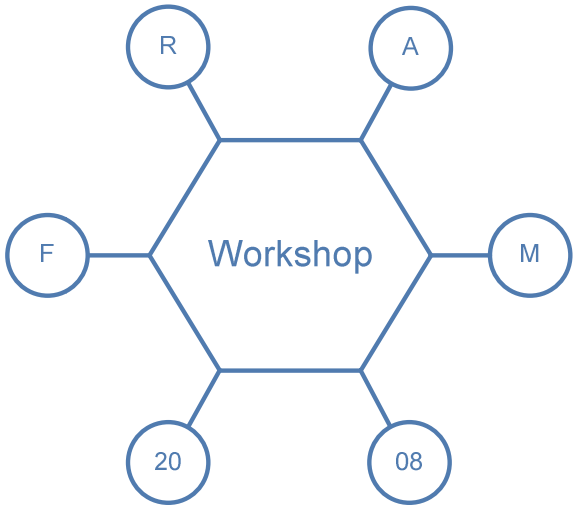


FRAM Workshop

20-22 February 2008

École des Mines de Paris
Sophia Antipolis

Preface and a disclaimer

On behalf of the organizing committee I would like to thank all of you for your participation and contribution to the workshop!

This document is a sort of summary of what we discussed and heard during three days in Sophia Antipolis. At the end of the document you will find the list of "take home points" from this workshop that you all handed in on the yellow form, you will also find the topic-wishes for next time. Thanks also to Luigi, for compiling the result from the post-it session, and to Erik, for writing the major part of the notes on his own presentation since I was not able to attend it.

Please not that the contents of this document is based mainly on my ***notes*** from the discussions and presentations given. ***Quick and dirty*** has been the motto when putting them together and our aim has been to give them to you as soon as possible after the workshop. If something seems brilliant that is entirely thanks to all of you, if something seems inaccurate or straight out stupid I am to blame. The notes does not claim to be complete in any way and are thought to be a reminder to some of the things that said and discussed. The parts named "Overheard in the room" are quick notes on comments and discussion topics that followed after a presentation.

But the document begins with a short crash course in FRAM and some useful info.

By the keyboard: Josephine Speziali
Contact: josephine.speziali@gmail.com

For questions regarding this and future FRAM workshops please contact Denis Besnard (denis.besnard@crc.ensmp.fr) or Luigi Macchi (luigi.macchi@crc.ensmp.fr).

Crash course in FRAM

FRAM consists of the five following steps:

0. Define the purpose of modelling (risk assessment) and describe the target situation or scenario to be analysed.
1. Identify essential system functions; characterise each function by six basic aspects (Input, Output, Time, Control, Preconditions & Resources)
2. Characterise the (context dependent) potential variability using a checklist. Consider both normal and worst case variability. The checklist lists the following Common Performance Conditions to be considered:
    a. Availability of resources
    b. Training and experience
    c. Quality of communication
    d. HMI and operational support
    e. Access to procedures and methods
    f. Conditions of work
    g. Number of goals and conflict resolution
    h. Available time (time pressure)
    i. Circadian rhythm
    j. Crew collaboration quality
    k. Quality and support of organisation
    l. Learning of the organisation
3. Define functional resonance based on possible dependencies (couplings) among functions.
4. Identify barriers for variability (damping factors) and specify required performance monitoring.

The FRAM Visualizer can be downloaded for free at:

http://code.google.com/p/framvisualizer/

First day – Wednesday 2008-02-20

From FRAM to FRAM

Presented by: Erik Hollnagel
From: École des Mines de Paris
Contact: erik.hollnagel@crc.ensmp.fr

The workshop started with a presentation of the history of models for accident investigation and safety assessment. In order to be useful a model and method has to be able to account for the characteristics of the system. According to Perrow system can be characterized by the tightness of the coupling between its components and by the complexity of its interaction. Erik presented a slightly altered version of Perrows famous diagram where the interaction dimension is replaced by tractability, see Figure 1.

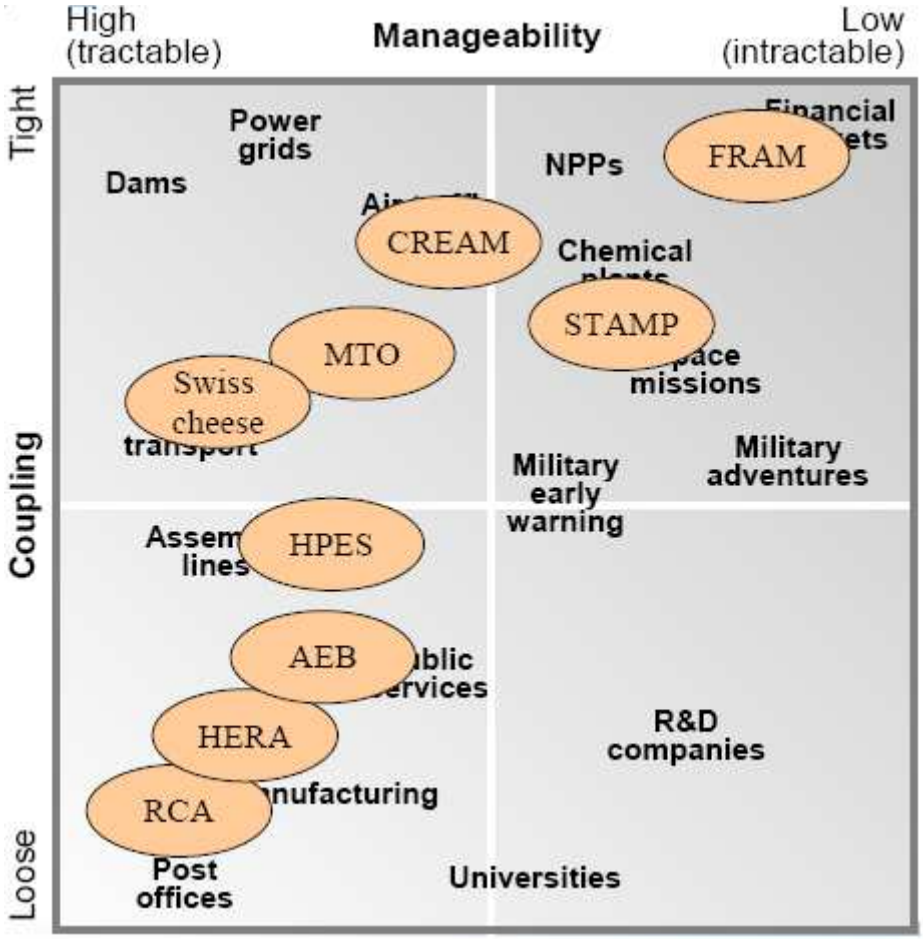


Figure 1 – A modified version of Perrows diagram with methods plotted according to the type of system they can account for,

Erik also explained how FRAM is based on four principles:

The principle of equivalence of successes and failures FRAM adheres to the resilience engineering view that failures represent the flip side of the adaptations necessary to cope with the real world complexity rather than a failure of normal system functions. Success depends on the ability of organisations, groups and individuals to anticipate risks and critical situations, to recognise them in time, and to take appropriate action; failure is due to the temporary or permanent absence of that ability.

The principle of approximate adjustments Since the conditions of work never completely match what has been specified or prescribed, individuals and organisations must always adjust their performance so that it can succeed under the existing conditions, specifically the actual resources and requirements. Because resources (time, manpower, information, etc.) always are finite, such adjustments are invariably approximate rather than exact.

The principle of emergence The variability of normal performance is rarely large enough to be the cause of an accident in itself or even to constitute a malfunction. But the variability from multiple functions may combine in unexpected ways, leading to consequences that are disproportionally large, hence produce a non-linear effect. Both failures and normal performance are emergent rather than resultant phenomena, because neither can be attributed to or explained only by referring to the (mal)functions of specific components or parts.

The principle of functional resonance The variability of a number of functions may every now and then resonate, i.e., reinforce each other and thereby cause the variability of one function to exceed normal limits. The consequences may spread through tight couplings rather than via identifiable and enumerable cause-effect links, e.g., as described by the *Small World Phenomenon*. This can be described as a resonance of the normal variability of functions, hence as functional resonance. The resonance analogy emphasises that this is a dynamic phenomenon, hence not attributable to a simple combination of causal links.

He went on to discuss some issues of the details of the modelling. One important point is to make a distinction between the model and instantiations of the model. The model is the description of the functions, for instance as the table or frame descriptions in the visualizer. The instantiation is the possible couplings (or links) between the functions, either at a certain point in time or corresponding to certain conditions. In the model itself, these links are potential rather than actual. When they are made actual, they represent a specific instantiation.

This distinction goes someway to resolve the issue of the visualization, i.e., the hexagons with lines between them, which represents an instance of the model (typically a generic instance), but not the model itself. The presentation later by Herrera & Woltjer served to clarify that, by using the instations as time steps in the development of an incident.

A further point is how one should represent alternative outcomes of a function, e.g., that the result of an evaluation can be either positive or negative. In normal flow diagrams this is shown as two outputs from, e.g., a decision node. FRAM is, however, not a flow charting tool,

and it is therefore inappropriate to make a one-to-one transformation from a flow diagram or flow chart. The proposed solution is to introduce the concept of a state. The output or result of a function can be a change in a state, or the value of a state. For example, if the function is to evaluate a proposed solution, then the output could be "solution evaluated: <positive>" (or "solution evaluated: <negative>"). This could be written as follows:

Function name:	Evaluate a proposed solution
Input	Proposed solution
Output	Solution evaluated: <positive>
Time	
Precondition	
Control	
Resources	

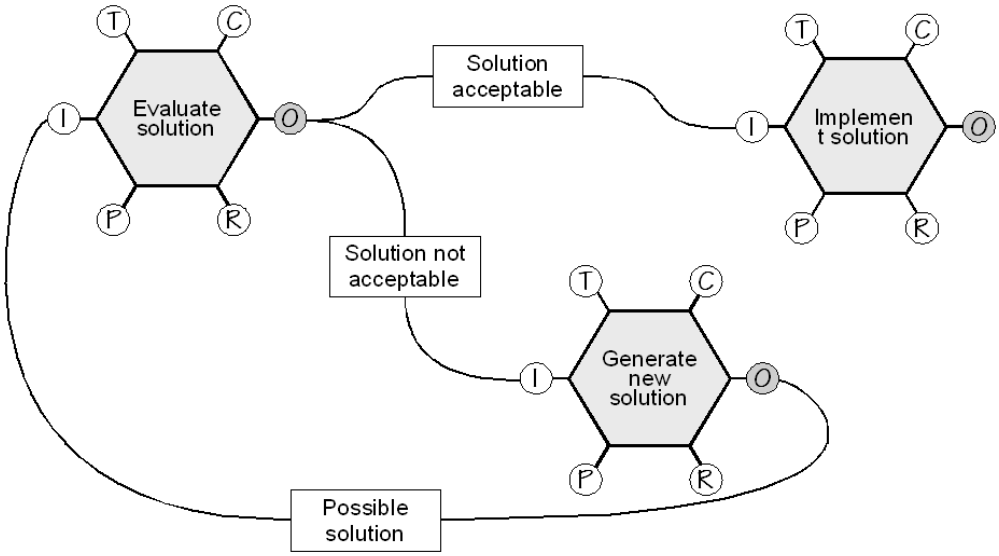
If the evaluation was positive, the next step would be to implement the solution. If the evaluation was negative, the next step would be to generate another solution. Whereas the flow diagram would show this as two outputs from a 'decision' node, FRAM would describe it as follows:

Function name:	Implement solution
Input	Proposed solution
Output	
Time	Solution has been evaluated
Precondition	Solution evaluated: <positive>
Control	
Resources	

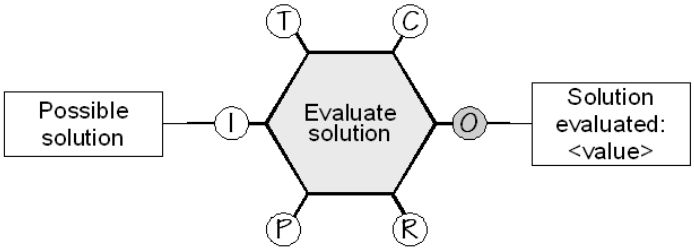
Function name:	Generate a solution
Input	
Output	
Time	Solution has been evaluated
Precondition	Solution evaluated: <negative>
Control	
Resources	

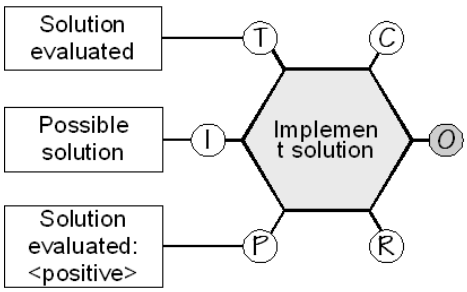
For either function, the model defines that it will not begin until the solution has been evaluated. (Note that this is a condition that may be overruled by performance variability.) The difference between a positive and a negative outcome is reflected in the preconditions. In this case the implementation will only begin if a solution has been evaluated and the outcome was positive, whereas the search for a new solution only will begin if a solution has been evaluated and the outcome was negative. The model contains both conditions, but an instantiation of the model, i.e., hexagons with lines between them, will only show one.

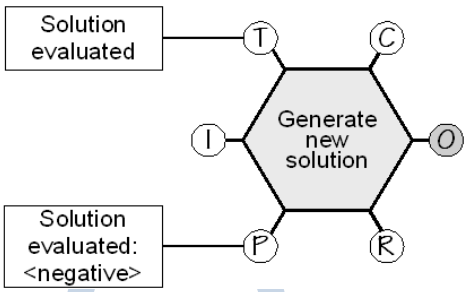
So instead of having:



We will have:







as a FRAM model.

Normal people in normal organisations : FRAM analysis of a mid-air collision

Presented by: Paulo Carvalho and Jose O. Gomes
From: National Nuclear Energy Commission resp. Federal University of Rio de Janeiro
Contact: paulov@ien.gov.br, joseorlando@nce.ufrj.br

Presentation specific info:

A brief introduction to the midair collision at 37000 ft, over Brazil. between the N600XL and GOL Flight 1907 was given. Many different things contributed to the accident (such as a turned off TCAS, a flight plan that was not followed, incomplete clearance dialogues and radar and communication problems). Many of these contributors where known and "normal" but together they created a situation where it seems like the system was not aware that two planes where approaching each other on the same level.

Seven FRAM-functions was identified: ACC monitor radarscopes, ACC airspace control, ACC communication, Fly in controlled space, Flight clearance communication, Flight plan approval, Write flight plan. These functions were loosely order from left to right in the FRAM visualizer. Beside the seven functions three design-functions (ATC workstation HSI, ATC radio design, avionics HSI design) was added. Connections between functions was coloured in black, green, yellow and red depending on how well they worked in the situation. And functions that was judged to have varied in a way that contributed to the accident was marked with red flags, see Figure 2.

Overheard in the room

A discussion started on how many functions to include and it was pointed out that all preparation is left out from this analysis and that it could be included in the analysis. The need for a description of the normal operation and variability, to compare with, was also brought up.

There seems to be a tendency to order functions from left to right according to "time of appearance" but this might be due to the placement of input being at the left and output at the right of the hexagon.

How would you promote FRAM?

"It helps you understand how people work normally and why things go wrong"

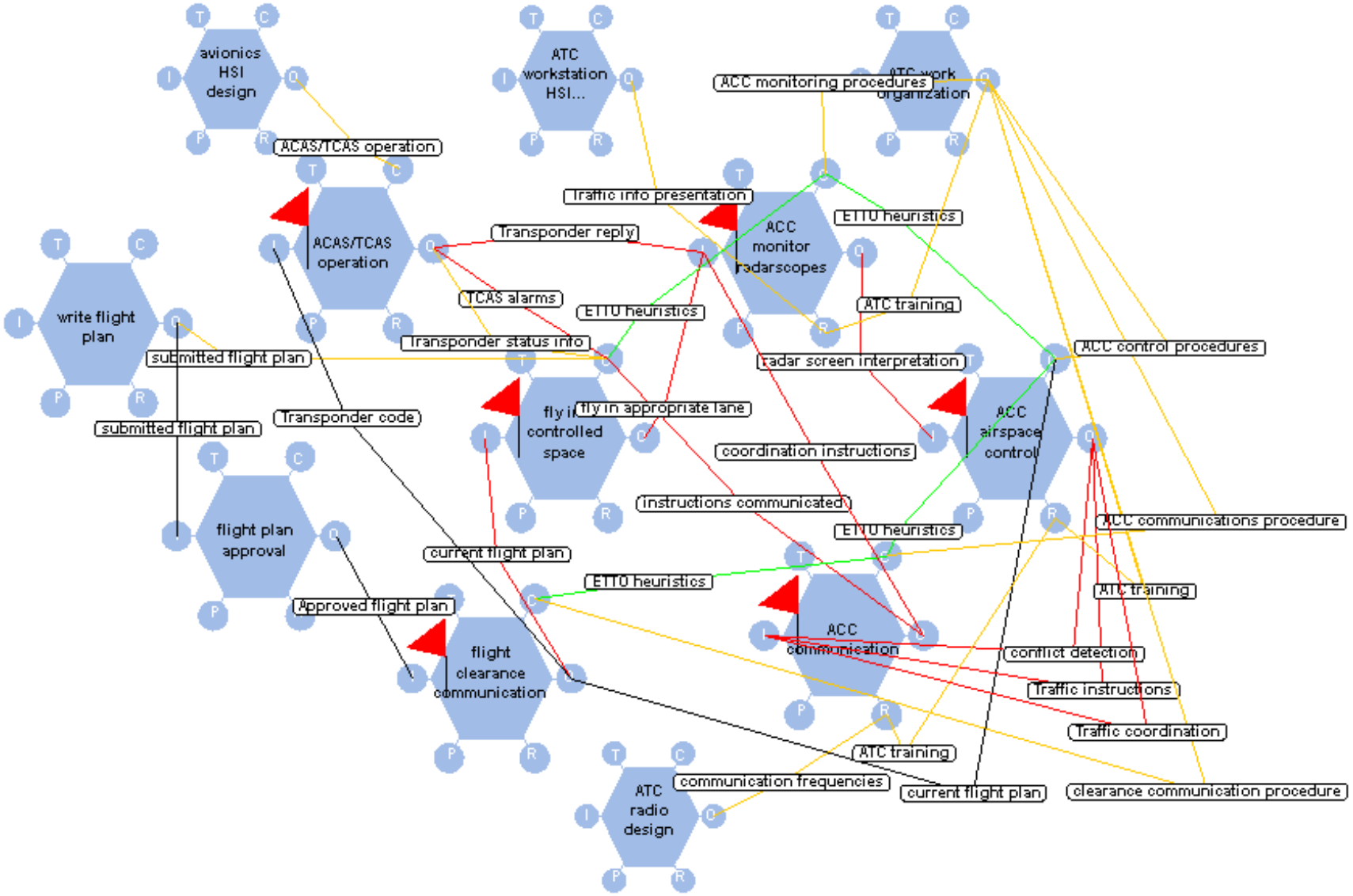


Figure 2 – FRAM Visualizer visualization of the Brasilian mid air collision

Aviation Accident Investigation and ATM Automation Risk Assessment using the Functional Resonance Accident Model

Presented by: Rogier Woltjer
From: Linköpings University
Contact: rogwo@ida.liu.se

Rogier has done FRAM-work within his PhD-project including both analysis of teamwork in command and control, aviation accident analysis (e.g. Alaskan Airline 261) and air traffic control risk assessment. The PhD also includes development of the FRAM model and has focused on the later of the five steps.

Rogier listed a number of challenges for FRAM that he has found during his work, among these the following could be found:

- FRAM version of ”drift into failure”?
- Modelling of factors that are performed over long time periods (aircraft design, maintenance, certification) and combining this with short time horizon in the same instances, various time horizons, how to model?
- Task or risk analyses use to establish a FRAM model
- FRAM models functions and their performance, not steps of cognitive processes, but how to model ”cognitive functions” and their variability with FRAM? Minimal models?
- Presentation of FRAMs, how can we keep FRAM models and their instances tractable?
- Connection between FRAM and Envisioned World Problem?
- The fact that we can model the same 'item' as many aspects (e.g., a plan as an I, P, C, R), is that a richness of the method, and a good way to make sure every critical aspect is addressed, or more of an unwanted confusion?
- (How) should we define the aspects more precisely? Can we address the relationships between aspects more explicitly?
- EH: A FRAM is a specification of functions and aspects, excluding links. At the same time, there is no right starting point of function analysis, there you need to follow the links. So how do you build up a FRAM while not at the same time including the links in the description? Can functions and links really be separated during analysis, or only after the analysis?
- Can we more formally describe the relationship between aspects and CPCs? How does this connect to the 3-layer thinking?

Overheard in the room

There is a tendency to end up with a sequential model with FRAM hexagons but this is probably due to the fact that a lot of work is done sequential.

The difference between states and functions was discussed and an example was that "issuing a [ATC] clearance" is a function but "an issued clearance" is a state.

A good start for an analysis could be a previously made task analysis, *but* it is not all you need.

Regarding the challenge of modelling whistleblowers one way suggested was to look at reporting systems and model the functions of the reporting system. An argument against modelling this was that you only know that the whistle blowers were right afterwards and that before an accident their knowledge drowns in other "irrelevant" ideas of what could go wrong. A counterargument was that by looking at and modelling both verbal and written reports you can find out how the information system works and improve it. There is also the whistleblower who goes outside the organisation (e.g. to the media) which could be seen as a sign of something being wrong in the organisation.

Question: When you do a (FRAM) analysis of an accident how do you make sure that you connect with the larger control system?

How would you promote FRAM?

"It is useful when you need to explain how or why it goes wrong even though everything seems to be going right, you can do this with the concept of normal variability and before I get to the examples people tend to give me examples of their own."

Second day - Thursday 2008-02-21

A FRAM analysis of aviation mishaps

Presented by: Sébastien Travadel & Didier Delaître
From: B.E.A
Contact: sebastien.travadel@bea-fr.org, didier.delaitre@bea-fr.org

Sébastien & Didier presented a FRAM analysis of an incident that occurred on approach to Paris-Orly the 23 November 1997. The involved flight was an MD83 registered F-GRMC. The flight differed from both the horizontal and the vertical path and came as close to the ground as 67 feet before climbing and making a "go-around".

In the analysis different types of nodes (functions were identified: *Crew action* (considered as "Actions") and *Aircraft motion* and *System display* (considered as "States"). Actions are triggered by the input whereas for states the input is processed by the system to modify the state. But sometimes actions and states can be merged into one node

Table 1 – Difference between Action and State nodes

	"Action" node	**"State" node**
Input	Triggers the action	Processed by the system to modifty the state
Output	Produced by the action	Final state
Control	Immediate check associated with the action	
Resource	Describe the level of resource available at that moment	
Preconditions	Contextual elemant that influence the result	Condition for the state to evolve
Time	Indicate the location in the sequence	

The nodes was organised according to the flight path and the captains actions. An example of a node can be found below:

Table 2 – An example of a function

	Captain index positioning
Input	Index on 020
Input	LOC CAP displayed
Output	Index positioning: wrong
Output	Announce LOC CAP HDG QFU
Preconditions	Track 258 selected
Time	12:29:43
Resources	
Control	Comparison to expected QFU
Control	Needle close to expected position

3 interesting sequences was highlighted by FRAM

- Captain's sequence awareness (the captain had a sequence awareness that counter-balances poor situational awareness, he knew that something was wrong).
- Captain's understanding (erroneous track selection).
- Captain's decision to go around (was explained by the pilot as: "I felt that I was not stabilized", but he should have been stabilized much earlier so what did he actually mean?)

Finally FRAM was found to enhance data collection in course of the investigation, it highlights deficiencies of functions and it shows the evolution of the context.

With the help of the FRAM Visualizer the functions where organized according to the flight path, see Figur 3.

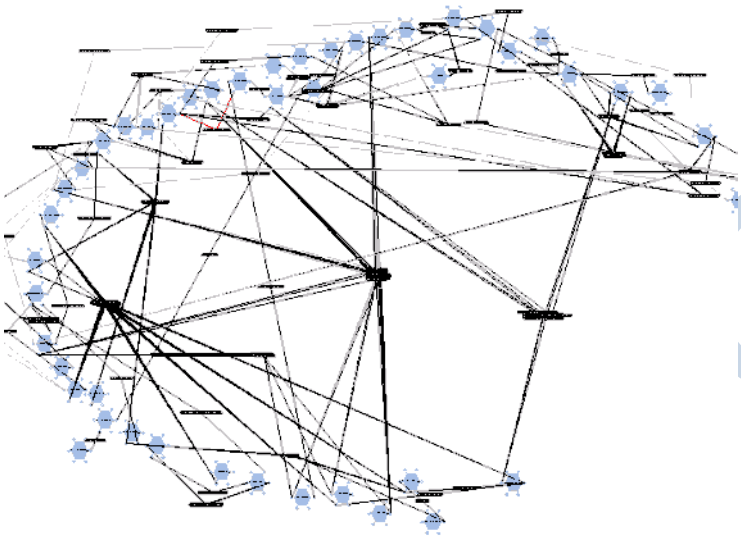


Figure 3 – Functions organized according to flight path.

Overheard in the room

One question raised is why procedures has been considers as precondition and not as control. Maybe both can be right since it is a precondition that there should be a procedure but as the action is carried out it is the procedure that controls how the action should be carried out. The fact that you could often fit a thing (like procedures) into many of the aspects could be a strength but also confusing.

It was argued that the description presented is a very good one of *what happened* but that it does not answer the question *why* it happened which would make it possible to avoid similar accidents and incidents. And that to use the T to indicate the time it happened is not as interesting as looking if the time was sufficient or not. This is probably due to the fact that the work so far has only covered the first step of FRAM.

It was also brought up how to model decision making and cognitive aspects and if this was necessary to do or not. Related to this a discussion started about the relation between data collection and analysis and it was said that even though FRAM, in the BEA case, has been used only to describe what has happen some sort of analysis has taken place anyway. It was concluded that if the analysis would be taken further, beyond Step 1, the questions about why it happened would probably be answered.

Which data was most difficult to model/gather?

"We had no problem, but it might be an issue if you use it in a real time investigation, and you have to use the model early in the investigation to know what data to collect. One reason we did not do a full analysis is that there was not sufficient data available"

A comparison of the FRAM and STEP models in the aviation domain

Presented by: Ivonne Herrera & Rogier Woltjer
From: SINTEF resp. Linköping University
Contact: ivonne.a.herrera@sintef.no, rogwo@ida.liu.se

The presentation tried to answer the questions about what the advantages of the both methods are and what can we learn from them? STEP and FRAM has been applied to an air traffic incident, where a Boeing B737-36N enroute from Stavanger to Gardemoen came into a significantly lower approach than expected. STEP was developed in 1987 and it sorts data in a timeline with tasks divided between actors performing the tasks, see Figure 4.

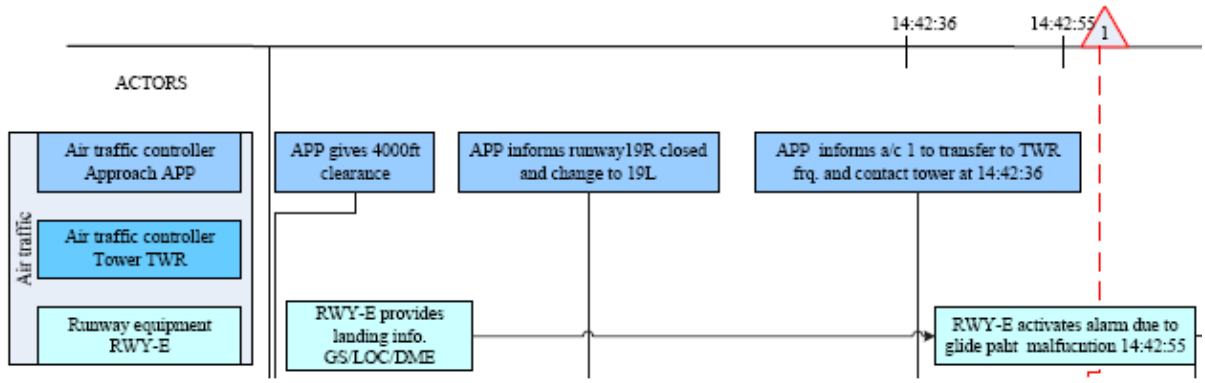


Figure 4 – A small part of a STEP analysis of the incident presented.

In the FRAM analysis which actor was performing a function was visualised by colour coding of the hexagons, see Figure 5.

Functions with normal (reasonable) performance variability were identified and so were variability that was out of the ordinary. And in the visualization it is possible to follow the variability through the model, between the functions.

The recommendations of the accident investigation boards were mapped into the analysis to see what barriers that was suggested and which of the variability found in the analysis that they would dampen. When this was done the analysis made it possible to come up with more recommendations.

Reaction from the accident investigation board was generally positive but they found it limiting that there was no Common Performance Condition (CPC) called “Other” or something similar.

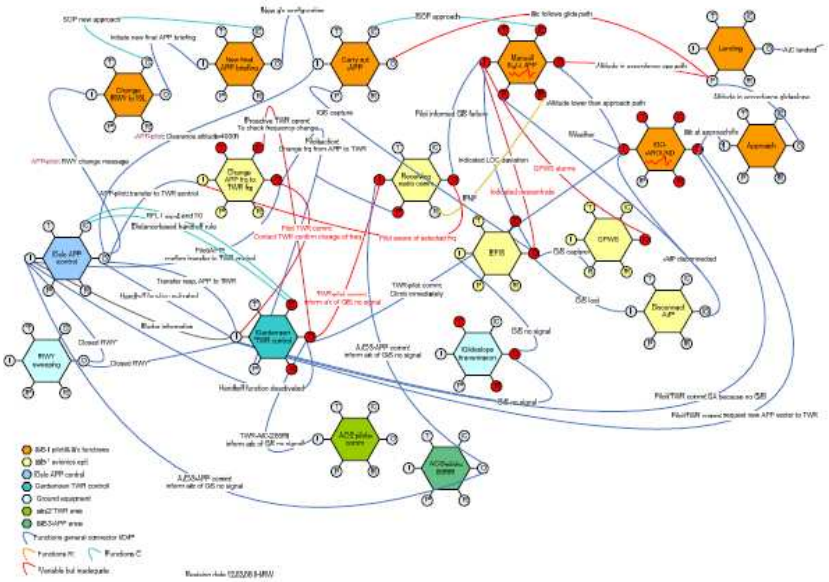


Figure 5 – AFRAM analysis of the same incident as in Figure 4.

Overheard in the room

Barriers should be represented as functions in order to be able to consider the variability contribution from the barriers. Regarding barriers it was also discussed whether trying to constrain variability is compatible with ideas about variability as something normal. A comment to this is that some variability you will want to constrain and other variability you do not want to constrain. It is also important to note that barriers can both dampen and constrain variability and sometimes dampening and not constraining it is preferable. The fact that the word barrier has a negative cling to it is a problem and perhaps we could use something else that is more neutral since barriers has both positive and negative contribution to the system.

The idea that FRAM should not be used for recommendations was raised but this was met with protests saying that FRAM should indeed be used for recommendations. Ivonne's and Rogier's experience with the Norwegian accident investigation board supports this later view.

The choice made in the visualisation would be interesting to know more about so that we all could use it in the same way. And learn from Ivonne's and Rogier's experience.

All examples so far has been rather short examples, in healthcare an analysis was made over 149 days, something that would create an enormous amount of hexagons. So the trick then would be to choose those which are relevant, something that you can only knew once you have analysed them?

What is a function?

"A combination of Eriks descriptions and a feeling."

Which data was most difficult to gather or model?

"What is normal and regular and understandable behaviour? That was something that needed to be defined."

FROM A4 to the FRAM Visualiser, to Post-It notes, to Visio

Presented by: Dominic Furniss
From: University College London
Contact: d.furniss@ucl.ac.uk

In a PhD project Dominic has focused on understanding the choice and use of HIS methods in a system of HIS practise. He started by conducting a number of interviews that resulted in a large amount of data which eventually was organised with the help of FRAM. This presentation was a very visual one that is hard to summarize with words, but hopefully Figure 6 can be a memory aid.

Regarding visualization a quote by Miles and Huberman (1994, p.11)was given: *You are what you eat* might be transposed to *You know what you display*.

Organising the information with the FRAM-visualizer enabled recognising more connections than was recognised before but the visualisation soon was filled with a lot of connections. But to sort it all out each function was written on post-its. A template was also created to describe the function and its CPCs. To begin with some things were not fitting very good into the concept of functions but in hindsight these things can be categorized as states.

Overheard in the room

We all feel that we want to fit all the information onto one page, should we let that decide the level of granularity? There is a problem that when a analysis gets larger than a certain amount you can never look have a grasp of everything at the same time and you and up looking at smaller parts of it at a time. On the other hand a good model lets you analyse things in a systematic way and if you can also visualize it in a good way that is a bonus. Maybe we should not rely too much on the visualization.

It was pointed out that the question about visualization is a reoccurring question seems to be how we represent the information and that maybe a more important thing is to represent it in a way that the addressee understands them. It might be okay that the representation varies depending on who is supposed to understand it. Something that could also be related to the concept of bandwidth in communication. Maybe too much time is spent on discussion on how to represent the material and more focus should be on the theoretical and practical parts of the method, because; how often do someone ask which method we use and want us to present that… what we are asked for is results, such as recommendations.

There seems to be different ways of applying FRAM and the question was raised if this inconsequence could not be a problem.

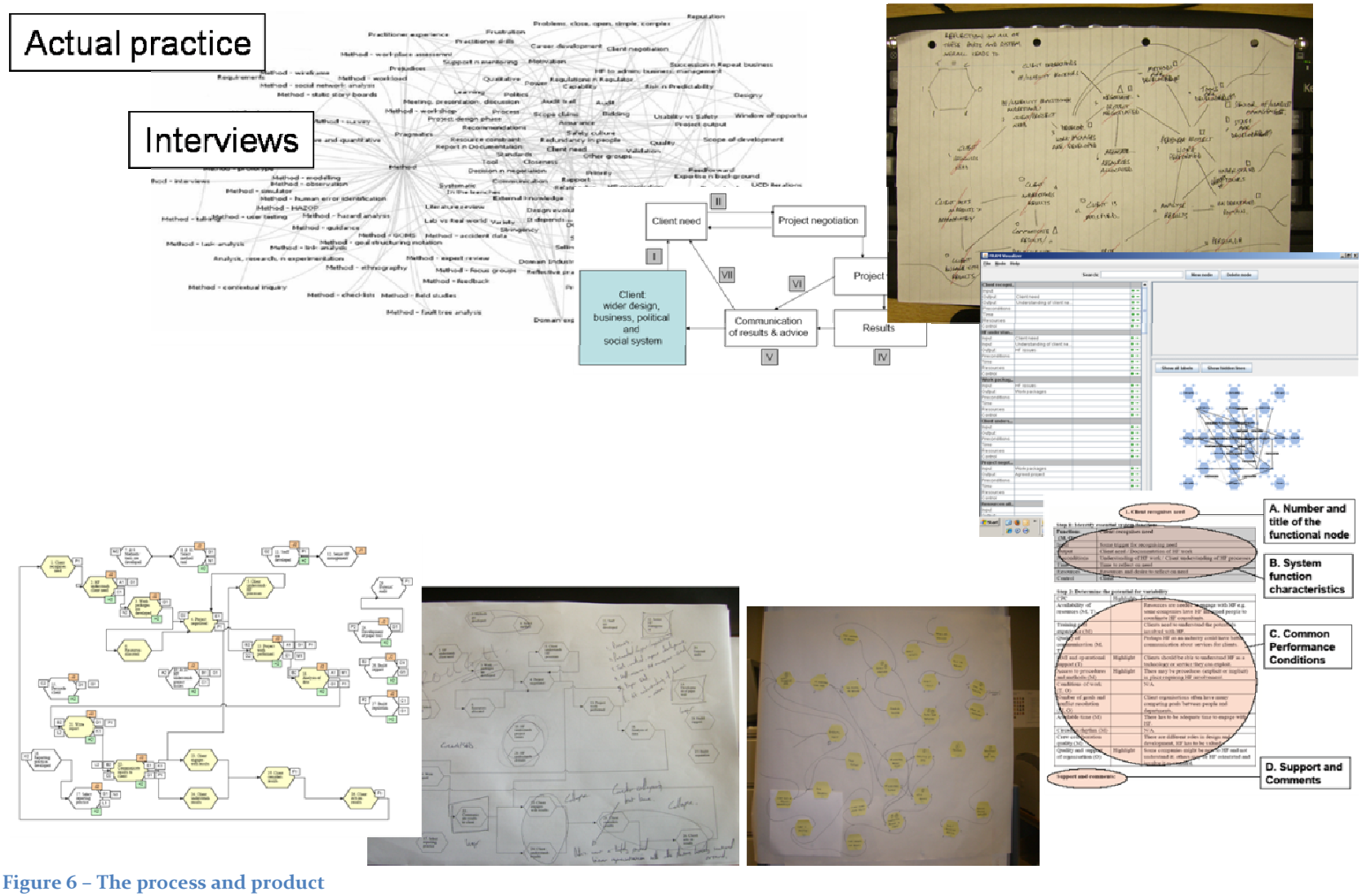


Figure 6 – The process and product

Structured brainstorming

Chaired by: Denis Besnard
From: École des Mines de Paris
Contact: denis.besnard@crc.ensmp.fr

A structured brainstorming was held with "Functions" as a topic, the topic most wished by the participants of the workshop. The task was to in groups answer the following questions:

1. How do we identify functions (level of granularity, span, critical functions)?
2. How do we take into account the difference between *functions* and *actions and states*?

Group A

1. Different level of detail of describing things. You could either consider functions, activities and tasks as different ways of describing the system on a different level or call them different pieces of the system.
2. Regardless of whatever function you choose when you take a picture of, and look at the situation that is a state.

Group B

1. No distinction between functions and actions
2. The output from a function is depending on all the parameters (Input, Output, Preconditions, Resources, Time and Control) and that output comes in the shape of a state.

Group C

1. A set of actions to achieve a purpose or a goal
2. A state is on instantiation of a result of a function. A function can have different states. A state can exist independent of a particular function.

Group D

1. A function is an activity that is necessary to perform the task. You understand what the functions in a particular situation are by asking e.g. operators what they do.
2. Results that has happened as a result of actions or activities

Overheard in the room

Is discharging a patient and liberating a bed the same function? If your are interesting in emptying beds it probably is, so it depends on what you are interested in. The state of the bed has been "occupied" and is then changed into being "empty". The state of the patient was "hospitalised" and changed to "discharged".

FRAM seems to need functions, does it need states? Yes, because that is a way to get out of the problem with output of the form "yes" or "no". It makes the diagram less messy, It could also be a way to trace state changes throughout the system (ex flight level).

A function occurs and a state is something that is. A function transforms a state into another. Functions are things that are done to bring about a certain state.

Regarding the level of granularity Denis threw out a suggestion that "the human level should be *the* level of granularity and the rest is uninteresting" as a starting point for a discussion. This suggestion found some supporters but others say that that level of granularity would not account for the system in a way that makes it possible to assume a systemic view. It was also suggested that the level of granularity is not interesting as long as what has happened can be described. And that the decision of how far to go is dependent on what variability we want to explain.

Last day – Friday 2008-02-22

The amplitude of resonating features and conditions of healthcare systems

Presented by: Rob Robson
From: Winnipeg Regional Health Authority
Contact: rrobson@shaw.ca

Ideas about how functional resonance and FRAM can be of use in health care. In Canada 1 out of 13 patients admitted to health care will experience some sort of significant adverse event (death or serious injury) during their visit, because of a breakdown of the system. ¼ of these are related do medication, e.g. giving someone the wrong medication etc. A lot more people that die in hospitals than get murdered, maybe it is time for PSI-Winnipeg instead of CSI-Miami…

When looking at healthcare safety there are different levels you could study it from (patient-provider interactions, clinical programs, single facilities, multiple linked facilities, etc.) and maybe one should look at it from the patients point of view.

There is a focus on quantitative data in healthcare but we need quantitative to. And the focus should shift from S/P/O (Structure/Process/Outcome) to S/P/P(Structure/Process/Patterns of behaviour).

Plsek's five key patterns (Learning organization, Value assigned to relationships, Decision-making, Power-sharing, Conflict management) are important, but how do you measure them? We need to find a way to do it that is accepted and scientific.

A very sad pre-Christmas story

A healthy 57 year male was removing Christmas lights in May and falls 3.5 m from a ladder. A fall that results in pain in his shoulder and pain with deep breathing. He was taken to the community hospital emergency department where he met a physician who is an experienced specialist, but not an emergency physician that has recently immigrated to Canada. A chest ray was taken and he was diagnosed as having a collapsed lung, pneumothorax, and a dislocated shoulder. A chest tube where inserted but the chest tube returned blood so additionally to the pneumothorax, hemothorax (blood accumulated in the pleural cavity) was assumed and a second chest tube was inserted. The shoulder was reduced and medication was given. The patient started to suffer from abdominal pain and got worse when it was discovered that both chest tube was accidentally inserted into the liver, which also explained the presence of blood in the first chest tube. When this was discovered the patient needed two months to recover and it turned out that the shoulder was not dislocated and there was never any pneumothorax, but there was a small fracture in the shoulder.

With the help of the "new view" introduced by Dekker findings showed that:

- New doctor never had any orientation
- The doctor was not informed that diagnoses could be consulted electronically
- The doctor did not consult other doctors (gender/age factors)
- Credential process is a mess (three instances that does not talk to eachother)
- 5/6 nursed working was newly graduated
- Doc believed there was a pneumothorax (consistent with patient complaints and exam)
- Doc did correct procedure (based on wrong diagnosis) incorrectly.

Variability factors:

- Number of doctors: 1-2
- Number of nurses: 4-6
- Number of patients : all rooms/stretchers full and 12 patients waiting
- Experiential mix of nurses: very wide (no standard exists)
- Orientation of new doctors: slim to nil
- Facility/regional credentialing process: crisp to soft - rarely messy
- Licensing body approval: slow fluctuations in response to political pressure – change in past two years that led to much higher acceptance of FMGs.

FRAM question:

- I licensing body approval a function in this case?
- Is the described change in licensing body approval of FMGs an example of resonance??
- Should systemic functions with primarily qualitative features be excluded from FRAM analysis?
- Can the resonance of qualitative systemic functions be described?
- Can very low amplitude low frequency resonating functions interact in a non-linear manner with other similar qualitative systemic functions?
- Can we distinguish between low amplitude, low frequency resonating features and background noise?

Overheard in the room

It was brought up that you should keep in mind that the population in a hospital is a very vulnerable population and that the numbers therefore gets very high. Bu this was contradicted by a claim that the numbers were probably low. And even if a patient that would surly die soon giving him/her medication that caused death is still not preferable.

Regarding the mix of experienced and non experienced nurses there should be a balance, only experienced would not be good either.

A lot of the things brought up should be covered by the common performance conditions (CPCs).

A big difference between a doctor and e.g. a pilot is that the doctor does not go down with the patient if something happens. So there is a difference in consequences. This was meet by a comment saying that “when the pilot crashes into the mountain with his passengers he also dies, when the doctor accidentally kills a passenger he goes home and have dinner with his wife” is an argument that is wrong! It is not like that. It was also brought up that whereas the

pilot dies the doctor have the opportunity to learn something from the incident and that could be seen as an advantage.

The question was raised that if we are to use FRAM to capture different types of variability we have to have ways to assess the amplitude of the variability we are assessing. Is there a way to capture this difference in variability in FRAM as it is, and do we need it? From the reactions to the question there seemed to be a need for this.

It was also questioned if it is possible to talk about amplitudes and frequencies as low or high, since fore every function the scale is different (e.g. flight hours in one function something totally different in another). What suggests that there is some use to talk about it is that if it was a very high amplitude we would probably notice it, hence there must be low and high. On the other hand it might be more interesting to look at the change in amplitude and frequency.

Under which circumstances would the approach suggested not apply?

"*There are incidents and accidents in healthcare were what happened is not that complex where we not need to ask this type of questions and do this type of analysis. "*

But the trick is to know when this is the case…

The building of predictive performance models from emperical data

Presented by: Jim McMenemy
From: Winnipeg Regional Health Authority
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A presentation about risk profiling in the air taxi sector of the aviation industry. Things to take into consideration when flying in the pacific region is the western coastal terrain, the mountains, the weather (low clouds and hurricane winds are usual), operations are often over water and in isolated places and that many operations are single pilot operations.

There is a structural hierarchy of actors from Government, via regulators etc. down to the actual work being performed. And there are also different, in a sense competing, boundaries such as safety and economics.

The accidents in the 125 accident reports analysed where categorised into Rasmussens categories of mistakes, violations, slips and lapses (and undetermined). Of the accidents 62% where categorized as mistakes. Generic accident maps where created of the accident and from this four different main factors was found: mountains, weather, coastal terrain and equipment. None of them surprising at all. But to actually get an accident there seems to be a need to add two things: A low experienced pilot and a self dispatch system. Could this be resonance?

Overheard in the room

One answer to the question above is that maybe we do not need to talk about resonance, could it be just correlation of factors?

If you ask is "this" resonance… what do you mean by "this"? - One example could be variation of experience level… A variation that in combination with being self dispatched can constitute an issue. But if the pilot is not self dispatched this variability does not seem to matter that much. On the other hand the experience of the pilot should not be seen as resonance.

Regarding databases there is interesting what is actually being recorded in the database. Interesting thing to add could be example what kind of training was given, the financial status of the person involved etc. And maybe these kinds of aspects can be found by going further back with the help of FRAM. In the investigation above the only thing the database was actually good for was to get the file number and bring out the actual file. So the work already made by putting together was not of use to the investigation.

Could there be a cross domain application of this work?

"Yes I hope so; I think this type of retrospective look at previous investigation and gather them together is needed. Something that I hope will help make the whole investigation procedure more efficient in the future. I am hoping that we could do the same thing in healthcare."

FRAM Visualizer

"Presented" by: Peppe Bergqvist
From: Linköping University
Contact: petbe082@student.liu.se

The FRAM Visualizer can be downloaded for free at:
http://code.google.com/p/framvisualizer/

The following topics where briefly discussed:

- Colour coding of hexagons, as in Ivonne's and Rogier's example
- A way to show which parts of the hexagon that are used which are used or not
- Would we want the tool to be step based or free forming?
    - It could be good with something that helps us building up the model, the first step
    - It is good to have structure but there is a need to be able to go back
- Different layers/levels with functions
- Two categories: functions and states. But the states could probably be listed and there is no need to add a new symbol
- Instantiation, model and case. It would be interesting to make the model first without instantiation and then do the instantiation later. But the question would be how to make the instantiation, if we no longer make it "automatically".
- 3D sucks – use the axis. Right now there is no specific use to the location of hexagons.
    - Maybe with a choice on what to put on the axis
    - Maybe to export it to another program

  - 3D aspect
  - Mac-zoomfunction when you move over the hexagon
- Handle variability
- The method should not be driven by the tool, the tool should be driven by the method.
- How do we support this development in the future
  - Forum
  - How can we finance Peppes work?

Modelling normal performance variability with FRAM, And: Risk analysis with FRAM

Presented by: Ivonne Herrera & Camilla Tveiten
From: SINTEF
Contact: Ivonne.A.Herrera@sintef.no , Camilla.K.Tveiten@sintef.no

A presentation focusing on how we capture normal variability, both positive and negative characteristics, without looking only for errors.

For each step of FRAM questions/comments on how this is done was raised. These questions follow below:

Step 0

- What is a target situation of normal work
- Target situation – successful operation – what does this mean?
- What is a good enough scenario description?

Step 1

- Level of analysis
  - On what level should functions be described in order to obtain a good analysis?
- How do we describe time and its impact short term – long term?
- When to stop the description?

Step 2

- We have a check list but it limits the ”things to look for”
  - How do we capture other ”CPCs” that are important

Step 3

- How you identify “resonance” that is essential to the system
  - Resonance between two normal processes

Step 4

- How you go from resonance to “damping factors” identification
- How do we select essential “damping factors”

- Which kind of "damping factors" support flexibility, early warnings, creativity and improvisation
- What to look for? What do we do from a risk perspective?
- Performance monitoring is an important factor when FRAM is used in risk analysis and for risk prevention.

Camilla and Ivonne also mentioned that they are working on some risk assessment and that they hopefully will be able to present something about that next year.

Overheard in the room

There has to be a differentiation between what we accept as performance variability and what needs to be managed on an individual level. When we look at performance variability we have to look at the adaptations that are necessary to make it work and people will tell you about this (we have to do it like this to make it work).

First of all we need to know what the people really do. Then we can represent it in FRAM. On the other hand it was argued that this is not the case, FRAM is not just a representation since it offers you a possibility to analyse and understand the system.

Given that you can group functions into a larger function there will be resonance within the function. But when that is the case you should probably split it up and not keep it as a single function.

How do we assess the variability? Repeated observation, statistical records?

Maybe the term of functional resonance should not be used?

What is the problem of having resonance? Is it a lack of control? Is it functional effect on other functions? We want to prevent losing control over the resonance, and manage the resonance within safe limits.

Structured brainstorming about the assessment part of FRAM

Chaired by: Denis Besnard
From: École des Mines de Paris
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The last day ended with a post-it brainstorming session asking participants to write down *What should the method do for me* any questions or suggestions they might have on post it that where then organised into the following categories:

Communication and representation

- Help identify risk interactions and potential for dampening/managing out of control resonance
- Support in getting insight potential for resonance
- Which kind of risk picture we obtain from FRAM
- Is there a need to visualize variability differently than it is done now
- FRAM should be easy to apply with illustrations on how the COC might fit with TIPCOR
- The graphical representation should support and enhance prerequisite imagination
- Explainability of the method to laymen. If not --> no future
- FRAM should provide broad framework so that relevant information is obtain
- The FRAM product should communicated to the consumer of the risk assessment i.e. a no-FRAM person
- Text boxes to describe how and why functions can vary

Quantitative and qualitative

- evaluation/assessment of severity of resonance

- Can/should the predictive model include a degree of risk (probability) for interactions?
- How can FRAM indicate:
- probability/frequency of risk
- 2.severity of consequence of resonance
- FRAM as a perspective risk assessment tool: I would like to be able to assess the impact of a new tool on the system
- Can FRAM be quantitative?
- Need to do a quantitative assessment?
- Should predictions be qualitative or quantitative?
- How can predictions be calibrated/verified/ validated?
- Do we really be concerned with identifying quantifying resonance or looking at acceptable level of function variation is enough?
- Could FRAM measure future risk?

Descriptive normal

- How cognitive work analysis can support to identify essential functions in order to assess risks?
- Offering a basis for comparing processes and simulation
- Describe “normal” operations? Work as performed

- To describe as much normal work in as many as different industries as possible in order to know more about variability
- How can representative scenarios be obtained or developed?
- CPCs mapping into FRAM elements? It is possible to make it explicit?
- More structure on CPC's (vs.) Functions
- How can date from pas accidents/incidents improve/support risk analysis?

Variability

-identification and recognition of factors of variability

- How do we differentiate resonance from co-variance
- Generalizable predictions will it be possible or restricted to narrow specifics?
- How we identify thresholds for variability and functional resonance
- If there are several features that contribute to the resonance going out of control could it predict the relative importance/contribution of each variable to the event
- Is physical resonance an analogy worth developing?
- FRAM can be used to structure "what if" scenarios to assess potential for risk
- Propagation of variability
- FRAM should be able to allow outside the box-thinking. Enhance anticipation
- Identify positive and negative contribution of important connections
- Tools to help trace resonance possibilities between aspects of different functions
- FRAM should be able to represent recursive relationships
- Let non-linearity not spoil predictability. So indicate the possibility not the value
- Explicitly functions that will be time critical for resonance

Miscellaneous

- Can FRAM help define acceptable level of risk?
- Elaborate a case study so that users could work together at the same time
- FRAM should be able to model systems that do not yet exist
- What it should do: reduce accidents
- Could it predict or guide/help identify the degree of impact and how it would impact the system and or point of operations
- How can FRAM help to improve the understanding of what is a cause of accidents?
- I would like to see methodological steps which show how functions identified in hindsight can be applied in foresight
- How can FRAM indicate. Help to develop risk controls
- Does looking ahead rely on the same FRAM principles as retrospective FRAM?
- Could you provide examples of performance indicators in the framework of FRAM?
- Could we try for the next step to define some "typical response" which would serve as basic functions with values reasonably accepted by the community?
- What information can prospective analysis rely on?
- Identify situations related to resonance process to verify that suppressing factor of accident leads to avoid accident

- The value taken by the functions should have a strong correlation with the experiment we can do. The risk assessment should be associated with a "measurement" of the possible variation
- How should we establish the link between a specific sequence described using FRAMN and a risk assessment? The question here is to identify what can be dropped in the description for one event and still have track of the variation/resonance.

Feedback and future

After the workshop a lot of the participants handed in the yellow feedback form, answering three questions: *What are the main points that you will bring back home from this workshop?*, *What topics would you like to address during the next workshop?* and *Anything else?*. Below a summary of the contributions can be found.

What are the main points that you will bring back home from this workshop?

- FRAM could be used to model dynamic interactions.
- Use FRAM as a risk assessment method.
- More ideas regarding selection of functions.
- Still confused but motivated.
- FRAM is maturing bit still relatively "green" for an adequate functional decompositions: the identifications of performance variability of FRAM functions remains to be explored and developed.
- Basic elements of FRAM across diverse settings.
- Functional Resonance Analysis Method – new and more broad which I like.
- There is not one right way to do or present a FRAM – a lot of I is context dependent. How straight you follow it, What you are doing it for, how you lay out the flakes etc.
- A better idea of model vs. instantiation, states functions and sub-functions.
- I will certainly bring home a better understanding of the principles behind the model.
- The concept of resonance and variability seems to me the key point of the method. That was not immediately clear on the book.
- The potential use of FRAM to better understand systems (complex…) and, more importantly, a way to better understand their dynamics. Although a lot more may be needed to "control " dynamix processes, this is a good first step.
- More confusion.
- Some ideas how to move from linear to systemic.
- I do not believe in team work and popup[*] discussions.

What topics would you like to address during the next workshop?

In addition to the points handed in on the yellow form many of the presentations, especially Rogiers presentation(*Aviation Accident Investigation and ATM Automation Risk Assessment using the Functional Resonance Accident Model*) and Ivonnes and Camillas' presentation

[*] This word was kind of hard to read, so my apologies if it is misinterpreted.

(*Modelling normal performance variability with FRAM and: Risk analysis with FRAM*), contains questions to work on and maybe address next time.

- Risk assessment.
- FRAM & Resilience Engineering how they complement, or not, each other.
- Strengths and limitations.
- FRAM best for which kind of situations.
- How do we use the "functions" identified to predict future, possible, incidents and accidents? Can we assign a degree of risk to resonant interactions?
- More applications, beyond aviation.
- More broad application context – not just aircraft.
- [Unreadable word] with variability.
- Normal work, positive, negative, performance.
- I would like to model a small example together in the beginning of the workshop (not so experienced users will learn the model and everyone will have a common example to refer to).
- I would be interested in understanding how FRAM can be used to model complex system. More practical examples applied to different levels (organisational, front end operations) might be useful.
- Discussing experience.
- Modelling an example together.
- I expected more *work* from a *work*shop, the discussions need more steering not to get away from the topic (FRAM)and become just another general safety discussion.
- How to identify trends with FRAM.
- Where is the resilience in FRAM?
- In many of the visualizations presented parameters/aspects/connectors has been coloured to indicate that something is not good with the variability. This indicates a underlying mapping of CPCs and aspects. How this is done needs to be sorted out in order to assure that findings from the second step are kept in following steps.
- The connection between retrospective and prospective data.
- Let's talk more detailed and precisely about the FRAM examples, which are demonstrated (more detailed discussion).
- More focus on the use of FRAM as a way to describe systems under "normal" conditions and how this can help us shift from a reactive analysis of events (instantaneous) towards a more proactive approach.

Anything else?

- Very good workshop, thanks for the preparation.
- Would like to have discussions in smaller groups.
- Excellent food!
- The number of participants was a little bit high.
- Really nice workshop.
- Good to mix over buffet.

- Maybe do group working at beginning to speed interactions – I have no experience of this and don't know how it might work.
- Use flip chart pads to collect participants ideas during discussions: you might actually ask people to write down their ideas related to a discussion point and then post it on a common board. That during the discussion, not only during the brainstorming.
- You might consider lateral thinking techniques to apply to the management of the workshop
- More specific discussions.
- When activities then with specific tasks/functions.
- When considering workshops such as these versus most conferences and congresses it's like looking at quality versus quantity. I much rather stick with quality, so more focused workshops and not so much conferencing.

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