Best Practices in Safety Investigations

How to write a balanced Just Culture investigation report

Tony Licu
Head of Safety Unit
EUROCONTROL Network Manager Directorate
Castelldefels/Barcelona May 2017
Overview

- Background to Safety-II thinking
- S-I and S-II in a nutshell
- Systemic Thinking and its 10 principles
- S-II in Investigations
- Systemic Occurrence Analysis Methodology
Safety-I and Safety-II

In a nutshell
Safety-I in a nutshell

- **Definition of safety:** As few things as possible go wrong
- **Manifestation:** Adverse outcomes, ‘unacceptable’ risks
- **Mechanism:** Causality credo
- **Foundation:** Bimodality & decomposability
- **View of human:** Predominantly treated as a liability or hazard
- **Safety management principle:** Respond to occurrences or unacceptable risks
- **Occurrence investigation:** Identify causes & contributory factors to adverse outcomes
- **Risk assessment:** Determine likelihood of adverse outcomes
Safety-II in a nutshell

- **Definition of safety**: As many things as possible go right
- **Manifestation**: All possible outcomes, especially typical ones
- **Mechanism**: Emergence
- **Foundation**: Performance adjustments & performance variability
- **View of human**: Resource necessary for system flexibility and resilience
- **Safety management principle**: Continuously anticipate developments and events
- **Occurrence investigation**: Understand how things usually go right as a basis for understand how they occasionally go wrong
- **Risk assessment**: Understand conditions where performance variability can become difficult or impossible to monitor and control
Systems Thinking for Safety

Systems Thinking for Safety: Ten Principles
A White Paper
Moving towards Safety-II

DNM Safety

FIELD EXPERT INVOLVEMENT
LOCAL RATIONALITY
JUST CULTURE
DEMAND & PRESSURE
RESOURCES & CONSTRAINTS
INTERACTIONS & FLOWS
TRADE-OFFS
PERFORMANCE VARIABILITY
ENRICHMENT
EQUIVALENCE
Putting systems thinking in practice

Practical advice structured around 10 Principles

Principle 2. Listen

People do things that make sense to them and in their context. Listen to their stories and understand their objectives, goals, and focus of attention at the time.

Work needs to be understood from the perspective of the people doing the work.

Listen to people’s stories. Consider how field experts can best tell their stories from the point of view of how they experienced events at the time. Try to understand the person’s situation and world from their point of view, both in terms of the context and their moment-to-moment experience.

Understand goals, plans and expectations in context. Discuss individual goals, plans and expectations in the context of the flow of work and the system as a whole.

Understand knowledge, activities and focus of attention. Focus on knowledge at the time, not your knowledge now. Understand the various activities and focus of attention at a particular moment and in the general time-frame. Consider how things made sense to those involved, and the system implications.

Seek multiple perspectives. Don’t settle for the first explanation; seek alternative perspectives. Discuss different perceptions of events, situations, problems and opportunities, from different field experts and perspectives. Consider the implications of these differential views for the system.

Read more
1. Involve field experts as co-designers, co-investigators, co-researchers, co-learners

2. Understand local perspectives, stories and experiences

3. Reflect on our mindsets, assumptions & language

4. Consider demand on the system and the pressure imposed

5. Investigate the adequacy of resources appropriateness of constraints

6. Look at flows of work and system interactions

7. Understand trade-offs in context

8. Understand adjustments and the nature of variability

9. Consider system-wide patterns, cascades & surprises-in-waiting

10. Understand everyday work

System Focus

Equivalence

Field Expert Involvement

Local Rationality

Just Culture

Demand & Pressure

Resources & Constraints

Interactions & Flows

Trade-offs

Performance Variability

Emergence

Trade-offs in context

Interactions & Flows

Resources & Constraints

Demand & Pressure

Local Rationality

Just Culture

Field Expert Involvement

Equivalence
How to find out what goes right...

Safety Investigation
Rationale

- Need to move on from ‘human error’
- Reduce fear of considering human performance
- Put human performance in proper system context
- Integrate insights from systems safety, systems human factors, and systems thinking
- Make theory more engaging and memorable
- White Paper available on SKYbrary

http://www.youtube.com/watch?v=CD9YqdWwwdw
Moving forward with Safety-II

System Focus

View of system outcomes
- Equivalence
- Field Experts
- Local Rationality
- Just Culture

View of the person as part of the system
- Demand, Production Pressure & Goal Conflicts
- Resources & Constraints
- Interactions & Flow
- Efficiency-Thoroughness Trade-off
- Performance Variability
- Emergence

View of human & system performance

Network Manager nominated by the European Commission
Enabling co-investigation and co-learning
Flexible tools to encourage communication and creativity
The language of investigation

- Mis-see...
  - Expectation bias
- Misrecall
  - Information...Memory capacity overload
- Inadequate mentoring
- Incorrect decision...
  - Failure to consider side effects
- Unclear information transmitted...
- Unclear speech
- Unreliable equipment
- Unclear procedure
- Complacency
- Lack of responsibility
The problem with negative contributory factors

- Apply only to failures (infrequent) in safety occurrences (rare)
- Constant expansion needed as more faults are found
- More categories = fewer data in each category
- Can be seen as blaming
- Do not allow learning about what goes right
- Leads to partial analysis
- Need a focus on **performance variability** of activities, functions & resources
Did the controller fail to detect the information completely?

No detection of visual information


Does the situation or interaction concern the detection of visual information?

See - detection

Focuses on the situation and context. Local rationality perspective. Suggests a starting point for further investigation.
Investigation & Learning Cards
Purpose & Rationale

- Assist training, investigations and other learning activities
- Development ACHIEVED with investigator involvement
- Structured around high-level EUROCONTROL RAT – Risk Analysis/eTOKAI (Tool Kit for ATM Occurrence Investigations) explanatory factors
- Includes 10 principles to help systemic application
- Potential uses:
  - Investigator training
  - Post-discussion/interview/observation summary
  - Analysis and reconstruction
  - Risk assessment
  - Safety refresher training
Organisation of the Cards

There are several individual cards for each section of the explanatory factors. Each card introduces a different issue for analysis, reflection or discussion.

<table>
<thead>
<tr>
<th>Fundamental Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel</td>
</tr>
<tr>
<td>Interaction with the Environment</td>
</tr>
<tr>
<td>Equipment</td>
</tr>
<tr>
<td>Contextual Factors</td>
</tr>
</tbody>
</table>
**Fundamental Principles**


People have to balance the thoroughness and efficiency of performance in a complex and uncertain environment.

Consider how people balance efficient and thoroughness, from their point of view, and understand the tactics they use to maintain efficiency (e.g., multitasking, recognition) and thoroughness (e.g., checking).

---

**Principle 6. Demand, Production Pressure & Goal Conflict**

Pressures relating to efficiency and capacity have a fundamental effect on performance.

Performance needs to be understood in terms of demands, resulting pressures and conflicts between goals of production and protection.
Decision

Judging or projecting the accuracy of spatial or temporal information and forming a decision or plan to achieve an intended outcome.

Judgements and decision-making requires continuous adjustments to the context and conditions. Decision making must be considered from the point of view of the person, including goals, knowledge, understanding of the situation and focus of attention at the time, as well as the context of work.

Photo by Andrew Tarrant
Systemic Occurrence Analysis Methodology
SOAM Antecedents

- The Reason Model ~ circa 1990
  - Developed from Professor James Reason’s work on human error and “organisational accidents”

- Tripod Delta ~ circa 1994
  - Developed for Shell Petroleum, based on Reason Model

- ICAM ~ circa 2000
  - Developed for BHP Billiton, based on Reason Model and Tripod Delta
How SOAM can help

- A methodology that includes structured processes to:
  - identify and classify a range of contributing factors
  - sort out irrelevant, non-contributing facts
  - move from a focus on human error/s to identify systemic causes ~ support for ‘Just Culture’
  - analyse simple events through to high severity incidents and accidents
  - clearly link recommendations to the facts of the analysis
The “Swiss Cheese” model of accident causation

Resilient systems have successive layers of defences, barriers, & safeguards

Some holes due to active failures

Other holes due to latent conditions (resident ‘pathogens’)

(Hazards)

(Losses)

(After Reason, 2000)
Modelling Organisational Occurrences

Organisational Factors

Management decisions, organisational processes, organisational culture, etc.

Contextual conditions

Error-producing conditions

Violation-producing conditions

Human Involvement

Errors

"Unsafe acts"

Violations

Barriers

Bad outcome

Occurrence

Latent Condition pathways

(after Reason, 1991)
The Reason Model
Organisational Error Chain

- Organisational and System Factors
- Contextual Conditions
- Human Involvement
- Limited window/s of opportunity
- Absent or Failed Barriers
- ACCIDENT

People, Task, Environment

Latent Conditions

Active Failures

“Unsafe Acts”

(adapted from Reason, 1990)
Runway Overrun, Bangkok September 1999
Accident Summary

On 23 September 1999, at about 2247 local time, a Boeing 747-438 aircraft overran runway 21 Left (21L) while landing at Bangkok International Airport, Thailand.
Accident Summary

The overrun occurred after the aircraft landed long and aquaplaned on a runway which was affected by water following very heavy rain.

The aircraft sustained substantial damage during the overrun. None of the three flight crew, 16 cabin crew or 391 passengers reported any serious injuries.
SOAM analysis key steps

1. Review the Facts
2. Identify the Absent or Failed Barriers
3. Identify the Human Involvement
4. Identify the Contextual Conditions
5. Identify the Organisational Factors
6. Validate the OFs against the Occurrence
<table>
<thead>
<tr>
<th>PEOPLE</th>
<th>HARDWARE</th>
<th>SOFTWARE</th>
<th>ENVIRONMENT</th>
<th>ORGANISATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>FO did not fly the aircraft accurately during final approach</td>
<td>Importance of reverse thrust as stopping force on water-affected runways not known</td>
<td>No appropriately documented info, procedures regarding operations on water-affected runways</td>
<td>Reduced visibility &amp; distraction: rain and windscreen wipers</td>
<td>No formal risk assessment conducted when changed landing procedure researched</td>
</tr>
<tr>
<td>Captain cancelled go-around decision by retarding thrust levers</td>
<td>Most pilots not fully aware about 'aquaplaning'</td>
<td>No policies, procedures on duty or work limits for pilots with flying &amp; non-flying duties</td>
<td>Qantas B747s generally operated in good weather &amp; to aerodromes with long, good quality runways</td>
<td>Cost-benefit analysis of new landing procedure was biased</td>
</tr>
<tr>
<td>FO awake for 19 hours at the time of the accident</td>
<td>Confusion after thrust levers retarded, in high workload situation</td>
<td>Documents unclear (eg., key terms not well defined)</td>
<td>Bangkok runway was resurfaced in 1991</td>
<td>Contaminated runway issues not covered in recent years during crew endorsement, promotional or recurrent training</td>
</tr>
<tr>
<td>Captain did not order a go-around earlier</td>
<td>Boeing advised that if idle reverse technique is adopted, it should be the exception rather than the rule</td>
<td>Most pilots disagreed they had adequate training on landing on contaminated runways</td>
<td>“Landing on Slippery Runways” (Boeing doc) not distributed in Qantas since 1977</td>
<td>“Landing on Slippery Runways” (Boeing doc) not distributed in Qantas since 1977</td>
</tr>
<tr>
<td>Recent crew experience using full reverse thrust lacking</td>
<td>Absence of reverse thrust during landing roll not noticed, not used</td>
<td>Partial loss of external visual reference due to heavy rain</td>
<td>No formal review of new procedures after 'trial' period</td>
<td></td>
</tr>
<tr>
<td>Crew did not use an adequate risk mgt strategy for approach and landing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Captain awake 21 hours at time of accident</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Captain &amp; FO quite low levels of flying prior 30 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Raw Data Refinement

<table>
<thead>
<tr>
<th>PEOPLE</th>
<th>HARDWARE</th>
<th>SOFTWARE</th>
<th>ENVIRONMENT</th>
<th>ORGANISATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>FO did not fly the aircraft accurately during final approach</td>
<td>Importance of reverse thrust as stopping force on water-affected runways not known</td>
<td></td>
<td>Reduced visibility &amp; distraction: rain and windscreen wipers</td>
<td>No formal risk assessment conducted when changed landing procedure researched</td>
</tr>
<tr>
<td>Captain cancelled go-around decision by retarding thrust levers</td>
<td>Most pilots not fully aware about 'aquaplaning'</td>
<td>No appropriately documented info, procedures regarding operations on water-affected runways</td>
<td></td>
<td>Cost-benefit analysis of new landing procedure was biased</td>
</tr>
<tr>
<td>FO awake for 19 hours at the time of the accident</td>
<td>Confusion after thrust levers retarded, in high workload situation</td>
<td>No policies, procedures on duty or work limits for pilots with flying &amp; non-flying duties</td>
<td></td>
<td>Contaminated runway issues not covered in recent years during crew endorsement, promotional or recurrent training</td>
</tr>
<tr>
<td>Captain did not order a go-around earlier</td>
<td>Boeing advised that if idle reverse technique is adopted, it should be the exception rather than the rule</td>
<td>Documents unclear (eg., key terms not well defined)</td>
<td></td>
<td>“Landing on Slippery Runways” (Boeing doc) not distributed in Qantas since 1977</td>
</tr>
<tr>
<td>Recent crew experience using full reverse thrust lacking</td>
<td>Absence of reverse thrust during landing roll not noticed, not used</td>
<td>Most pilots disagreed they had adequate training on landing on contaminated runways</td>
<td></td>
<td>No formal review of new procedures after 'trial' period</td>
</tr>
<tr>
<td>Crew did not use an adequate risk mgt strategy for approach and landing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Captain awake 21 hours at time of accident</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Captain &amp; FO quite low levels of flying prior 30 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**AC1 overruns runway at Bangkok after landing long, recent heavy rainfall, and water on runway.**
**PEOPLE**

- Crew employed flaps 25/ idle reverse landing configuration
- FO did not fly the aircraft accurately during final approach
- Captain cancelled go-around decision by retarding thrust levers
- FO awake for 19 hours at the time of the accident
- Captain did not order a go-around earlier
- Recent crew experience using full reverse thrust lacking
- Crew did not use an adequate risk mgt strategy for approach and landing
- Captain awake 21 hours at time of accident
- Captain & FO quite low levels of flying prior 30 days

**HARDWARE**

- Normal practice to use flaps 25/idle reverse
- Importance of reverse thrust as stopping force on water-affected runways not known
- Most pilots not fully aware about 'aquaplaning'
- Confusion after thrust levers retarded, in high workload situation

**SOFTWARE**

- Revised approach/landing procedure introduced in 1996: flaps 25, idle reverse thrust
- No appropriately documented info, procedures regarding operations on water-affected runways
- No policies, procedures on duty or work limits for pilots with flying & non-flying duties
- Documents unclear (eg., key terms not well defined)
- Most pilots disagreed they had adequate training on landing on contaminated runways
- No policies or procedures for maintenance of recency for management pilots

**ENVIRONMENT**

- Very heavy rainfall, runway surface affected by water
- Reduced visibility & distraction: rain and windscreen wipers
- Qantas B747s generally operated in good weather & to aerodromes with long, good quality runways
- High workload situation, distraction or inexperience
- Partial loss of external visual reference due to heavy rain

**ORGANISATION**

- Introduction of new landing procedure poor
- No formal risk assessment conducted when changed landing procedure researched
- Cost-benefit analysis of new landing procedure was biased
- Contaminated runway issues not covered in recent years during crew endorsement, promotional or recurrent training
- “Landing on Slippery Runways” (Boeing doc) not distributed in Qantas since 1977
- No formal review of new procedures after 'trial' period

---

**Use the remaining factors to build the Analysis chart**

---

**AC1 overruns runway at Bangkok after landing long, recent heavy rainfall, and water on runway.**
Qantas B747s generally operated in good weather & to aerodromes with long, good quality runways

Captain awake 21 hours at time of accident

Captain & FO quite low levels of flying prior 30 days

Recent crew experience using full reverse thrust lacking

Crew did not use adequate risk mgt strategy for approach and landing

Crew employed flaps 25/ idle reverse landing configuration

FO did not fly the aircraft accurately during final approach

FO awake for 19 hours at the time of the accident

Captain cancelled go-around decision by retarding thrust levers

Captions not fully aware about "aquaplaning"

Confusion after thrust levers retarded, in high workload situation

Absence of reverse thrust during landing roll not noticed, not used

Captain & FO quite low levels of flying prior 30 days

No policies or procedures for maintenance of recency for management pilots

Cost-benefit analysis of new landing procedure was biased

Contaminated runway issues not covered in recent years during crew endorsement, promotional or recurrent training

"Landing on Slippery Runways" (Boeing doc) not distributed in Qantas since 1977

No formal review of new procedures after "trial" period

Very heavy rainfall, runway surface affected by water

Very heavy rainfall, runway surface affected by water

Very heavy rainfall, runway surface affected by water

Raw Data

Very heavy rainfall, runway surface affected by water

QF1 overrun runway at Bangkok after landing long, recent heavy rainfall, and water on runway.

Very heavy rainfall, runway surface affected by water

Captain did not order a go-around earlier

Recent crew experience using full reverse thrust lacking

Crew did not use an adequate risk mgt strategy for approach and landing

Captain awake 21 hours at time of accident

Crew employed flaps 25/ idle reverse landing configuration

FO did not fly the aircraft accurately during final approach

FO awake for 19 hours at the time of the accident

Captain cancelled go-around decision by retarding thrust levers

Captions not fully aware about "aquaplaning"

Confusion after thrust levers retarded, in high workload situation

Absence of reverse thrust during landing roll not noticed, not used

Captain & FO quite low levels of flying prior 30 days

No policies or procedures for maintenance of recency for management pilots

Cost-benefit analysis of new landing procedure was biased

Contaminated runway issues not covered in recent years during crew endorsement, promotional or recurrent training

"Landing on Slippery Runways" (Boeing doc) not distributed in Qantas since 1977

No formal review of new procedures after "trial" period
Contextual Conditions

- Describe the context of the event ~ the conditions existing immediately prior to, or at the time of the accident

- Check Question:

  “Does the item describe an aspect of the workplace, local organisational climate, or a person’s attitudes, personality, performance limitations, physiological or emotional state that helps explain their actions?”
Human Involvement

- Describe the errors or violations (actions or omissions) by operators at the scene which “triggered” the accident

- **Check Question:**

  “Does the item describe an action or non-action (error or violation) that immediately contributed to the occurrence?”
Absent or Failed Barriers

- Describe the “last minute” measures which failed or were missing, and therefore did not prevent the accident

- Check Question:

  “Does the item describe a work procedure, aspect of human awareness, physical obstacle, warning or control system, or protection measure designed to prevent an occurrence or lessen its consequences?”
Organisational Factors

- Describe the organisational and system factors (failures) which created, or allowed, the prevailing contextual conditions

- Check Question:

  “Does the item describe an aspect of an organisation’s culture, systems, processes or decision-making that existed before the occurrence and which resulted in the contextual conditions or allowed those conditions to continue?”
Aircraft overran runway after landing long

No serious injuries (391 pax, 19 crew)

Potential for more serious outcome

Aircraft repair cost: $100,000,000 (?)

Damage to company reputation

Very heavy rainfall, runway surface affected by water

Crew not aware of critical importance of reverse thrust as stopping force on water-affected runways

Most pilots not fully aware about 'aquaplaning'

Qantas B747s generally operated in good weather & to aerodromes with long, good quality runways

New 1996 approach/landing procedure inappropriate

Normal practice to use flaps 25/idle reverse

Recent crew experience using full reverse thrust lacking

Reduced visibility & distraction: rain and windscreen wipers

Captain & FO quite low levels of flying prior 30 days

FO awake for 19 hours at the time of the accident

Captain awake 21 hours at time of accident

High workload situation

First Officer did not fly the aircraft accurately during the final approach

Captain did not order a go-around earlier

Captain cancelled go-around decision by retarding the thrust levers

Landing procedure

Absence of reverse thrust during landing roll not noticed, reverse thrust not used

Crew Resource Management

• Aircraft overran runway after landing long
• No serious injuries (391 pax, 19 crew)
• Potential for more serious outcome
• Aircraft repair cost: $100,000,000 (?)
• Damage to company reputation
Recommendations

- Provide recommendations that will prevent recurrence of this scenario

- Recommendations should be directed to the responsible position, and must address all identified:
  1. Absent or Failed Barriers
  2. Organisational Factors
Aircraft accident in Bangkok, Thailand.

**ACCIDENT**

- Aircraft overran runway after landing long
- No serious injuries (391 pax, 19 crew)
- Potential for more serious outcome
- Aircraft repair cost: $100,000,000 (?)
- Damage to company reputation

**SOAM Chart**

**Aircraft Accident**

- **Boeing 747-438**
- **Bangkok, Thailand**
- **September 1999**

**OTHER SYSTEM FACTORS**

- **PP** Regulations covering contaminated runway operations deficient
- **AC** CASA surveillance of airline flight operations deficient

**ORGANISATIONAL FACTORS**

- **PP** No appropriately documented info, procedures re operations on water-affected runways
- **CO** “Landing on Slippery Runways” (Boeing doc) not distributed in Qantas since 1977
- **TR** Contaminated runway issues not covered during crew endorsement, promotional or recurrent training in recent years
- **CO** Documents unclear (eg., key terms not well defined)
- **OC** Mgt decisions informal, “intuitive”, “personality-driven”
- **RM** No formal risk assessment conducted when changed landing procedure researched
- **CM** Introduction of new landing procedure poor
- **CM** No formal review of new procedures after 'trial' period
- **CG** Cost-benefit analysis of new landing procedure was biased
- **WM** No policies or procedures for maintenance of recency for management pilots
- **WM** No policies, procedures on duty or work limits for pilots with flying & non-flying duties

**CONTEXTUAL CONDITIONS**

- Very heavy rainfall, runway surface affected by water
- Crew not aware of critical importance of reverse thrust as stopping force on water-affected runways
- Most pilots not fully aware about 'aquaplaning'
- Qantas B747s generally operated in good weather & to aerodromes with long, good quality runways
- New 1996 approach/ landing procedure inappropriate
- Normal practice to use flaps 25/idle reverse
- Recent crew experience using full reverse thrust lacking
- Reduced visibility & distraction: rain and windscreen wipers
- Captain & FO quite low levels of flying prior 30 days
- FO awake for 19 hours at the time of the accident
- Captain awake 21 hours at time of accident
- High workload situation
- Crew employed flaps 25/idle reverse landing configuration
- First Officer did not fly the aircraft accurately during the final approach
- Captain did not order a go-around earlier
- Captain cancelled go-around decision by retarding the thrust levers

**HUMAN INVOLVEMENT**

- Flight crew did not use an adequate risk management strategy for approach and landing

**ABSENT OR FAILED BARRIERS**

- **Landing procedure**
- **Absence of reverse thrust during landing roll not noticed, reverse thrust not used**
- **Crew Resource Management**
- **First Officer awake for 19 hours at the time of the accident**
- **Captain awake 21 hours at time of the accident**
- **High workload situation**
- **Crew did not employ any risk management strategy for approach and landing**
- **Captain did not order a go-around earlier**
- **Captain cancelled go-around decision by retarding the thrust levers**
- **No formal risk assessment conducted when changed landing procedure researched**
And finally a new technique in the making...

**SAT – Situation Analysis Toolkit**
SAT in conjunction with *The Field Guide to Understanding “Human Error”*

- Step 1 – Getting HF Data
- Step 2 – Building a Timeline
- Step 3 - Leaving a trace
- Step 4 – Constructing influences and interactions
- Step 5 – making recommendations
Thanks for listening. Any questions?