Functional Resonance Analysis Method

Proactive systemic assessment

Technical meeting on the Interaction between Individuals, Technology and Organization – A systemic approach to safety in practice

Vienna, Austria
IAEA Headquarters
10 – 13 June 2014
• Private shareholders founded in 1992, from the aviation domain

• A multi-disciplinary team: HF experts, engineers, psychologists, ergonomists
  ▪ Permanent staff: 12 in France (Paris), 3 in Australia (Melbourne)

• Specialised in reliability and performance of complex socio-technical systems
  ▪ Bridging between research and applications to industry
  ▪ Know-how transfer
Systemic approach

1. A systemic perspective implies analysing the impacts of the constant dynamic interaction between and within the human, technical and organizational factors comprising the socio-technical system, as well as the interactions within and between organizations within the larger system that this particular system is a part of.

2. A systemic perspective implies describing accidents on the level of the socio-technical system as whole rather than on the level of specific cause-effect mechanisms.

3. A systemic perspective implies taking into account factors that lie far away in time and space from the moment things went wrong

*Hollnagel, 2004; Dekker, 2011*
Steps for a systemic approach to safety

1. Knowing where the risks are, prioritising and building an ad-hoc system of defences

2. Setting this “paper model” alongside the real situation and making adjustments accordingly, particularly to various shifts in practice

3. Carrying out the analysis at a higher level and considering the macroeconomic and political constraints

4. Asking how much resistance it still has to exceptional circumstances

*Amalberti, 2013*
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Amalberti, 2013
Linear models

How does accident happen?

Data → Method → Linear Accident Model → Simple/Complex

Interpretation → Conclusions

Accident models assumptions

- A system/event can be decomposed into meaningful elements/steps
- Parts and components either work or fail
- Order of events is predetermined and fixed
- Combinations of events are orderly and linear
- Accidents are due to cause-effect chain of events

Simple: Independent causes, Failures, malfunctions

Complex: Interdependent causes (active errors + latent failures)
Safety assessment approaches

TRADITIONAL approach

ACCIDENT DUE TO

Failures
Errors

SAFETY ACHIEVED

Constraining performance

Hale and Hovden (1998)
**Accident models assumptions**

- Principles of functioning of systems are unknown or only partly known
- Description of system is difficult and contains many details
- Description takes a long time to make
- System’s structure changes before description is completed
- Important to understand system dynamics (variability)
- Accidents emerge from the normal functional adjustments of the system

Accidents are consequences of normal adjustments, rather than of failures. Without such adjustments, systems would not work.
Safety assessment approaches

TRADITIONAL approach

SYSTEMIC approach

ACCIDENT DUE TO
- Failures
- Errors

SAFETY ACHIEVED
- Constraining performance
- Managing performance variability

Combination of performance variability
Accidents are consequences of normal adjustments, rather than of failures. Without such adjustments, systems would not work.
FRAM principles

- Performance has to be adjusted to meet working conditions. Since resources are always finite, adjustments are always approximate.

- Success is the ability to anticipate risks and critical situations, recognise them in time and take appropriate actions. Failure is the temporary inability to do so.

- Both success and failures cannot be explained only by referring to the (mal)functions of specific component.

- The variability of a number of functions reinforce each other and thereby cause the variability of one function to exceed normal limits.

- Equivalence of success and failures

Approximate adjustment

Emergence

Functional resonance
FRAM steps

1. Recognise the purpose of the analysis.
2. Identify and describe the functions.
3. The identification of variability.
4. The aggregation of variability.
5. Consequences of the analysis.
Recognise the purpose of the analysis.

Accident analysis

Risk assessment

Look for what SHOULD have gone right but did not

Look for what SHOULD go right
Identify and describe the functions

A function refers to the activities required to produce an outcome

Sources for describing functions: e.g.
- Description of events and system/work documentation
- Procedures, named individual functions
- Work descriptions
- Design case, use case, scenario
- Functional decomposition
- Task analysis
- Goals-means task analysis

Technological functions
Human functions
Organisational functions
Step 1 – Functions and aspects

Identify and describe the functions

Can be a constraint but can also be considered as a kind of resource.

Supervises or adjusts a function, plans, procedures, guidelines or other functions.

Used or transformed to produce the output.

Aspect

System conditions that must be fulfilled before a function can be carried out.

Resource

Needed or consumed by function to process input (e.g., matter, energy, hardware, software, manpower).

Input

Precondition

Time

Control

Function

Output

Produced by function.
Step 1 – Foreground and background

**Identify and describe the functions**

**Background functions:**
create the context in which foreground functions are performed

**Foreground functions:**
The focus of analysis
Step 1 – Upstream and downstream

INSTANTIATION

Upstream functions

Downstream functions

Identify and describe the functions
Step 1 – Model and Instantiation

Identify and describe the functions

FRAM MODEL

INSTANTIATION

Function 1

Function 2

Function 3

Function 4
Step 1 in practice

1. Start by a function that appears to be essential for the scenario
2. There is no single or right level of description
3. Start describing at a “natural” level
4. Functions always contain a verb phrase
5. A FRAM model is the textual description of functions (NO LINKS)
6. An Instantiation represents the way functions are coupled in a specific scenario
7. Functions are potentially coupled if they have common aspects
8. A FRAM model can contain functions at a different degree of elaboration
9. All the aspects of a function must be described for at least another function in the model *(model has to be consistent and complete)*
10. Not all aspects of a function must be described
ATM Example: Human–Technological-Organisational
Step 2 – Sources of variability

The identification of variability

Functions vary in how they are carried out. The variability of a function results in a variability in its Output

Technological functions: performed mainly by machinery

Human functions: performed by individuals or informal groups

Organisational functions: performed by groups of people where activities are explicitly organised

Internal variability: due to the nature of the function itself

External variability: due to the variability of the working environment

Variability is partially predictable because it is due to adjustments performed for a purpose
Step 2 – Sources of variability

### The identification of variability

#### Technological functions
- **Internal variability**: Sources: Few, well known, Low
- **External variability**: Sources: maintenance, Low

#### Human functions
- **Internal variability**: Sources: Very many, psychological & physiological, High frequency, large amplitude
- **External variability**: Sources: Very many, social and organisational, High frequency, large amplitude

#### Organisational functions
- **Internal variability**: Sources: Many, function specific, Slow frequency, large amplitude
- **External variability**: Sources: Many, instrumental, Low frequency, large amplitude

How does variability look like in practice?
The identification of variability

### Manifestations of variability

<table>
<thead>
<tr>
<th>Step 2 – Manifestation of variability</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Temporal characteristics</th>
<th>Too early</th>
<th>On time</th>
<th>Too late</th>
<th>Not at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technological function</td>
<td>Unlikely</td>
<td>Normal, expected</td>
<td>Unlikely, but possible</td>
<td>Very unlikely</td>
</tr>
<tr>
<td>Human function</td>
<td>Possible</td>
<td>Possible, should be typical</td>
<td>Possible, more likely than early</td>
<td>Possible to a lesser degree</td>
</tr>
<tr>
<td>Organisational function</td>
<td>Unlikely</td>
<td>Likely</td>
<td>Possible</td>
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### Step 2 – Manifestation of variability

#### The identification of variability

#### Manifestations of variability

<table>
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How does variability combine and resonate?
Step 3 – Aggregation of variability

What is its performance variability?
Step 3 – Aggregation of variability

What is its performance variability?

How is the output going to be?
The aggregation of variability

To understand how variability may combine and lead to unexpected outcomes

**Functional coupling:** variability due to couplings between upstream and downstream functions

<table>
<thead>
<tr>
<th>Upstream Output variability</th>
<th>Possible effects on downstream function</th>
</tr>
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<tbody>
<tr>
<td><strong>Timing</strong></td>
<td></td>
</tr>
<tr>
<td>Too early</td>
<td>Premature start; Input possibly missed [V↑]</td>
</tr>
<tr>
<td>On time</td>
<td>No effect, possible damping [V↓]</td>
</tr>
<tr>
<td>Too late</td>
<td>Function delayed, leading to short-cuts [V↑]</td>
</tr>
<tr>
<td>Omission</td>
<td>Function not carried out or severely delayed [V↑]</td>
</tr>
<tr>
<td><strong>Precision</strong></td>
<td></td>
</tr>
<tr>
<td>Imprecise</td>
<td>Loss of time, loss of accuracy, misunderstandings. [V↑]</td>
</tr>
<tr>
<td>Acceptable</td>
<td>No effect [V↔]</td>
</tr>
<tr>
<td>Precise</td>
<td>Possible dampening. [V↓]</td>
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Possible increase of variability

Possible damping of variability

Neutral for variability

© Hollnagel, 2012
Step 3 – Aggregation of variability

### Function Z

<table>
<thead>
<tr>
<th>Input</th>
<th>Aspect 1</th>
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<tbody>
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<td></td>
<td>Aspect 2</td>
</tr>
<tr>
<td>Output</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>Aspect 4</td>
</tr>
<tr>
<td>Time</td>
<td></td>
</tr>
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<td>Aspect 3</td>
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In the instantiation, where the possible variability combine and resonate?
To propose ways to manage emergent risks

Focus of recommendations to:
1. Eliminate hazards
2. Prevention of risks
3. Protection from effects
4. Facilitation of positive factors
5. Monitoring variability (performance indicators)
6. Dampening variability
Conclusions

1. FRAM applies a systemic perspective to safety assessment

2. Analysis:
   1. of the impacts of the dynamic interaction between and within the human, technical and organizational factors comprising the socio-technical system;
   2. of the interactions within and between organizations within the larger system;
   3. of the variability of performance which is at the basis of both successes and failures

3. Description on the level of the socio-technical system as whole rather than on the level of specific cause-effect mechanisms taking into account factors that lie far away in time and space from the moment things could go wrong
Wait… I’ve got few questions!!

Let's leave....

Thank you for your attention