Australian Government
Australian Transport Safety Bureau

ATSB

Human Factors

Module 2: Human factors evidence collection

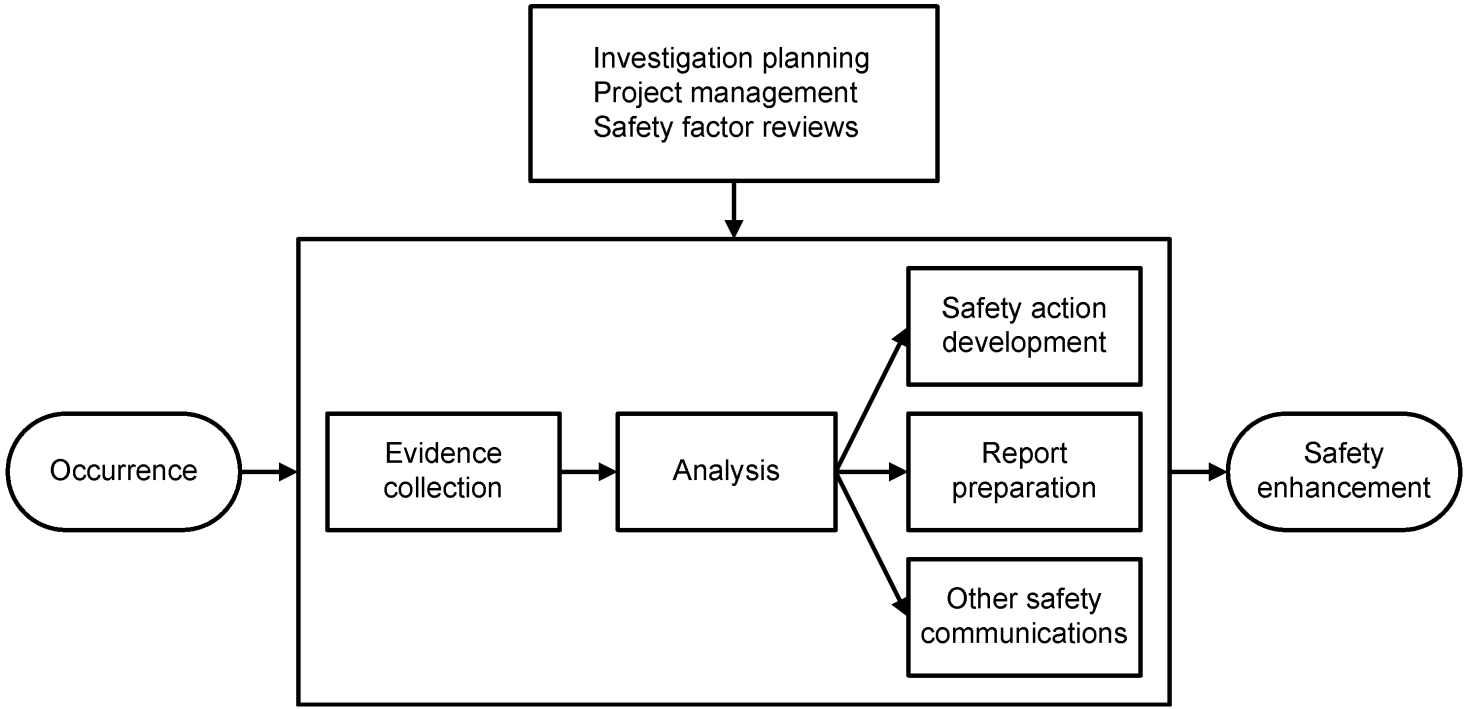
Presented by
Mike Walker and Stu Godley

ICAO APAC AIG Workshop
15 August 2023 Singapore

Module 2: Evidence collection

- General aspects
- Types / sources of evidence
- Human factors interviewing
- Asking about fatigue
- Analysing human factors information
- Some more general principles

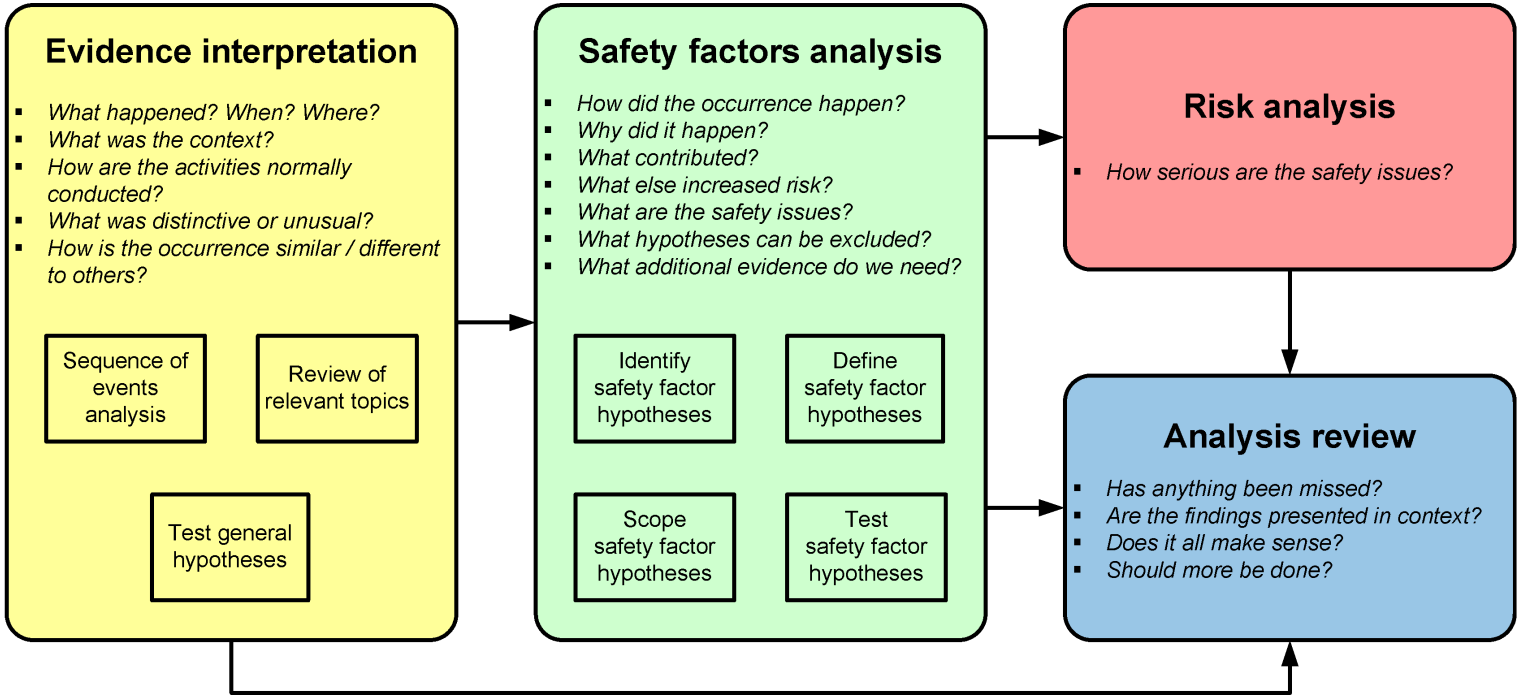
Investigation process



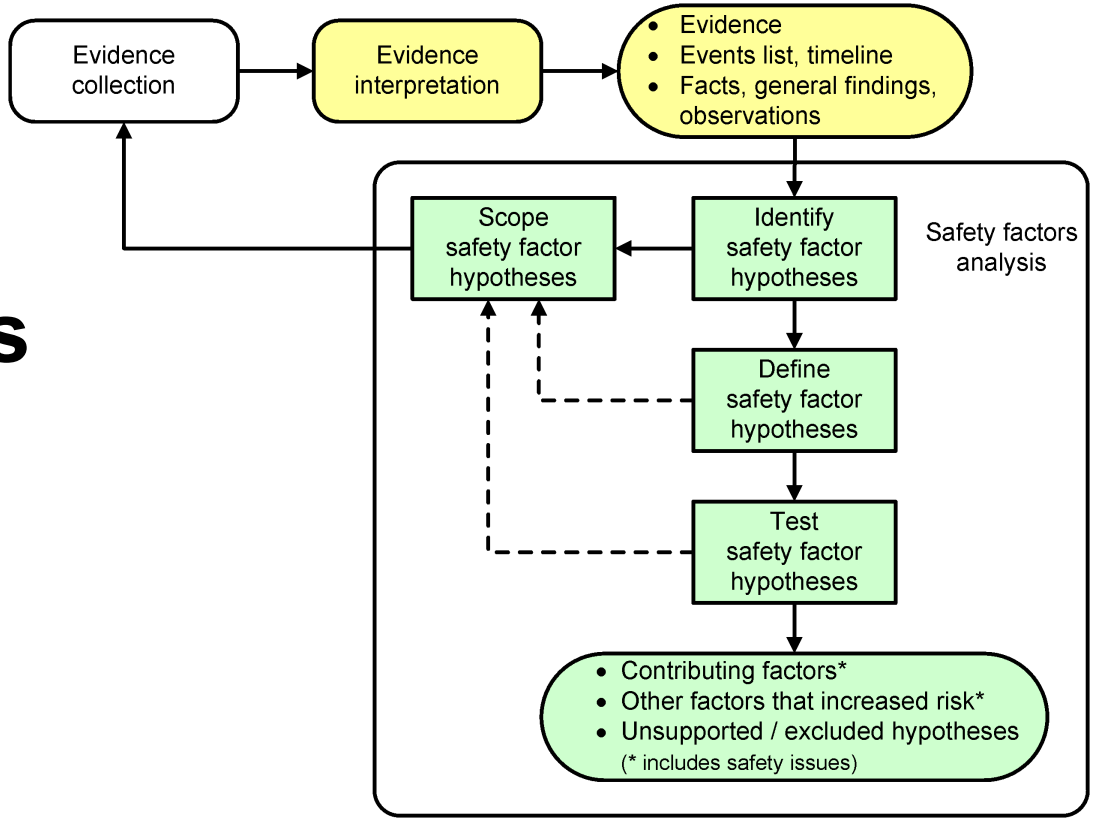
HF evidence collection

- Iterative process
  - collect evidence, review, identify hypotheses and collect further evidence to test these hypotheses
  - wide-angle and telephoto approaches
- Prioritise collection of perishable evidence
- Depth / extent may depend on nature and severity of accident / incident, resources available, preliminary findings, …
- Coordinate with other investigation activities / team members
- Range of checklists can assist

Analysis process



Safety factors analysis process



Evidence collection – wide angle

- Sample basic data on a range of topics
  - some routine evidence always collect (e.g. licence details, medical certificate, flight and duty times, weather conditions…)
  - some focus on topics that are clearly relevant (based on what we already know and our experience)
- Need to have an open mind
  - never know what may be relevant later
- Need to review what we have before we finish an activity (e.g. before leave an accident site)

Evidence collection – telephoto

- Make decisions about what evidence to collect based on analysis of evidence already obtained
- Focussed around specific topic(s) or hypotheses
- Collect evidence both for and against a series of hypotheses
- Still use an open mind (avoid confirmation bias)

Investigator biases

Confirmation bias
- seek to confirm rather than try to disprove

Group think
- tendency for team to move towards agreement

Risky shift
- decision by team less cautious than members would make on their own

Hindsight bias
- perceive past event as being more predictable than would have been at the time

Fundamental attribution error
- overemphasise role of personal factors, underemphasise situational factors

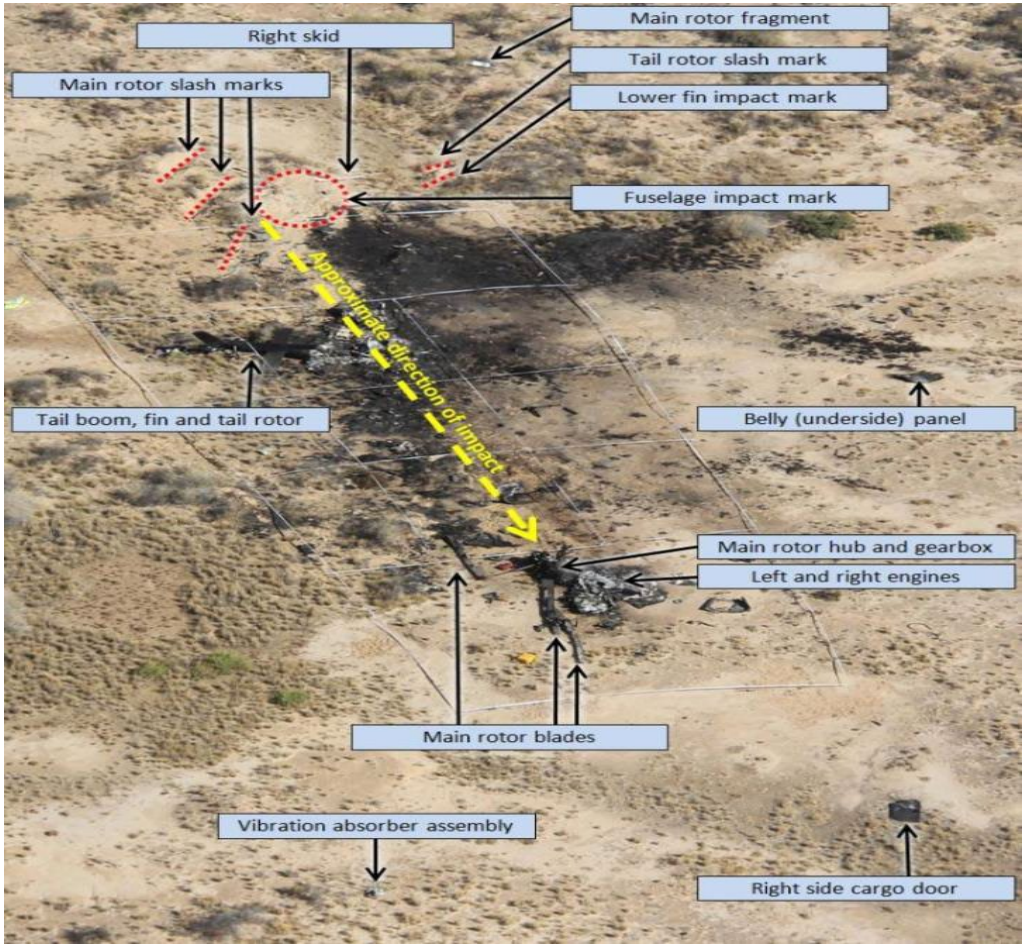
Availability heuristic
- rely on examples that come easily to mind

Module 2: Evidence collection

- General aspects
- Types / sources of evidence
- Human factors interviewing
- Asking about fatigue
- Analysing human factors information
- Some more general principles

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



Questions

- What are the main types of human factors evidence to collect at the accident site?
- What other human factors evidence should we collect?

Sources of human factors evidence

Type	Examples
Recorded data	vehicle data recorders, vehicle voice/image records, GPS / radar data, CCTV, video or photographs of event, meteorological recordings, phone records, ...
Site measurements and observations	line of sight measurements, target-background contrast, control positions, presence of medications, ...
Interviews	witnesses, participants, other operational personnel, experts, …
Medical records and tests	post-mortem, toxicology, drugs / alcohol, medical assessments (pre and post occurrence), vision / hearing assessments, …
Technical documentation	procedures manuals, training manuals, system descriptions, maps / charts, regulations / orders,...
Operational records	logbooks, technical logs, trip reports, occurrence notifications, weather observations, job sheets, repair records, check and training records, ...

Sources of human factors evidence

Type	Examples
Workplace / equipment assessments	visibility, lighting, noise, workload, display / control design, task activities, …
Simulations	recreate occurrence or alternate scenarios, assess workload, assess target visibility, …
Human performance databases	anthropometry, biomechanics, target detection, response time, sleep, error rates, times of useful consciousness, g load effects, …
Research studies	applied and pure research on normal performance for various contexts, effects of various factors on performance, …
General / accepted facts	physical laws (e.g. law of gravity, fire needs oxygen), astronomical data (such as sunrise time, sunset time, sun position), ...
Specialised evidence interpretation or modelling tools	biomathematical models of fatigue (FAID, FAST, SAFE), perceptual modelling, collision detection analysis, …

Sources of human factors evidence

Type	Examples
Hazard / occurrence databases	operator, manufacturer, national, overseas, other industries, …
Surveys	interview-based, focus groups, questionnaire, … [can focus on specific event, type of task, previous occurrences, hazards, safety climate, …]
Safety management documentation	manuals, risk assessments, training needs analyses, communications, project management documentation, …
Audits / assessments	internal audit, external audit, project review, ...
Organisational comparisons	procedures, training, equipment design, safety management processes, …
Expert opinions	medical, perception, fatigue, …

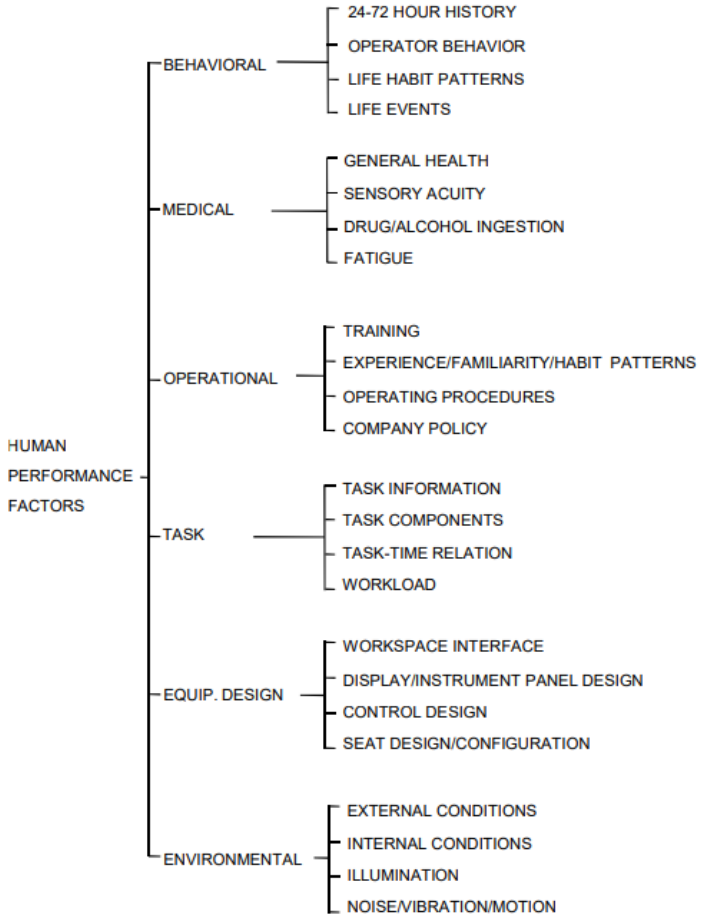
Human factors checklists

- Many checklists available, none perfect or suited to all situations
- Some checklists better suited for:
  - on-site evidence collection
  - evaluating a vehicle / equipment / system / workstation
  - interviews
  - analysis (e.g. identifying hypotheses)
- Need to consider when will use them and for what purpose
- Best approach:
  - use HF knowledge, knowledge of occurrence / situation, and checklists to develop a tailored evidence collection plan

Module 2: Evidence collection

- General aspects
- Types / sources of evidence
- Human factors interviewing
- Asking about fatigue
- Analysing human factors information
- Some more general principles

NTSB: Human performance group activities for investigation



Human factors interviewing checklist

- Based around 12 topics
  - information processing (detailed account stage)
  - local conditions (8) (background information stage)
  - risk controls / organisational aspects (3) (background information stage)
- Should sample each of the topics in an interview
- Checklist provides prompts
  - should develop a more detailed interview plan with team members
- Checklist provides approximate order of topics
  - need to tailor to suit situation

ATSB Human factors interviewing checklist

Topic	Sub-topics
Information processing (during event)	• Perception • Focus of attention • Memory • Situation assessment / awareness • Decision making • Response execution (actions)
Knowledge, skills, experience	• General qualifications / experience • Specific qualifications / experience • Consolidation • Recency
Task demands	• Workload (amount) • Task complexity • Time pressure • Distractions (see also focus of attention) • Physical workload / effort
Equipment / ergonomics	• Availability, usability, reliability • Displays /controls • Alarms / warnings • Tools / devices • Maps / charts • Workspace layout and equipment (seating, access, obstructions…)
Procedures / guidance	• Availability, usability, relevance • Normal procedures • Emergency procedures • Checklists • Job aids / decision aids

Topic	Sub-topics
Physical environment	• Visibility (outside vehicle / workstation) • Lighting / illumination / glare • Noise / vibration • Temperature / humidity / air quality • Rain / wind
Social factors	• Teamwork and communications • Interpersonal differences / gradient • Peer pressure
Fatigue / alertness	• Work and sleep hours • Sleep quality • Level of alertness • Normal sleep pattern • Factors influencing sleep • Other factors influencing alertness
Recent history	• Recent meals / drinks • Caffeine / related substances • Non-work activities
Medical / physiological factors	• General health / fitness / wellbeing • Specific medical conditions • Recent illness / injury • General physical capabilities • Medications • Alcohol / smoking / other substances
Personal factors	• General disposition / mood • Recent or significant changes • Non-work issues
Organisational aspects	• Task pressures • Morale / culture / climate • Safety reporting / management • Safety lessons

Human factors question bank

- Based around the 12 topics
- Number of questions asked about each topic is matter of judgement
- Question bank provides an acceptable way of asking relevant questions – need to adapt to suit the situation
- Need to integrate selected questions into an interview plan
- Use open questions before closed questions
- If an answer is too short, ask for additional details

Information processing probes

- *Describe what you can recall seeing / hearing in as much detail as possible.*
- *Describe your assessment of the situation at the time. What cues did you use to make this assessment?*
- *Imagine that you were asked to describe the situation at that point in time to another xxx (e.g. pilot, master, driver, engineer). How would you summarise the situation?*
- *Were you reminded of any previous experiences at the time? What were they? Why were they similar?*
- *What were your main goals at the time? What were you trying to do?*

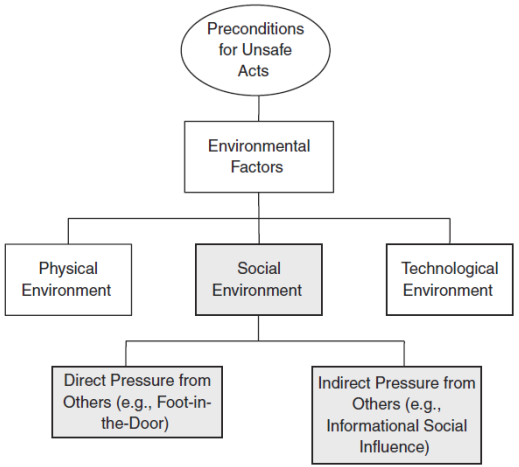
Social / organisational pressures

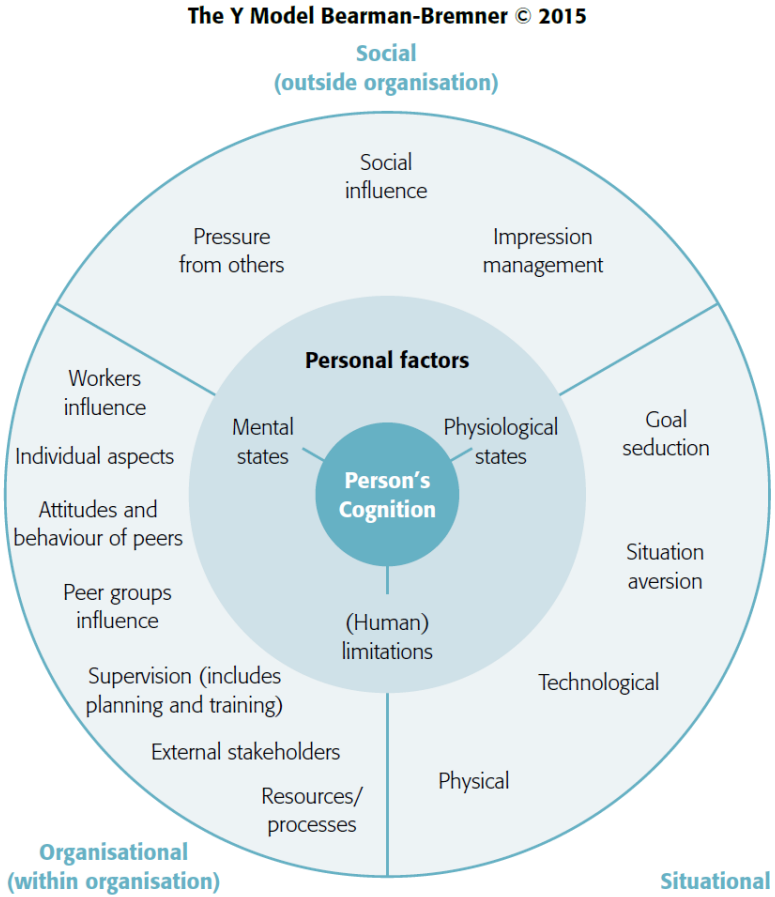
- Range of pressures can influence safety-critical personnel:
  - time pressure
  - peer pressure (to follow practices / norms)
  - pressure to commence flight / trip
  - pressure to continue flight / trip
  - pressure to not report hazard / incident / fatigue
  - client / passenger pressure
  - perceived versus actual pressure.
- Effects can be subtle and difficult to measure

Pressures in Alaskan pilots

- 24 of 28 interviews identified social/organisational pressures
- Informational social influence:
  - observing others or chief pilot successfully flying
- Inured to risk through reinforcement / normalisation of deviance:
  - foot in the door / slippery slope
- Self-motives:
  - not wanting to disappoint customers
  - reluctance to admit defeat
  - maintaining reputation

(Paletz et al. 2009)





Bearman & Bremmer, 2016

Questions on pressures

- Best way to examine social and organisational pressures is through interviews
  - people involved and/or people in similar role
- Examples:
  - *To what extent did you perceive any pressure or incentive to do XXX? (e.g. undertake the flight/trip, complete the task, do the task a certain way, not report a hazard or defect, …) Can you describe what you mean in more detail? Can you provide any specific examples of that?*
  - *What would you have expected to happen if you XXX? (e.g. turned around, not accepted the task, not departed, reported a defect, reported fatigued) Has this result happened before? Do you have any specific examples?*

Emotion, mood, morale

- Dynamic and complex relationships between morale, mood, culture, attitudes, emotion…
- Effects can be subtle and difficult to measure
- Many studies have shown emotion / mood can influence many aspects of cognition and performance
- Tehrani and Molesworth (2016):
  - 45 participants exposed to either +ve or –ve mood manipulator, watched preflight safety video, conducted unscheduled evacuation
  - +ve mood participants made less errors, completed evacuation quicker

Module 2: Evidence collection

- General aspects
- Types / sources of evidence
- Human factors interviewing
- Asking about fatigue
- Analysing human factors information
- Some more general principles

Fatigue

- “… a physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental and/or physical activity) that can impair a person’s alertness and ability to perform safety-related operational duties” (ICAO 2020)

Effects of fatigue on performance

Area of human performance	Indicators (What would we see?)
General cognitive functioning	• Increasing difficulty problem solving • Decreasing vigilance • Increasing difficulty with communication tasks • Increasing difficulty with hand eye coordination • Increasing reaction time • Increasing information processing time.
Problem solving	• Decreased flexibility – not adapting to change in situation. • Increased perseveration in the face of evidence the plan is not working.
Memory	• Error type is related to memory (lapse) • Increased difficulty maintaining information in short term or working memory: Asking for information multiple times • Having to refer to reference material frequently • Leaving tasks unfinished • Frequent reminders from coworkers.
Attention and vigilance	• Error form is related to attention (slip) • Slower response to stimuli • Not responding to stimuli • Less focus on task as demonstrated by decreased secondary task behavior (less proactive task management).
Reaction time	• Responds to stimuli more slowly than usual • Excessively long time to react to emergency situation • Prolonged time to make a decision
Mood	• Increased lethargy • Decreased interest in task • Increased irritability
Physiological effects	• Indications of succumbing to sleep (nodding off, falling asleep) • Early warning signs (long eye blinks, rubbing eyes, yawning)

Rudin-Brown & Rosberg (2021)

How much sleep is enough?

- Most adults need at least 7 hours of sleep each day to achieve maximum levels of alertness
- Restricting sleep to 6 hours or less a night over multiple nights will result in significant performance decrements
- Prior sleep wake (PSW) rule - The following is inconsistent with safe system of work:
  - less than 5 hours in previous 24 hours
  - less than 12 hours sleep in previous 48 hours
  - being awake for more than the hours of sleep in last 48 hours

(Dawson and McCullough 2005; Dawson and others 2021)

Fatigue questions during interviews

- Key problems with many interviews – do not get enough information about sleep
- Need to ask questions about each of the sub-topics

Fatigue / alertness	• Work and sleep hours • Sleep quality • Level of alertness • Normal sleep pattern • Factors influencing sleep • Other factors influencing alertness

About fatigue interviewing questions 1

- Deeper dive when:
  - major accident
  - available information indicates there has been significant sleep restrictions in the last 3 days
  - the occurrence happened during a time of reduced alertness (0200–0600), or the individual worked during that period and the occurrence happened soon after
  - the individual involved had been awake for an extended period (more than 16 hours)

About fatigue interviewing questions 2

- Deeper dive when:
  - the individual's actions appeared to involve inaction, slow response time, non-detection of a signal/alert or exaggerated over-correction of control actions
  - there appears to be indications of symptoms of fatigue in the individual's behaviour at the time (e.g. yawning, comments about tiredness, naps, microsleeps)
  - there appears to be indications of sources of fatigue (e.g. long duty times, night shifts, long periods requiring significant concentration or high workload)

Fatigue data collection form

- Sleep information is perishable
- Short questionnaire can be sent to interviewee or used during interview
- Captures bare essential information about sleep and alertness
- Kept short to maximise likelihood will get completed

Fatigue data collection form

Section One: 72 hour Sleep Wake History

Time zone: _____

Date completed: _____

Home Base Time	0000 0100	0100 0200	0200 0300	0300 0400	0400 0500	0500 0600	0600 0700	0700 0800	0800 0900	0900 1000	1000 1100	1100 1200	1200 1300	1300 1400	1400 1500	1500 1600	1600 1700	1700 1800	1800 1900	1900 2000	2000 2100	2100 2200	2200 2300	2300 2400
Three days prior:																							
Two days prior to occurrence: (Date):																							
Day prior to occurrence: (Date):																							
Date of occurrence: (Date):																							

Key: A = awake off duty D = awake on duty S = main sleep period N = nap X = time of event

Notes about any information used to complete this timeline (rosters, smart watch, smart phone, any other information referred to):

Fatigue data collection form

Section two: Related information

Alertness at the time
Please rate your perceived level of alertness **at the time of the accident/incident**
(circle the relevant box)

1	2	3	4	5	6	7
Fully alert	**Very lively**	**Ok, somewhat fresh**	**A little tired**	**Moderately tired**	**Extremely tired**	**Completely exhausted**

Sleep quality
Please rate your quality of sleep for the last sleep period prior to the accident/incident
(circle the relevant box)

Very good	Good	Average	Poor	Very poor

Please rate your quality of sleep for the sleep periods prior to your last sleep period
(circle the relevant box)

Very good	Good	Average	Poor	Very poor

Normal sleep
For a shift/day like the day of the accident/incident, what are your normal sleep and wake times?

Time asleep:		Time awake:	

For days when you are not working, what are your normal sleep and wake times?

Time asleep:		Time awake:	

Medical conditions
Please describe any medical conditions you have (or had at the time) that can affect your sleep or your level of alertness

Medication
Please provide details of any prescription, over-the-counter or natural medications you normally take (or were taking at the time)

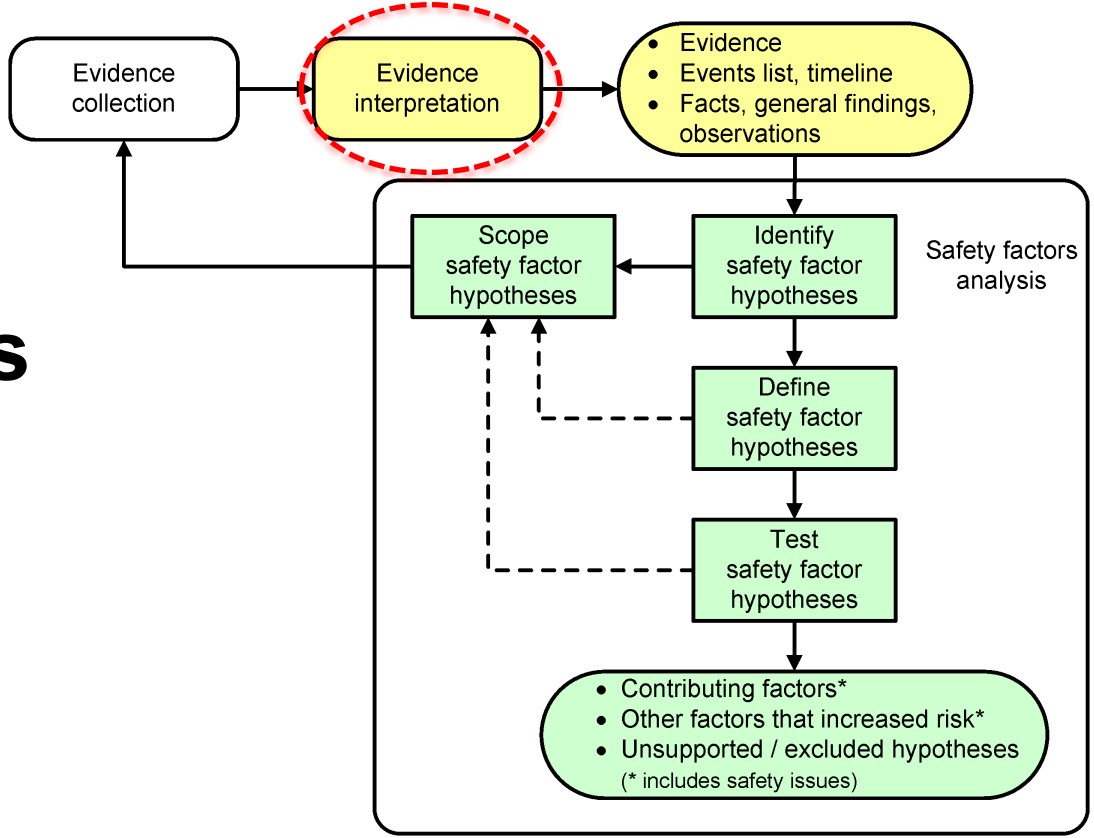
Personal and environmental factors
Please describe any other personal or environmental factors that affected your sleep or alertness prior to the accident/incident (Examples could include newborn children, personal stress, environmental noise, heat/humidity, phone calls…)

Other
Please describe any other factors you believe may have reduced your level of alertness prior to the accident/incident.

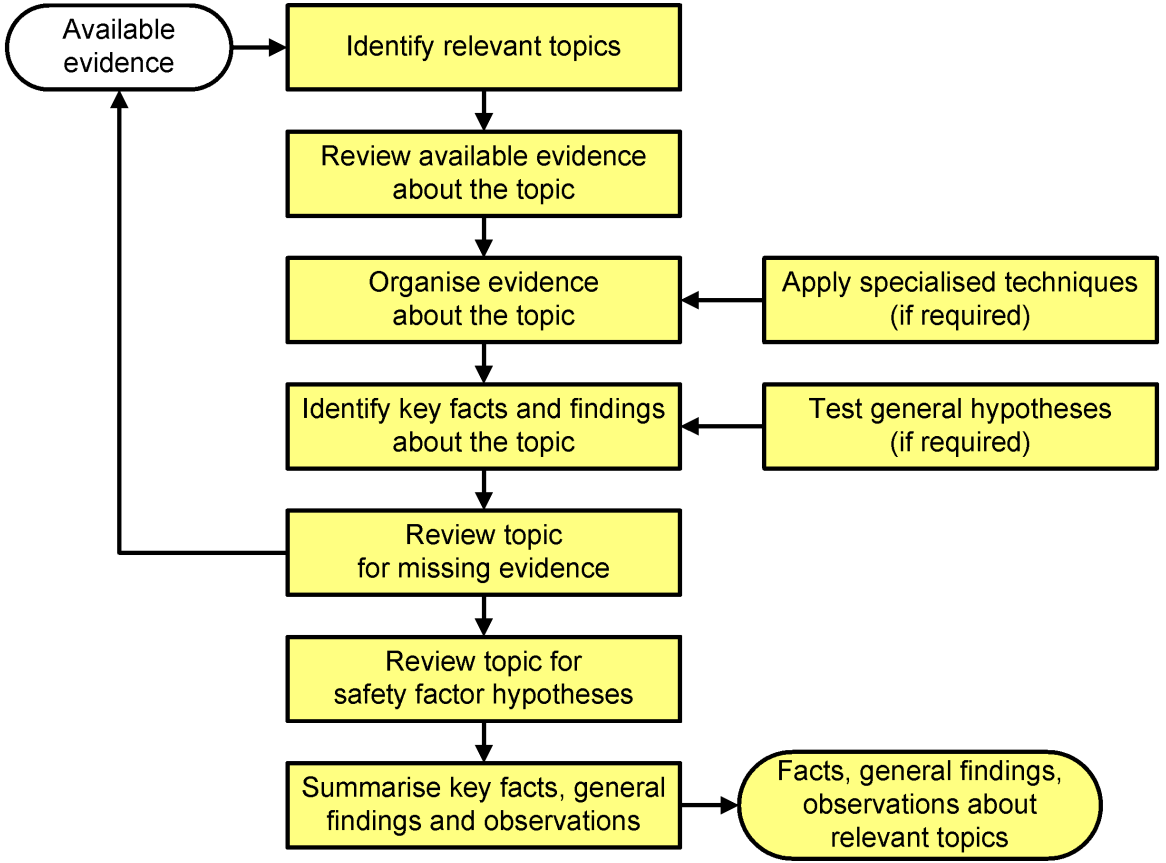
Module 2: Evidence collection

- General aspects
- Types / sources of evidence
- Human factors interviewing
- Asking about fatigue
- Analysing human factors information
- Some more general principles

Safety factors analysis process



Review of relevant topics



Ways of organising evidence

- Chronologically (timeline, event list…)
- Thematically (evidence matrix)
- Comparatively (comparison table)
- Spatially / geographically (overlays, wreckage plots…)
- Statistically (scatter plot…)
- Functionally (flowchart, control structure…)

Types of sequences

- Accident / incident sequence of events
- Individual's recent history (72+ hours)
- Individual's training / experience history
- Maintenance history
- Vehicle / component history
- Project history
- Audit history
- Regulatory oversight of an operator
- Related occurrences

Evidence matrix

Source name	Source details	Observation location	Aircraft details	Timing	Height	Speed	Sound	Direction of travel	Weather
X1	Ex Jetstar pilot	Leongatha	C337, white with green stripes	1200-1300	1,500 ft	Normal cruise	Loud noise	To Inverloch/ Lower Tarwin	Fine
X2	Radio modeller for 35 years	Inverloch	Light coloured, Two engines	1230-1330	1,500 – 2,500 ft	Fair bit faster than 337 that does shark patrols	Very loud Props out of sync	From Moorabbi n to Cape Liptrap	Only very high clouds Very good visibility
X3	Lives in Moorabbin circuit area, so familiar with light aircraft	Beach??	Two push-pull engines Looks like Lockheed Lightning Landing gear retracted	1245	3 times higher than circuit height	Cruise speed	Quieter than C337 taking off	½ km out to sea flying towards Cape Liptrap	Fine, light winds, no reduction in visibility
X4		Inverloch	Twin tails and black markings at		Lower than		Very noisy	Toward Pt Smyth or	Good with light wind

Safety Culture Assessment Tool Worksheet			
Completed by:		**Date:**	
Organization being described:			
	Safety Culture Spectrum		
	Pathological	***Bureaucratic***	***Generative***
	'Extremely discouraging' of effective safety management		***'Extremely encouraging' of effective safety management***
Hazard information is	Suppressed	Ignored	Actively sought
Examples	•		
Safety messengers are	Discouraged or punished	Tolerated	Trained and encouraged
Examples	•		
Responsibility for safety is	Avoided	Fragmented	Shared
Examples	•		
Failures lead to	Cover-ups	Local Fixes	Inquiries and systemic reform
Examples	•		
New ideas are	Crushed	Seen as problems	Welcomed
Examples	•		
Conclusion: Describe the extent to which the organization's safety culture is supportive of effective safety management			
Implication – Is the organization sufficiently mature to implement effective safety management practices and is the degree of oversight being provided appropriate? Explain.			

Note: Remember to update the ISIM safety analysis with any changes or additions.

Guide to investigating organizational and management factors, 2nd Ed, TSB, 2014

Comparing similar things

- Some useful distinctions:
  - Work as imagined (how should be done)
  - Work as done (normally)
  - Work as done (this time)
  - Work as disclosed, observed, instructed, measured…
- Change analysis / gap analysis

Purpose	Comparison of trips		
	A: Trip 1	B: Trip 2 (accident)	C: Normal trip
Context		Manager wanted duck back on time to take out visitors. Driver replaced fuses in main pumps.	
Start	Couple of minutes past scheduled 1100, normal (driver). On time (tour guide)	1339 (bit later than normal)	Start at 1100 or 1330 (or just after)
Ramp	Arrived about 1125 [driver] Problem with main bilge pumps; called mechanic, switched off for few minutes and switched on, did not fix. Used emergency pumps only. [driver] Phone call to mechanic took 4 minutes.	Arrived about 1401 [GPS] Main pumps not working so switched to emergency pumps and front engine pump. [driver]	20-25 minutes to get to water
Time on water	Normal [driver, tour guide] Some time spent dealing with pumps at start	GPS shows entered water about 1401, by 1403 had moved away from ramp. Accident about 1439. Probably had about 4 minutes left on water if continued route to exit ramp.	45 minutes on water [owner] Normally bit back from full speed, slow down at points of interest [driver]
Route taken	Normal [driver, tour guide]	Driver: slowed down at the Carillon as normal – sometimes go through islands fairly slowly to look at birds and Carillon –this time he elected to keep going to catch up some time. Tour guide: Tim went to left of islands when usually go between them –never seen this before.	
Weather	No breeze, water flat. [driver]	Breeze picked up a bit but water pretty flat. Waves up to 20-30 cm. [driver, police]	Don't do tour if too windy or rough [driver, tour guide].
End	About 1300 (normal)		End at 1300 or 1530 (depends on traffic)
Overall assessment			

Useful evaluation questions

Facts and findings about the topic:

- What aspects of the topic are consistent with a normal operation?
- What aspects of the topic are not consistent with a normal operation?
- What aspects of the topic are interesting, salient or distinctive?
- What aspects of the topic are surprising or unusual?
- What patterns or trends about the topic are interesting, salient or distinctive?
- What aspects of the set of evidence are difficult to understand or explain?
- What does the set of evidence suggest about the context in which relevant events and conditions occurred?
- Is there conflicting evidence about any important aspects?
- What are other implications of the set of evidence?
- What else is worth remembering or communicating to others?

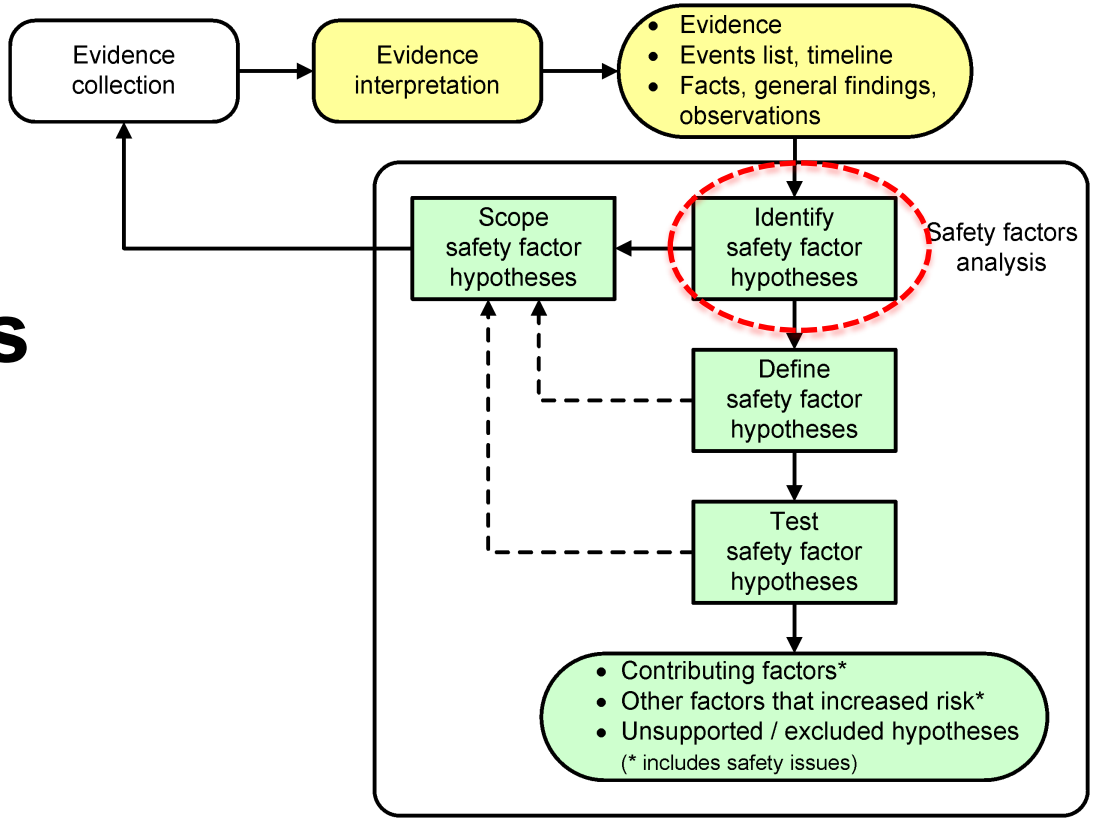
Missing evidence about the topic:

- What key information about the topic is missing?
- Does the set of evidence contain sufficient information about the topic? In what areas would more evidence be useful?
- What other sources of evidence about the topic are available? Are they more useful or reliable than what you already have?

Safety factors:

- What events or conditions associated with the topic appeared to increase risk?
- What events or conditions associated with the topic could or should have decreased risk but did not?

Safety factors analysis process



Some key questions

- If we had the same situation again, what would we want the person to do differently?
- Why did the action make sense to the person at the time?
- What aspects of the local context made it difficult to perform tasks effectively?
- Would other individuals in the same type of situation perform the same way?
  - Yes: what task / environmental / system conditions make you think this?
  - No: what differences between this individual and many others make you think this?
- What was the ‘error type’? What factors are commonly associated with this error type and were potentially relevant this time?

Individual actions

- What actions by safety-critical or front-line personnel increased safety risk?
- If we had the same situation again, what would we want the personnel to do differently?
- What are the individual actions we need to explain?
- What actions by operational personnel were needed to effectively prevent the adverse situation? Which of these actions were not effective?
- What actions by operational personnel were needed to effectively recover from the adverse situation? Which of these actions were not effective?
- What other actions by operational personnel:
  - were unusual compared to normal operations?
  - were absent compared to normal operations?
  - were inconsistent with published or normal procedures?
  - were inconsistent with best practice or ideal performance?
  - have been factors in similar occurrences?

Local conditions to individual actions

- What local conditions increased safety risk?
- Why did the action make sense to the individual(s) at the time?
- What aspects of the local context made it difficult to perform tasks effectively?
- Would other individuals in the same type of situation perform the same way?
  - Yes: what task / environment / system conditions make you think this?
  - No: what differences between this individual and many others make you think this?
- What local conditions:
  - were unusual compared to normal operations?
  - were at levels inappropriate for normal operations?
  - changed in the period prior to when the event(s) occurred?
  - were inconsistent with best practice or the ideal situation?
  - have been factors in similar occurrences?
- Were there limitations with understanding how to do tasks or how the system functioned?
- Were there limitations with the information provided about task progress or system performance?

- Were there problems, limitations or concerns with any of the following:
  - knowledge, skills, experience (including recency, consolidation…)
  - fatigue, alertness (sleep quantity / quality, hours awake, time of day, sustained workload…)
  - medical and physiological factors
  - personal circumstances (recent changes, preoccupations…)
  - recent behaviour (nutrition, hydration, exercise…)
  - task demands (workload amount / complexity, distractions, time pressure…)
  - physical environment (illumination, glare, noise, vibration, temperature, humidity, air quality…)
  - operating environment (weather conditions, visibility, quality of information provided by external parties…)
  - social factors / teamwork (authority gradient, interpersonal differences…)
  - equipment / systems
  - procedures, training, guidance
  - organisational environment (relationship with supervisor, morale, job design, company pressure to do tasks…)

- What was the 'error type'? What factors are commonly associated with this error type and are potentially relevant? Consider the following table.

Error type	Local conditions / aspects to consider
Detection / perception error	Obstructions, target salience, contrast with background Perceptual abilities (vision, hearing) Expectancies (recent / total experience) Focus of attention, workload, distractions, Scanning technique Fatigue (if completely missed)
Situation assessment / diagnostic error	Expectancies (recent / total experience) System knowledge Way information is presented / salience of cues Similarity of perceived situation to actual situation
Decision / action selection error	Training, experience with situation System knowledge Time / task pressure
Action execution slip	Focus of attention, workload, distractions Similarity of task sequence with other tasks Task progress feedback
Action execution lapse	Focus of attention, workload, distractions Reliance on prospective memory Fatigue
Routine violation	Design of procedure (ease of compliance) Awareness / understanding of procedure Consequences if follow versus not follow rules (effort, comfort, perceived risk, peer feedback, supervisory feedback…)
Exceptional violation	As per routine violation Time pressure / task pressure Available resources

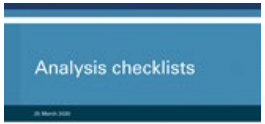
Risk controls

- What risk controls were in place to eliminate, prevent or minimise the likelihood of problems with the occurrence events, individual actions and local conditions? (i.e. preventive controls)
  - Were these controls effective? If not, how were they ineffective?
  - Did these controls operate as designed or intended? If not, how were they different?
- What risk controls were in place to detect, correct, or minimise the consequences of problems with the occurrence events, individual actions and local conditions? (i.e. recovery controls)
  - Were these controls effective? If not, how were they ineffective?
  - Did these controls operate as designed or intended? If not, how were they different?
- What other risk controls could have been in place to better prevent or reduce the likelihood of problems with the occurrence events, individual actions and local conditions?
- What other risk controls could have been in place to better detect or manage problems with the occurrence events, individual actions and local conditions?
- If we had the same situation again, what would we want the organisation to do differently with its risk controls?

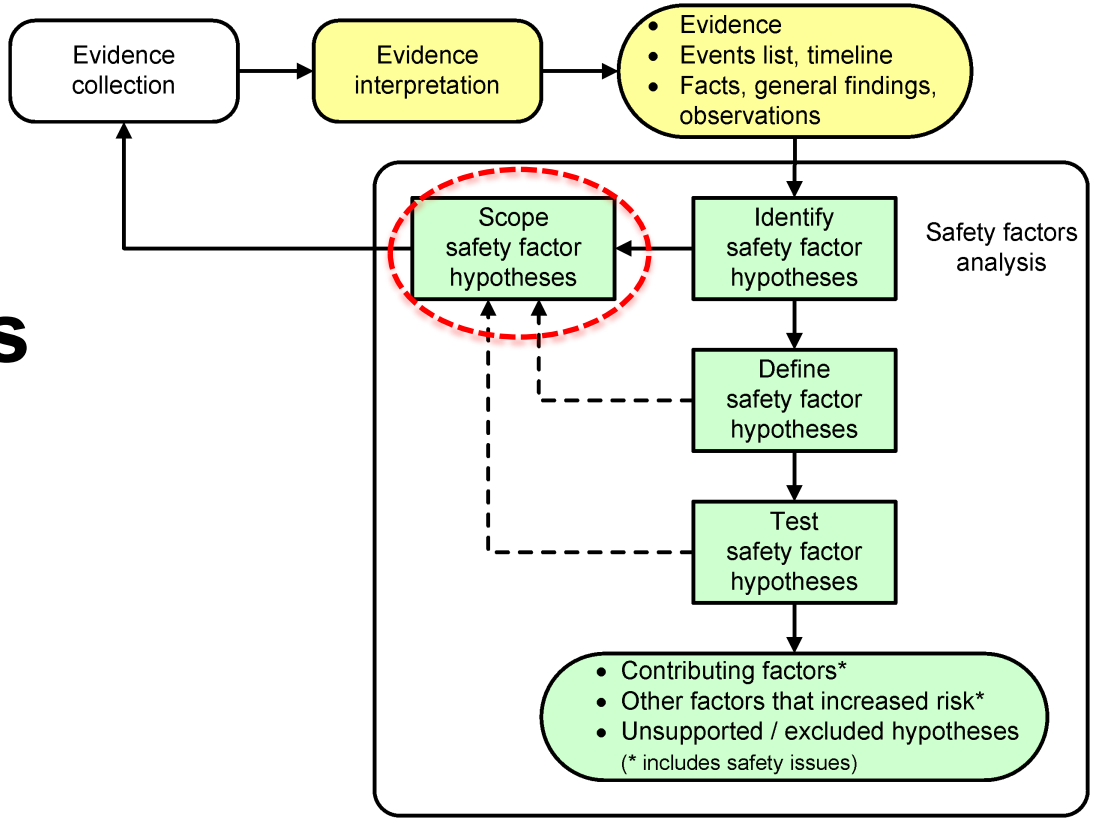
Organisational influences – internal

- What processes did the organisation have in place to develop, monitor, manage and minimise problems with its risk controls?
  - Were these processes effective? If not, how were they ineffective?
  - Did these processes operate as designed or intended? If not, how were they different?
- What other processes could have been in place to better minimise limitations with the risk controls?
- If we had the same situation again, what would we want the organisation to do differently with its safety management processes?
- Why did the design of the risk controls make sense to the organisation (or management personnel) at the time?
- Was there awareness of the problems with the risk controls prior to the occurrence?
  - Yes: what risk assessment and communication processes occurred? Were there any limitations?
  - No: what hazard identification processes occurred? Were there any limitations?
- What internal organisational conditions made it difficult for the organisation to effectively develop, monitor, manage or minimise problems with its risk controls?
- What aspects of the way the organisation was managing its risk controls (or safety in general):
  - were unusual compared to similar organisations?
  - were absent compared to similar organisations?
  - were inconsistent with formal requirements or guidance?
  - had recently changed?
  - have been factors in similar occurrences?

- Were there indications of problems with the organisation's safety culture? What are specific examples? What common themes are involved in these examples?
- Were there problems, limitations or concerns with any of the following:
  - hazard identification, risk assessment
  - training needs analysis, procedures development, equipment selection / testing
  - change management
  - occurrence reporting, occurrence investigation
  - internal auditing
  - collection and analysis of safety information
  - organisational learning / benchmarking
  - organisational structure
  - corporate memory
  - skills of key management / safety personnel
  - communication processes, leadership / management style,
  - safety philosophy / priorities.



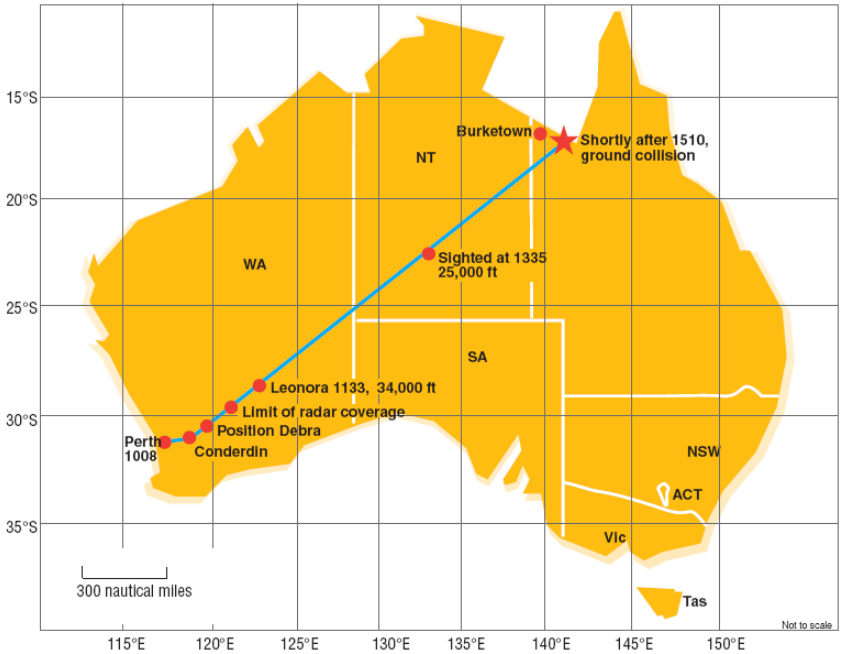
Safety factors analysis process



Identify potentially useful evidence to obtain

- Identify the evidence you would like for each hypothesis. Consider:
  - If the hypothesis is true, what would we expect to see or find? How can we measure this?
  - If the hypothesis is false, what would we expect to see or find? How can we measure this?
  - How can we prove it is true?
  - How can we prove it is false?
  - What data is normally collected for this type of hypothesis? (to prove existence and/or influence)
  - How can we determine the breadth / range / magnitude of the potential problem? (particularly relevant for safety issues)

Expectations – hypoxia?

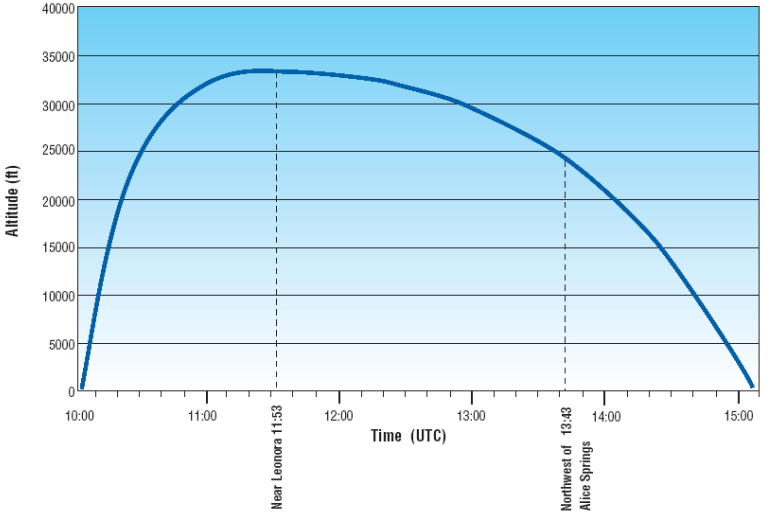


Department of Transport and Regional Services
Australian Transport Safety Bureau

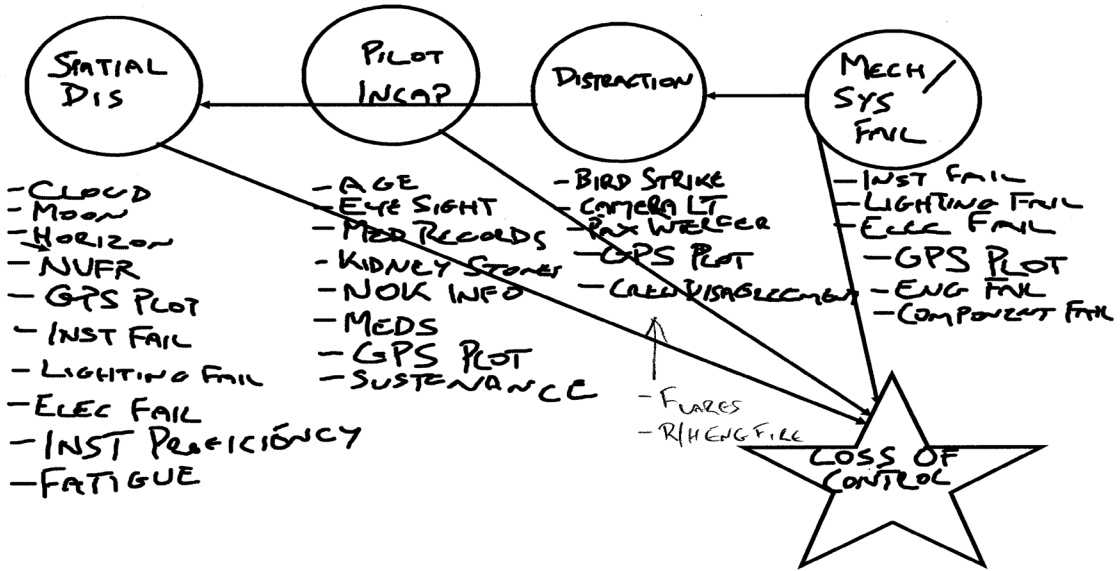
INVESTIGATION REPORT
200003771

Pilot and Passenger Incapacitation

Beech Super King Air 200 VH-SKC
Wernadinga Station, Qld
4 September 2000



Comparing hypotheses



Compare competing hypotheses

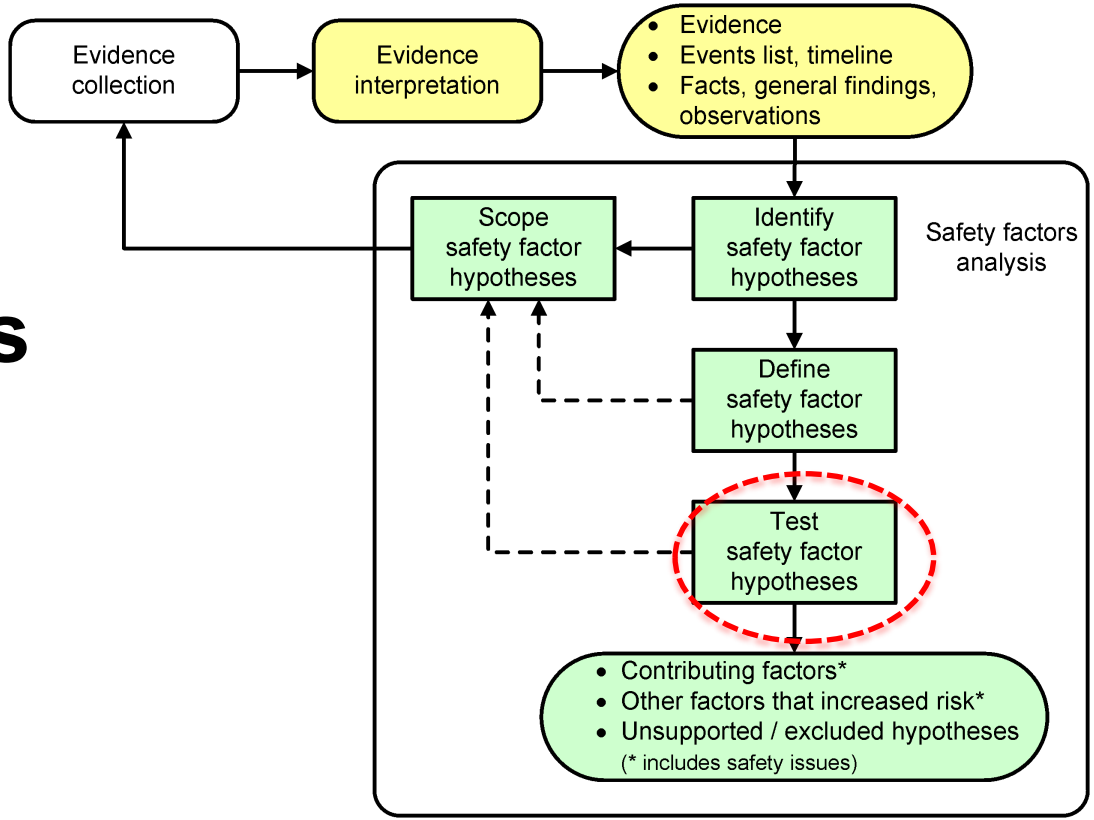
- Key facts: What are the key facts that a good explanation should be able to explain? How well does the SF explain these key facts?
- Existence: What evidence do we have that the SF existed?
- Frequency: How common is the SF?
- Plausibility: How plausible is this explanation?
- Covariation: How often has this SF explained this type of target factor before?
- Expectations: If this SF explains the target factor, what would we expect to see? (existence, influence)
- Required assumptions? If this SF explains the target factor, what assumptions do we need to make? Are these assumptions realistic?
- Other: What are the other strengths of this SF as an explanation? What are the other limitations?

Australian Government
Australian Transport Safety Bureau
ATSB
Analysis checklists
26 March 2020

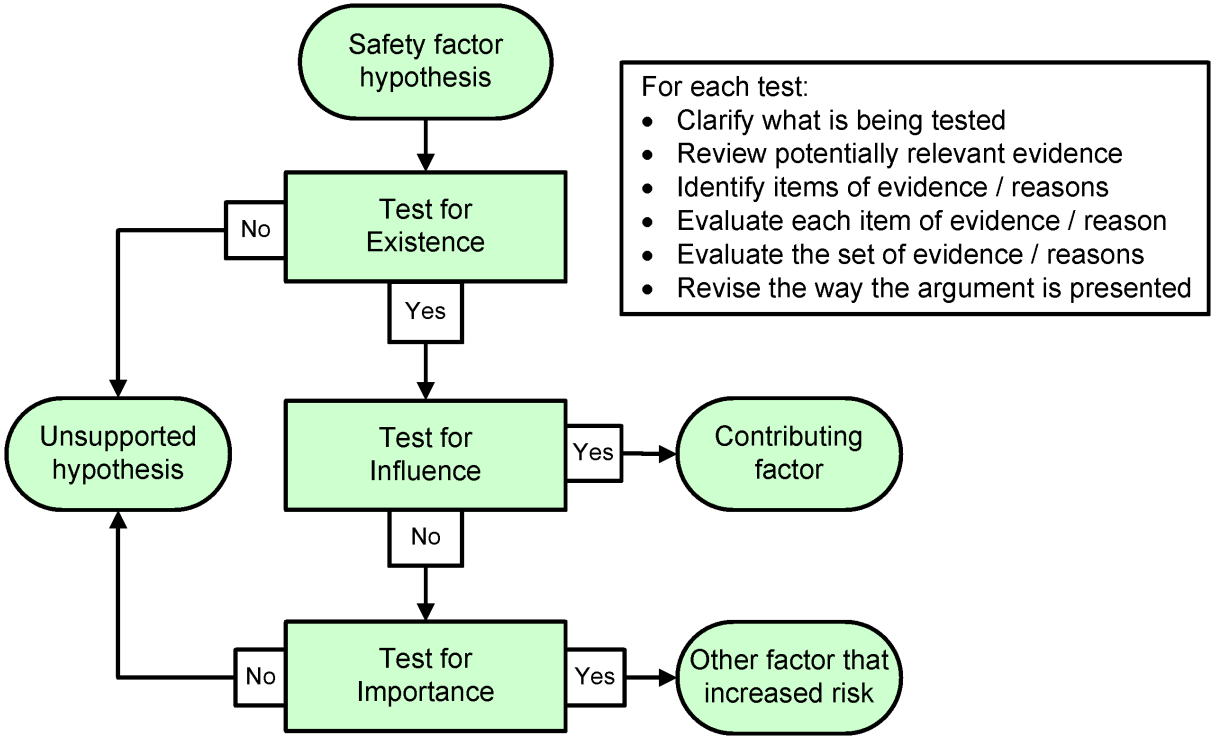
Topic	Incapacitation	Spatial disorientation (SD)
Fact 1: Control of flight appeared normal up to 1,500 ft	Can explain if was sudden incapacitation.	Indicates pilot has some instrument flying ability and using instruments during this period.
Fact 2: Helicopter departed to north-east when should have departed to south	No direct connection.	No direct connection, unless indicates distraction present.
Fact 3: Gradually increasing bank and descent for 38 sec	Unsure - need to confirm whether flight profile consistent with no control inputs (or fixed control inputs)	Can explain if is undetected / uncorrected SD (Type 1)
Existence?	Post-mortem not useful. No real indicators of cardiac problems; has had kidney stones in past but no evidence this time.	No specific or direct evidence available to say either way.
Frequency?	Sudden and total incapacitation is very rare.	More common than total incapacitation, particularly in degraded visual conditions.
Plausibility?	Plausible if flight profile consistent with no control inputs or perhaps fixed control inputs.	Plausible given conditions (e.g. dark night, no autopilot, no instrument rating) if pilot distracted from instruments.

Topic	Incapacitation	Spatial disorientation (SD)
Covariation?	Has been a few cases, but none known with same profile (limited search). Need to confirm flight profile consistent with no control inputs.	SD found in several similar air transport accidents with same profile; also in helicopter accidents. Flight profile much more likely if crew not monitoring instruments.
Expectations?	If kidney stones would expect some prior symptoms (not sudden and total). If sudden / total incapacitation would expect no variation in control inputs.	No visual cues. Pilot with distraction or high workload (not attending to instruments).
Required assumptions?	Sudden / total incapacitation: flight profile is consistent with no or at least sustained control inputs. Passengers do not detect and attempt recovery.	Pilot is not attending to instruments after reaches 1,500 ft. No external visual cues; non-visual cues below detection threshold. Passengers do not detect and attempt recovery
Other strengths / limitations?		May help explain wrong heading after take-off.
Overall assessment	Need to do simulator trials to see if can match flight profile with no / fixed control inputs.	Need to confirm non-visual cues below detection threshold.

Safety factors analysis process



Testing hypotheses



Safety factor hypothesis	The pilot was experiencing a level of fatigue that has been demonstrated to adversely influence performance.

Reason or evidence	Strengths / limitations	Rating
Long duty day, first flight starting 0716 with 8 flights (4.3 hours flight time). Previous day 5 flights and 7.5 hours flight time, ending 1637.	Times from GPS unit and are reliable. However, pilot had regular breaks on day of accident, including prior to accident flight. Flying conditions were also not problematic.	Supports
8 hours + sleep opportunity night before; at least 7 hours (good) sleep previous night and normal 8 hours (good) sleep nights before that.	Exact sleep in last 24 hours unknown. Sleep for previous nights reported by partner and (based on report) not a concern. No other sources available.	Opposes
Accident at 1900 and pilot had been awake at least 12.5 hours.	Time of day not that significant; time awake a concern but not excessive.	No effect
No-one reported noticing any problems with pilot's health or behaviour, or signs of tiredness.	Pilot interacted with many people in afternoon / evening, including just prior to accident flight. All reports consistent. However, ability to detect fatigue would be limited.	Unsure

Overall evaluation	No other exacerbating factors. Long duty day is a concern. However, no apparent cumulative sleep debt and without evidence of affected sleep night before or high workload with the flights it is difficult to conclude the pilot was experiencing a sufficient level of fatigue.
Existence?	No

Existence items
- Direct observation
- Symptoms
- Sources
- Predictions
- Expectations

- Clearly supports
- Clearly opposes
- Generally relevant

- Frequency
- Practicability
- Relative strength

- Other perspectives

Influence items
- Reversibility
- Plausibility
- Covariation
- Alternative explanations

- Clearly supports
- Clearly opposes
- Generally relevant

- Expectations
- Key aspects

- Timing
- Location
- Magnitude
- Enhancers
- Inhibitors

- Other perspectives

Importance items
- Risk level (safety issues)
- Risk-related aspects (not safety issues)

- Relationship to change
- Potential for learning
- Completeness
- Consistency
- Scope
- Other perspectives

Evaluate item
- Relevance
- Credibility

- Other strengths
- Other limitations
- Other perspectives
- Appropriateness

Evaluate set
- All parts
- Assumptions
- Consistency
- Extent of support
- Extent of opposition

- Sufficiency
- Gross error check

Criteria for testing hypotheses

Module 2: Evidence collection

- General aspects
- Types / sources of evidence
- Human factors interviewing
- Asking about fatigue
- Analysing human factors information
- Some more general principles

Some general principles (3)

- Ask lots of questions when identifying contributing factors to individual actions (there are no silly questions)
- Keep an open mind (always ask ‘what else?’)
- Consider error types and cognitive processes when identifying reasons for actions (but do not dwell on them)
- Look for similar occurrences, and analyse for key features, patterns, trends
- Note that ‘interesting’ is not always the same as ‘important’ (always ask ‘so what’)

Some general principles (4)

- Establish existence before influence
- Integrate HF activities into whole investigation
- Use a team-based approach where possible
- Always consider quality / credibility / validity / reliability / relevance of any research evidence you use

Some general principles (5)

- Recognise your limitations and seek assistance when required
- Recognise your potential for decision-making biases
- Treat personal and sensitive information ethically
- Maintain objectivity and fairness
- Use appropriate language in any reports

Importance of language

Terms to avoid	‘Use with caution’	Preferred terms
• Failure • Violation • Complacency • Incompetence • …	• Bias • Conscientiousness • Situational awareness • Error, mistake, lapse, omission…	• Expectation • Fatigue, alertness • Stress • Workload • …

Adapted from Toni Flint (2019)

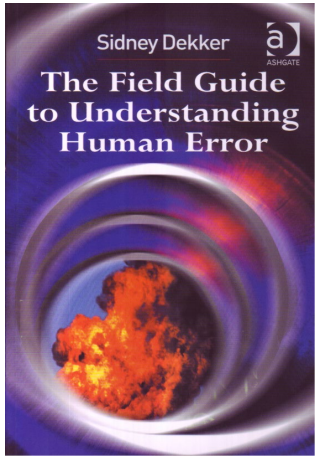
Safety factors analysis process

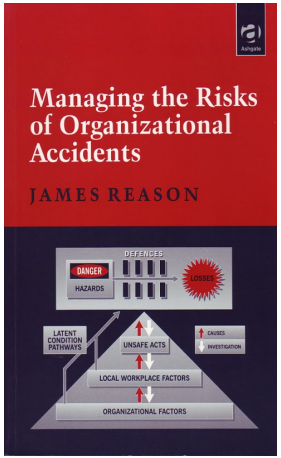
Dekker (Understanding human error)
1. Describe the sequence of events
2. Divide the sequence of events into episodes
3. Find what the world looked like during each episode
4. Identify knowledge, focus of attention and goals
5. Step to a conceptual description

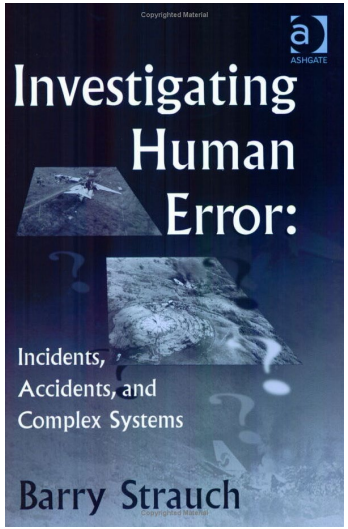
TSB (Canada) (investigating human factors)
1. Collect occurrence data
2. Determine occurrence sequence
3. Identify unsafe acts/decision and conditions
4. Identify error or adaptation (violation) type
5. Identify failure modes
6. Identify behavioural antecedents
7. Identify potential safety problems

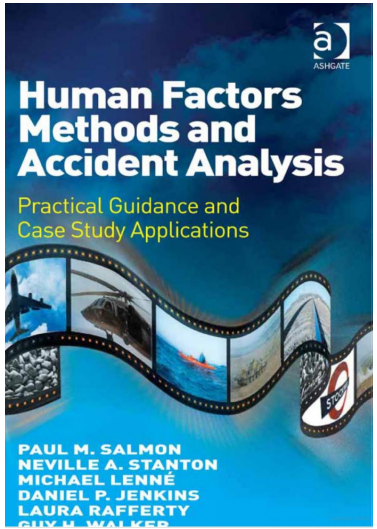
Safety factors analysis process

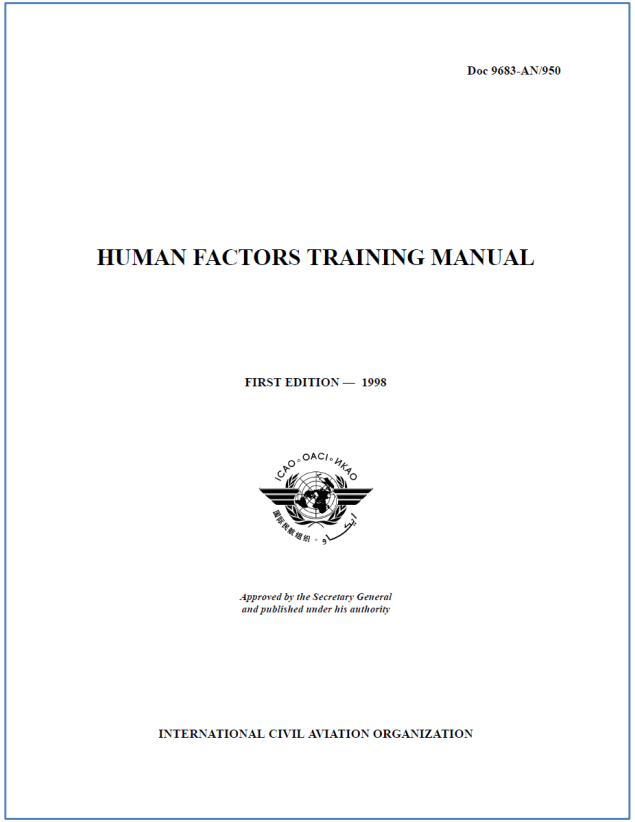
ATSB (investigating human factors)
1. Evidence collection
2. Evidence interpretation (including sequence of events)
3. Identify, define, test - individual actions that increased risk
4. Identify, define, test - local conditions that increased risk
5. Identify, define, test - risk controls that increased risk
6. Decide if mandate to examine organisational influences
7. Identify, define, test – organisational influences that increased risk


Sidney Dekker
The Field Guide to Understanding Human Error
ASHGATE


Managing the Risks of Organizational Accidents
JAMES REASON
DEFENCES
DANGER
HAZARDS
LOSS
LATENT CONDITION PATHWAYS
UNSAFE ACTS
CAUSES
INVESTIGATION
LOCAL WORKPLACE FACTORS
ORGANIZATIONAL FACTORS


Copyrighted Material
Investigating Human Error:
Incidents, Accidents, and Complex Systems
Barry Strauch
ASHGATE


Human Factors Methods and Accident Analysis
Practical Guidance and Case Study Applications
PAUL M. SALMON
NEVILLE A. STANTON
MICHAEL LENNÉ
DANIEL P. JENKINS
LAURA RAFFERTY
ASHGATE


Doc 9683-AN/950
HUMAN FACTORS TRAINING MANUAL
FIRST EDITION — 1998
ICAO • OACI • ИКАО
Approved by the Secretary General and published under his authority
INTERNATIONAL CIVIL AVIATION ORGANIZATION