit – scope needs to be focussed around attempting to explain what, how and why

(ATSB Final Report pp.7-9)

Human factors investigation

- Seeks to determine the reasons for the individual actions that increased risk
- Focuses on reasons that can reduce the likelihood of future individual actions or the consequences of such actions
- Needs to be integrated with the investigation of operational factors, technical factors, …
- There is no one tool or checklist – need a framework and process
- Provides a different perspective in an investigation
- Does not involve dream analysis, counselling, séances, or anything you see on TV shows like *Lie to Me*, *The Mentalist*…

Who should investigate human factors?

- Every trained investigator should be able to collect basic HF information
- Domain investigator + HF investigator = best outcome
- HF investigator: HF specialist with investigation training
- For major investigations, or when there are significant HF aspects, HF investigator should be part of team as early as possible
- When there are HF findings, HF investigator should be involved in analysis and write-up of HF information

Module 1: Models and principles

- What is human factors?
- The ATSB analysis model
- Some principles for investigating human factors
- The SHELL model

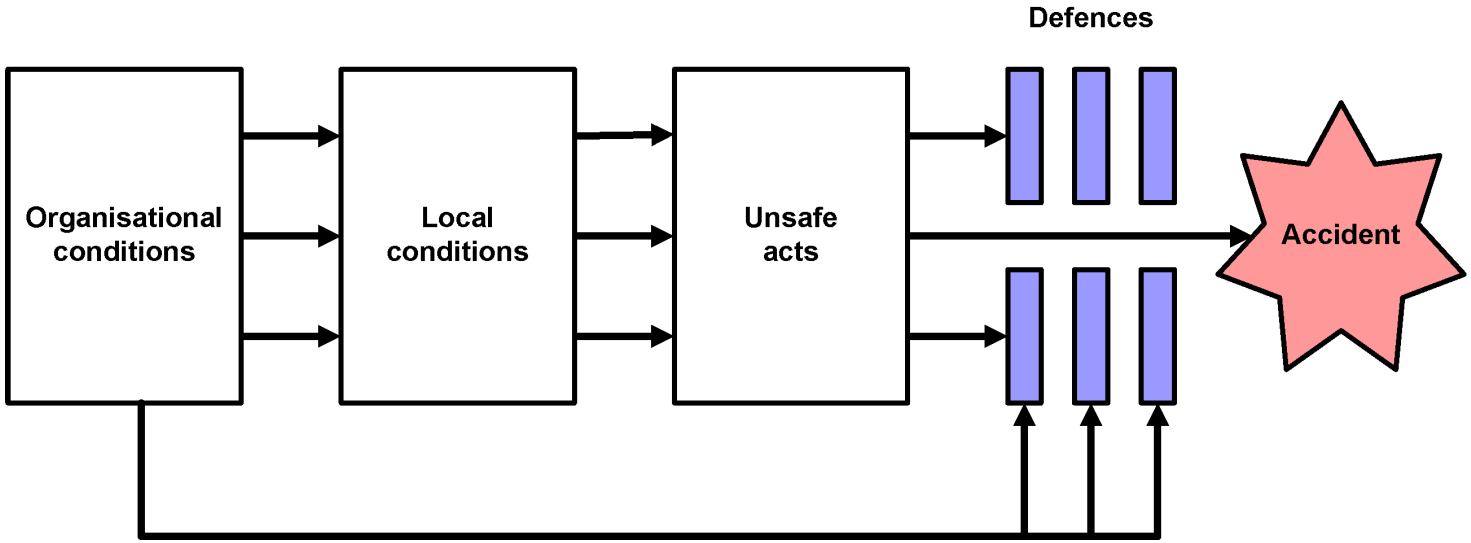
Safety factors

- Event or condition that increases risk
  - something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or severity of the adverse consequences associated with an occurrence
- Can be classified as:
  - Contributing factors
  - Other factors that increased risk
- Safety factors that are organisational or systemic problems are ‘safety issues’

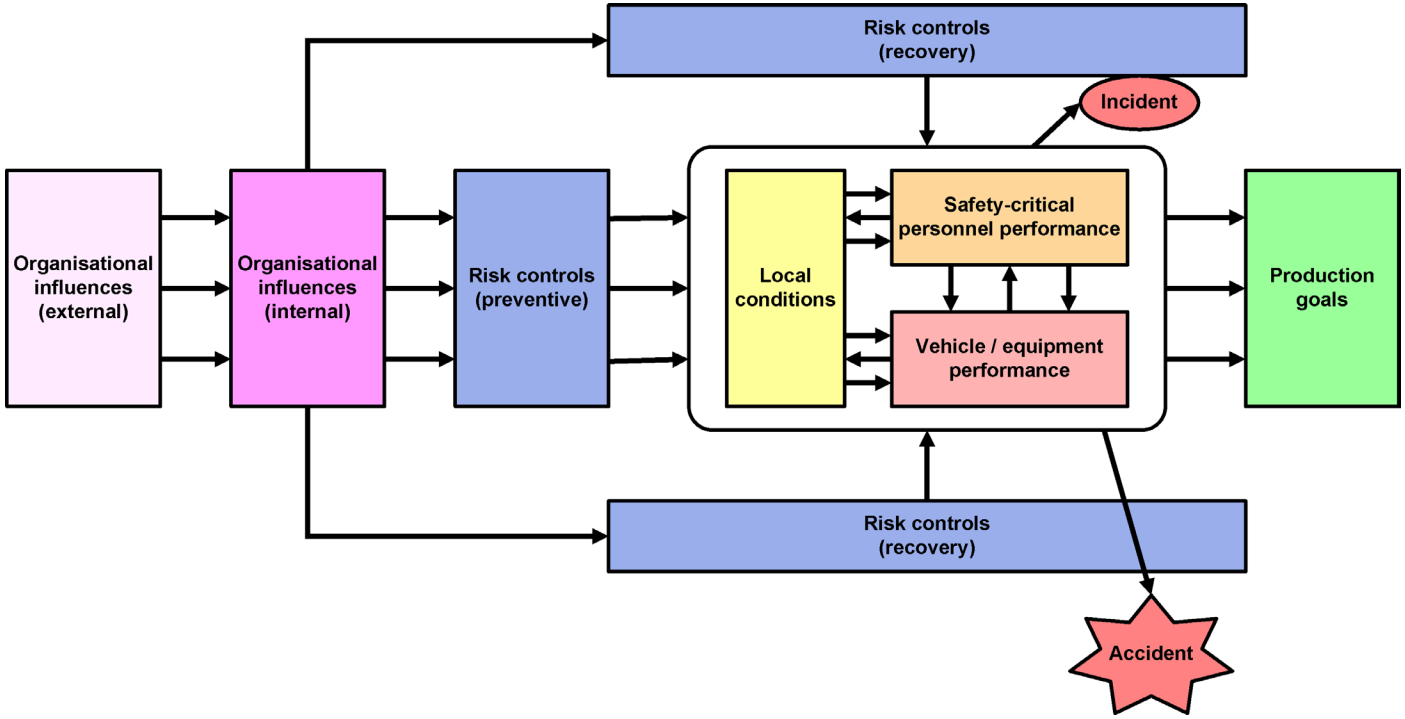
Use of models

- Models are useful in investigations for:
  - identifying safety factor hypotheses (most important)
  - maintaining awareness of progress during an investigation
  - communicating the results of an investigation
  - providing a taxonomy for classifying factors in a database
- No model will suit all situations
- Models are not analysis methods - they help identify hypotheses, not prove hypotheses
- A good model helps you ask good questions when identifying hypotheses

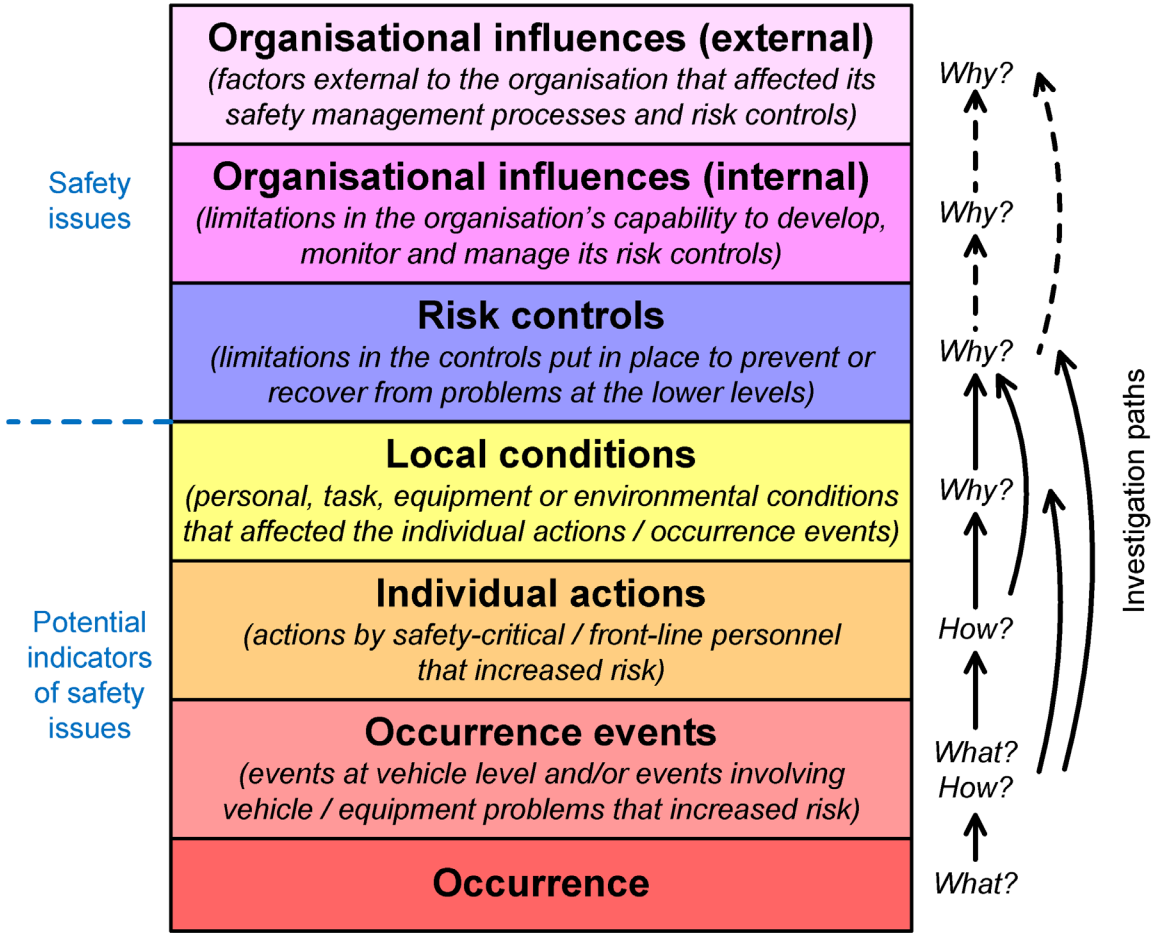
Reason model

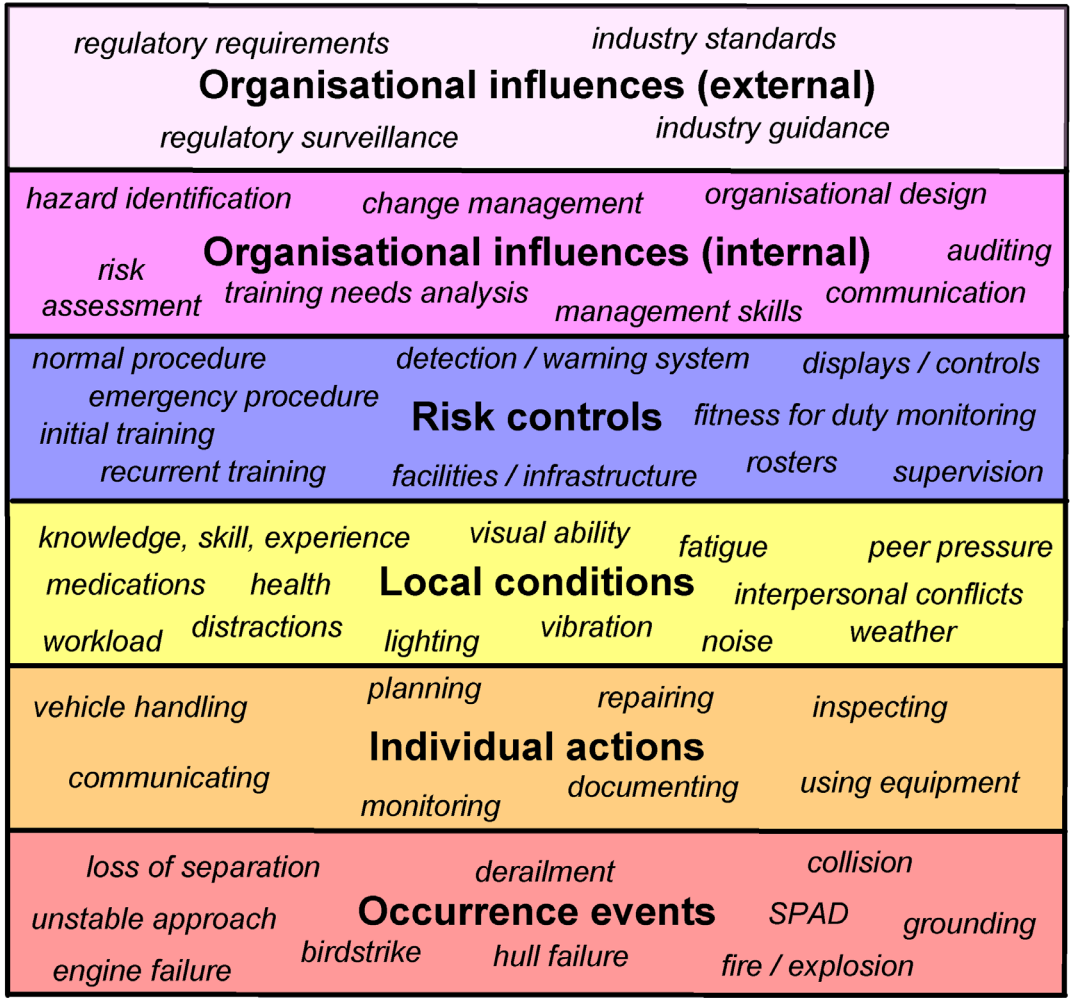


ATSB adaptation of the Reason model

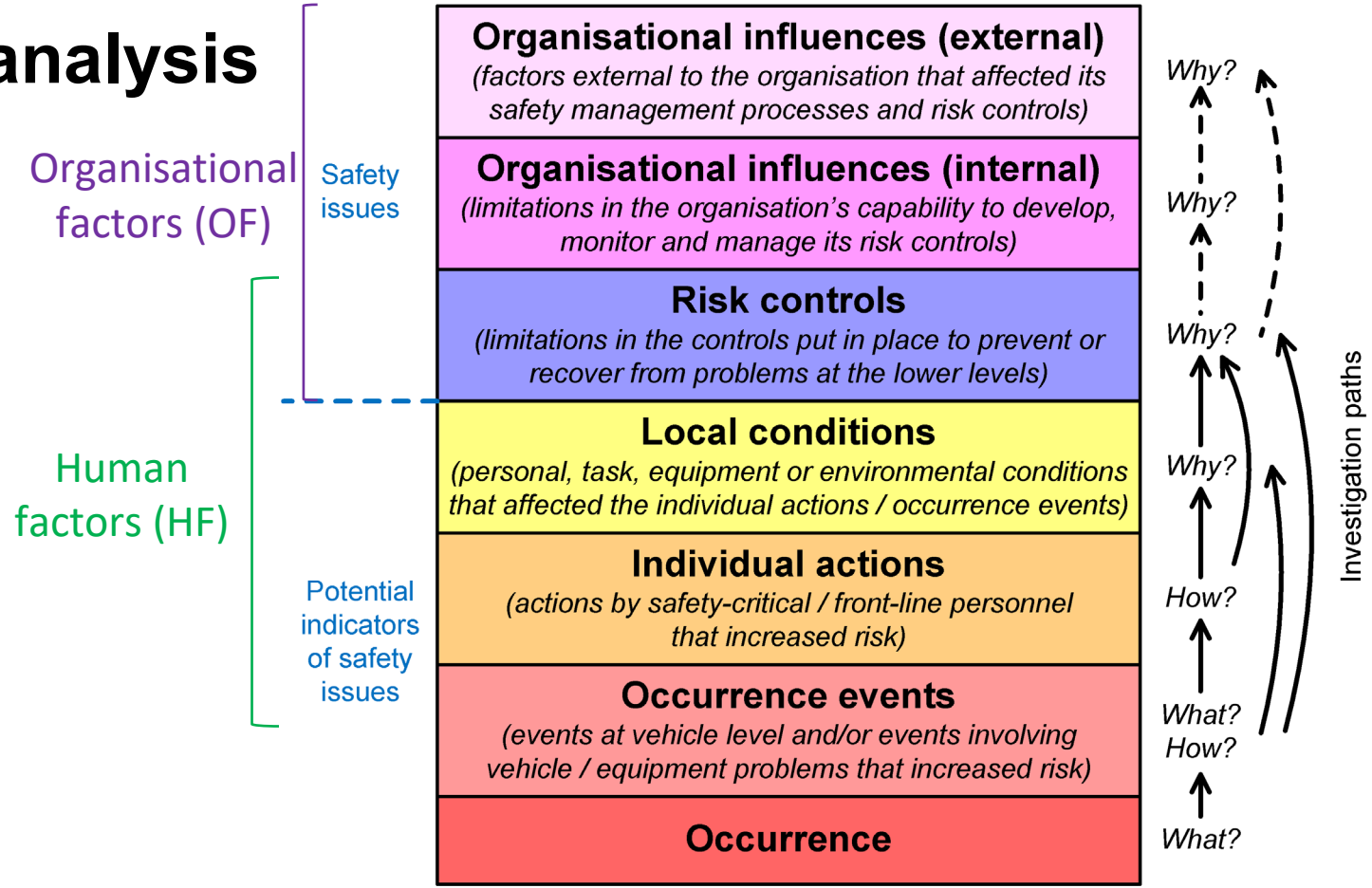


ATSB analysis model




regulatory requirements
industry standards
Organisational influences (external)
regulatory surveillance
industry guidance
hazard identification
change management
organisational design
Organisational influences (internal)
auditing
risk assessment
training needs analysis
management skills
communication
normal procedure
detection / warning system
displays / controls
emergency procedure
Risk controls
fitness for duty monitoring
initial training
recurrent training
facilities / infrastructure
rosters
supervision
knowledge, skill, experience
visual ability
fatigue
peer pressure
medications
health
Local conditions
interpersonal conflicts
workload
distractions
lighting
vibration
noise
weather
vehicle handling
planning
repairing
inspecting
Individual actions
communicating
monitoring
documenting
using equipment
loss of separation
derailment
collision
unstable approach
Occurrence events
SPAD
grounding
engine failure
birdstrike
hull failure
fire / explosion

ATSB analysis model



Occurrence events

- Key events that describe what happened
- Generally refer to what a transport vehicle was doing
- Includes all safety factors that are events – except individual actions
- Includes technical problems / failures
- Events that ultimately need to be explained
- Provide platform to start analysis of safety factors
- Includes the 'key occurrence event'

Individual actions

- Observable behaviours by safety-critical personnel (e.g. flight crew, cabin crew, controllers, maintenance engineers, dispatch and loading personnel…) that increase risk
  - most accidents involve individual actions
  - actions that increase risk are relatively rare
  - most actions that increase risk do not result in an accident
- Can be classified in different ways
  - type of task (e.g. vehicle handling, monitoring, communicating, …)
  - stage of information processing (e.g. perception, situation assessment, decision, action)
  - ‘error type’ (e.g. slip, lapse, mistake, violation)

Individual actions – other points

- Symptom of problems rather than source of problems
- Best viewed as actions that, if we had the same situation again, we would want the person to perform differently
  - this approach minimises concerns regarding responsibility and blame
- Should not be the focus or the end point of an investigation
- Part of the ‘how’, not part of the ‘why’
- Provides platform for identifying higher level safety factors

Local conditions

- Conditions associated with the immediate context or environment in which individual actions and occurrence events / technical problems occur
- Often termed ‘task and environmental conditions’, ‘antecedents’, ‘preconditions’
- If increase safety risk, could be termed ‘local hazards’ or ‘local threats’
- Part of the ‘why’
- Can be classified in many ways (e.g. SHELL model)

Local conditions – SHELL model

Local conditions

Knowledge, skills, experience
- general and specific qualifications/experience, consolidation, recency…)

Task demands
- workload (amount), task complexity, time pressure, distractions, physical workload / effort…)

Physical environment
- visibility, lighting / illumination / glare, noise / vibration, temperature / humidity / air quality, rain / wind…

Social factors
- teamwork and communication, interpersonal differences / authority gradient, peer pressure…

Organisational environment
- task pressures, morale / culture / climate…

Fatigue, alertness
- sleep quantity, sleep quality, level of alertness, hours awake, time of day, sustained workload…)

Recent history
- Recent meals / drinks, caffeine / related substances / non-work activities…

Medical / physiological factors
- general health / fitness, medical conditions, recent injury / illness, general physical abilities, medications, alcohol / other substances…)

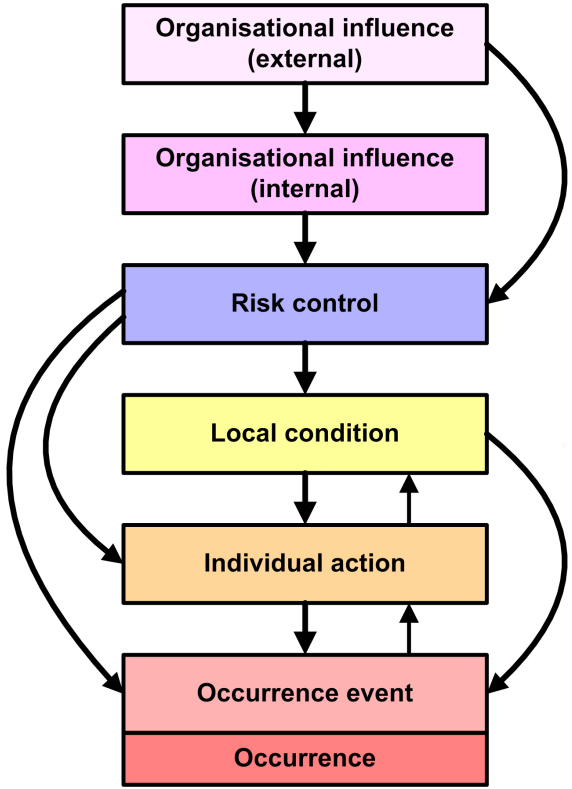
Personal factors
- general disposition / mood, recent or significant changes, non-work issues…

Procedures, guidance
- Availability / usability / relevance, normal / emergency procedures, checklists, job aids / decision aids…

Equipment / ergonomics
- availability / usability / relevance, displays / controls, warnings / alarms, tools, charts, workplace layout…

Relationship between levels

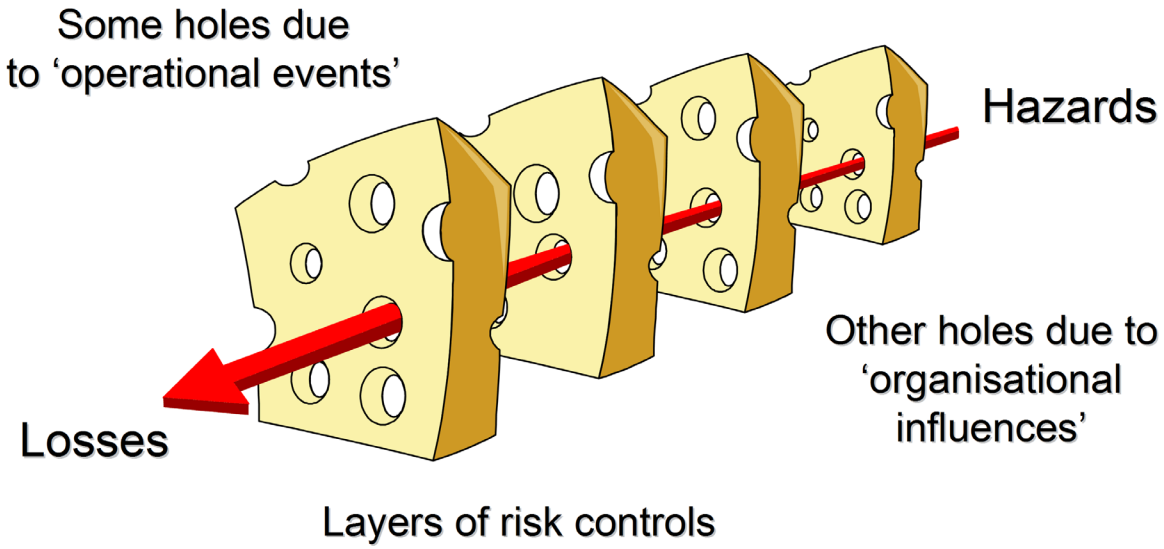
- Model is a guide, not a law
- Influence between levels can be dynamic, complicated
- Individual actions can be influenced by local conditions, risk controls and other individual actions (and indirectly by organisational influences)



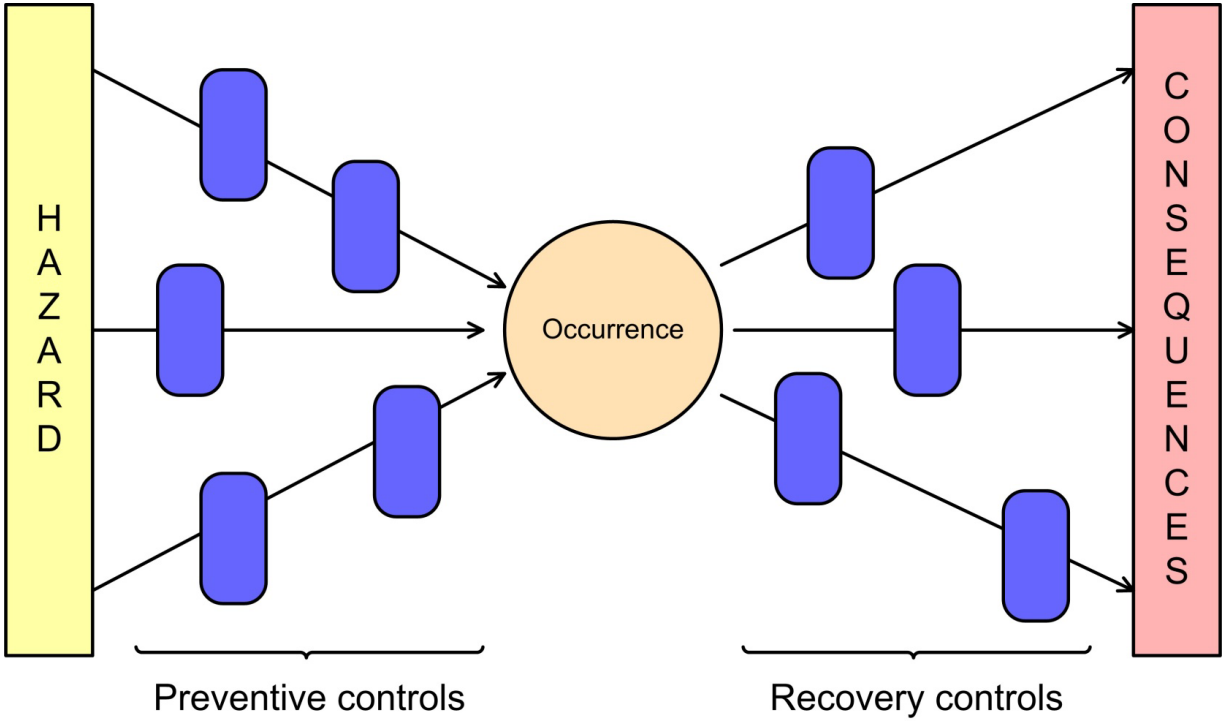
Risk controls

- Measures put in place by an organisation to facilitate and assure safe performance of the operational components
- Prevent hazards resulting in losses
- Outputs of a management system
- Often termed ‘defences’, ‘barriers’, ‘safeguards’
- If increase safety risk, is a ‘safety issue’
- Key focus of safety investigations
- Part of the ‘why’

Swiss cheese model



Bow tie model



Risk controls - types

- Preventive: reduce likelihood of undesirable local conditions, individual actions, occurrence events
  - procedures, training, equipment, rosters, supervision…
- Recovery: detect, correct or minimise effects of adverse local conditions, individual actions, occurrence events
  - detection / warning (stall warning, TCAS, …)
  - restore system (ATP, emergency procedures, …)
  - containment / protection (PPE, crashworthiness, …)
  - escape / rescue (exits, emergency lighting, lifejackets, …)

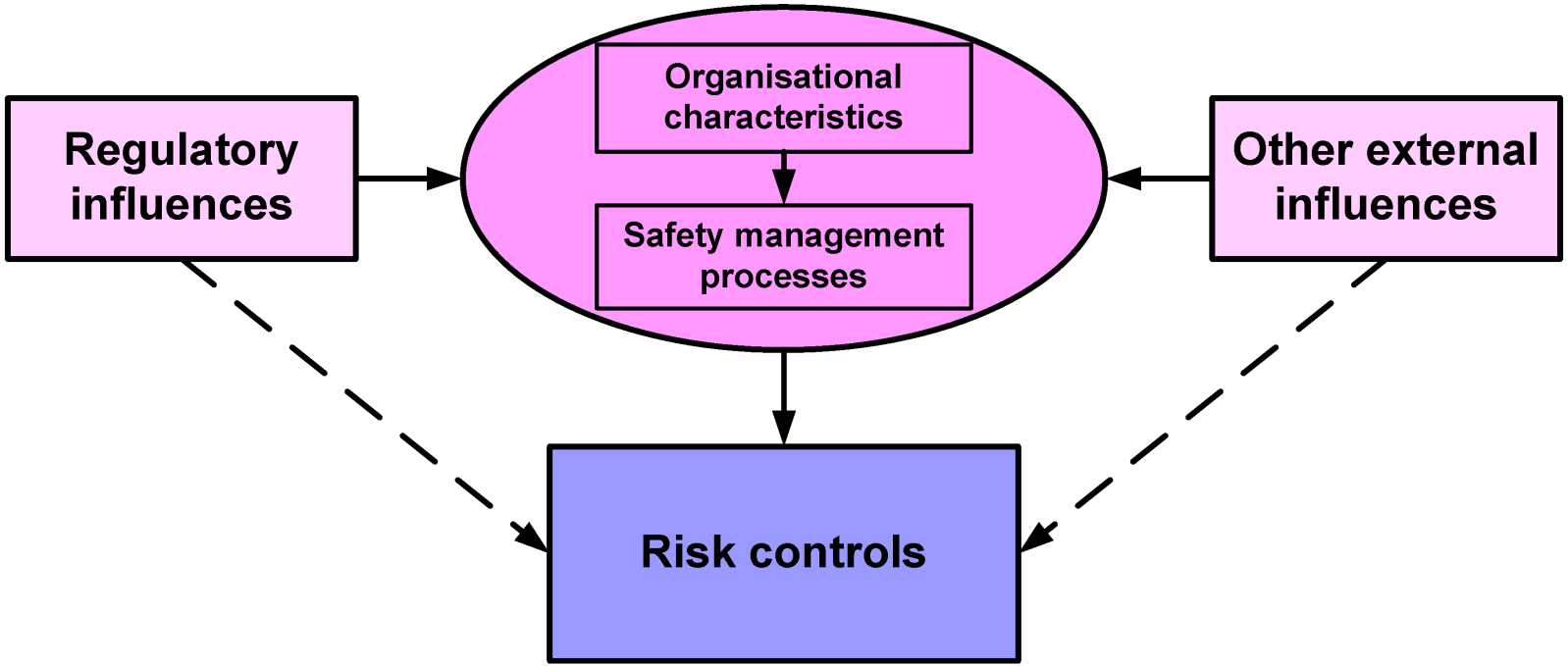
Risk controls - hierarchy

- Key HF principle:
  - fit the task to the person, not the person to the task
- Technical / physical controls (engineered systems, equipment-based…) generally preferred to administrative controls
- Common hierarchy of controls preference:
  - eliminate the hazard
  - substitute (or replace) the hazard
  - use engineering controls
  - apply administrative (or procedural) controls
  - use personal protective equipment

Internal organisational influences

- Conditions that establish, maintain or otherwise influence the effectiveness of an organisation's risk controls
- Management processes rather than management outputs
- If increase safety risk, is a 'safety issue'
- Part of the 'why'

Internal organisational influences



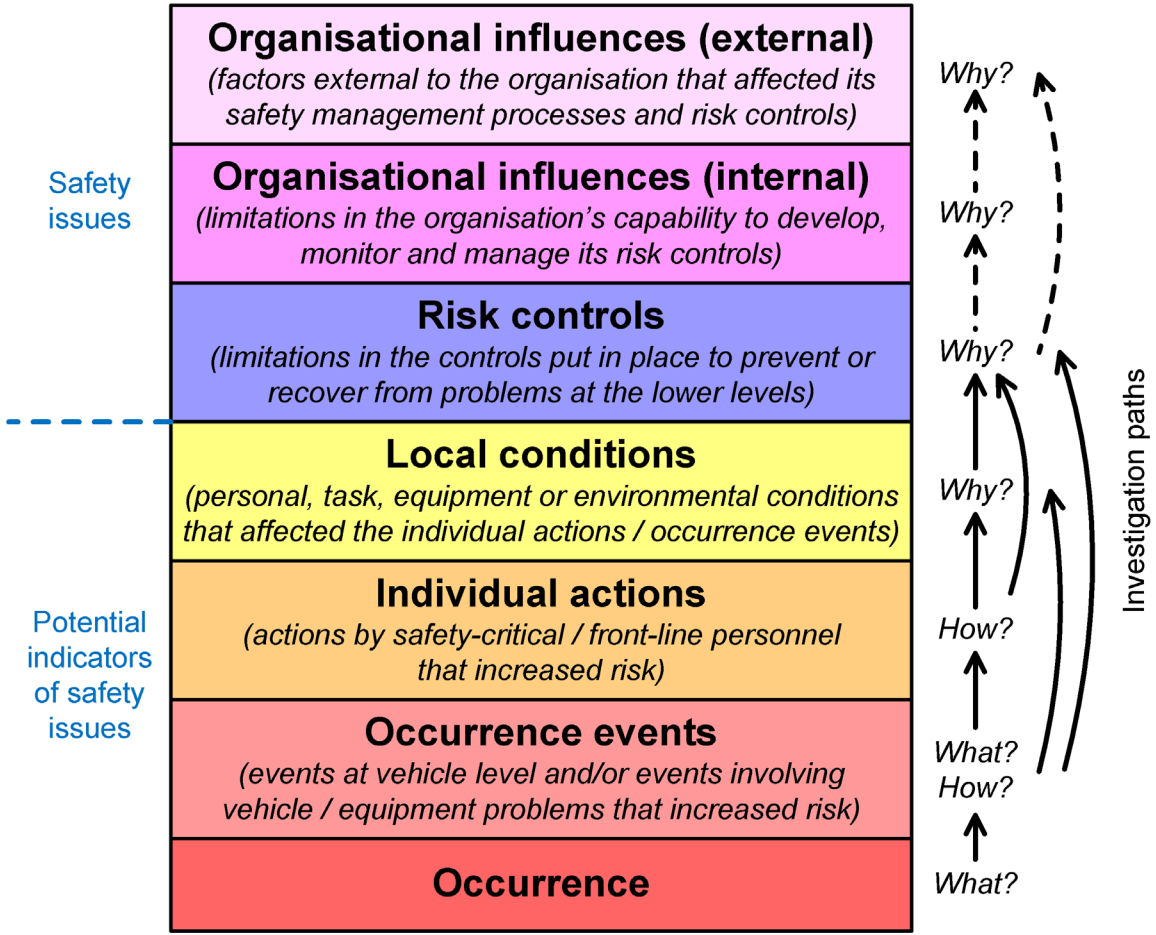
Internal organisational influences

Safety management system processes	Organisational characteristics
- hazard identification - risk assessment - training needs analysis - procedures development - equipment selecting / testing - change management - occurrence / hazard reporting - occurrence investigation - internal auditing - collection and analysis of safety information - organisational learning / benchmarking	- organisational structure - corporate memory - skills of key personnel - safety culture / safety climate - communication style / processes - leadership / management style - safety philosophy / priorities

External organisational influences

- Processes and characteristics of external organisations which influence an organisation's risk controls, safety management processes and other characteristics
- Includes regulatory requirements, surveillance, industry standards, guidance…
- If increase safety risk, is a 'safety issue'
- Part of the 'why'

ATSB analysis model

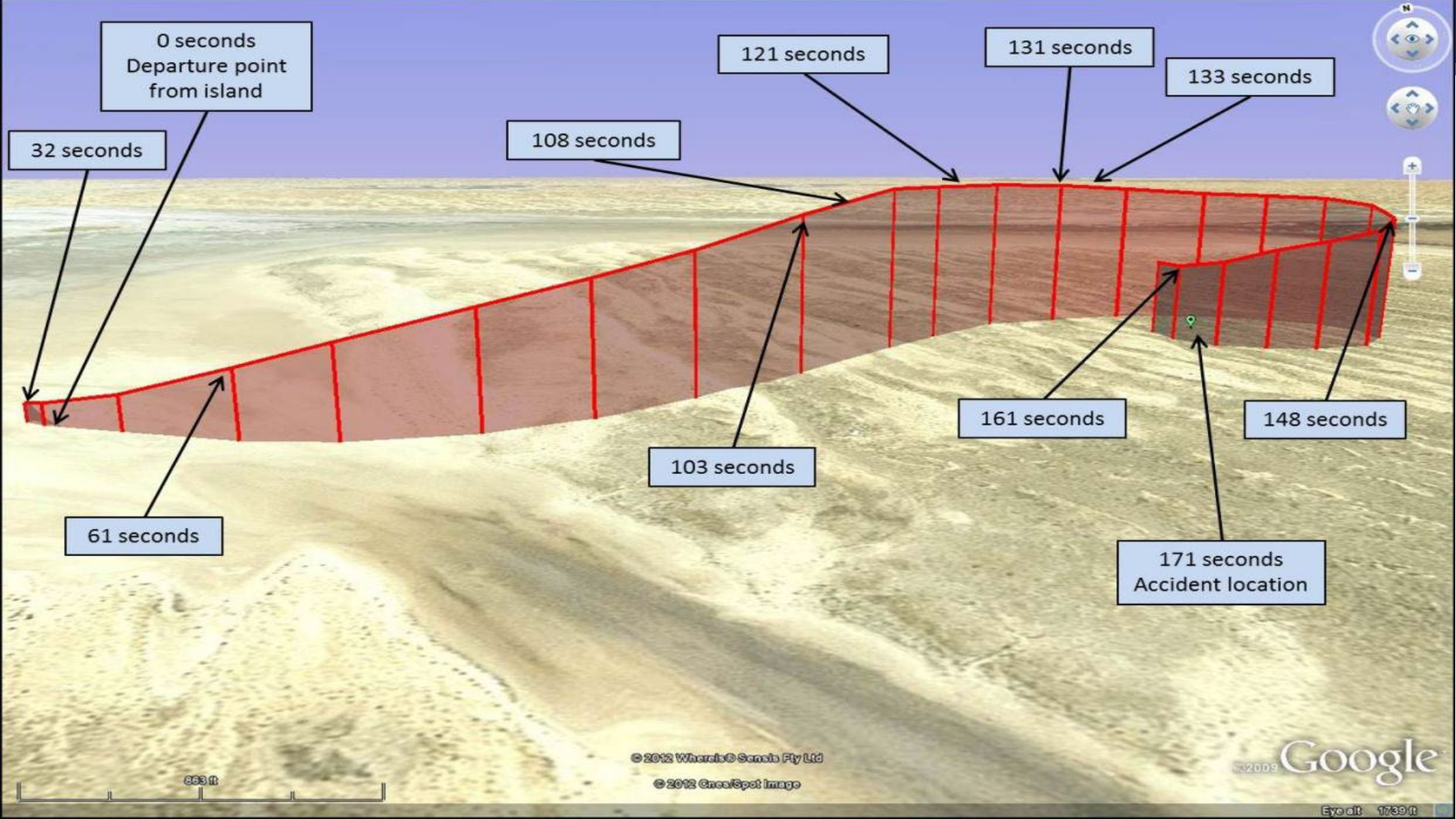


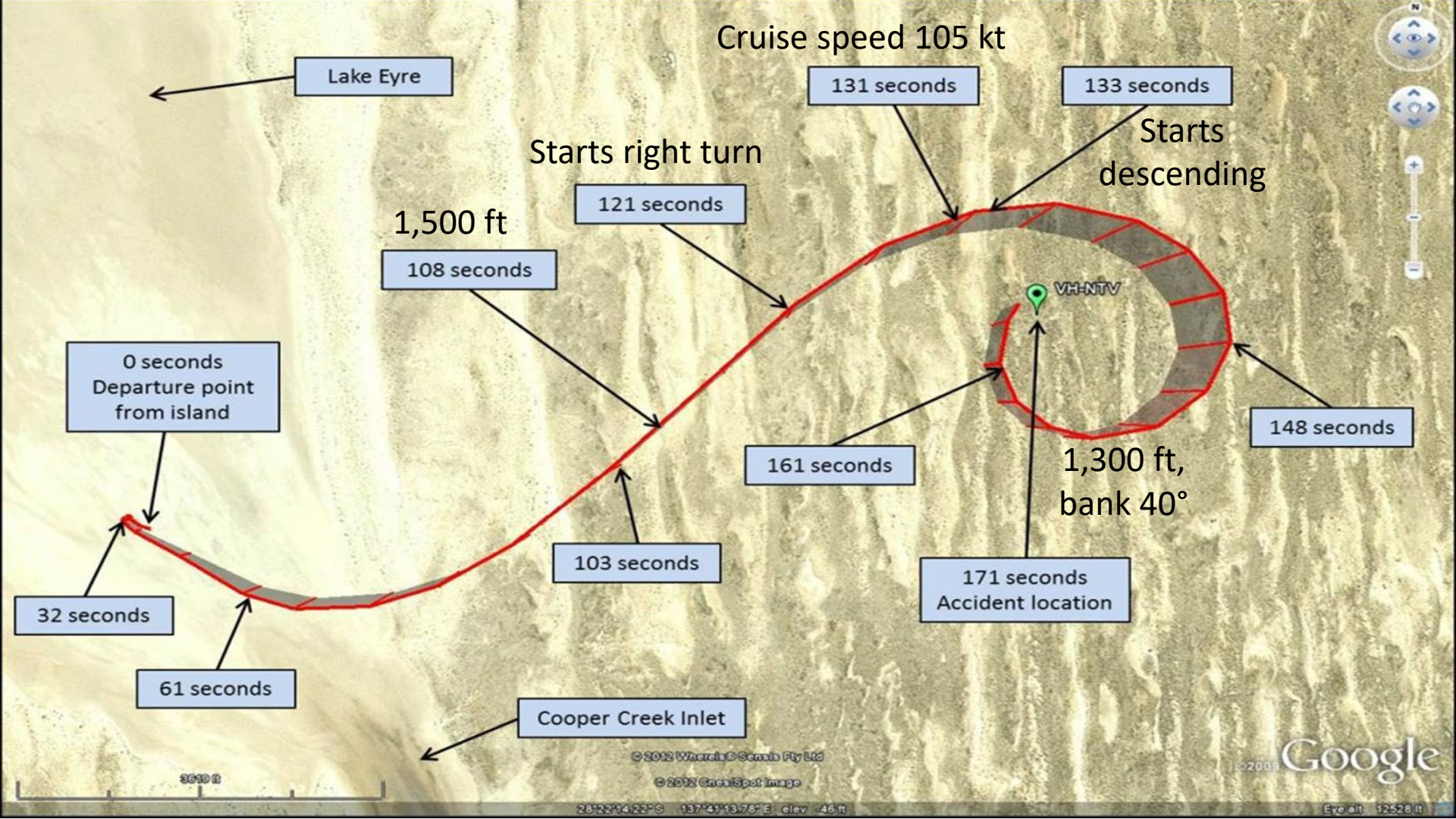
Simple accident

- Individual actions?
- Local conditions?
- Risk control (problems)?
- Organisational influences?

AS355 example

- VH-NTV, AS355F2, 3 POB
- Conducting a film documentary
- Experienced media pilot
- Spent the late afternoon and early evening with a tour group in remote location
- Departed after nautical twilight
- No cloud, no moon, no terrestrial light sources
- Helicopter seen departing to north-east; was meant to depart to south
- Loss of control and collision with terrain


0 seconds
Departure point
from island
32 seconds
108 seconds
121 seconds
131 seconds
133 seconds
61 seconds
103 seconds
161 seconds
148 seconds
171 seconds
Accident location
© 2012 Whereis® Sensis Pty Ltd
© 2012 CNES/Spot Image
Google


Cruise speed 105 kt
Lake Eyre
131 seconds
133 seconds
Starts descending
Starts right turn
121 seconds
1,500 ft
108 seconds
VH-NTV
0 seconds
Departure point
from island
148 seconds
161 seconds
1,300 ft,
bank 40°
103 seconds
171 seconds
Accident location
32 seconds
61 seconds
Cooper Creek Inlet
© 2012 Whereis® Sensis Pty Ltd
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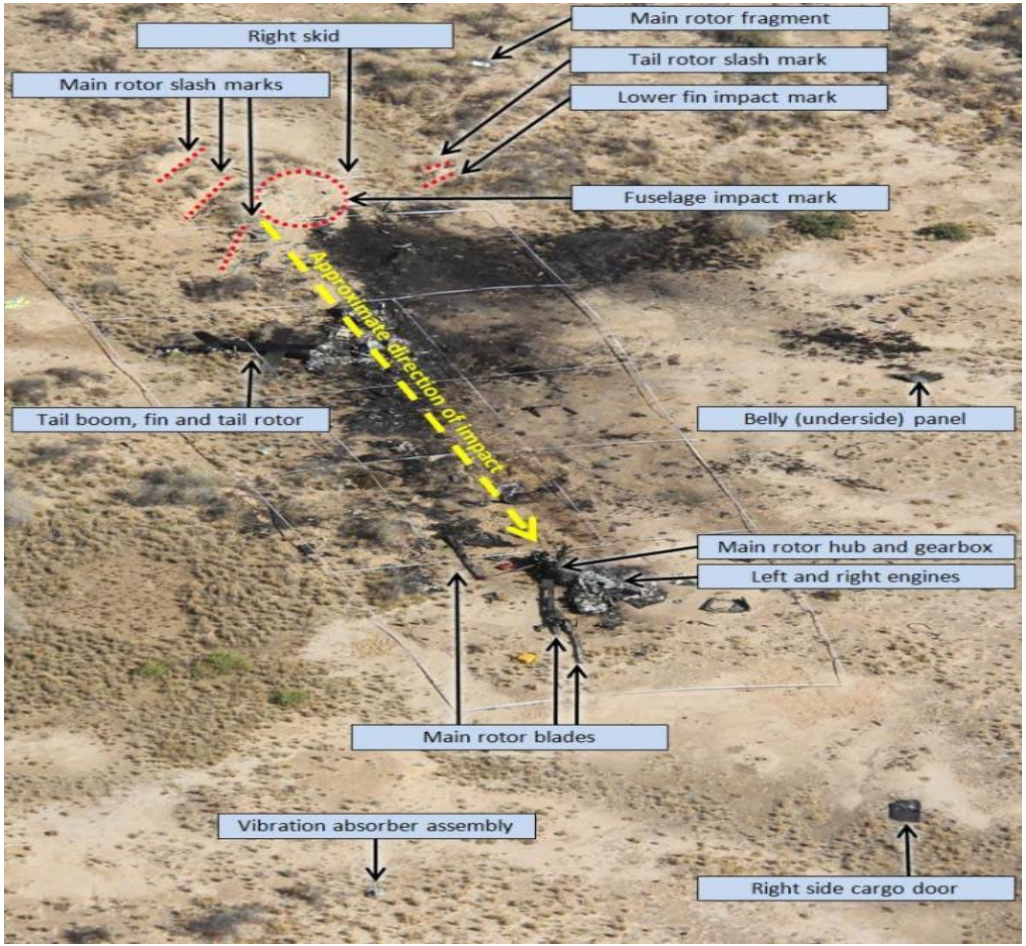
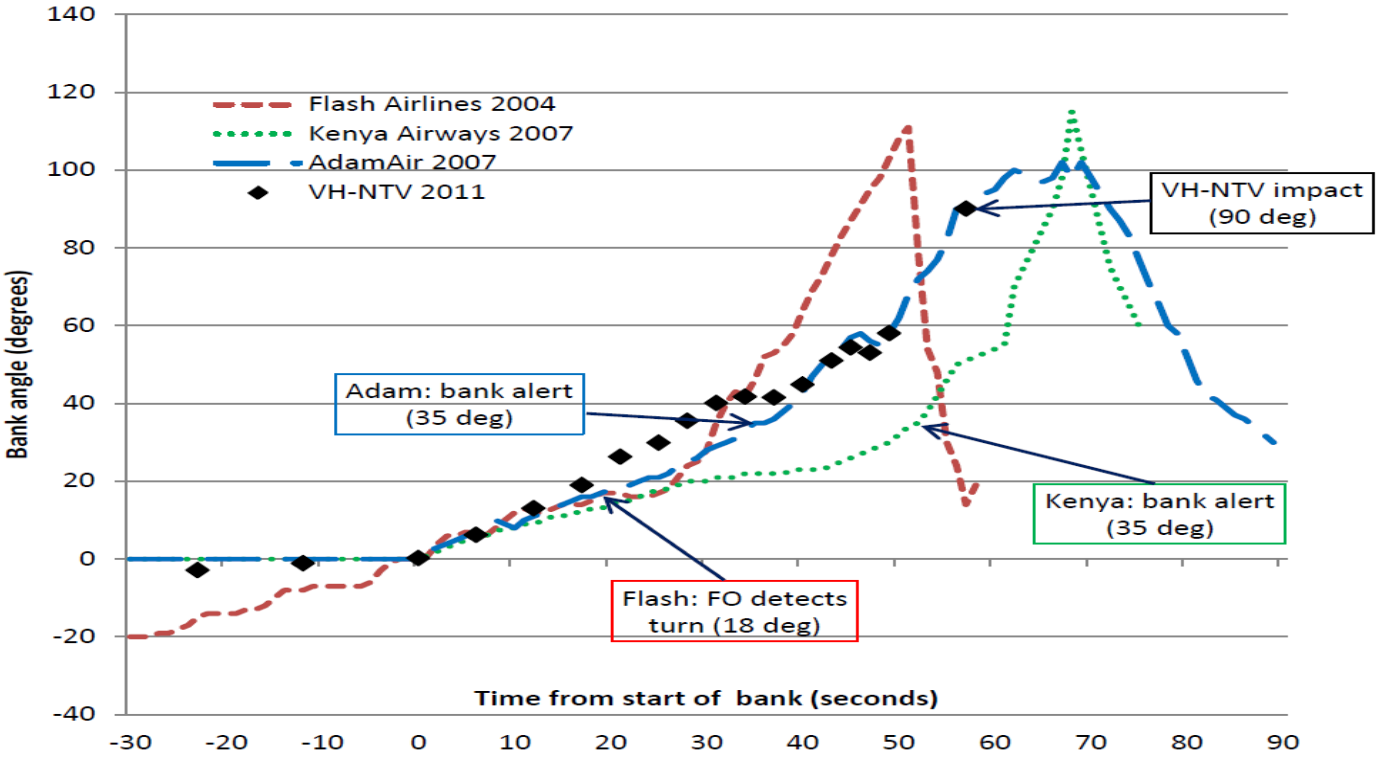
Google

AS355 site

- Impact 3 km east-north-east of departure point
- All major components at site
- No indications of fire prior to impact
- Impacted terrain at high speed, 90-degree right-side low attitude

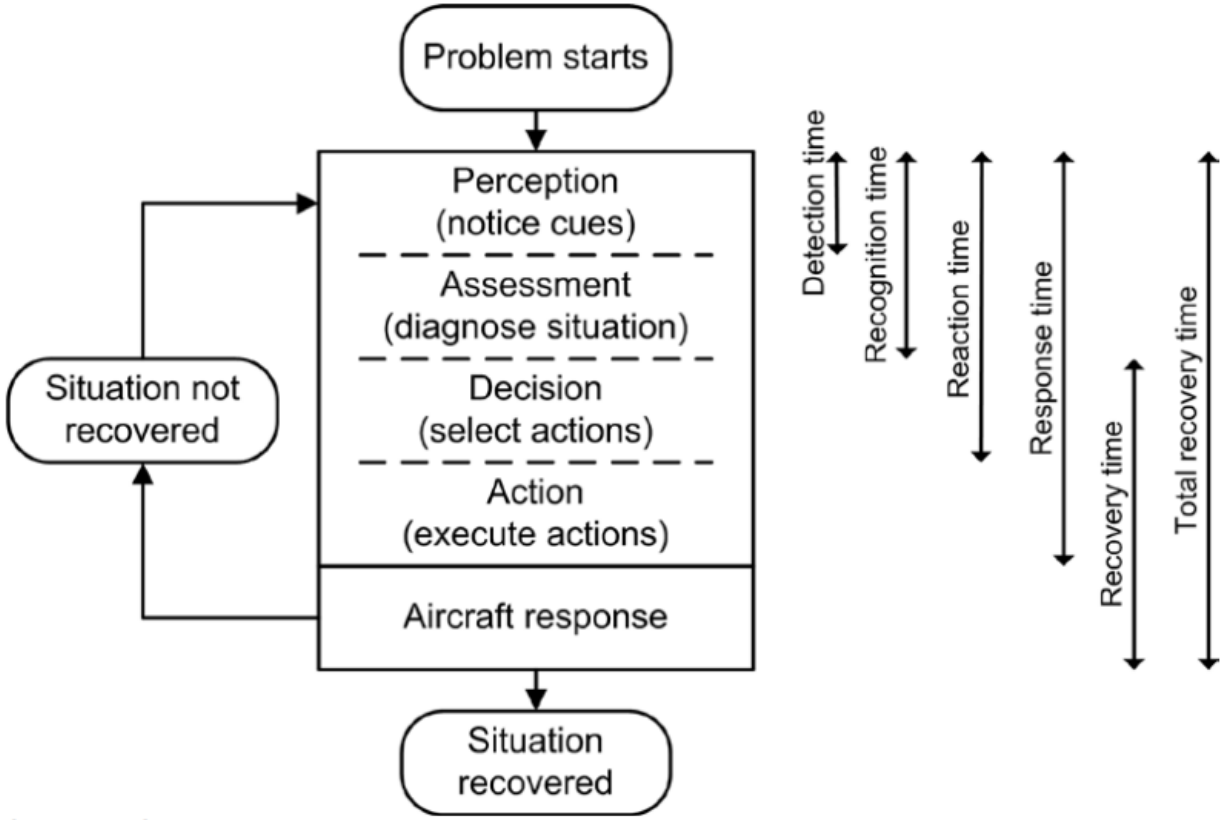


Gradual increase in bank angle

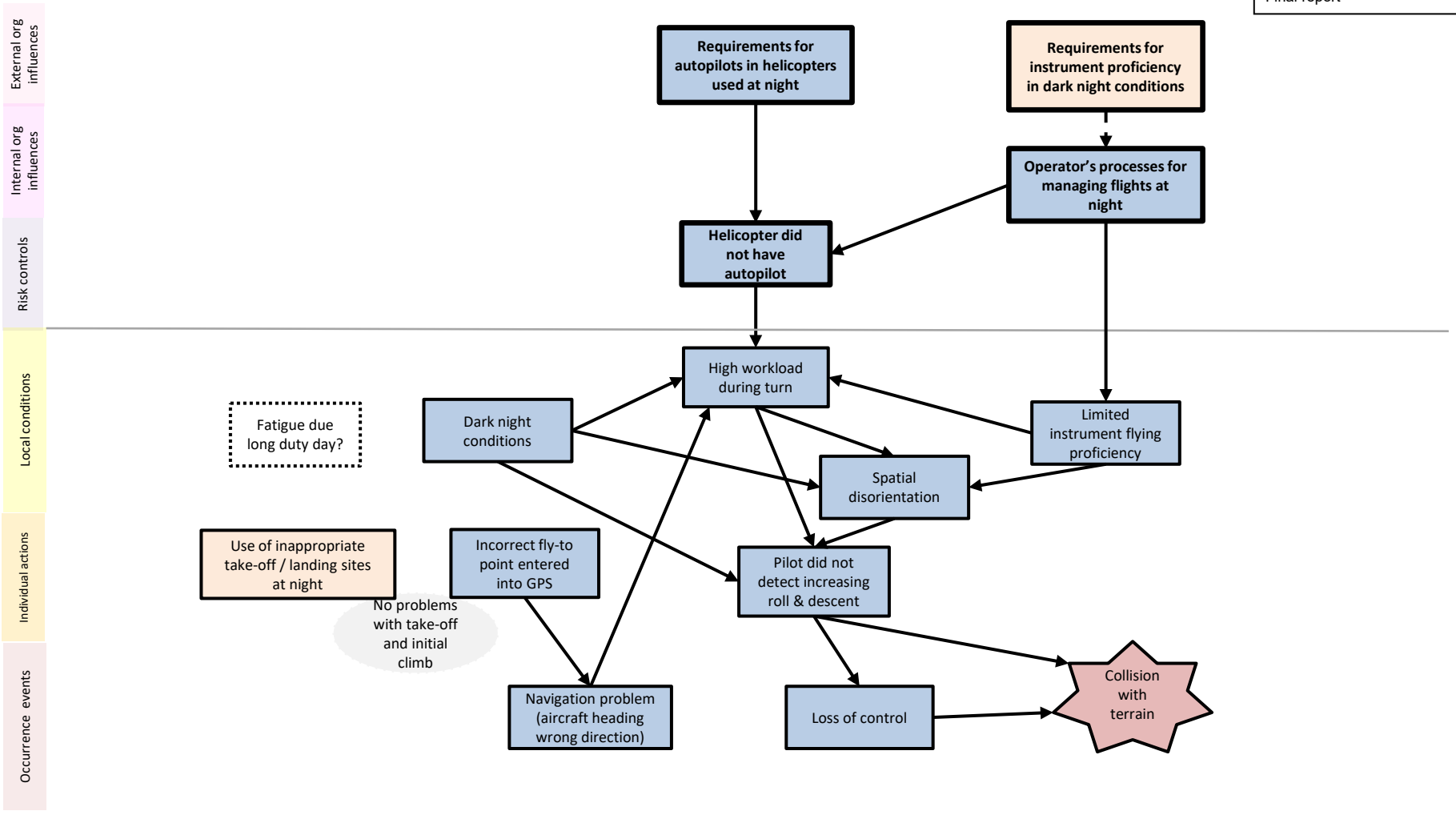


Perceived
Actual
Cockpit view
Not actual conditions
Day view intended to show aircraft relative position only
Actual Pitch, Perceived Pitch
Actual
Perceived
Actual Roll, Perceived Roll
Actual
Perceived
255
270
Time to
Impact
70.0
G Meter
(NOT IN AIRCRAFT)
Start
Stop
1000
NAMRL 2005

Figure 21: Activities involved in recovering from a problem

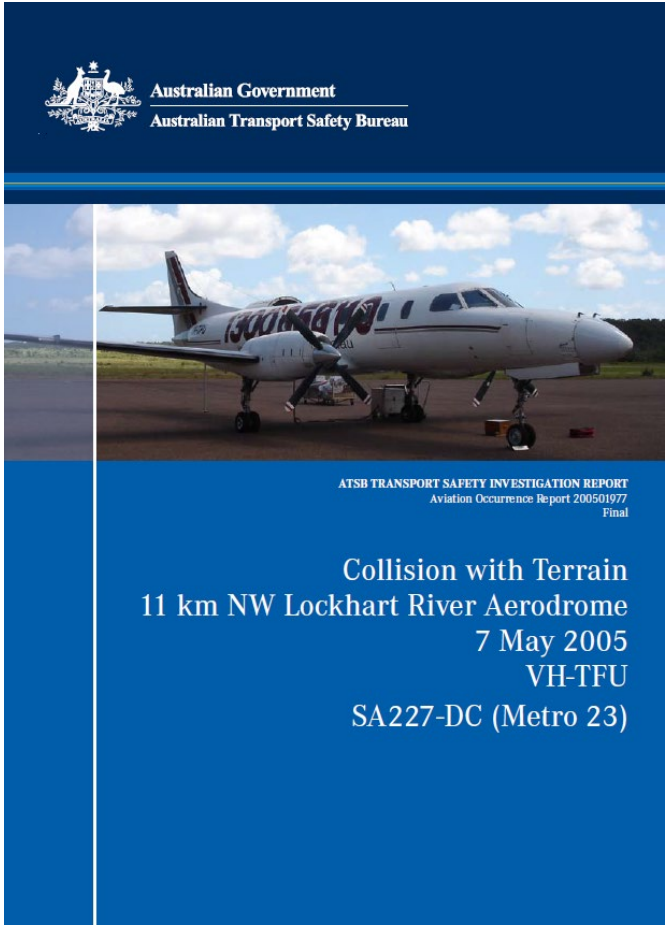


Source: ATSB

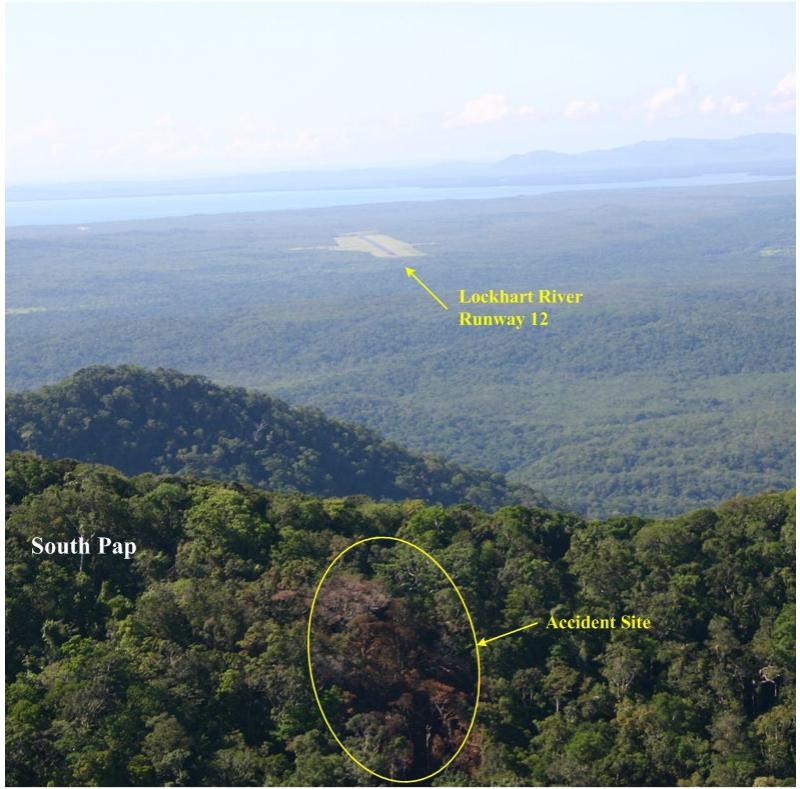

External org influences
Internal org influences
Risk controls
Local conditions
Individual actions
Occurrence events
Requirements for autopilots in helicopters used at night
Requirements for instrument proficiency in dark night conditions
Operator's processes for managing flights at night
Helicopter did not have autopilot
High workload during turn
Fatigue due long duty day?
Dark night conditions
Limited instrument flying proficiency
Spatial disorientation
Use of inappropriate take-off / landing sites at night
Incorrect fly-to point entered into GPS
Pilot did not detect increasing roll & descent
No problems with take-off and initial climb
Navigation problem (aircraft heading wrong direction)
Loss of control
Collision with terrain

Lockhart River example

- Metro (SA227)
- 2 flight crew, 13 passengers
- Bamage to Lockhart River
- IMC at Lockhart River
- RNAV (GNSS) approach
- CFIT



Bamaga
Accident flight route
Lockhart River
Cairns
N
GREAT BARRIER REEF
CAPE YORK PENINSULA
CAIRNS


Lockhart River
Runway 12
South Pap
Accident Site

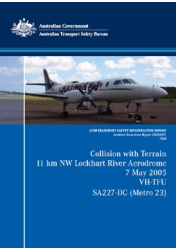

Australian Government
Australian Transport Safety Bureau
Collision with Terrain
11 km NW Lockhart River Aerodrome
7 May 2005
VH-TFU
SA227-DC (Metro 23)

Figure 7: Representation of the instrument panel layout for VH-TFU[40]

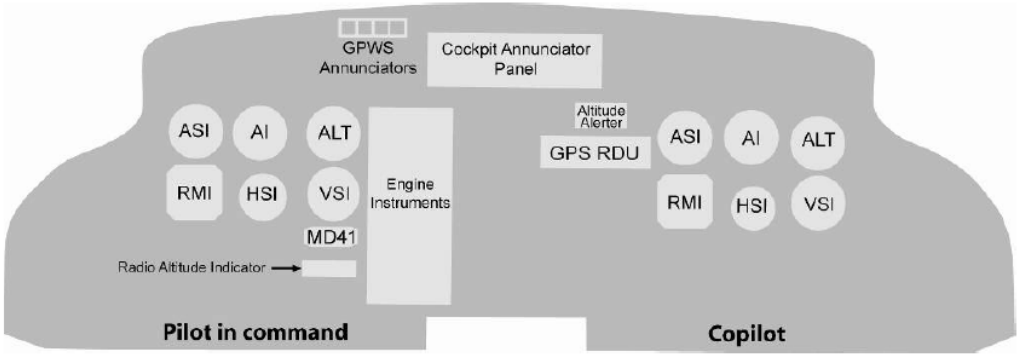
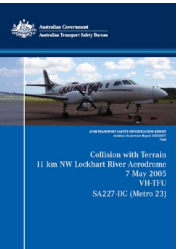
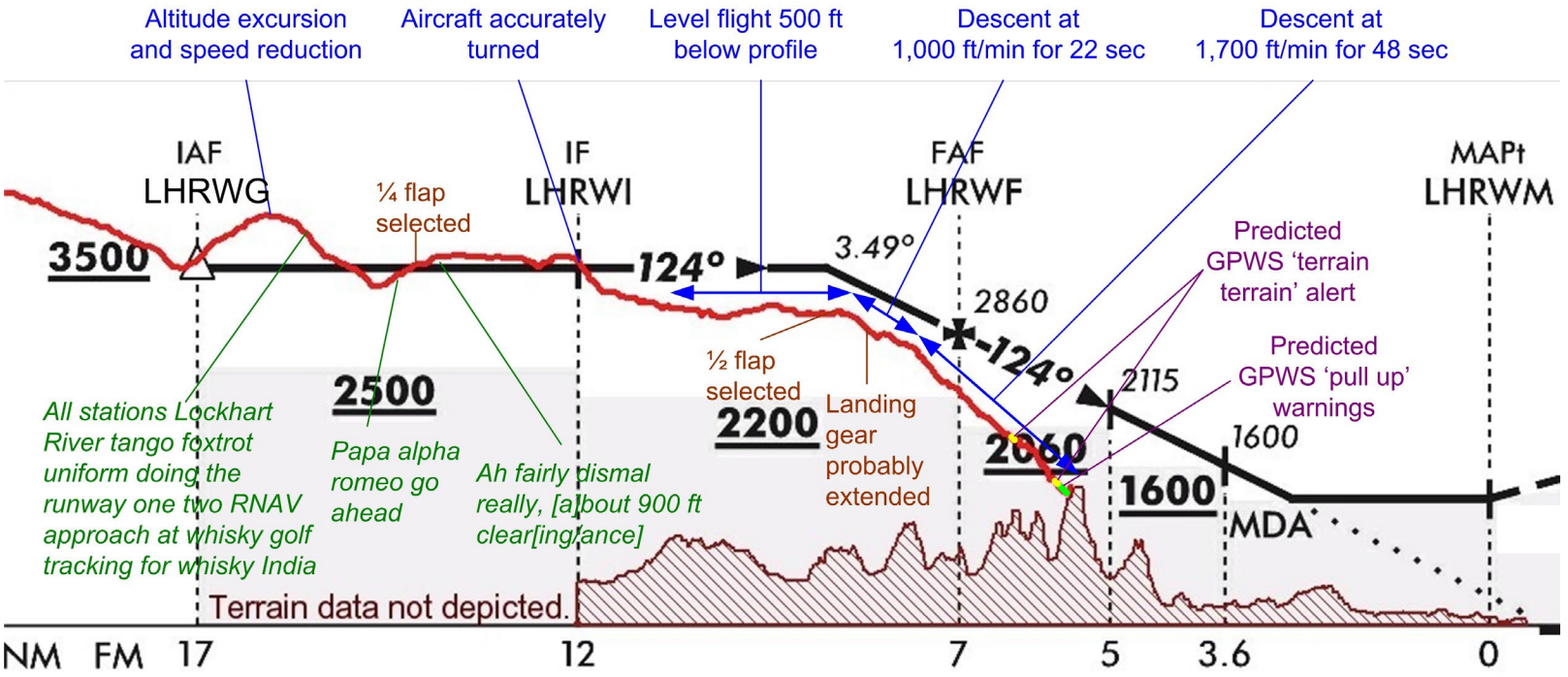
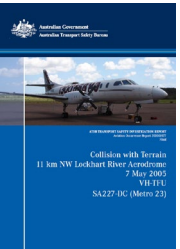
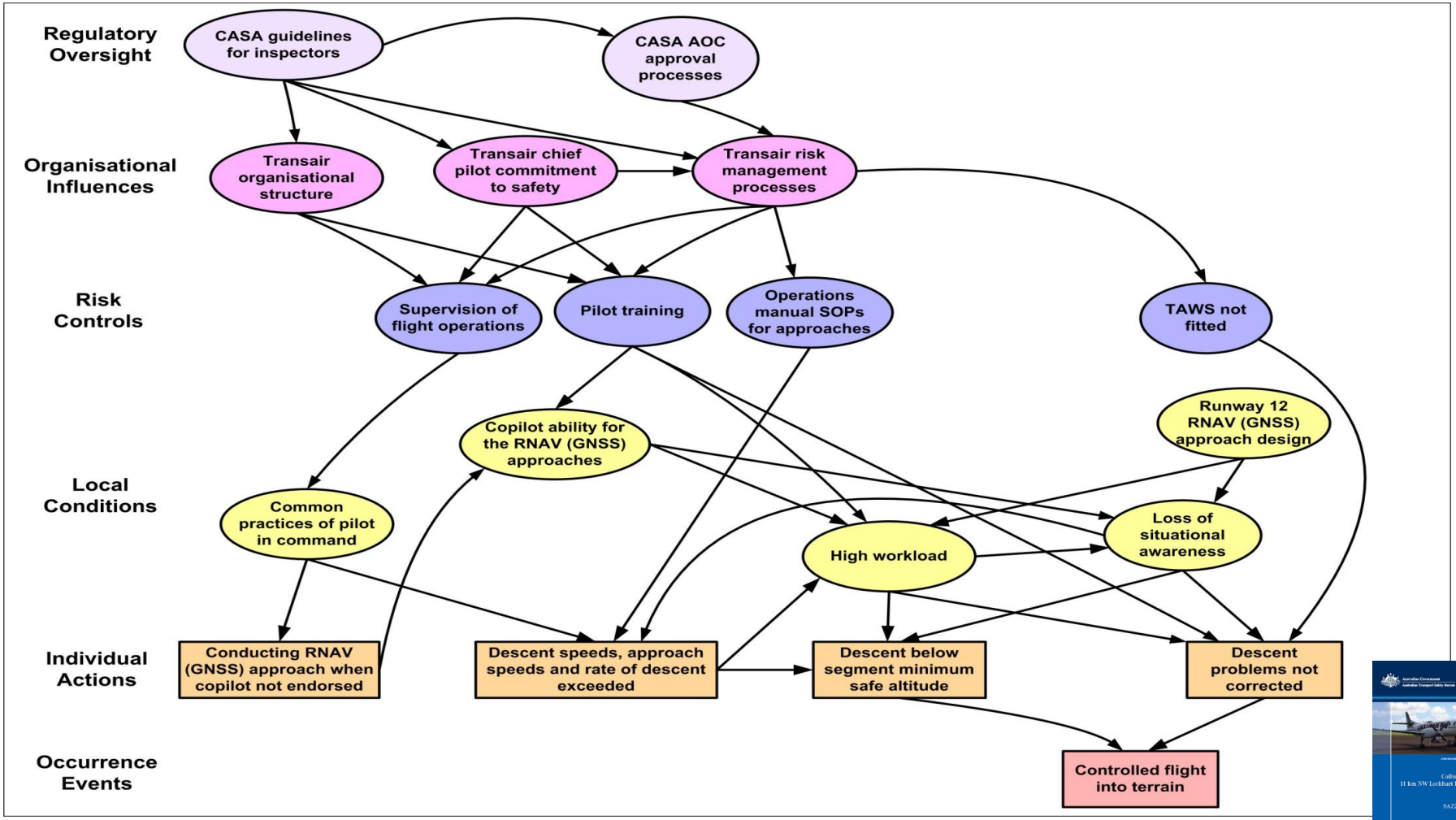


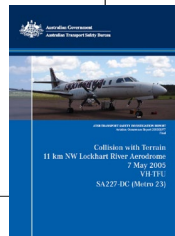
Figure 12: Garmin GPS 155XL receiver display unit




Altitude excursion and speed reduction
Aircraft accurately turned
Level flight 500 ft below profile
Descent at 1,000 ft/min for 22 sec
Descent at 1,700 ft/min for 48 sec
IAF LHRWG
IF LHRWI
FAF LHRWF
MAPt LHRWM
3500
¼ flap selected
124°
3.49°
2860
-124°
Predicted GPWS 'terrain terrain' alert
Predicted GPWS 'pull up' warnings
½ flap selected
2500
2200
Landing gear probably extended
2115
1600
2060
1600
MDA
All stations Lockhart River tango foxtrot uniform doing the runway one two RNAV approach at whisky golf tracking for whisky India
Papa alpha romeo go ahead
Ah fairly dismal really, [a]bout 900 ft clear[ing/ance]
Terrain data not depicted.
NM FM 17
12
7
5
3.6
0


Collision with Terrain
11 km NW Lockhart River Aerodrome
7 May 2005
VH-TFU
SA227-DC (Metro 23)


Regulatory Oversight
CASA guidelines for inspectors
CASA AOC approval processes
Organisational Influences
Transair organisational structure
Transair chief pilot commitment to safety
Transair risk management processes
Risk Controls
Supervision of flight operations
Pilot training
Operations manual SOPs for approaches
TAWS not fitted
Local Conditions
Copilot ability for the RNAV (GNSS) approaches
Runway 12 RNAV (GNSS) approach design
Common practices of pilot in command
Loss of situational awareness
High workload
Individual Actions
Conducting RNAV (GNSS) approach when copilot not endorsed
Descent speeds, approach speeds and rate of descent exceeded
Descent below segment minimum safe altitude
Descent problems not corrected
Occurrence Events
Controlled flight into terrain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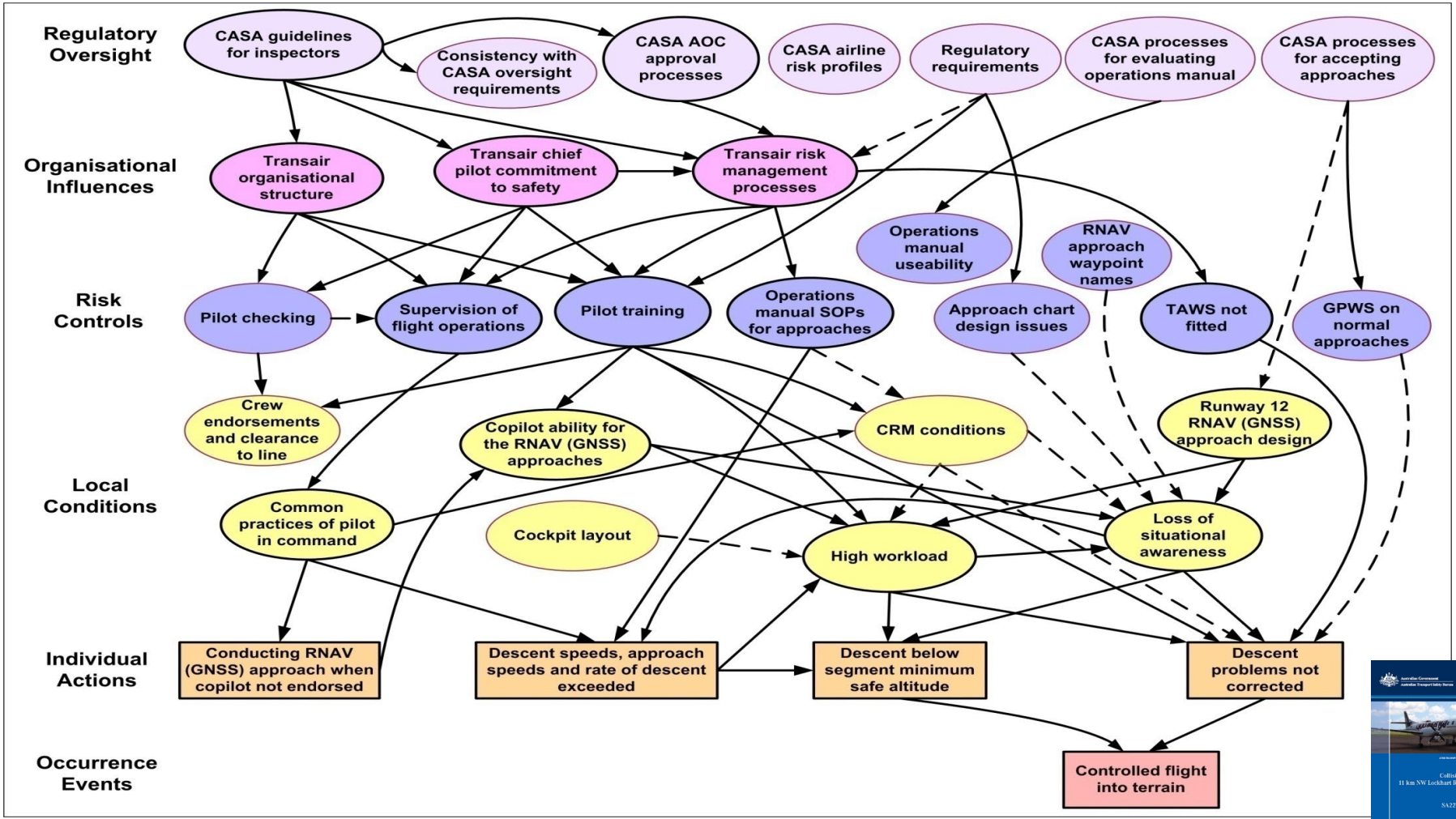
Regulatory Oversight
Organisational Influences
Risk Controls
Local Conditions
Individual Actions
Occurrence Events
CASA guidelines for inspectors
Consistency with CASA oversight requirements
CASA AOC approval processes
CASA airline risk profiles
Regulatory requirements
CASA processes for evaluating operations manual
CASA processes for accepting approaches
Transair organisational structure
Transair chief pilot commitment to safety
Transair risk management processes
Operations manual useability
RNAV approach waypoint names
Pilot checking
Supervision of flight operations
Pilot training
Operations manual SOPs for approaches
Approach chart design issues
TAWS not fitted
GPWS on normal approaches
Crew endorsements and clearance to line
Copilot ability for the RNAV (GNSS) approaches
CRM conditions
Runway 12 RNAV (GNSS) approach design
Common practices of pilot in command
Cockpit layout
High workload
Loss of situational awareness
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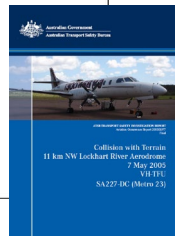
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- What is human factors?
- The ATSB analysis model
- Some principles for investigating human factors
- The SHELL model

Some general principles (1)

- Focus on enhancing safety rather than solving puzzles
- Be evidence-based but pragmatic
- Identify the individual actions, then try to explain them
- Look for actions we would like done differently in similar situations in the future (rather than ‘unsafe acts’)
- Focus on observable actions before mental states

Some general principles (2)

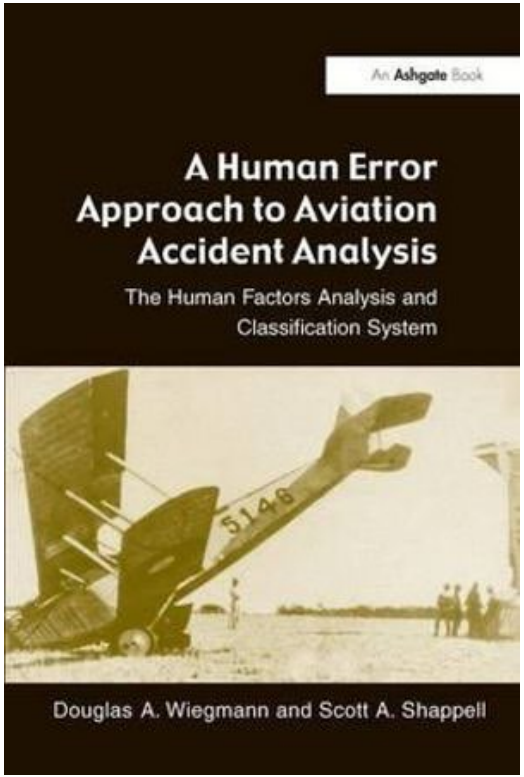
- Always consider the sequence and the context
- Understand what normal operations look like
- Always look for system-based explanations of actions (may not always find)
- Consider individual actions as part of the ‘how’ (not part of the ‘why’)
- Always consider why it may have made sense to the person at the time

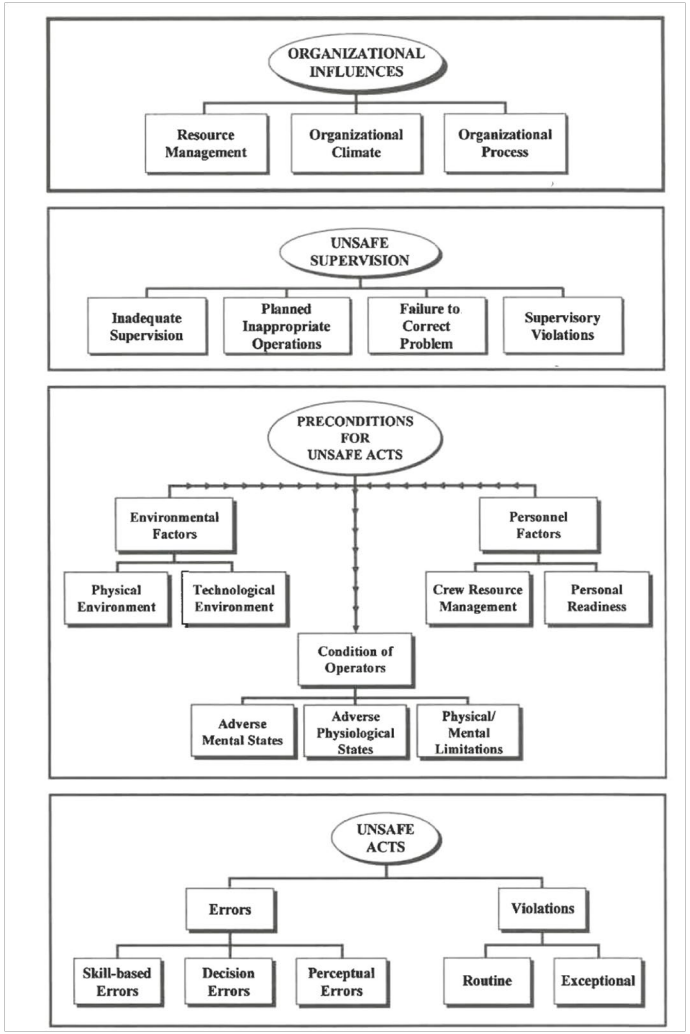
Module 1: Models and principles

- What is human factors?
- The ATSB analysis model
- Some principles for investigating human factors
- The SHELL model

- Additional slides if needed on HFACS

HFACS


An Ashgate Book
A Human Error Approach to Aviation Accident Analysis
The Human Factors Analysis and Classification System
5148
Douglas A. Wiegmann and Scott A. Shappell


ORGANIZATIONAL INFLUENCES
Resource Management
Organizational Climate
Organizational Process
UNSAFE SUPERVISION
Inadequate Supervision
Planned Inappropriate Operations
Failure to Correct Problem
Supervisory Violations
PRECONDITIONS FOR UNSAFE ACTS
Environmental Factors
Personnel Factors
Physical Environment
Technological Environment
Crew Resource Management
Personal Readiness
Condition of Operators
Adverse Mental States
Adverse Physiological States
Physical/ Mental Limitations
UNSAFE ACTS
Errors
Violations
Skill-based Errors
Decision Errors
Perceptual Errors
Routine
Exceptional

ATSB model versus HFACS

ATSB analysis model	HFACS
External organisational influences	
Internal organisational influences	Organisational influences
Risk controls	Unsafe supervision
Local conditions	Preconditions of unsafe acts
Individual actions	Unsafe acts of operators
Occurrence events	

HFACS

Table 3.1 Selected examples of unsafe acts of operators

ERRORS	VIOLATIONS
Skill-based Errors	***Routine***
❑ Breakdown in visual scan	❑ Inadequate briefing for flight
❑ Inadvertent use of flight controls	❑ Failed to use ATC radar advisories
❑ Poor technique/airmanship	❑ Flew an unauthorized approach
❑ Over-controlled the aircraft	❑ Violated training rules
❑ Omitted checklist item	❑ Filed VFR in marginal weather conditions
❑ Omitted step in procedure	❑ Failed to comply with departmental manuals
❑ Over-reliance on automation	❑ Violation of orders, regulations, SOPs
❑ Failed to prioritize attention	❑ Failed to inspect aircraft after in-flight caution light
❑ Task overload	
❑ Negative habit	***Exceptional***
❑ Failure to see and avoid	❑ Performed unauthorized acrobatic maneuver
❑ Distraction	❑ Improper takeoff technique
Decision Errors	❑ Failed to obtain valid weather brief
❑ Inappropriate maneuver/procedure	❑ Exceeded limits of aircraft
❑ Inadequate knowledge of systems, procedures	❑ Failed to complete performance computations for flight
❑ Exceeded ability	❑ Accepted unnecessary hazard
❑ Wrong response to emergency	❑ Not current/qualified for flight
Perceptual Errors	❑ Unauthorized low-altitude canyon running
❑ *Due to* visual illusion	
❑ *Due to* spatial disorientation/vertigo	
❑ *Due to* misjudged distance, altitude, airspeed, clearance	

Note: This is not a complete listing.

Table 3.2 Selected examples of preconditions of unsafe acts

CONDITION OF OPERATOR	PERSONNEL FACTORS
Adverse Mental States	***Crew Resource Management***
❑ Loss of situational awareness	❑ Failed to conduct adequate brief
❑ Complacency	❑ Lack of teamwork
❑ Stress	❑ Lack of assertiveness
❑ Overconfidence	❑ Poor communication/ coordination within & between aircraft, ATC, etc.
❑ Poor flight vigilance	❑ Misinterpretation of traffic calls
❑ Task saturation	❑ Failure of leadership
❑ Alertness (drowsiness)	
❑ Get-home-itis	***Personal Readiness***
❑ Mental fatigue	❑ Failure to adhere to crew rest requirements
❑ Circadian dysrhythmia	❑ Inadequate training
❑ Channelized attention	❑ Self-medicating
❑ Distraction	❑ Overexertion while off duty
Adverse Physiological States	❑ Poor dietary practices
❑ Medical illness	❑ Pattern of poor risk judgment
❑ Hypoxia	
❑ Physical fatigue	**ENVIRONMENTAL FACTORS**
❑ Intoxication	**Physical Environment**
❑ Motion sickness	❑ Weather
❑ Effects of OTC medications	❑ Altitude
Physical/Mental Limitations	❑ Terrain
❑ Visual limitations	❑ Lighting
❑ Insufficient reaction time	❑ Vibration
❑ Information overload	❑ Toxins in the cockpit
❑ Inadequate experience for complexity of situation	**Technological Environment**
❑ Incompatible physical capabilities	❑ Equipment/controls design
❑ Lack of aptitude to fly	❑ Checklist layout
❑ Lack of sensory input	❑ Display/interface characteristics
	❑ Automation

Note: This is not a complete listing.

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Table 3.3 Selected examples of unsafe supervision

Inadequate Supervision
- ❑ Failed to provide proper training
- ❑ Failed to provide professional guidance/oversight
- ❑ Failed to provide current publications/adequate technical data and/or procedures
- ❑ Failed to provide adequate rest period
- ❑ Lack of accountability
- ❑ Perceived lack of authority
- ❑ Failed to track qualifications
- ❑ Failed to track performance
- ❑ Failed to provide operational doctrine
- ❑ Over-tasked/untrained supervisor
- ❑ Loss of supervisory situational awareness

Planned Inappropriate Operations
- ❑ Poor crew pairing
- ❑ Failed to provide adequate brief time/supervision
- ❑ Risk outweighs benefit
- ❑ Failed to provide adequate opportunity for crew rest
- ❑ Excessive tasking/workload

Failed to Correct a Known Problem
- ❑ Failed to correct inappropriate behavior/identify risky behavior
- ❑ Failed to correct a safety hazard
- ❑ Failed to initiate corrective action
- ❑ Failed to report unsafe tendencies

Supervisory Violations
- ❑ Authorized unqualified crew for flight
- ❑ Failed to enforce rules and regulations
- ❑ Violated procedures
- ❑ Authorized unnecessary hazard
- ❑ Willful disregard for authority by supervisors
- ❑ Inadequate documentation
- ❑ Fraudulent documentation

Note: This is not a complete listing.

Table 3.4 Selected examples of organizational influences

Resource Management

Human Resources
- ❑ Selection
- ❑ Staffing/manning
- ❑ Training
- ❑ Background checks

Monetary/Budget Resources
- ❑ Excessive cost cutting
- ❑ Lack of funding

Equipment/Facility Resources
- ❑ Poor aircraft/aircraft cockpit design
- ❑ Purchasing of unsuitable equipment
- ❑ Failure to correct known design flaws

Organizational Climate

Structure
- ❑ Chain-of-command
- ❑ Communication
- ❑ Accessibility/visibility of supervisor
- ❑ Delegation of authority
- ❑ Formal accountability for actions

Policies
- ❑ Promotion
- ❑ Hiring, firing, retention
- ❑ Drugs and alcohol
- ❑ Accident investigations

Culture
- ❑ Norms and rules
- ❑ Organizational customs
- ❑ Values, beliefs, attitudes

Organizational Process

Operations
- ❑ Operational tempo
- ❑ Incentives
- ❑ Quotas
- ❑ Time pressure
- ❑ Schedules

Procedures
- ❑ Performance standards
- ❑ Clearly defined objectives
- ❑ Procedures/instructions about procedures

Oversight
- ❑ Established safety programs/ risk management programs
- ❑ Management's monitoring and checking of resources, climate, and processes to ensure a safe work environment

Note: This is not a complete listing.