Day1 November 15 (Tue)				
No.	Time	Title	Author	Abstract
	13:00-13:10	Opening Remarks		
1	13:10-13:50	System analysis and improvement methodology with Work Domain Analysis and Functional Resonance Analysis Method, a win-win combination	Naruki Yasue Enrique Ruiz Zúñiga	Complex nowadays manufacturing systems often require the use of advanced analytical tools for system design, analysis, and improvement. Reasons for this requirement commonly are the size and complexity of the systems and the mix of sociotechnical systems combining automated and manual processes. Computerized modelling tools are usually able to handle this complexity, commonly translated into interrelations with a high number of processes and variables associated with the different parts of the system. However, the modelling part of sociotechnical systems focusing on human behaviour and performance is not straight forward to achieve with traditional simulation tools. Aiming to analyze and improve sociotechnical systems considering operators' skill levels, a methodology for complex manufacturing system with the Functional Resonance Analysis Method (FRAM) and Work Domain Analysis (WDA) is proposed. The WDA provides a general overview of the entire system to identify the key process by organizing functions involved in the working environment in a hierarchical form. On the other hand, the FRAM is utilized to visualize detailed interrelations between functions of the key process based on the WDA results and envision the effect of variabilities. This study proposes a systematic procedure for system analysis and improvement based on an interactive process of these two methods. The methodology has been implemented in two industrial case studies to analyze the performance of the entire system when considering the operator's skill levels in some identified key processes. These key processes include a set of manual and automated tasks, predominating human behaviour for the control and management of the task and its outcome. To apply the proposed methodology, the behaviour of the operators was analyzed and summarized with a set of interviews and additional data collection methods such as observations, documentation analysis, and eye-tracking experiments. The methodology outcome highlights the capability of identifying key processes and variables limiting the system, guiding the data collection process, analyzing the applicability of selected approaches in manufacturing, and helping to represent and analyze the data in a structured manner to serve as a decision support system for managers and stakeholders. Keywords. Functional Resonance Analysis Method, Work Domain Analysis, Sociotechnical Systems, Manufacturing.
2	13:50-14:30	Attending the requirements of the O&G Regulator in Brazil: use of FRAM for human factors analysis and accident investigation	Josué E. Maia França	The activities of the O&G chain in Brazil – exploration, production, refining, transport and distribution of hydrocarbons – are regulated by a government agency called ANP – Agência Nacional do Petróleo, Gás Natural e Biocombustíveis. This institution was created in 1997 to be the regulatory body for all industrial activities that handle crude oil, natural gas and biofuels in Brazil, being directly linked to the Brazilian Ministry of Mines and Energy. Its main function is to establish rules through ordinances, resolutions and normative instructions, monitoring and auditing their mandatory compliance. In the performance of this function, SGSO and SGIP regulations were created, establishing in their management practices the recognition and treatment of Human Factors. Presiding in a non-prescriptive manner, such regulations – SGSO and SGIP – do not explicitly determine which tools, methodologies and techniques should be used for the management of Human Factors, and it is then up to the regulated – the oil companies – to choose and apply them. Based on all the epistemology and practices established by Safety-II concepts, the company XYZ (fictitious name) developed a response strategy with FRAM, using this methodology for the analysis of critical work activities, with a focus on Human Factors. As a result, FRAM models were developed for N2 (nitrogen) production activities onboard offshore platforms, for FPSO flare start-up activities and for risk assessment of onshore oil production activities. With that, the FRAM allowed a systemic analysis of the individual, organizational, technological and environmental elements of workplaces' interactions, allowing the recognition and analysis of Human Factors. In addition, the FRAM was also applied for the analysis of accidents that occurred in offshore workplaces, enabling an expanded and adequate understanding of the functioning – and failure – of the complex sociotechnical work system of O&G industrial chain.
	14:30-15:00	Coffee break		
3	15:00-15:40	Near miss analysis of falls from scaffolding in the construction industry using FRAM	Terutoshi Tomotoki	The number of deaths due to work-related disasters in the construction industry in Japan has now decreased to one-tenth of the postwar peak . During the period when disasters occurred frequently, disaster prevention measures were implemented by analyzing the disasters that occurred. Nowadays, risk assessment is conducted before any work is started, and when a disaster occurs, disaster analysis is conducted to prevent recurrence. The near-misses are also analyzed in the same way as disasters in order to prevent recurrence. This study attempts to analyze near-misses in the construction industry by FRAM (Functional Resonance Analysis Method), using scaffolding assembly work as a case study among the most common occupational accidents in the construction industry, namely falls. FRAM is performed in four steps: function identification, variability identification, variability aggregation, and recurrence prevention program. The causes of near-misses can be used to identify the resilience that allowed the disaster to be averted. Using tables covering the four steps and FRAM diagrams, we analyze the causes and prevention of recurrence and action program from the changes of functional variability.
4	15:40-16:20	Functional Dynamics of Sociotechnical Software Systems	Tanner Lund	Complex software systems grow ever increasingly integrated with our work and lives. Large, multi-component, dynamical software systems and their responsible teams form an ever-evolving, compelling object of study. Studies of incident command and facilitation in similar contexts has proven fruitful for understanding broader patterns and principles. We now turn to functional analysis of the systems themselves, building models thereof out of interviews, systems of record, transcripts of incident response and other artifacts. Findings illuminate the dynamics of such systems and inform operational strengths and weaknesses.
5	16:20-17:00	Thinking from Incidents - Security Resilience	Tomoko Kaneko	Resilience engineering argued that it is not multi-layered protective wall security, but the flexibility to change dynamically that enhances security. Dr. Hollnagel noted that the biggest difference between Safety and Security is the "type" of threats that each has to deal with. Safety deals with Regular Threats (predictable threats such as component failure, control breakdown, etc.). Security, on the other hand, deals with Irregular Threats (threats that cannot be predicted, such as intrusion from unexpected routes). For known threats, a strong defense wall is effective, and a strong system structure can protect the system from known threats, but it is "nearly impossible" to prepare system defenses in advance against unknown and unpredictable threats. According to Dr. Hollnagel, the only way to counter unpredictable threats is not through defenses, but through more active capabilities. In other words, resilient security does not add new defenses, but rather emphasizes the four capabilities of Monitor, Respond, Learn, and Anticipate, as in resilience engineering, to achieve a secure environment by enhancing them as security-enhancing capabilities. I argue that the four capabilities of Monitor, Respond, Learn, and Anticipate, as in resilience engineering, can be enhanced as security improvement capabilities to achieve a secure environment. To confirm these claims, I validated my resilient analysis based on the Functional Resonance Method (FRAM) with a case study of an incident report of a security incident at the National Institute of Advanced Industrial Science and Technology (AIST). In this incident, unauthorized accesses were sequentially made to both (1) a mail system using cloud services and (2) an internal system built in monolithic form at AIST. I conducted our analysis based on the idea that FRAM does not define failure events in advance, but focuses on the relationship between each function and the variation of mutual input/output. I considered that FRAM has effective applicability not only to dynamic systems such as control systems, but also to security incident analysis in information systems. As a result, I was able to confirm that the weaknesses were overcome by adding the functions that apply to the four capabilities, re-creating the diagram with additional countermeasure plans, and then overlooking the diagram. In addition, in this case, the FRAM model simulated an actual attack path. At the symposium, I hope to discuss "security and safety," "security by design," and "security resilience" after presenting specific examples of this case study.

Day2 November 16 (Wed)				
No.	Time	Title	Author	Abstract
6	9:00-11:30	FRAM Modeling Workshop		FRAM modeling workshop : Building FRAM model "How to enjoy Japanese garden". Japanese garden is one of the essence of Japanese Zen culture. It might be quite mysterious what is the phylosophical aspects of enjoying Japanse garden and why it is estimated as the heart of Japanese culture. In this workshop, we will discuss how to use FRAM with the modeling theme "How to enjoy Japanese Garden". With the central function "Enjoy Japanese Garden", we will learn and discuss what is the trigger input of the enjoyment, what is prerequisite of the garden culture, what is required resource to make the garden, how to control the important feature of the garden and finally, how to implement "Time" factor into gardening. If weather is fine, we will go out and feel the beautiful garden in front of the conference room while discussing. Have fun!
	11:30-130	Lunch break		
7	13:00-14:00	Need for graceful extensibility of the adaptive capacity: a lesson from a FRAM analysis of the fatal medication adverse event focusing on ETTOing	Kazue Nakajima	A fatal incident of wrong medication occurred in a Japanese acute care hospital on the third day of the nine-day New Year holidays. The case involved one pharmacist in the medication dispensing unit and two nurses in an inpatient ward of the hospital. Responding to a physician's urgent order for an antibiotic injection, the pharmacist took a wrong injection of a muscular relaxant agent. Two nurses did not notice the mistake with the primed double-check. We analyzed the case with a FRAM focusing on ETTOing made by the parties involved. The analysis found that the capacity for maneuver in the pharmacy department was saturated because the department failed to anticipate the extremely busy situation, unprepared for the additional workforce and the critical function of independent double checks. For proactive safety management in the changing environment under resource constraints, extensible adaptive capacity is needed through flexible workload management and some resource inputs such as the use of technology. It is not a good idea to introduce more repetitive checking in many steps of medication dispensing and matching check processes. The case had been sent to a prosecutor's office as a possible criminal liability. It turned out that the three healthcare professionals were not prosecuted, partly because the accident investigation report described human ETTOing in everyday clinical work and the non-linear effect of these ETTOing in the complex system.
8	14:00-14:40	FRAM and LEAN as tools for describing and improving the referral process between outpatient clinics in a Danish Hospital: complementary or	Mariam Safi Robyn Clay-Williams Tine Grau Frans Brandt Bettina Ravnborg Thude	In Denmark, outpatient specialist care is delivered at hospital-based outpatient clinics for non-acute patients. The specialist can also refer patients to other specialists for diagnoses and treatment. The referral process of patients between the internal medicine specialist outpatient clinics at the University Hospital of Southern Denmark is inefficient which is resulting in unnecessary inter-departmental referrals. These outpatient clinics are; nephrology, cardiovascular, endocrinology and pulmonology. The findings from our recent register study "Today's referral is tomorrow's repeat patient" showed that one-third of all referrals are from internal sources, and can potentially be avoided. An inefficient referral process means; a) ineffective use of physician and hospital service, and b) over testing and repetitive testing. The goal of the managers at the Hospital is to understand the referral process and identify quality improvements (QI) to reduce unnecessary internal referrals for the benefit of patients and healthcare professionals.
9	14:40-15:20	Learning from the field: using FRAM to analyse the geologist's works in Brazil, Argentina and South Africa outcrops	Josué E. Maia França	Since the first hominids settlements that gave rise to the peoples that exist today, the relationship between humans and the rocks that surround them is part of and shapes their daily lives. The first tools found in the fossil record of Neanderthals and early Sapiens villages demonstrate an ancient relationship between humans and rocks intrinsic to the evolution of humanity. Throughout history, with the discovery of ores and the development of new artifacts, this relationship has indeed evolved, but has remained innate to human nature. Currently, from this ancient relationship, geologists and geophysicists across the globe perform various activities with these rocks, from the study of their evolutionary morphology to sustainable construction on steep slopes in places of difficult access. In this sense and based on the exploration activities of the O&G industrial chain, this study presents systematic research of the field activities of geologists, geophysicists and petroleum engineers, studying the formations and geological faces of models of oil reservoirs in outcrops. These outcrops, located in South Africa, Argentina and Brazil, have unique characteristics and distinct hazards, which are dynamically managed with the interaction between professional experience, wild environment and specific outcrop conditions. Although the complex combination of these elements provides a certain uncertainty regarding the management of the risks of these activities, through the FRAM modeling of three different outcrops, in three different locations, it is perceived that the natural human variability is the key element to build a resilience performance that promotes safety and productivity for these geological field activities. Additionally, it was noticed that specific non-technical skills, such as communication, situational awareness and teamwork are present in the performance of these activities, regardless of outcrop and local conditions.
	15:20-15:50	Coffee break		
10	15:50-16:30	Ship Navigation from the concept of Safety-II: The Flexibility and Adaptability of Ship Officer.	I Gde Manik Sukanegara Adhita	This research provided insight into how the human role, in this case, seafarer, can be more appreciated to maintain safety in future ship operations. The research novelty mainly focuses on implementing the Safety-II point of view to analyze ship officer performance. The early stage of this research has been done by analyzing the actual ship navigation process at its functional level. As a continuation, this recent research aimed to elaborate intensely on ship officer performance variability in dangerous ship encounters to determine how human adaptability maintains the system to work in normal performance. The final version of this research aimed to provide a comprehensive analysis of ship officer performance in which the human role and technological advancement can create better ship operation, especially in the case of navigation. The Safety-II point of view emphasizes the necessity to focus on how successful performance occurs in actual work. Functional Resonance Analysis Method (FRAM) is a method that was introduced as the first attempt to implement this idea. FRAM uses a term function to describe the need for something to be done in the system. It classifies the function as either human, technological, or organizational. The implementation of the Safety-II perspective in ship operation has successfully provided an essential idea of onboard work at the functional level using the FRAM model. The daily activities were collected based on the training ship Fukaemaru operation through direct onboard observation. As a result, functional resonance stemming from the upstream-downstream relationship and endogenous and exogenous variability has been recognized as the source of performance variability in navigating the ship. Further analysis that implements the same idea has been done to elucidate ship officer variability performance in a narrower context, that is, ship encounter situation, through simulation experiments. A distinct representation of officer variability performance is provided by generating unexpected ship encounter situations in a simulation experiment in a ship simulator. Two different system propagation has been captured from the simulation. In general, the simulation has shown that officer performance is relatively stable. The participant who performed the same initial action propagates the function in a relatively similar pattern. Some evidence of function activation and precision affecting system output has also been captured. Furthermore, the flexibility of human performance can be systematically expressed using the FRAM model.
11	16:30-17:10	Functional Analysis of Safe-Ship Operations: Envisioning Success Factors of Great Captains	Takayuki Hirose	It is difficult to envision evolving-real fields of practice, where new technologies are introduced and function, at the early phase of research and development (R&D) process. The problem often results in many challenges to design new technologies including automation, and this is also the case with the R&D of the Maritime Autonomous surface ships (MASS); although it is essential to reveal skills of experienced captains and identify functional requirements for the technology, it is difficult to fully understand how safe-ship operations can be realized by traditional approaches, i.e., literal research, simulations, or experiments independently. To address the issue, we 1) developed a "model of safe-ship operations" by using Functional Resonance Analysis Method, 2) conducted interviews with experienced captains to confirm the adequacy of the FRAM model, and 3) analyzed data obtained from simulation-based experiment in which participants/captains were engaged in the simulation-based ship operation and required to avoid collision. The developed FRAM model suggested that ship operation consists of very complicated cognitive tasks, contrary to the traditional idea that such tasks can be represented as a sequential process of cognition, decision, and action. Also, the result of interviews and data analysis found that a specific function of the FRAM model, called "mid-term planning" plays a significant role in the safety of the operations; one characteristic behavior of the experienced captains was early decision making so that they can start the collision avoidance maneuvers before they get into a domain where related navigation rules are applied, and options of the collision avoidance maneuvers are limited. Consequently, the analysis result found that the cognitive process observed in the FRAM model and its related characteristics of the experienced captains are success factors of the safe-ship operations or great captains.
	18:00	Dinner Party	Tetsuo Sawaragi	Chairman of the FRAMily 2022 program committee Prof. Tetsuo Sawaragi will make welcome speech at the dinner party.

Day3 November 17 (Thu)				
No.	Time	Title	Author	Abstract
12	9:00-9:40	On the Emerging Status of FRAM Functions	David Slater Rees Hill	Currently the ability of a FRAM function to deliver an output is determined solely by the presence and status of any interacting external aspects generated by the outputs of upstream functions. Most of the discussion of the variability of these interactions has thus focussed on the scalar, or temporal properties of these aspects. The FMV software then allowed the highlighting of any functions perceived to be particularly variable. Attempts have also been made to assign classes of properties to the generating functions, e.g., by the nature of the agent assigned to deliver that function, Technological, Human, or Organisation. The software was then capable of assigning levels of variability typically expected of that agent. There have since been a number of attempts to introduce a more formal approach to how the status of these functions can display system “resonance” (notably Riccardo’s myFRAM). Attempts have also been made to follow the progression of a process using a time series observed or posited, of aspect states (Doug Smith’s DynaFRAM) But a new extension to the FMV software allows a more formal approach to tracing the effects of this variability as the FRAM instantiations develop. This extension makes it possible to assign values of particular properties of individual functions as “metadata” and to program algorithms to reflect how the outputs of these functions are affected. It is then possible to follow how these outputs could go on to affect the way downstream functions behave. This facility has been successfully demonstrated in a previous paper to predict how a Formula 1 pit stop crews “bend” the WAI rules to produce better WAD release times for their teams. The JAMSS research team have been using it to predict outcomes of uncertain futures such as in exchange rates. This facility is currently being employed to revisit the Clayton Tunnel crash and to better understand the details of ICU Trauma teams’ responses. The presentation will review these applications and also address and suggest some newer ideas, particularly how this feature can be used to show how ordinal and temporal time can be treated in a series of developing instantiations.
13	9:40-10:20	Understanding human factors variabilities through the lens of FRAM: a FRAM-based human factors taxonomy	Wulin Tian Carlo Caponecchia	Functional Resonance Analysis Method (FRAM) has been used in a wide range of areas. One of the main steps in FRAM is to identify the variabilities in the FRAM model. FRAM users, including those with a particular interest in human components, employ a range of different techniques to identify variability in their analyses. Currently, indexing the human factors related variabilities largely depends on the analysts’ expertise. Findings from interviews with Subject Matter Experts (SMEs) indicate that they believe that a more structured approach to capturing the human factors related variabilities could bring multiple benefits to FRAM, such as more reliable analysis results. The present study aims to develop and test an approach for identifying human factors related variabilities in FRAM analysis. Based on our previous research, this proposed approach suggests adding a pre-analysis checklist and using a FRAM-based human factors taxonomy. The pre-analysis checklist is intended to be used for preparing the FRAM net for human factors-focused analysis, including naming the functions with a verb phase, using an operator-centered label, providing clear time points of functions/couplings if the analysis is conducted retrospectively, and checking the categorization of the six aspects. Following this process, the analyst selects the applicable human factors related variabilities from the taxonomy. The selected variabilities can be assessed as background or foreground variabilities. The background variabilities refer to those that could impact the entire FRAM model, while the foreground variabilities are those which could influence the particular function(s). A sample of undergraduate and postgraduate aviation students will analyse an aviation incident using the proposed approach or an unstructured approach for identifying human factors variabilities. Results will be compared in terms of effectiveness in identifying a range of HF variabilities, and usability of the approach.
14	10:20-11:00	Dynamic FRAM modelling	Doug Smith	Dynamic FRAM modelling applies the work-as-done principle to variability. When a FRAM model is created it should represent all the possible ways (or as many as practicable) a system can function. Variability is then used to understand how different outcomes of the system are achieved. In the past, variability has mainly been assessed by considering typical amounts of variability in individual functions and how it might propagate downstream. While the work-as-done principle can be applied, in the sense that the workers who execute the functions can inform the variability assessment, there are often elements that remain uncertain and/or difficult to justify. 1) Assessing typical amounts of variability gives a general understanding of functionality, however, it can be unclear which specific combinations of functional variability (instantiations) might produce the outcomes you are interested in. As well, are all combinations of variability possible in practice, or would some instantiations be only hypothetical and not necessary to consider or manage in practice. 2) This is particularly relevant to multi-stakeholder systems. The propagation of variability through the system may not be well understood by the workers of the system. They may be able to see how variability in their work may influence others’ work down stream. Dynamic FRAM modelling can be used to track variability through the recording and visualization of instantiations (functional signatures). There are 3 things that should be tracked for each instantiation: 1) the function(s) that is executed, 2) the time the function(s) is executed, and 3) the output of that function(s) that is executed. This can be tracked “as-done” for an instantiation. As you collect more instantiations you can compare them to try to understand why different functional variations produce different outcomes, and how/if they should be managed. How to manage and assess all this information (pertaining to instantiations) is not trivial and will require further discussions among FRAM users. The intention of dynamic FRAM modelling (for now) is to provide an approach to enrich the understanding of system variability as it pertains to the FRAM. A companion software for the FMV, DynaFRAM, is created to help visualize instantiations (functional signatures) of FRAM models. This software is freely available for FRAM users at https://www.engr.mun.ca/~d.smith/dynafram.html
15	11:00-11:40	FRAM to Contextualise Specifications of Software Systems	Tomohiro Oda Shigeru Kusakabe	Our presentation will introduce our ongoing project to use FRAM in software development. Software defects are not only caused by error-prone coding but also by an ill-fitting specification of the software. VDM (Vienna Development Method) is a method to improve the quality of specifications by defining the functions of the system in a formal and executable manner. A formal specification defines the functionality of a software system with logical formulae called preconditions, postconditions and invariants. Those formulae make assumptions about the use of a software system explicit to prevent implicit limitations and unexpected effects on the system’s functions. An executable specification enables software testing techniques, such as unit testing, to be applied to the specification. A test case in unit testing validates a use scenario with preconditions, postconditions and invariants, and confirms expected effects after performing the use scenario. Formal and executable specifications are thus rigorous approaches to improving mathematical correctness and practical conformity of software systems. There, however, still exist risks of generating an ill-fitting specification due to variability during the operations of the system. While a formal specification defines the functionalities of a software system in a strict and fixed manner, the functionalities may be used in ways that were not foreseen during development. Unit testing, for example, can ensure the properties of the system’s functionalities only in a concrete series of the system’s functions. The specification might remain fragile against reasonable variability in the operations. The authors are working on applying FRAM as a complement to VDM, to overview how the system would fit in the application domain and its variability. While VDM focuses on the internals of the software system to be developed, FRAM can illustrate the activities outside of the system and their variability. We expect FRAM’s four principles of equivalence of success and failure, approximate adjustments, emergence, and functional resonance to reinforce the conformance of the specifications to the possible and yet unexpected change of the use situations. We have developed a development tool that manages mappings between VDM’s definitions and FRAM’s functions using link information embedded within description or comment fields called annotations. Our tool can also generate skeleton definitions from a FRAM diagram with annotations and vice versa. We are currently developing a mechanism to generate different ordering or skipping of operation calls in a test case based on variability noted in FRAM functions. We expect those mutated test cases to reinforce the specification’s adaptability against variability.
	11:40-13:00	Lunch break		
16	13:00-13:50	Natural Language Processing for text similarity in Aviation Safety Reports	Ronaldo Gamermann	Aviation safety reports are essential sources for the identification and analysis of risks in civil aviation. These reports are written in plain language, which requires the application of Natural Language Processing techniques for automatic and intelligent treatment. In the case of Brazil, the vast majority of reports are written in Portuguese. Therefore, for comparison with international database of reports that are written in English, a first step is the translation of Brazilian reports. In this work, a proposal for a machine translation model is presented based on the fine-tuning of pre-trained models. To this end, an aviationspecific language corpus is developed with the objective of generating example data for model training. Finally, a pre-trained model is fine-tuned with the corpus created in order to implement an automatic translation model that achieves good results in the task considering the specifics of the aviation language. As a result, a first model is implemented, presenting coherent results of translation between Portuguese/English in the specific domain of aviation. As future work, in a second step, a machine learning model capable of identifying similar narratives in large databases will be implemented. It is expected to contribute with a model that helps in the risk assessment process.
17	13:50-14:30	BayesianFRAM	Hideki Nomoto	This presentation will show how to develop Bayesian network using FRAM. Each input variability is calculated using input value and variability bias (weight value). For determining the variability bias (weight value), we will use machine learning. In this presentation, we will show how to build a currency exchange rate predictor. The predictor was implemented using FRAM’s programing extension. FRAM is the tool to analyze the effect of input variability against output. Bayesian inference was implemented as fuzzy logic which takes multiple inputs to determine a prediction value. According to FRAM modeling theory, the most important factor for defining function’s output is input variability. For this purposes, we converted all inputs from raw value to “rate of change”. This conversion contributed to normalize the input data. As the result, the built FRAM model became generic enough to be used for other value prediction such as traffic flow or people’s future behaviors. The predictor take the inputs such as short/long term interest rates, stock exchange rate, government bond price and consumer price index to produce currency exchange rate prediction using these values and weight values for each of them. Machine learning was conducted using the historical data from 2002 to 2021. The test was done using the data of 2022.
18	14:30-15:10	Explainable symptom detection in telemetry of ISS with Random Forest, FRAM and SpecTRM	Shota Iino	Flight controllers of the JEM (Japanese Experiment Module), one element of the International Space Station (ISS), are continuously monitoring ISS status, and it is important for them to detect signs of anomaly of its equipment as early as possible. Automatic symptom detection, in this context, can help flight controllers to assess unusual telemetry trends. To assess the trends efficiently, it is essential to provide the reason of detections. In this paper, we propose a new systemic symptom detection method combining three methodologies: the Functional Resonance Analysis Method (FRAM), the Random Forest Regression (RF), and the Specification Tools and Requirement Methodology-Requirement Language (SpecTRM-RL). The method was verified with data of Low Temperature loop (LTL) of JEM; an actual failure event of pump inverter in LTL was selected as a case study. In this case study, a selected objective variable was successfully predicted based on explanatory variables in normal period, whereas the predicted values showed larger deviation from the actual measured values in off-nominal period. The information for explaining the cause of anomaly was eventually identified with the proposed methods and validated by engineering knowledge. These results show the effectiveness of the new methods as the explainable machine learning-based predictive failure detection. The proposed method can be applied to fields where a single mishap of a system could lead to catastrophic hazard or instantaneous loss of human life due to impossibility of physical access (e.g., deep space explorations and remote medicine).
	15:10-15:30	Wrap-up Discussion with coffee and sweets	All	
	15:30-16:00	Closing Remarks	Erik Hollnagel	FRAMily Scientific Organizing Committee Prof. Erik Hollnagel will make the closing remarks speech.