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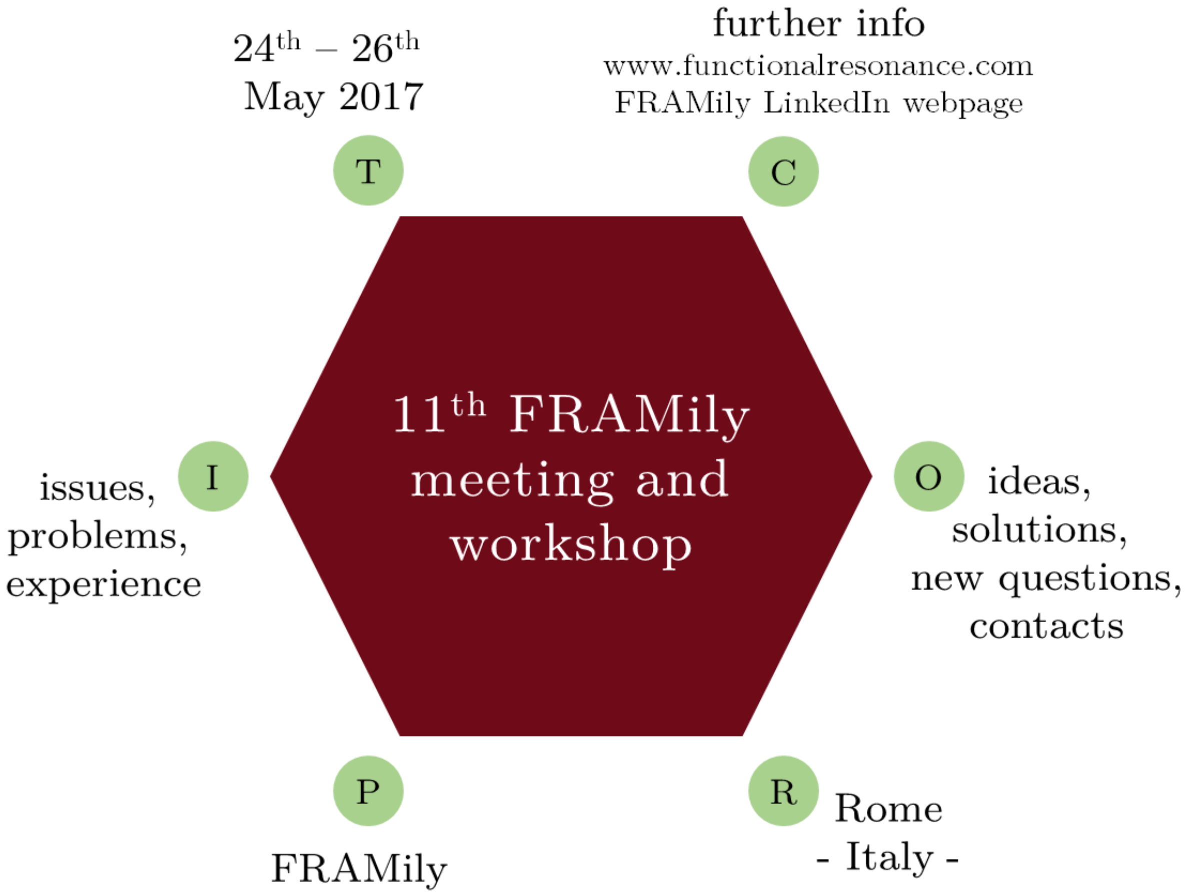

Book of Abstracts

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11th FRAMily Meeting and Workshop
24th-26th May 2017
Rome, Italy

Table of contents

Section 1 "FRAM for modelling complex adaptive socio-technical systems: system analysis"...... 1

FRAM analysis of "Walking in Tokyo Station" 2

Modeling Nuclear Safety: A Sociotechnical Systems Approach 3

Using FRAM to reduce skill mismatch: an application of public employment offices' guidelines 4

Five years of applying FRAM in Danish Health care settings: Patient Safety in Everyday Work 5

Section 2 "FRAM for modelling complex adaptive socio-technical systems: The effects of standardization" 6

Effect of standardization on the partial process of wheelset exchange in a repair center of Swiss Federal Railways 7

Functional modelling of the expected and actual impact of resilience guidelines on European critical infrastructure crisis management – added value of functional modelling for crisis management? 8

Understanding the impacts of enhanced automation in future ATM performance 10

Section 3 "FRAM for modelling complex adaptive socio-technical systems: System design"...... 11

Analyzing Software Development Process using FRAM - case study of personal level software process - 12

FRAM supporting the implementation of a patient responsible consultant: 13

One Patient - One Responsible Consultant 13

Section 4 "WTF!?! – What the…FRAM: Strengths, Weakness and the potential for further research" 14

Automation of the FRAM method for the purpose of hazard analysis 15

A multi-layer FRAM: The Abstraction/Agency framework for modelling complex socio-technical systems 16

Functional Analysis of a Joint Cognitive System: Agent and Inter- Agent Transformations of Information Flow, a case study in a Cockpit Environment 17

Applying and visualizing the FRAM for Arctic ship navigation 19

Section 1
"FRAM for modelling complex adaptive socio-technical systems: system analysis"

FRAM analysis of "Walking in Tokyo Station"

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In this presentation, author will perform FRAM analysis on how people can safely walk though Tokyo station main concourse which is one of Japan's busiest places. People are moving toward different directions, speeds and motivations. Although the situation in the concourse borders on chaotic, we seldom witness collision or any other unsafe incidents there.
The analysis will show how people can survive and thrive, without enforcing "safety control" or "safety constraints" and reveal the nature of self-organized architecture of the mass movement which resembles Craig Reynolds' "flock rule" of birds.

Modeling Nuclear Safety: A Sociotechnical Systems Approach

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The sociotechnical system is not just complex because it consists of many interdependent physical components but because it also contains non-technical components which interact dynamically. The Fukushima Daiichi nuclear accident provides an example of such complexity. Based on system thinking, the dynamic, unexpected, and uncontrolled relationships between different system components can cause an accident. Consequently, the systems approach to safety is an arguably adequate method to capture the dynamic behavior of system components. One example of system-based methods is the functional resonance analysis method (FRAM). The first step of FRAM is to identify system functions. In this paper, the Fukushima Daiichi accident has been analyzed to identify its functions. Two types of functions are proposed: core functions and boundary functions. The study identified 37 functions relevant to the accident.

Using FRAM to reduce skill mismatch: an application of public employment offices' guidelines

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Public employment offices' ability to properly match skills supply and demand is essential to improve the efficiency of human capital allocation (Desjardins et al., 2011; Leuven et al., 2010; McGowan et al., 2015). This objective is often failed (Gebauer, 2010), as a recent Italian study on job-matching services has proved (Provence of Pistoia, 2016). To prevent job mismatch risk, employment offices have often gone through important re-organization phases and have adopted strict guidelines oriented to drive applicants toward the most suitable actions: training, internships, jobs. Actually, the results are not satisfying. Job mismatch risk has to be assessed in a complex socio- technical environment in which different levels are comprised: (i) technical (data bases, repertories, official data, learning machines); (ii) human (the capability of operators to properly understand contents and skills of a plurality of professions, competencies, knowledges); (iii) organizational (rules, and interactions) which govern the actions to be adopted. Each one of these components are usually addressed separately (empowering the human operators, changing the organizational rules or installing new computer systems). In the present case, decisional levels are deeply influenced by personal behaviours and the application of rules that may, in some extent, be differently interpreted: in this perspective, it is impossible to get the point of a full job matching automation. In this contribute, we intend to discuss a systemic approach FRAM based: we propose the result of a recent analysis of employment offices guidelines and experiences, focused to understand and improve their performances and to reduce the skill mismatch risk. FRAM perspective has allowed improving a multidisciplinary integration and cooperation between different system stakeholders. In particular, The FRAM approach has been applied to describe the work-as-done and align it to the pursued results, as presented and discussed in several official contributions (CEDEFOP, OCSE, ILO, ISTAT). The overall analysis has been integrated with official data as well as with data on skills' mismatch collected by the quality system adopted by the Pistoia Provincial Employment Centers; it has been enriched, whether possible, with the indications arising from the above cited quality system, in order to improve it and make it more suitable for the real situation.

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CEDEFOP European centre for the development of vocational training http://www.cedefop.eu.int/

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ILO International Labour Organization "Skills mismatch in Europe", Geneva, 2014

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Five years of applying FRAM in Danish Health care settings: Patient Safety in Everyday Work

Jeanette Hounsgaard
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Five years of applying FRAM show how a description of everyday work can improve patient safety in Danish health care settings. The experience is that it is possible to identify, describe and understand adjustments in everyday work by using both the ETTO Principle[1] and the FRAM[2]. More than 40 analyses with FRAM has been prepared together with the health care professionals at the public hospitals in the Region of Southern Denmark. These analyses showed that FRAM offers a structured way to get knowledge about the adjustments and the performance variability in everyday work. The health care professionals are aware of the adjustments they make and can describe them. On the other hand, the health care professionals are not aware of how the adjustments sometimes can emerge into an unwanted and unexpected outcome for the patient.

The experience also showed that the FRAM model is a valuable tool to:

- provide a detailed description and an overview of the complexity of everyday work
- show dependencies and interactions between functions
- help the health care professionals to realize that even small adjustments in everyday work can lead to an unexpected large performance variability
- give a shared insight into how everyday work actually is performed
- give a common language and a common baseline to improve quality and patient safety
- help to identify opportunities for improving patient safety in everyday work and to predict the consequences of a change
- explain how an actual patient safety incident could happen, not caused by a failure in the system but the performance variability of everyday work

In addition, the health care professionals recognize easily their daily work in the model and find the model easier to 'read' than a verbal description.

In my presentation, I will demonstrate: 1) how adjustments of everyday work look like in Danish health care settings, 2) how they can be explained by using the ETTO principle, 3) how they sometimes can emerge into an unwanted and unexpected outcome for the patient and 4) how the insight into these adjustments support management and health care professionals to find new ways to improve patient safety.

[1] The ETTO Principle = The Efficiency-Thoroughness-Trade-Off Principle
[2] FRAM = Functional Resonance Analysis Method

Section 2

"FRAM for modelling complex adaptive socio-technical systems: The effects of standardization"

Effect of standardization on the partial process of wheelset exchange in a repair center of Swiss Federal Railways

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Industrial Partner: Swiss Federal Railways (SBB AG)

The Swiss Federal Railways (SBB) are facing rising costs and competition pressure. In order to develop procedures that reduce waste, the SBB uses the Japanese business philosophy Kaizen. One of three foundations of Kaizen is standardization. Standardization – in this research – is defined as the reduction or elimination of variability. This research analyses the process of wheelset exchange in a SBB repair center in order to identify effects of standardization. For that purpose a structured approach has been followed to investigate the following research question:

- What are the consequences of standardization in the process of wheelset exchange?

To answer this question, the FRAM method was applied. As a consequence the following sub-questions were investigated:

- o *What are the functions of the wheelset exchange?*
- o *How do the functions interact with each other?*
- o *Which functions are subject to variability?*
- o What happens when the variability in functions is restricted or eliminated?

In order to answer these questions a FRAM model of the process was built in two steps:

1. To build the FRAM model, 17 mechanics participated in a qualitative study. Through 10 observational interviews and 15 direct interviews the functions of the wheelset exchange, as well as their variabilities were identified.
2. To identify effects of restricting or eliminating variability, 5 mechanics participated in a workshop discussing on the basis of the model created in step.

The model consists of 102 functions in total, 77 of which are foreground functions. 75 out of the 77 foreground functions dispose of variabilities. The results show that, above all, flexible sequences have a positive impact on a successful wheelset exchange. An important aspect of standardization is the balance between standardization and flexibility. Hence, as a conclusion of the research it is recommended to standardize the wheelset exchange in a sophisticated manner by applying qualitatively different process and goal rules. On that basis concrete recommendations were made as to which functions should be standardized in what extent and which should not.

Full text available

Functional modelling of the expected and actual impact of resilience guidelines on European critical infrastructure crisis management – added value of functional modelling for crisis management?

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In recent years, crises and disasters (such as Eyjafjallajökull and Deepwater Horizon in 2010, Fukushima Daiichi in 2011) have made it obvious that a more resilient approach to preparing for and dealing with such events is needed. The Horizon 2020 project DARWIN will improve response to expected and unexpected crises affecting critical infrastructures and social structures. It addresses the management of both man-made events (e.g. cyber-attacks) and natural events (e.g. earthquakes). The main objective of the DARWIN project is the development of European resilience management guidelines. These will improve the ability of stakeholders to anticipate, monitor, respond, adapt, learn and evolve, to operate efficiently in the face of crises. The project has delivered a worldwide systematic literature survey [1] of resilience concepts and practices. Based on the most promising concepts [2], generic resilience guidelines [3] for Critical Infrastructures (CIs) are being developed. Ongoing work includes application and demonstration of the guidelines in pilot studies in health care and air traffic management as example CIs. A Community of Crisis and Resilience Practitioners (DCoP) was set up before and during the project. The role of the DCoP is as co-creators supporting the DARWIN project providing feedback on its work. The development of the generic resilience guidelines utilised a functional model of crisis management. This model describes different levels of granularity connecting resilience potentials (called previously abilities) to crises management.

This discussion proposal for the FRAMily 2017 meeting aims to present ongoing work and ideas on the modelling of the expected and actual impact of the DARWIN Resilience Management Guidelines.

Although the FRAM was not used explicitly in the development of the more high-level functional model, ideas and ongoing work on the mapping between a) essential crisis management functions and the expected impact of DARWIN resilience management guidelines, b) the actual impact as will be observed in the 2017 pilot studies in health care and air traffic management, and c) the relation between FRAM as functional modelling method and other modelling approaches.

[1] See DARWIN D1.1 literature survey:
http://www.h2020darwin.eu/images/documents/DARWIN_D1.1_Consolidate_resilience_concepts_and_practices_for_crisis_management.pdf

[2] See DARWIN D1.3 requirements on DARWIN resilience guidelines:
http://www.h2020darwin.eu/images/documents/DARWIN_D1.3_Practitioner_and_academic_requirements_for_resilience_management_guidelines.pdf

[3] For an initial version of the guidelines and the general crisis management functional model used to develop them, see DARWIN 2.1: http://www.h2020darwin.eu/images/DARWIN_D2.1_GenericResilienceManagementGuidelines.pdf

This discussion of ongoing research treats various aspects of the functional model ongoing work and the potential of the FRAM to contribute to this effort, and thus connects to at least four of the FRAMily 2017 themes:

- Use of the FRAM as assessment tool in relation to resilience abilities, in the sense that the DARWIN project in its resilience management guidelines for CI aims to connect needs and suggested resilience improvements in CI to traditional crisis management and risk assessment methods, with a functional model as a basis for development.
- FRAM for socio-technical system (and guideline) design, in the sense that the DARWIN guideline development is based on a functional model that may be extended with the use of FRAM.
- FRAM as method for resilience engineering, in that the DARWIN guidelines aim to provide strategies, processes, and ways of working for CI service providers' crisis and risk management, thereby helping CI to engineer and manage resilience in their socio-technical systems, where FRAM may be of use in guideline development.
- While risk based methods address avoidance, constraint and protection, FRAM might support and enhance understanding of everyday work as means to create, maintain and enhance successful operations.

Acknowledgement
The research leading to these results has received funding from European Union's Horizon 2020 Research and Innovation Programme, under Grant Agreement No 653289 (DARWIN). The other project partners are gratefully acknowledged: SINTEF (coordinator), Technische Universität Braunschweig, Carr Communications, Deep Blue Srl, ENAV S.p.A, Instituto Superiore de Sanità, Katastrofmedicinskt Centrum at Region Östergötland, and Ben-Gurion University of the Negev.

Understanding the impacts of enhanced automation in future ATM performance

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The increasing levels of automation and the high operational complexity that it frequently generates, pose many challenges for the identification and assessment of human factors and safety issues. Understanding the profound transformations that may result from the introduction of new automated features requires much more than the isolated analysis of each operational element to be potentially affected within the scope of foreseen (and linear) process flows.

The aviation industry continues to experience significant increments in automation. As the path towards fully automated ATM is set, many complex human factors and safety problems are rapidly emerging. Within the scope of the AUTOPACE project, FRAM was used to produce an in-depth understanding of ATM operations under future enhanced automation scenarios. Based on previously established operations concepts, a FRAM analysis was developed to simulate the impacts of planned new automated features, using predictable nominal and non-nominal operational scenarios.

The outcome of the FRAM based analysis will be presented and discussed in terms of its added value within the scope of AUTOPACE objectives. Various aspects relating to the use of FRAM and the visualizer as analysis tool will also be addressed.

Section 3
"FRAM for modelling complex adaptive socio-technical systems: System design"

Analyzing Software Development Process using FRAM
- case study of personal level software process -

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In this presentation, we explain our effort in analyzing software process using FRAM. We specifically focus on training of PSP (Personal Software Process)[1] which defines activities desirable for software developers at a personal level. It has a process template with associated training materials in stages by which we can develop and improve our software process at a personal level. After training, it is expected for trainees to master PSP and obtain ability to use it as a base of the continuous process improvement. We expect we can easily obtain successful instances of training while we cannot in considerable amount of cases. We perform FRAM analysis on the presence of successful functioning in the process template, and then perform FRAM analysis on the functional resonance along interdependencies in actual instances.

Full text available

[1] PSP is a service mark of Carnegie Mellon University

FRAM supporting the implementation of a patient responsible consultant: One Patient - One Responsible Consultant

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Because of the organization of the Danish Health Care system, patients often have contact with several consultants and experience a fragmented patient pathway. To enhance the continuity of the pathway and the professional quality of care, the Danish Regions, patient associations and medical associations, agreed to run trials on how to structure a system where one consultant has the overall responsibility of the pathway. The trials ran from January 2016 to October 2016 in the Region of Southern Denmark and the result of the trials evaluated in November/December 2016. The trials in the Region of Southern Denmark included seven trials in different clinical settings. FRAM was used in two ways: 1) to model how the involved parties imagined the work of a patient responsible consultant would be carried out and 2) to describe how the work was done in the trials to identify differences and similarities in different clinical settings. Both the differences and the similarities were the basis for understanding how the work of a patient responsible consultant could be realized in different clinical settings. The presentation focuses on the application of FRAM in the evaluation process.

Section 4
"WTF!?! – What the...FRAM: Strengths, Weakness and the potential for further research"

Automation of the FRAM method for the purpose of hazard analysis

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As a member of EUROCONTROL, Slovenia Control Ltd. takes advantage of provided guidelines and best practices to perform safety assessments of ATM functional systems. EUROCONTROL has developed its own methodology SAM (Safety Assessment Methodology). SAM is a framework containing methods and techniques to address the requirements of ESARR4 (EUROCONTROL Safety Regulatory Requirement).
In addition, Slovenia Control Ltd. is always on the lookout for new ways of assuring the highest possible level of safety of its ATM functional system. Recently the emphasis was put on FRAM (Functional Resonance Analysis Method) which provides a fresh approach to hazard assessment due to its ability to detect inter-dependencies that lead to complex hazards which can't be described using the existing methods. Literature review has illuminated the fact that there have been numerous extensions of FRAM in the sense of automating the process of searching through all the possible scenarios/instantiations for the ones where the variation of coupled functions resonates which causes the system to behave unexpectedly.

Full text available

A multi-layer FRAM: The Abstraction/Agency framework for modelling complex socio-technical systems

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A socio-technical system is inherently complex, due to non-linear and tight couplings among its components, i.e. the system's agents. Agents in a socio-technical system can be human or group of individuals acting at different levels of the system, as well as artefacts such as procedures, regulations or technical equipment.

Since complexity strictly depends on the resolution of the representation, this study aims at exploring the functional resonance space in order to represent the same system at different resolutions. Following Rasmussen's Abstraction Hierarchy (AH), this research develops an innovative two-dimensional framework: the Abstraction/Agency framework, as recently discussed in (Patriarca et al, 2017).

The framework we developed allows a systemic functional analysis at different levels of abstraction and among different agents. The outcome of the framework is a systemic multi-layer functional structure, relevant for safety and performance analysis. The framework is applicable at different hierarchical levels and allows maintaining a systemic perspective on the process. This fractal approach confirms the significance of FRAM's scale-invariance to understand the work domain and manage more properly knowledge on performance variability and functional inter-dependences.

References

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Functional Analysis of a Joint Cognitive System: Agent and Inter- Agent Transformations of Information Flow, a case study in a Cockpit Environment

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Description

Hutchins' paper 'How a Cockpit Remembers Its Speeds' (Hutchins 1995) analyzed the speed control during a descent on an MD-80 aircraft from a Joint Cognitive perspective. Hutchins addressed how cognition is distributed and synchronized over multiple agents and reveals how work is evenly distributed across human agents and apparently small and unremarkable devices and artefacts. Hutchins' emphasis on the importance of the unit of analysis in exploring the processes and knowledge structures that underpin the activity of a socio-technical system was further explored by this study.

In January 2017, a FRAM study was undertaken of the Hutchins' 1995 work-system, for a different aircraft, i.e. DC-9, in collaboration with three pilots who actually flew it. They provided the domain knowledge to produce an ecologically valid FRAM model. Manuals and procedures were used to model a first work-as- imagined draft by the four researchers involved in the study. This first desktop model was then adapted by the three former DC-9 pilots who were free to alter any functions and/or their aspects to shape a FRAM model from a work-as-done perspective.

The context in which artefacts are situated is implicit to understanding socio-technical systems and their underlying processes. During the making of the model it became clear that humans, device interfaces and artefacts all affected transformations of information flow. From the analysis, it emerged that changes from auditory to visual information and vice versa, or between semantic and spatial similarities were not restricted to just human cognition. Therefore, the traditional boundary between medium and agent was abandoned in favour of accepting aircraft systems and artefacts as agents of their own, all entitled to produce functions in the FRAM model.

By using a structured approach, knowledge of the suitability of FRAM to explore a work system previously studied could be assessed, and the results compared. Especially, Hutchins' interest in exploring beyond mere human agents can alter the focus on other units of analysis that might otherwise be overlooked. To achieve this an advanced VBA-based FRAM model builder was used, which is able to interact with FRAM Model Visualizer (FMV).

The meeting presentation will describe how building the model was undertaken, what was found, the understanding gained and results drawn with a comparison made with Hutchins paper. The usefulness and utility of specific preparatory steps before building a multi-layered FRAM model will be discussed.

Relevance

As FRAM is a relatively new method, the community might further scrutinize new approaches that are explained in the relevance and significance section below, and at the same time the FRAMiliy meeting is the opportunity best suited for the researchers to test their ideas with the expert community. We took a low- automation aircraft and a closed scenario, where the pilots interact with their flight deck environment with relatively low involvement from external actors. Thereby the focus is primarily to report to the community what was achieved by methodological enhancements to FRAM modelling, and its effects on the interpretation of FRAM output. Normally FRAM analysts can focus on developing functions and aspects to a revolving set of rigid rules, once they have determined which model boundaries

will best cover their research goal. But the results of this study also offers future researchers a chance to determine a level of granularity about the unit of analysis, in relation to the question which agents are entitled to create functions. This decision inherently forms an integrated whole with the question to which degree the researcher wants to study and understand, in Hutchins own words, 'how information is represented and how representations are propagated in the performance of tasks' (Hutchins, 1995).
Artefacts of work systems and how sense is made of these can be interpreted in various ways, Hutchins paper explored how the artefacts on a flight deck took on a sense that could not be found by considering only the human agent. Moreover, Hutchins developed an understanding of how the work-system sustained performance through agent-artefact coordination. How FRAM modelled this, and what sense a FRAM model brought of Hutchins work tells the community much about works systems, how to study them and the value of FRAM. On a case study level, it can also learn us how agents and artefacts make sense of work-systems, contribute and influence to system performance and their ability to sustain it.

Significance

Hutchins' paper (1995) described how this work-system observed and remembered the speeds by which the aircraft operated. This paper is a seminal paper in the human factors canon. In turning non-observable properties of system performance into adaptive strategies, the Joint Cognitive System approach describes an important function of work-as-done systems. Although the FRAM is by no means meant to apply cognitive labels to systems, it can paradoxically help to overcome the non-observability of some properties by translating it into uniform language of functions and aspects; but this time from a broader set of agents and a richer set of information flow transformations.Secondly, the study analysis element can focus on what interests us most in work-systems and socio- technical systems, being relationships. A better understanding and conceptualization of information flow transformations provided to be a key argument for the understanding of inter-agent relationships.

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Applying and visualizing the FRAM for Arctic ship navigation

Doug Smith
Memorial University of Newfoundland -Canada-

I would like to present my recent work and experiences at FRAMily 2017. My presentation will touch on 3 separate areas that I feel are of interest to the FRAMily: 1) The application of FRAM as a safety assessment tool for Arctic ship navigation. 2) The practical collection of data to inform safety assessments in the maritime domain. 3) A FRAM visualization technique. Based on my experiences at FRAMily 2016, I feel these areas are of interest to the FRAMily and could generate some good discussions.

The application of Arctic ship navigation is modelled as a collection of functions that constantly assess the operational conditions and decide to maintain a planned course or make adjustments to the course. This model then repeats numerous times over the course of a single voyage. The model "operates" each time with the data collection functions being partially completed and of various age. This means that the navigator must make decisions with partial and sometimes dated information. The EXXON Valdez case will be used to demonstrate the models utility.

When collecting data to apply the FRAM, it is best to understand the work as it is done. This means it is best to learn from ship navigators. Here I would like to briefly discuss an "experiment" I had planned with a Canadian shipping company to apply FRAM to their operation. In this case, recruitment has practically become very challenging due to the novel aspects of FRAM, its emergent properties, research ethics, also compliancy and blame culture in the maritime domain. I think this could initiate some good discussion about how others may be addressing these issues in other domains.

Lastly, I would like to share a FRAM visualization technique that I have been working on to display my work. It comes from the idea that a FRAM model is generically less meaningful, it is a collection of "potential" work functions that could be applied. As we apply cases to the model we give it more meaning. To visualize this, we can use take a snapshot of the operation where only a few of the functions maybe active at that instant in time (we highlight the active functions). Since the functions that are active at any moment in time are variable, we can create a video of the dynamics of functional performance. We can then compare the functional dynamics to the events that produced them for any time, t.

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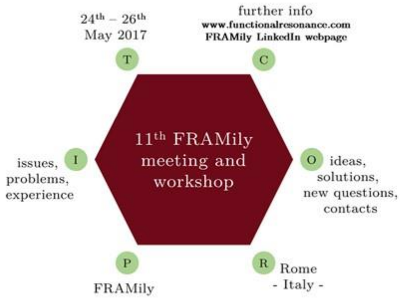

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