FRAM

New insight in accident analysis?

Comparing a multi-linear
(Sequentially Timed Events Plotting method, STEP, Hendrick & Benner, 1986)
and
a systemic
(Functional Resonance Accident Method, FRAM, Hollnagel, 2004)
method for accident analysis

Ivonne Herrera, Norwegian University of Science and Technology, NTNU, Norway
Rogier Woltjer, Linköping University, LiU, Sweden
Content

- Research questions
- Approach
- Modelling with FRAM
- Modelling with STEP
- Conclusions
Research questions

- Which new insights does FRAM, a new systemic method provide to accident analysis in comparison to STEP, an established multi-linear method?

  - What we can learn from both methods, how, when, and why to apply them, and which aspects of these methods may need improvement?
LN-KKL case

“… The aircraft came into a significant lower approach than expected …

… The approach was cancelled due to the aircraft was still in dense clouds and the aircraft drifted a little bit from the LLZ at OSL…

… The crew did not notice that the aircraft movements were not normal.”
Non-linear accident model

Assumption: Accidents result from unexpected combinations (resonance) of variability of normal performance

Consequence: Accidents are prevented by monitoring and damping variability. Safety requires constant ability to anticipate future events.

Hazards-risks: Emerge from combinations of normal variability (socio-technical system).

The future can be understood by considering the characteristic variability of the present.

Adapted from a presentation by Erik Hollnagel, 2004
FRAM

0 Define the purpose of modelling (accident investigation) and describe the target situation or scenario to be analysed

1 Identify essential system functions; characterise each function by six basic aspects

2 Characterise the (context dependent) potential variability using a checklist. Consider both normal and worst case variability

3 Define functional resonance based on possible dependencies (couplings) among functions

4 Identify barriers for variability (damping factors) and specify required performance monitoring
1 Function: Manual approach

- Pilot informed of glide slope failure
- Time available varies
- Autopilot disconnected
- Precondition
- Input
- Resource
- Pilot flying and pilot non-flying
- Output
- Control
- Standard Operation Procedures
- Altitude lower than approach path

NTNU
Norwegian University of Science and Technology
Short after clearance to 4000ft, the crew was informed that runway 19R was closed because of sweeping and that landing should take place at runway 19L.
LN-KKL case

Under the last part of the flight, at this time the aircraft has established localizer (LLZ) and glidepath (GP) for runway 19L, the glidepath signal was off.
LN-KKL case

The aircraft came into a significant lower approach than expected.
2 Potential for variability

11 Common Performance Conditions (CPCs)

Availability of personnel and equipment
Training, preparation, competence
Communication quality
Human-machine interaction, operational support
Availability of procedures
Work conditions
Goals, number and conflicts
Available time
Circadian rhythm, stress
Team collaboration
Organizational quality

Rating
Adequate
Temporarily inadequate
Inefficient
Inadequate
Adequate
Temporarily inadequate?
More than capacity
Temporarily inadequate
Adjusted
Inefficient
?
3 Resonance: Instantiation

- A/C-1 pilot & A/C functions
- A/C-1 avionics ept
- Oslo APP control
- Gardermoen TWR control
- Ground equipment

1. **Change APP freq to TWR freq**
   - Input (I)
   - Transmitter (T)
   - Channel (C)
   - Receiver (R)
   - Output (O)

2. **Transfer requested to TWR freq**
   - Pilot informed of G/S failure

3. **Transmitting radio comm**
   - Pilot-APP: confirm transfer to TWR freq

4. **Receiving radio comm**
   - Frequency still set to APP

5. **Auto-pilot approach**
   - Manual approach
   - Pilot informed of G/S failure

6. **Oslo APP control**
   - Flight on TWR freq

- **Gardermoen TWR control**
  - APP-Pilot: contact TWR on TWR freq

- **Auto-pilot**
  - A/P disconnected 14:43:27

- **Glideslope transmission**
  - A/P lost 14:42:55

- **Proactive TWR-APP comm:**
  - Check flight frequency change

- **No G/S signal**
  - 14:42:55
4. Recommendations

Training including for ATC & Pilots

• Situations where pilots/ATC have different experience
• Changing conditions
• Communication analysis (symbolic barrier)

• **Need to monitor overload, feedback and quality of communication** (monitoring performance)
Multi-sequential accident model

Assumption: An accident is a special class of process where a perturbation transforms a dynamically stable activity into unintended interacting changes of states with a harmful outcome.

Consequence: Accidents are prevented by identifying, classifying and eliminating safety hazards/problems. Safety requires constant ability to detect uncontrolled changes and counteract their effects.

Hazards-risks: Are disruptive changes (perturbations) that persons or things introduce, which trigger undesired interactions.
STEP worksheet

14:42:36  
APP REQUEST AC-1 TO CHANGE TO TWR FRQ 14:42:36

OSLO APP CONTROL

14:42:55  
PNF ACCEPTS TRANSFER 14:42:55

GARDERMOEN TWR CONTROL

14:42:57  
TWR INFORMS G/S FAIL AC-2 14:42:57

RUNWAY EQUIP. RWY-E

14:44:02  
AC-1 CHANGES FRQ TO TWR 14:44:02

CAPTAIN, COPILOT "PNF", "PF"

AC-1 NOSE MOVES DOWN, DISCONNECT A/P 14:43:27

AIRCRAFT AC-1

AC-1 CHANGES TO TWR FRQ

PNF CHANGES TO TWR FRQ

PNF MANUAL

GO AROUND

ALTITUDE 460ft

STEP applied to NAX541 incident (simplified example).
Conclusions

• FRAM provides a different explanation on how events are the result of the variability of normal performance and functional resonance

• STEP supports identifying and showing what happened and when

• FRAM, besides what and when, illustrates how: the dynamic interactions within the socio-technical system

• By taking into account context and dynamic interactions it was possible to identify new factors in the analysis of the incident
Remaining challenges

• A more structured approach to generating recommendations in terms of barriers and indicators

• Evaluating how well FRAM is suited as a method to collect and organize data during early stages of accident investigation
Fram is the strongest vessel in the world. This remarkable vessel has advanced further north and further south than any other surface vessel.

Thanks to: the investigators and managers of the Norwegian Accident Investigation Board, Ranveig K. Tinmannsvik, Erik Jersin, Erik Hollnagel, Jørn Vatn, Karl Rollenhagen, Kip Smith, Jan Hovden, several aviation experts and the participants in the 2nd FRAM workshop for helpful comments
Any questions?