Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

Lessons Learned from Human Factors Related Occurrence Investigations

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09 August 2016

Canada

Outline

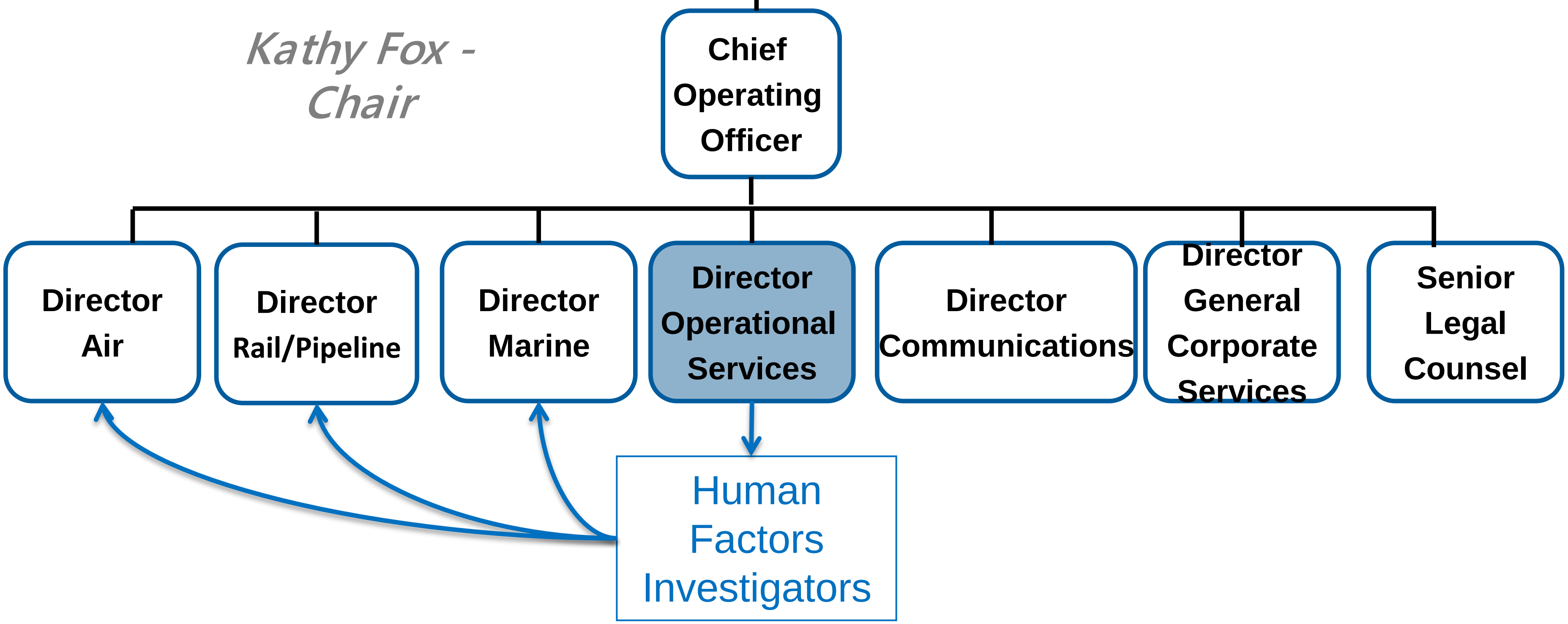
- Transportation Safety Board of Canada
- Investigating accidents
- Human and organizational factors
- Synopsis and findings from selected recent investigations

Transportation Safety Board of Canada

- Independent agency
- Report to Parliament through Government House Leader

- Mandate is to advance transportation safety in the marine, pipeline, rail and air modes of transportation by
    - Conducting independent investigations
    - Establishing what happened and why
    - Identifying safety deficiencies
    - Making recommendations
    - Reporting publicly on our findings

Kathy Fox - Chair



220 Employees; annual budget of CAD$30 million

Fulfilling our mandate

- Canadian Transportation Accident Investigation Safety Board Act (CTAISB)
  - Independence
  - Powers of investigation
  - Protection of information
  - Do not apportion fault or blame

- TSB Regulations
  - Defines accident / incident
  - Reporting
  - Legal framework to conduct investigations

How we investigate accidents

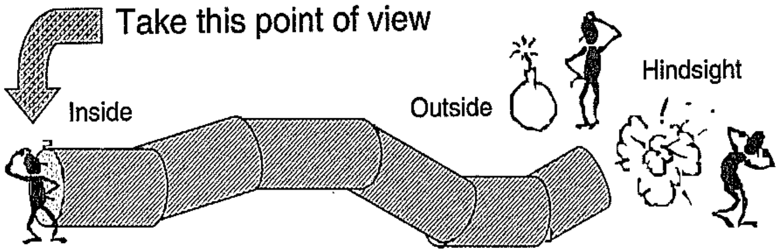
- Integrated Safety Investigation Methodology (ISIM)
- Iterative steps as understanding of the occurrence and safety deficiencies unfold
- Multi-causality model of accident causation, and not a primary cause.

Human factors

"Human Factors is concerned to optimize the relationship between people and their activities, by the systematic application of human sciences, integrated within the framework of systems engineering"

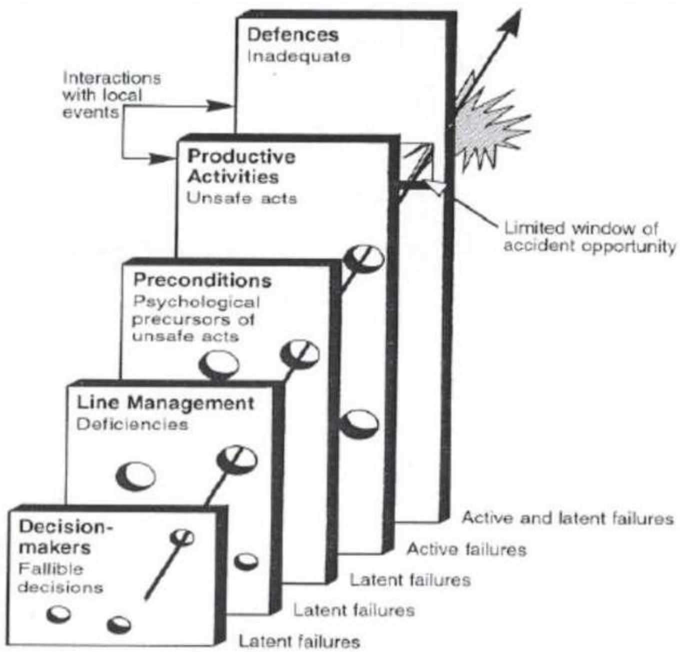
- ICAO Doc 9683 Human Factors Training Manual

Methods behind human factors investigation



Dekker, S. (2002).

Hawkins, E. (2005).



Reason, J. (2003).

Human factors data enable us to:

- Construct a history of actions and assessments
- Analyse the SHEL interfaces to determine breakdowns
- Determine what likely influenced the actions and assessments and why they made sense at the time
- Explain why the event sequence was not interrupted before the mishap
- Fully support the existence of an identified safety deficiency

Organization and management factors

Conditions which negatively impact human performance and make errors more likely; or negatively impact the organization's ability to proactively identify and deal with these conditions.

- A guide for investigating organizational and management factors, TSB

Methods behind organizational and management factors investigation

I need to decide how far to go in my investigation — Go to — Scoping Tool

I need to examine the flow of information about a hazard/ condition — Go to — "Who knew what?" Analysis

I need to show the link between O&M issues and this occurrence. — Go to — O&M Factor Assessment Tool

I need to describe the organization's safety culture — Go to — Safety Culture Assessment Tool

I need to verify that my analysis is sound — Go to — Quality Assurance Tool

Selected recent investigations

Operational Context

"The reconstruction of the mindset begins not with the mind. It begins with the circumstances in which the mind found itself."

Dekker (2002)

Resolute Bay – Controlled Flight into Terrain
Boeing 737-210C
20 August 2011

https://youtu.be/CHnmEp-fHxM

Findings as to causal and contributing factors A11H0002

1. The late initiation and subsequent management of the descent resulted in the aircraft turning onto final approach 600 feet above the glideslope, increasing the crew's workload and reducing their capacity to assess and resolve the navigational issues during the remainder of the approach.
2. When the heading reference from the compass systems was set during initial descent, there was an error of -8°. For undetermined reasons, further compass drift during the arrival and approach resulted in compass errors of at least -17° on final approach.
3. As the aircraft rolled out of the turn onto final approach to the right of the localizer, the captain likely made a control wheel roll input that caused the autopilot to revert from VOR/LOC capture to MAN and HDG HOLD mode. The mode change was not detected by the crew.

Findings as to causal and contributing factors A11H0002

4. On rolling out of the turn, the captain's horizontal situation indicator displayed a heading of 330°, providing a perceived initial intercept angle of 17° to the inbound localizer track of 347°. However, due to the compass error, the aircraft's true heading was 346°. With 3° of wind drift to the right, the aircraft diverged further right of the localizer.
5. The crew's workload increased as they attempted to understand and resolve the ambiguity of the track divergence, which was incongruent with the perceived intercept angle and expected results.
6. Undetected by the pilots, the flight directors likely reverted to AUTO APP intercept mode as the aircraft passed through 2.5° right of the localizer, providing roll guidance to the selected heading (wings-level command) rather than to the localizer (left-turn command).

Findings as to causal and contributing factors A11H0002

7. A divergence in mental models degraded the crew's ability to resolve the navigational issues. The wings-level command on the flight director likely assured the captain that the intercept angle was sufficient to return the aircraft to the selected course; however, the first officer likely put more weight on the positional information of the track bar and GPS.
8. The crew's attention was devoted to solving the navigational problem, which delayed the configuration of the aircraft for landing. This problem solving was an additional task, not normally associated with this critical phase of flight, which escalated the workload.
9. The first officer indicated to the captain that they had full localizer deflection. In the absence of standard phraseology applicable to his current situation, he had to improvise the go-around suggestion. Although full deflection is an undesired aircraft state requiring a go-around, the captain continued the approach.

Findings as to causal and contributing factors A11H0002

10. The crew did not maintain a shared situational awareness. As the approach continued, the pilots did not effectively communicate their respective perception, understanding, and future projection of the aircraft state.
11. Although the company had a policy that required an immediate go-around in the event that an approach was unstable below 1000 feet above field elevation, no go-around was initiated. This policy had not been operationalized with any procedural guidance in the standard operating procedures.
12. The captain did not interpret the first officer's statement of “3 mile and not configged” as guidance to initiate a go-around. The captain continued the approach and called for additional steps to configure the aircraft.

Findings as to causal and contributing factors A11H0002

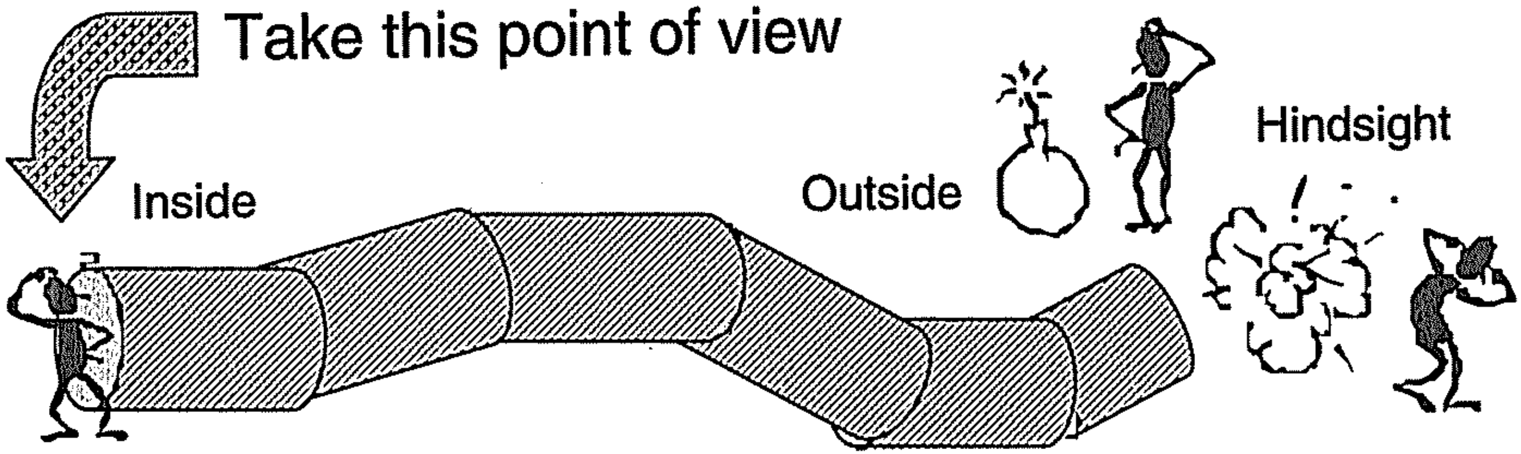
13. The first officer was task-saturated, and he thus had less time and cognitive capacity to develop and execute a communication strategy that would result in the captain changing his course of action.
14. Due to attentional narrowing and task saturation, the captain likely did not have a high-level overview of the situation. This lack of overview compromised his ability to identify and manage risk.
15. The crew initiated a go-around after the ground proximity warning system "sink rate" alert occurred, but there was insufficient altitude and time to execute the manoeuvre and avoid collision with terrain.
16. The first officer made many attempts to communicate his concerns and suggest a go-around. Outside of the two-communication rule, there was no guidance provided to address a situation in which the pilot flying is responsive but is not changing an unsafe course of action. In the absence of clear policies or procedures allowing a first officer to escalate from an advisory role to taking control, this first officer likely felt inhibited from doing so.

Findings as to causal and contributing factors A11H0002

17. The crew's crew resource management was ineffective. First Air's initial and recurrent crew resource management training did not provide the crew with sufficient practical strategies to assist with decision making and problem solving, communication, and workload management.
18. Standard operating procedure adaptations on FAB6560 resulted in ineffective crew communication, escalated workload leading to task saturation, and breakdown in shared situational awareness. First Air's supervisory activities did not detect the standard operating procedure adaptations within the Yellowknife B737 crew base.

“Why did their actions and assessments make sense at the time?

WHY DID IT MAKE SENSE?



Have you ever looked back on an event and said ‘why didn’t I see that ahead of time?’ When inside an unfolding situation signals are weak and what is important and unimportant is not always obvious.

Pitch excursion
Boeing 767-333
14 January 2011

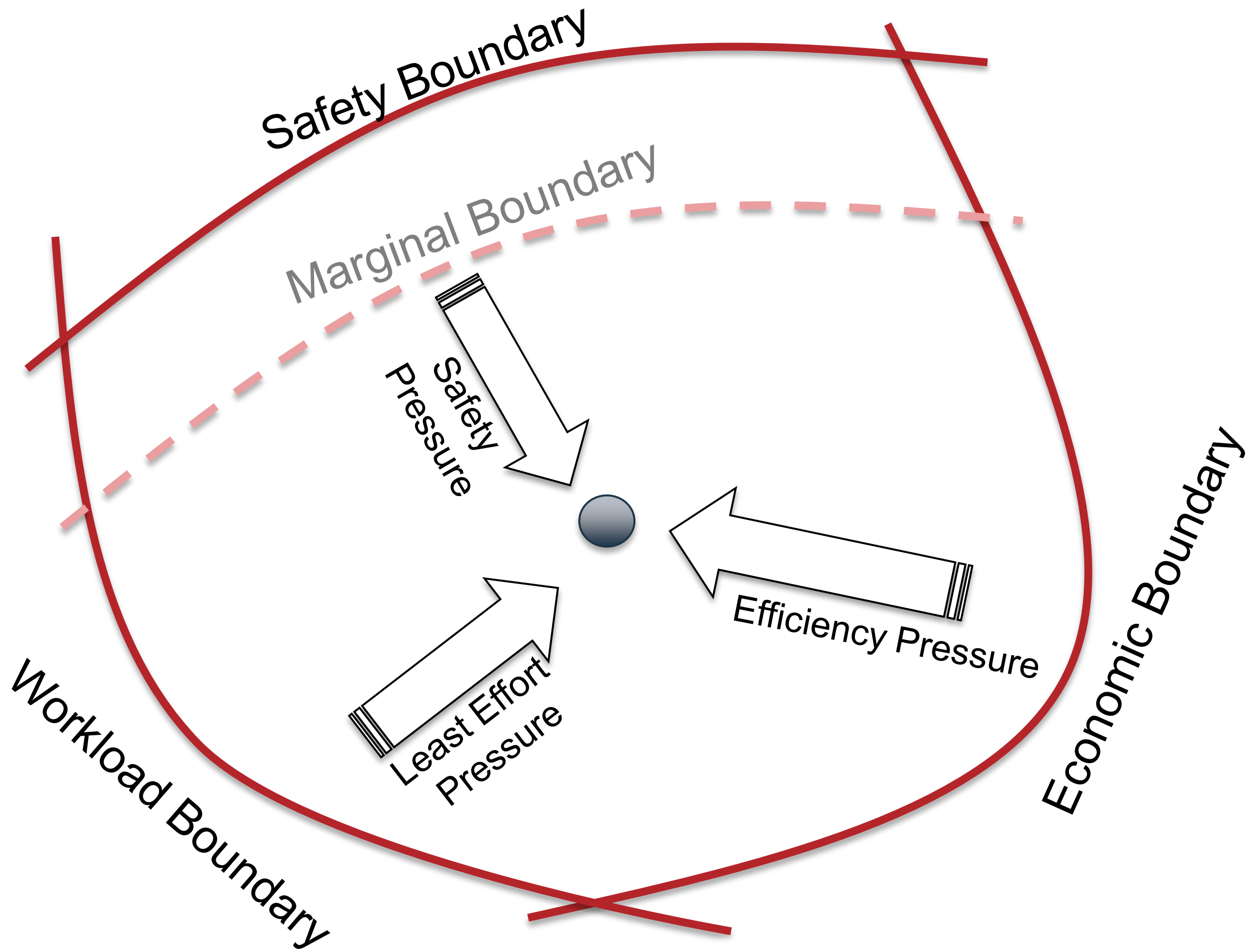
Findings as to causal and contributing factors A11F0012

1. The interrupted sleep obtained by the first officer prior to the flight increased the likelihood that rest would be needed during the overnight eastbound flight.
2. The first officer slept for approximately 75 minutes which likely placed the first officer into slow–wave sleep and induced longer and more severe sleep inertia.
3. The first officer was experiencing a circadian low due to the time of day and fatigue due to interrupted sleep which increased the propensity for sleep and subsequently worsened the sleep inertia.
4. By identifying the oncoming aircraft, the captain engaged the first officer (FO) before the effects of sleep inertia had worn off.

Findings as to causal and contributing factors A11F0012

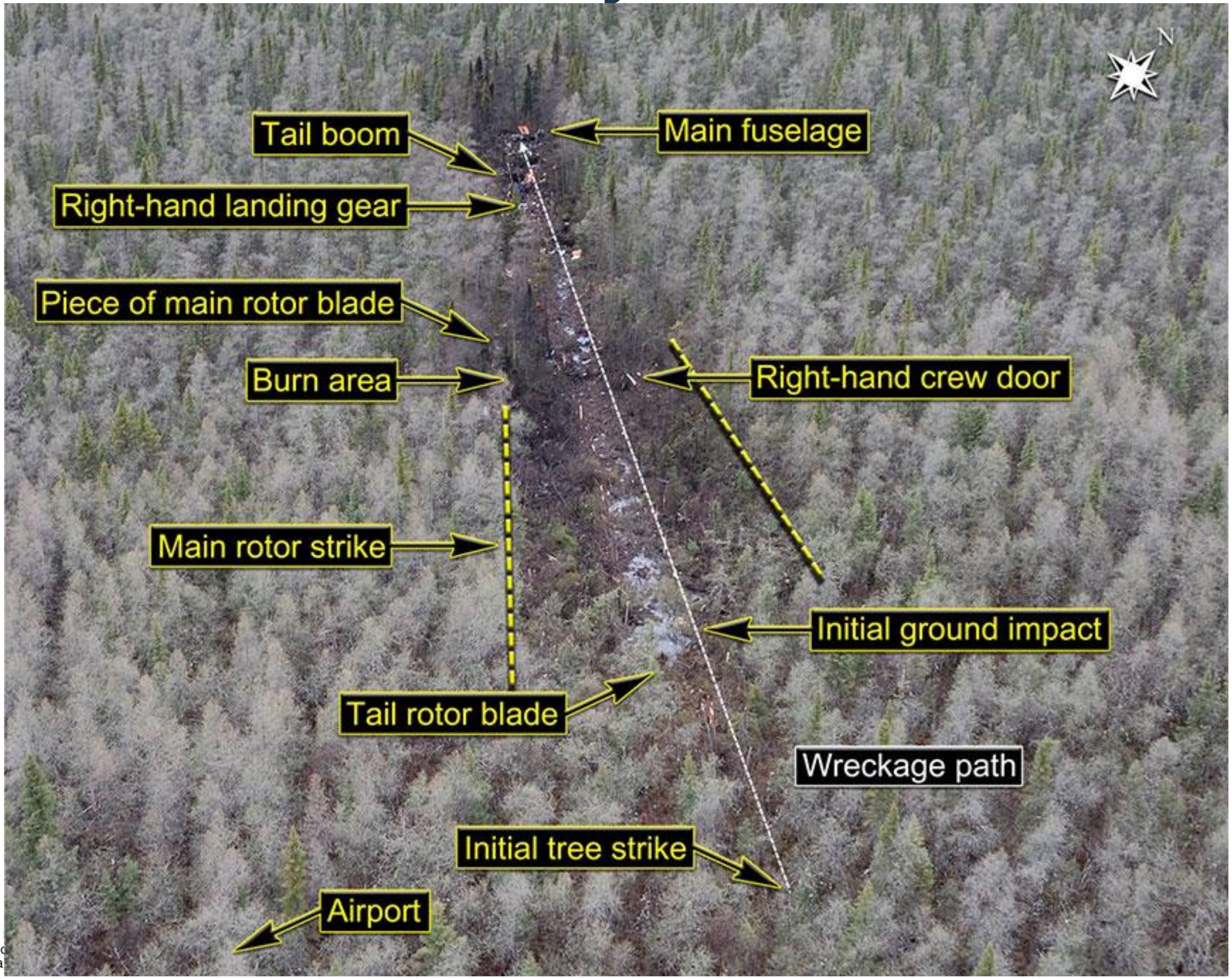
5. Under the effects of sleep inertia, the first officer perceived the oncoming aircraft to be on a collision course and pushed forward on the control column.
6. The frequency of training and depth of the training material on fatigue risk management to which the flight crew were exposed were such that the risks associated with fatigue were not adequately understood and procedures for conducting controlled rest were not followed by the flight crew.
7. Although the seatbelt sign was on and an announcement about potential turbulence was made, several passengers were injured during the event because they were not wearing their seatbelt.

Rasmussen’s Safe Operating Envelope

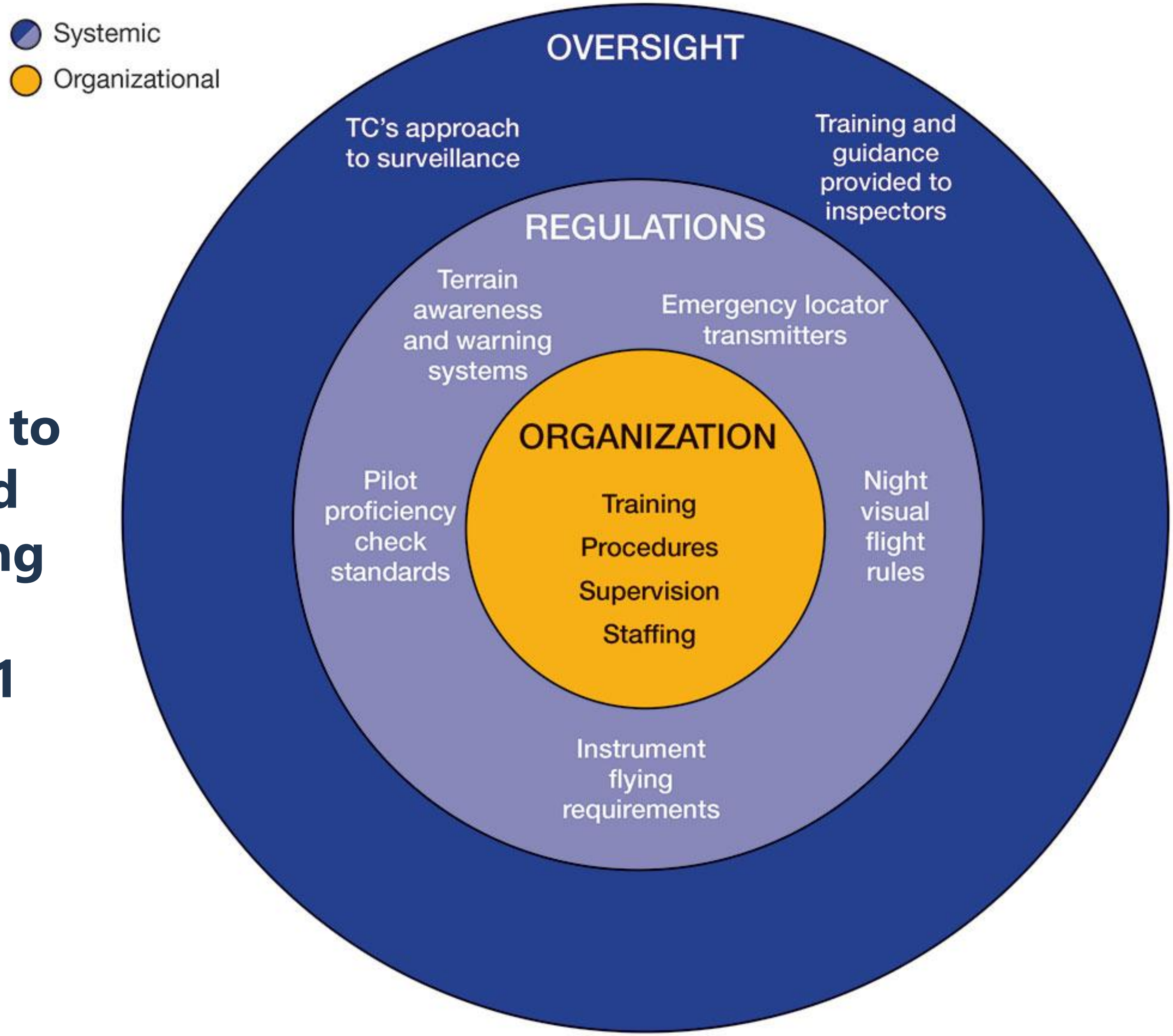


Adapted from Cook and Rasmussen (2005) in Woods, D., Schenk, J. and Allen, T.T. (2009). *An Initial Comparison of Selected Models of System Resilience*. In: C.P. Nemeth, E. Hollnagel and S. Dekker (Eds). Resilience Engineering Perspectives, Volume 2: Preparation and Restoration p.80

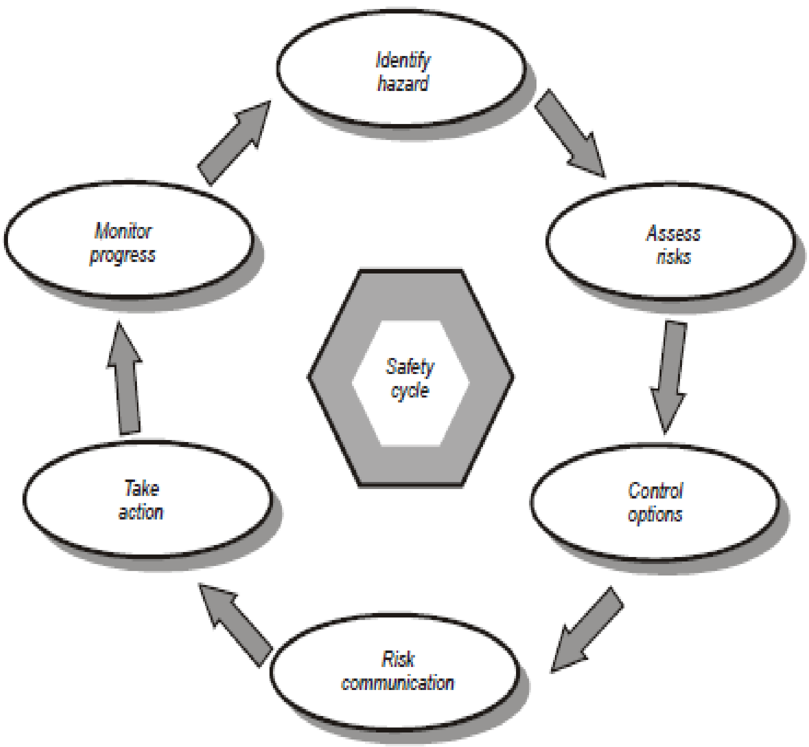
Controlled flight into terrain
Sikorsky S-76A (helicopter)
31 May 2013



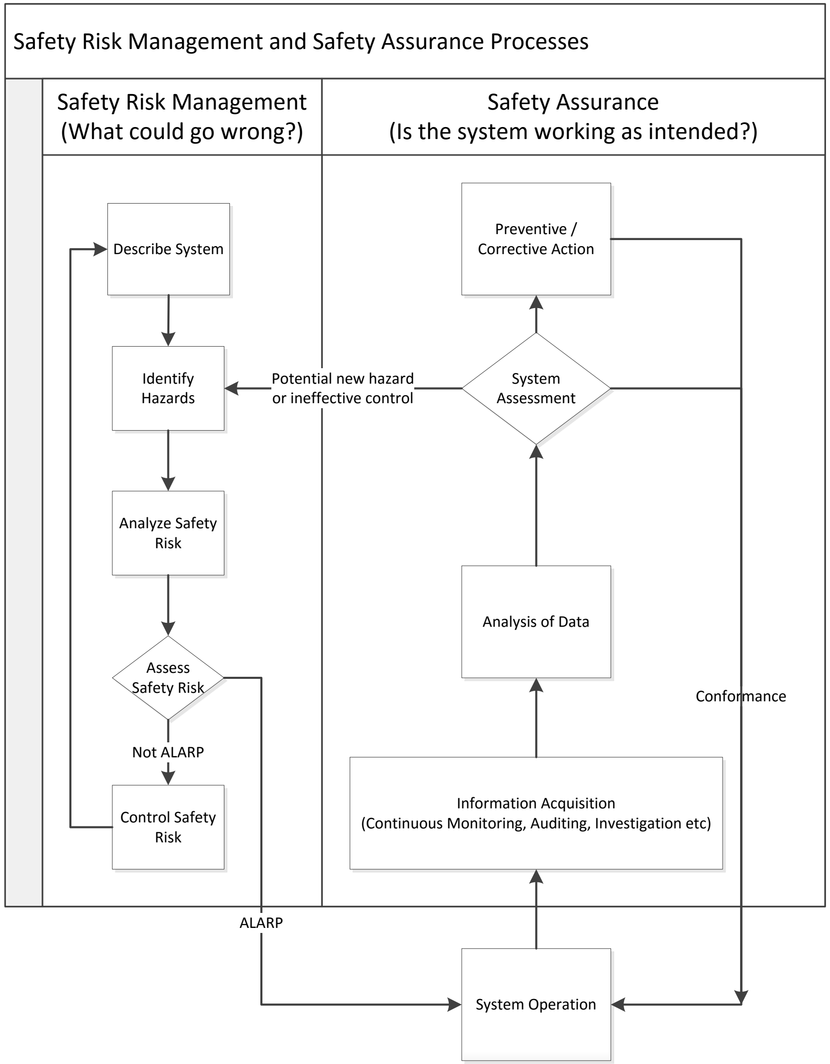
Findings as to causal and contributing factors A13H0001



Safety management and SMS

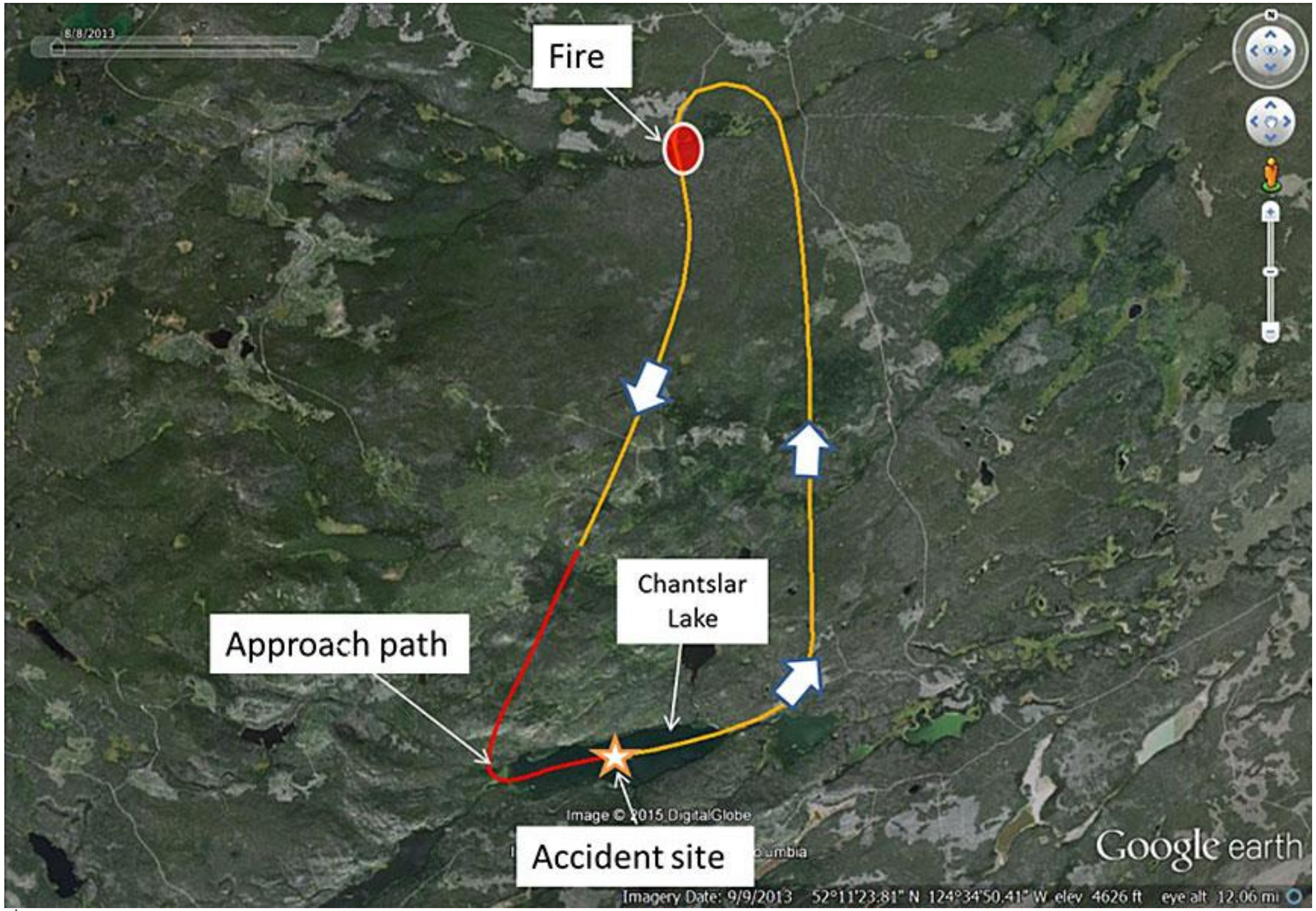


From ICAO Doc 9859.



From: Stroltzer et al (2008). Safety Management Systems in Aviation.

Stall at takeoff and collision with water
Air Tractor AT-802A Fire Boss Amphibian
14 August 2014

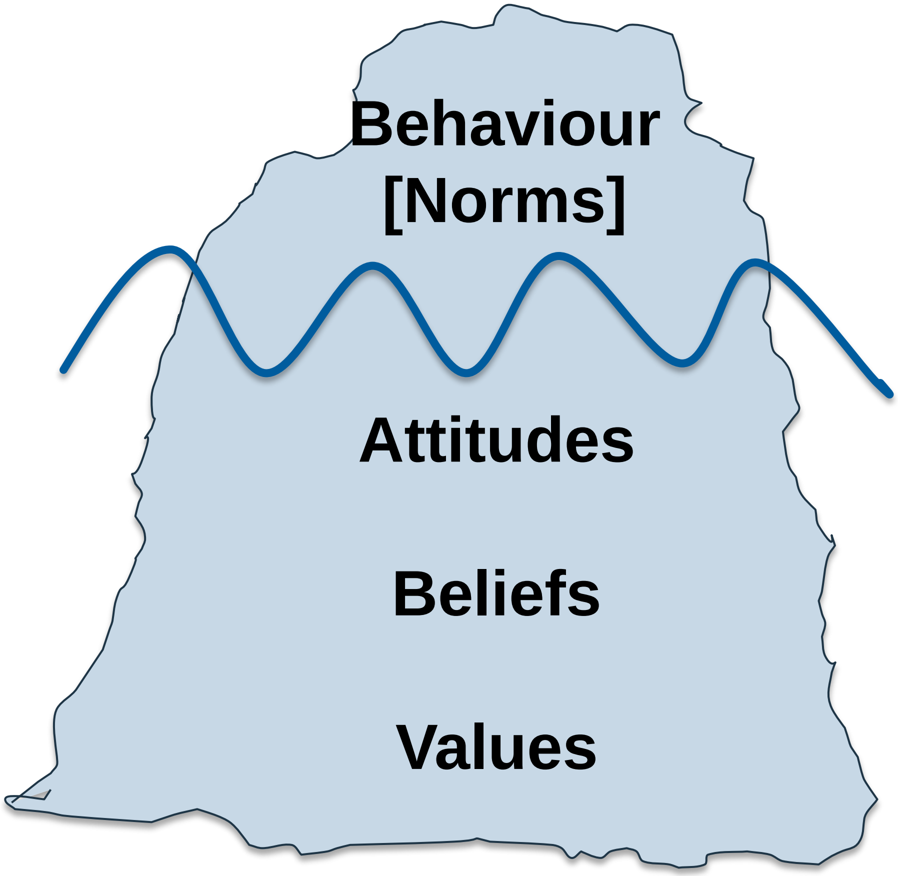


Findings as to causal and contributing factors A14P0132

1. A wing stalled either independently or in combination with an encounter with a wing-tip vortex generated by the lead aircraft. This caused a loss of control moments after liftoff, and resulted in the right-hand wing tip contacting the water and in a subsequent water-loop.
2. The operator's standard takeoff procedures did not specify a liftoff speed for scooping operations. Lifting off below the published power-off stall speed contributed to a loss of control at an altitude insufficient to permit a recovery.
3. The takeoff condition, with the aircraft heavy, its speed below the published power-off stall speed, and a high angle-of-attack contributed to the loss of control.
4. An understaffed management structure during organizational changes likely led to excessive workload for existing managers. This contributed to risks, contained within the standard operating procedures, not being addressed through the operator's safety management system, resulting in continued aircraft operations below published minimum airspeed limitations.

Safety Culture

Shared **values** (what is important) and **beliefs** (how things work) that interact with and organization's structures and control systems **to produce behavioural norms** (the way we do things around here)



Reason, J. (1997). Managing the Risks of Organizational Accidents. Ashgate, p.192.

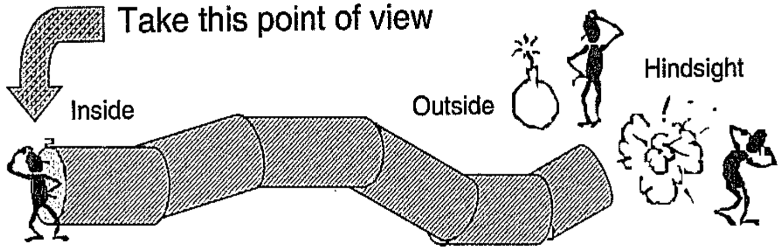
Engine failure after takeoff and collision with terrain DC-3C

Findings as to causal and contributing factors A13W0120

1. An accurate take-off weight and balance calculation was not completed prior to departure, resulting in an aircraft weight that exceeded its maximum certified take-off weight.
2. The right engine number 1 cylinder failed during the take-off sequence due to a pre-existing fatigue crack, resulting in an engine fire.
3. After the right propeller's feathering mechanism was activated, the propeller never achieved a fully feathered condition likely due to a seized bearing in the feathering pump.
4. The windmilling right propeller caused an increase in drag which, combined with the overweight condition, contributed to the aircraft's inability to maintain altitude, and the aircraft collided with terrain short of the runway.
5. The operator's safety management system was ineffective at identifying and correcting unsafe operating practices.
6. Transport Canada's surveillance activities did not identify the operator's unsafe operating practices related to weight and balance and net take-off flight path calculations. Consequently, these unsafe practices persisted.

Current investigations are examining

- Training, procedures, and energy management related to unstable approaches
- Use of restraints and passenger safety during turbulence



Dekker, S. (2002).

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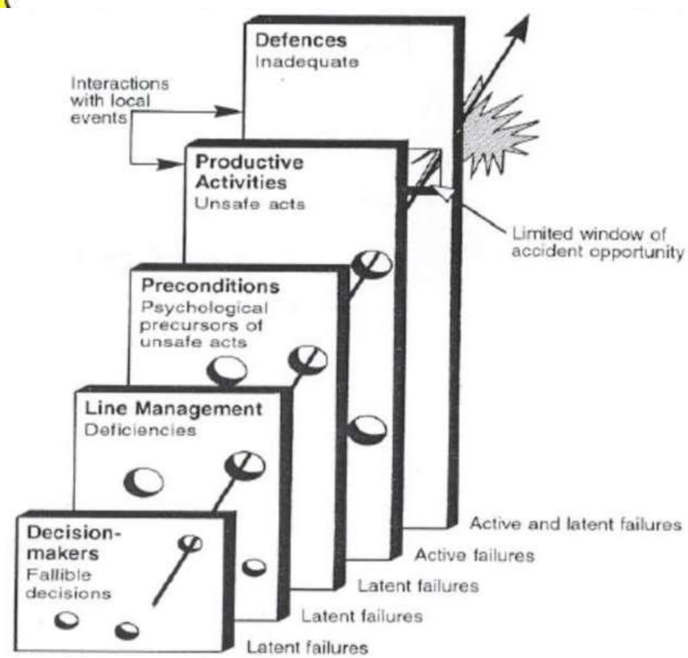

Reason, J. (2003).

Summary

Common factors include:

- Operations and context
- Physiology and fatigue
- Organizational response to financial and other pressure
- Safety management maturity
- Procedures and practice
- Crew coordination
- Stabilized approach
- Regulatory oversight
- Safety culture
- Company management

Your Experience

- Does your agency have a process for investigating safety management?
- Have you experienced the challenges we talked about?
- How did you overcome these challenges?

Canada