What is a Function in FRAM?

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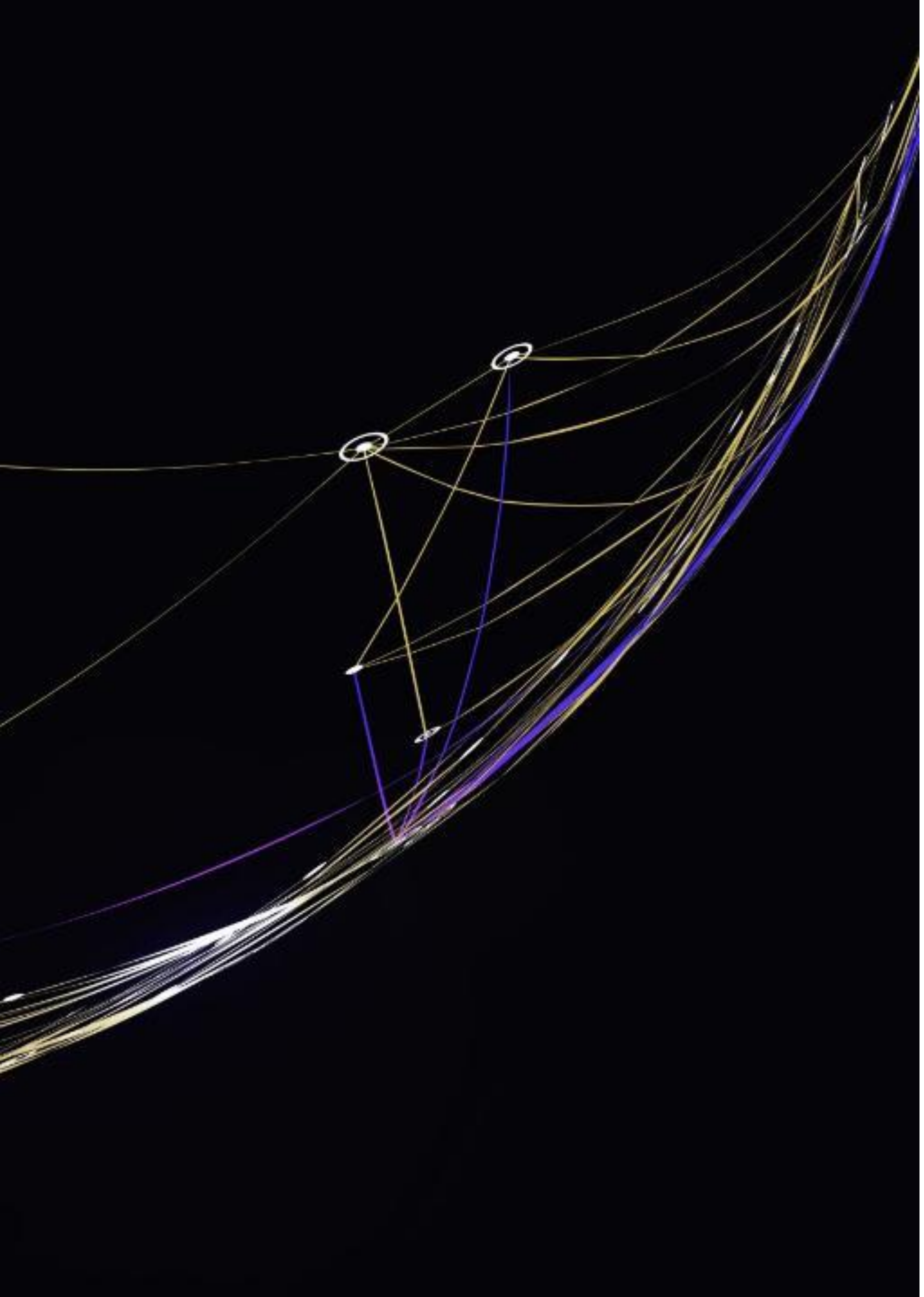
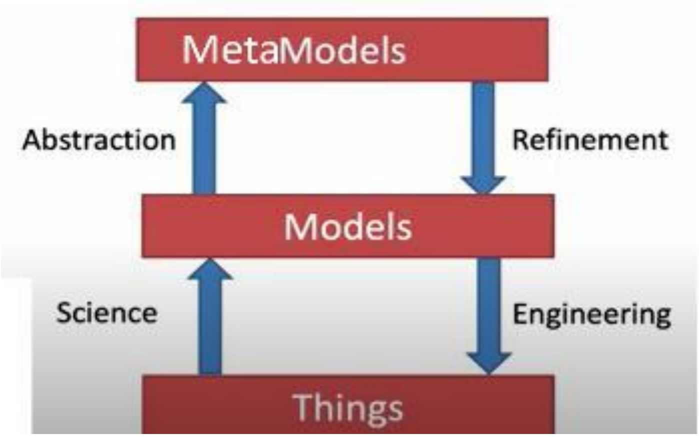


OUTLINE



Hollnagel revolutionised our ability to probe behaviours in complex sociotechnical systems with three key developments.

1. Introduced a metamodeling (abstraction) approach to model systems as FUNCTIONS. (not detailed physical components)

2. Recognised that the system behaves as an INTERACTING INTERDEPENDENT ASSEMBLY of these functions, not as a rigid array of isolated components.

3. Pointed out that in the real-world VARIABILITY in these interactions can lead to unexpected consequences.

His FRAM methodology now allows quantitative prediction of this variability of functional outputs leading to emergent system behaviours

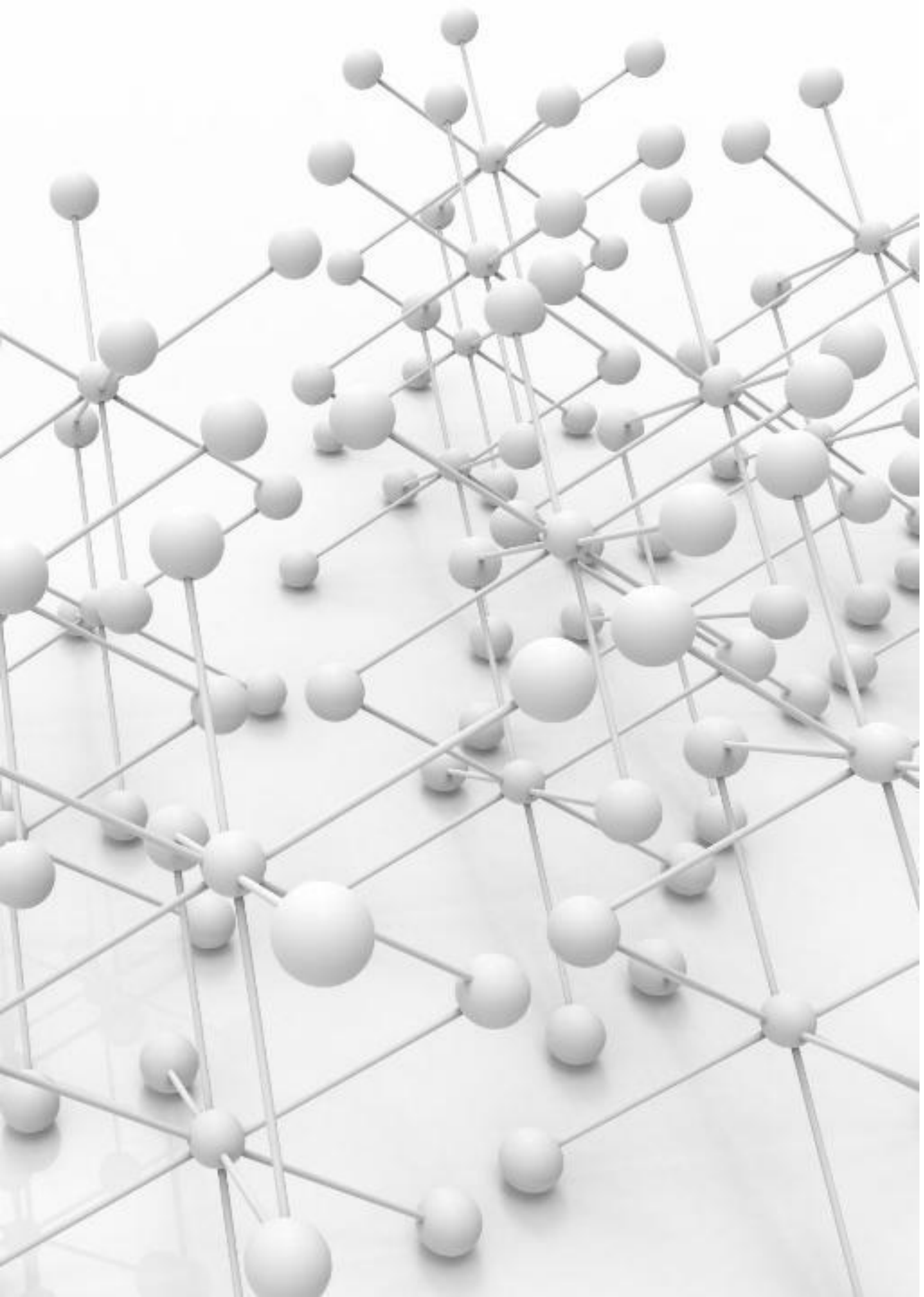
WHY A FUNCTION?

Because It is an abstraction (metamodel) of an activity, possibly too complicated and complicating to flesh out the physical details.

Normally a box is drawn around it and a veil over the internal mechanics, and just what it does is described – it produces something.

How? – it doesn't matter – just draw a "box" and just specify inputs and outputs

(Anyway, we can now use AI to generate an algorithm to "model" what the function does (as a "Black Box")

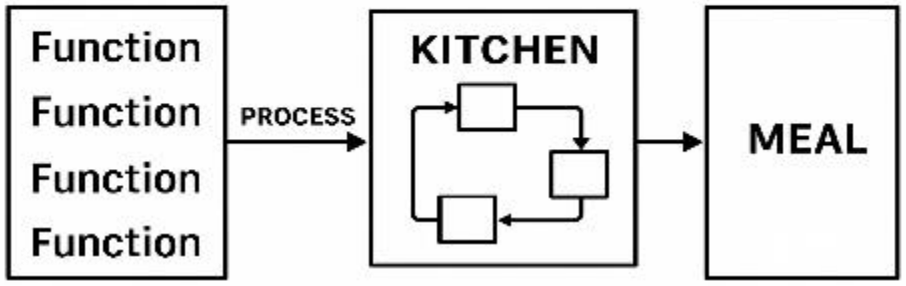


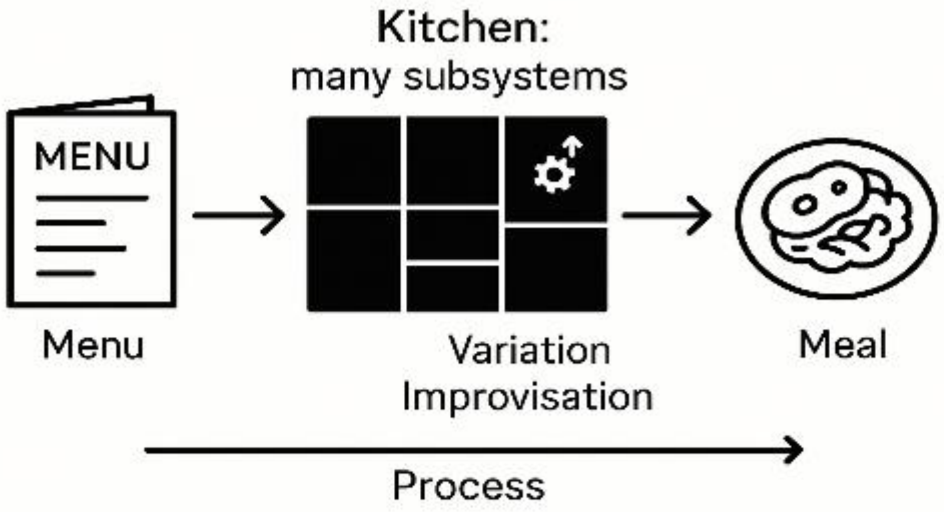
Systems

Similarly, a SYSTEM of functions can be "metamodelled" as a

- A Black Box full of interacting black boxes?
- Or perhaps as a notional set of linked BOXES AND ARROWS
- Or more formally as a Digraph of NODES AND EDGES
- Or mathematically as LOGIC TREES, NETWORKS, BAYESIAN OR PETRI NETS

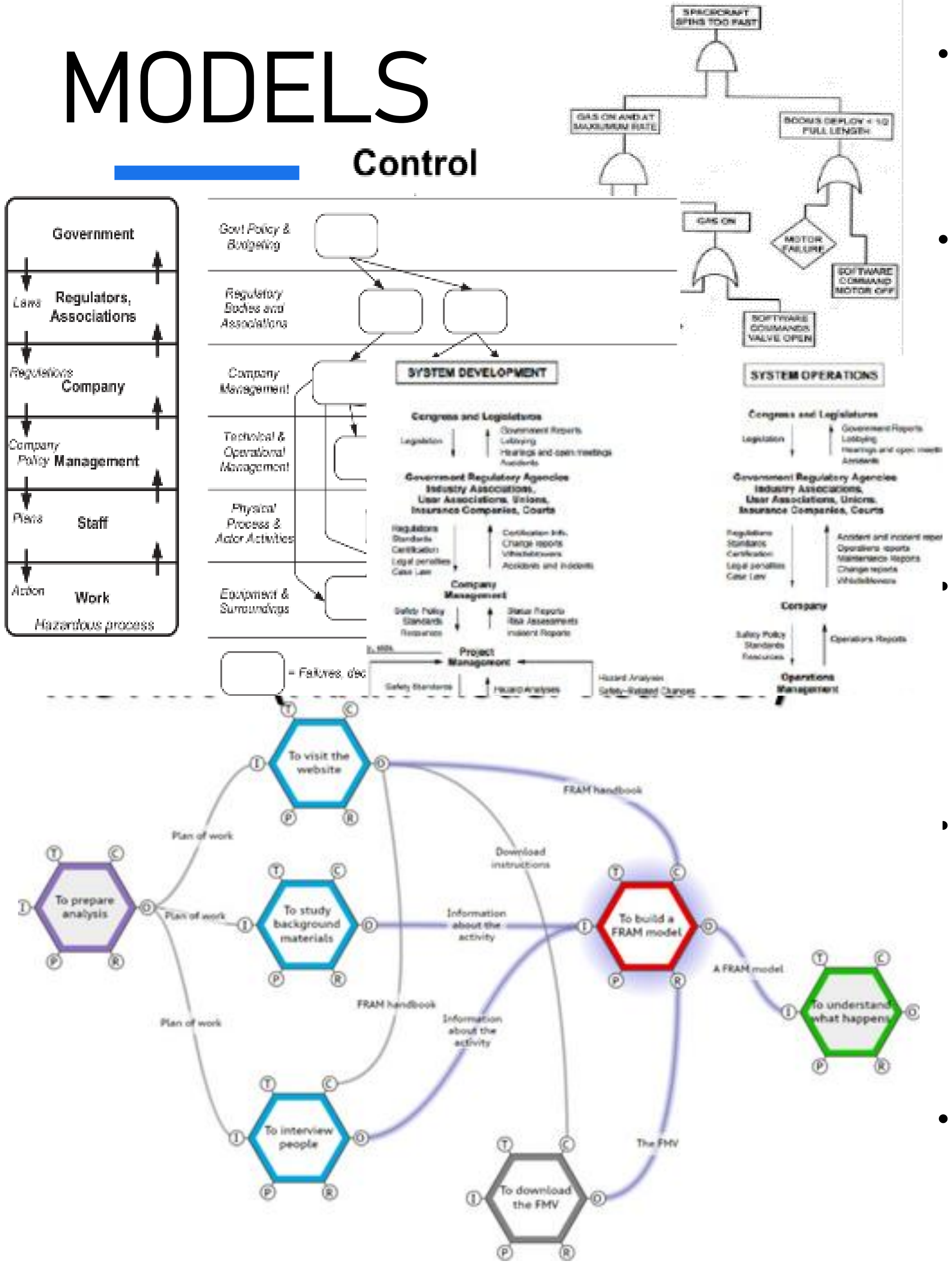
BLACK BOX OF BLACK BOXES?





- For example – A meal in a Restaurant could be produced from a Menu
- It could be a set menu – straightforward process
- Even an a la Carte selection can be theoretically catered for from the menu's system models above.
- But Hollnagel's genius was recognising and modelling what happens when there is an unplanned variation in the items of food supplied, the availability of cooking utensils and appliances, or the unique niche chef is sick?
- They work around it – you get fed (perhaps even better than expected?), but not necessarily exactly as advertised. (WAD/WAI)

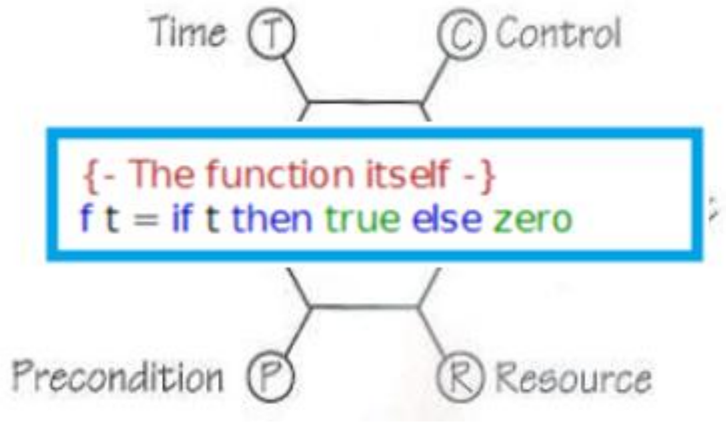
MODELS



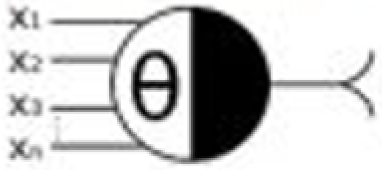
- Most legacy system models were designed to trace and identify consequences of failure, (to produce the meal?), e.g., Fault (Logic) Trees
- But for more complex components and organisations (software subroutines), Boxes and Arrows (e.g. SADT, and Accimaps) were more informative and showed the sequence of actions needed in the system. This has now developed into a more formal modelling approach SysML, which seems to be the standard go to approach endorsed by systems engineering.
- Leveson extended this into a so-called, a SYSTEM THEORETIC approach, which identified failures of the control arrows as “unsafe acts”, which seems to be appreciated in US accident investigation circles.
- But again, Hollnagel recognised the need to formalise all the interactions between functions in a system, not just the Control aspects. In fact, in his approach “to control” a function requires a further separate function to respond to the function’s outputs, not just a single link / aspect.
- (In real systems feedback is only possible given an event. This information must be passed forward to address the future behaviour of the system not just update a static network.)

FUNCTIONS

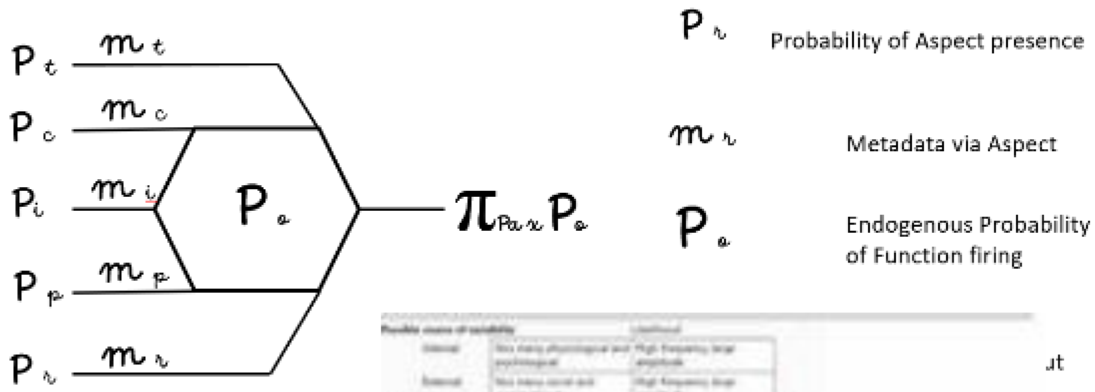
- In the static networks and digraphs, the nodes represent the result, event of the converging edges
- If we use the FRAM approach, the function is more than a node, it is a point where something happens to change the status of the system, as a result of the process carried out by the function.
- So, it is not necessarily the same fixed network or set of logic trees. (Ripples on a pond disturbed a stone splash. There are expected (designed, programmed) behaviours of these interacting functions, but in real systems the set or choices of a la carte can't be delivered exactly as specified, due to variability in the functional performances.
- Again, this variability and unexpected resonance between functions in the system (menu) is a key feature and insight from the FRAM approach.
- A particular meal produced form the variable menus is called an INSTANTIATION or manifestation emerging from that particular set of circumstances and resonances.



HOW DO FRAM FUNCTIONS, FUNCTION?

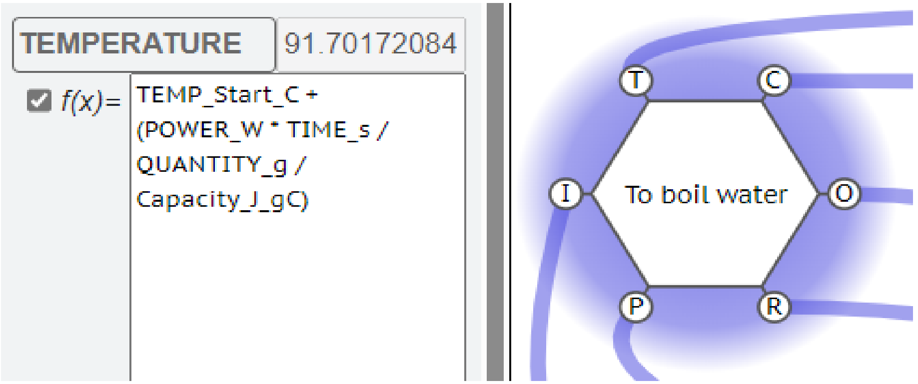


- In a FRAM function, the logic is simple.
- If all the necessary aspects are present (at that time?) – it fires / works / produces the required activity. If an Aspect is not present, it fails to fire, and the system process ceases (as designed)
- In practice the "quality" off these Aspects although present may vary – causing a corresponding variability in the outputs which in turn, provide varying quality Aspects for other functions in the system.
- These variations can amplify or dampen the output quality of other functions – i.e. resonate positively or negatively.
- This logic is demonstrated in the FMI, which checks if these Turing Machines have worked or not.
- The variability in the early FRAM was mainly speculation and inferred from observations of systems in practice to compare with the way the theoretical processes were imagined working.

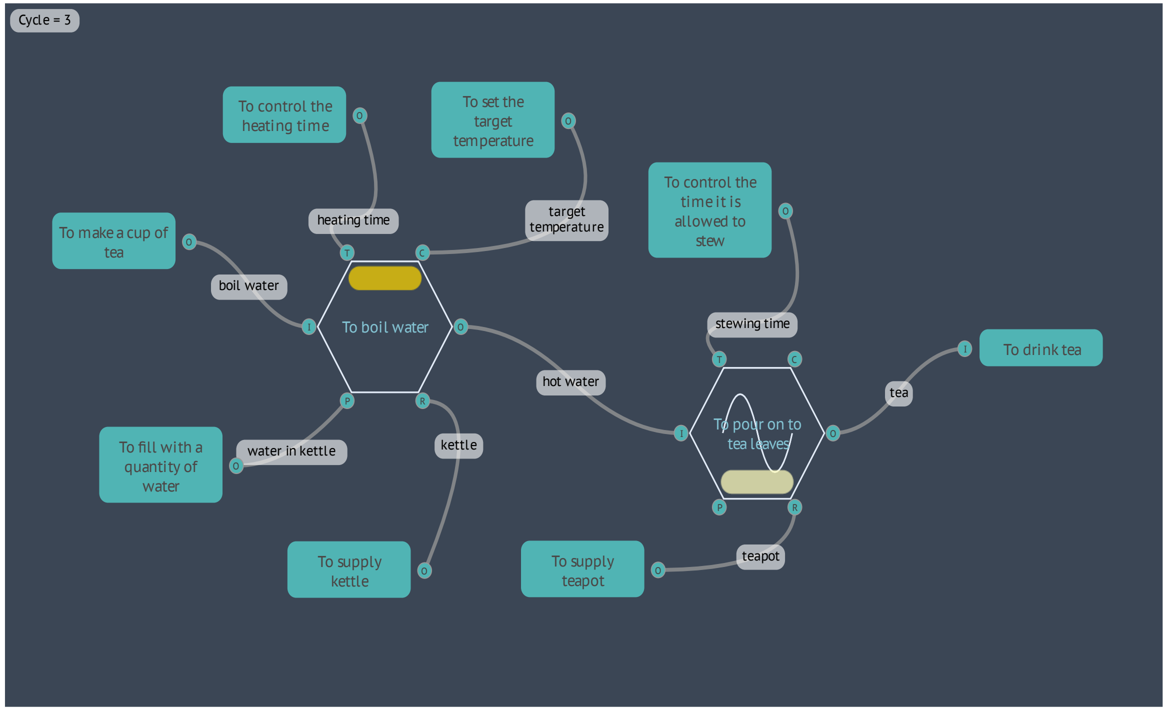


FRAM Model Interpreter

PREDICTION OF VARIABILITY AND RESONANCE



- The FMV took the FMI and added the ability to program the endogenous behaviours of these Turing machines and adjust the outputs not just for the presence of the Aspects but the "quality" of their usefulness to the function. This covers the non ideality of the upstream function outputs which in the original FRAM were described as e.g., not timely, not adequate, not as specified, etc.
- This metadata facility made the FRAM a fully quantitative, bona fide, generic system metamodelling methodology.

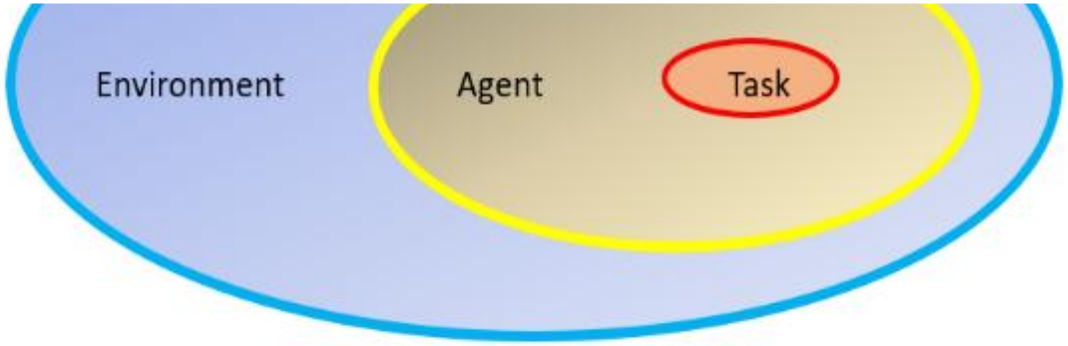


QUANTITATIVE INCLUSION OF WIDER INTERACTIONS

- Most systems modelled these days are complex and do not operate in hermetically sealed isolation. They operate in an environment, which can affect how the functions behave.
- The functions are often operated by human agents, which implies a diverse range of competence, experience, expertise and wellbeing issues which can affect the "quality" of the function's outputs.
- The tasks involved similarly can have different degrees of complexity, more or less, vulnerable to the quality of the environment and agency.
- Historically this has been researched as the factors responsible for errors and failures and there is a comprehensive quantitative database of predicted and observed effects that can be used in the metadata of the current FMV.

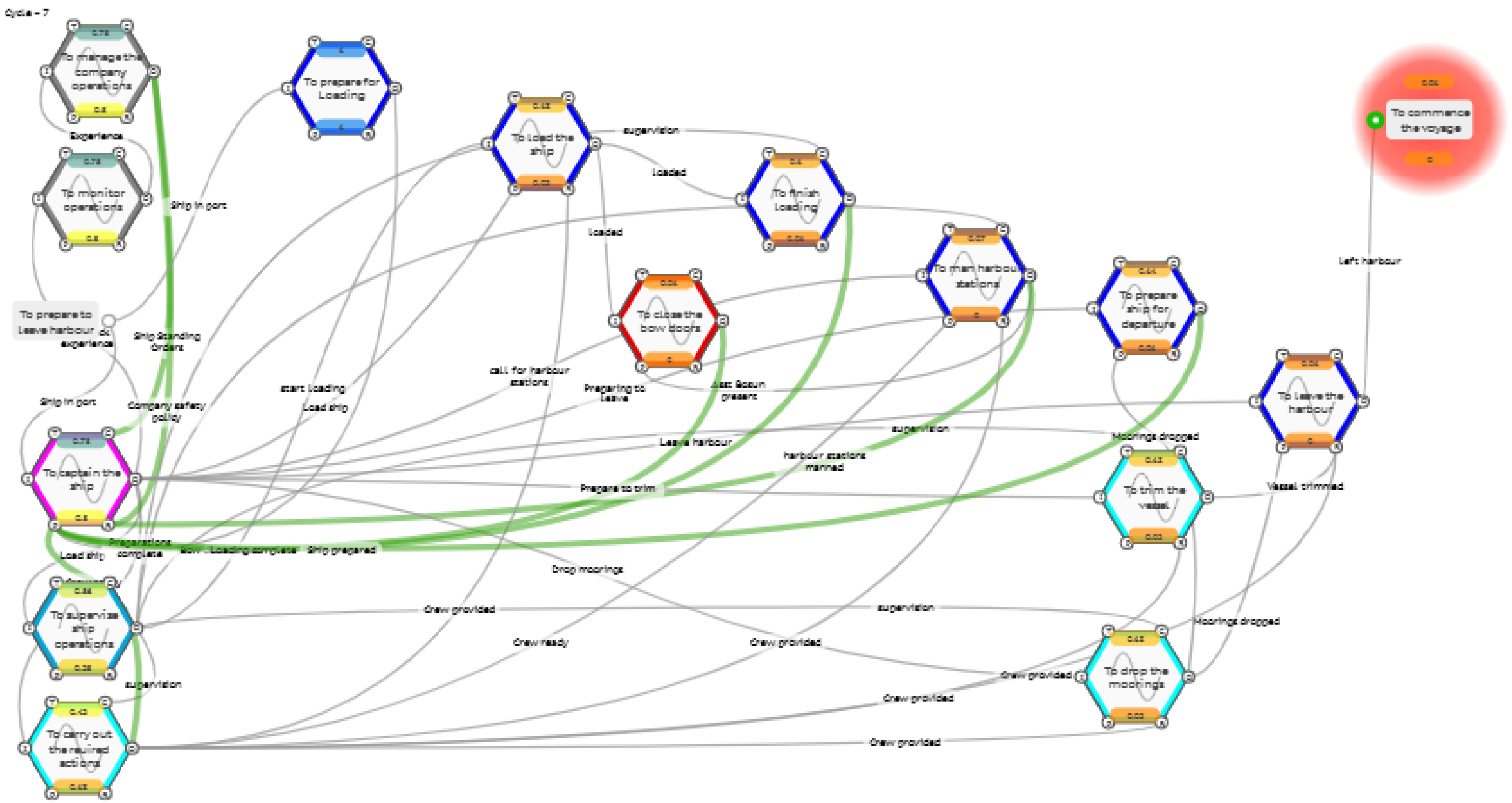
Error Factor	THERP (Range)	HEART (Range)	SPAR-H (Range)	CREAM (Range)	ATHEANA (Range)
Procedure Accuracy & Clarity	0.6 – 2.0	0.7 – 1.7	0.5 – 2.0	0.8 – 2.0	~0.8 – 2.0
Training, Knowledge & Skills	0.7 – 2.0	0.6 – 3.0	0.5 – 5.0	0.7 – 2.0	~0.8 – 2.0
Fitness for Duty	0.7 – 2.5	0.6 – 3.0	0.5 – 5.0	~0.7 – 3.0	~1.0 – 2.5
Workload Management	1.0 – 1.5	1.0 – 1.4	1.0 – 2.0	1.0 – 1.8	1.0 – 2.0
Communication	0.8 – 2.0	0.9 – 2.0	0.9 – 2.0	0.8 – 2.0	~0.8 – 2.0
Work Environment	1.0 – 2.0	1.0 – 2.0	1.0 – 2.0	1.0 – 2.0	1.0 – 2.0
Human System Interface	0.8 – 2.5	0.8 – 2.5	0.5 – 2.5	0.8 – 2.5	0.8 – 2.5
Task Complexity	0.7 – 1.8	0.7 – 2.0	0.67 – 2.5	1.0 – 3.0	1.0 – 3.0

Group	Representative Range	Representative Average
ENVIRONMENT	~0.8 – 2.0	~1.43
AGENT	~0.5 – 5.0	~1.85
TASK	~0.7 – 3.0	~1.63



Human Adaptability (not error?)

- Chains of sequential Human Functions, rapidly become extremely unlikely to be precise or on time. (Work as Imagined)
- So how do (Work as done) systems with multiple human functions manage to work successfully?
- How do they adapt to (cope with), less than expected (perfect) conditions, control and resources.
- The criteria for working or not, is / should be, purely the probability of the Aspect presences?
- But, if previous functions enable the conditions (Aspects), however imperfectly, the function works or not/ doesn't it?
- Can they work around the absence of Aspects



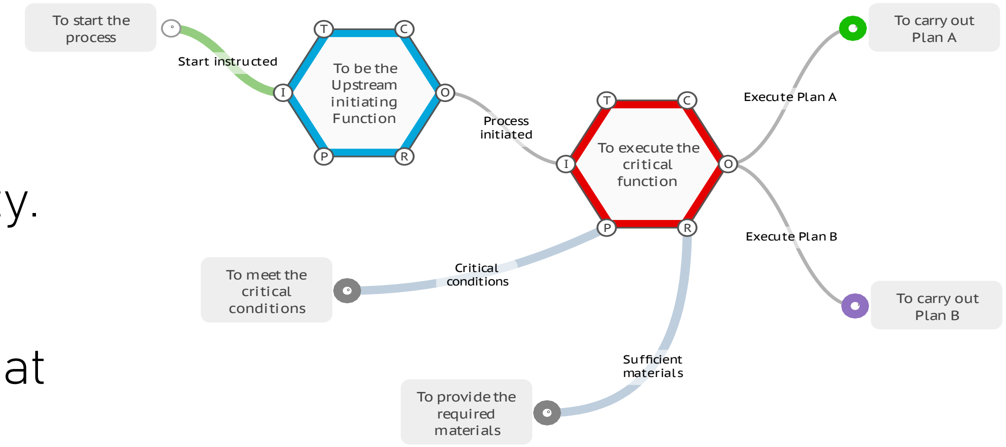
Tolerance Thresholds

- Finally, the FRAM work has suggested that although the quality of aspects and effects can be expressed as probabilities of effectiveness, there must be a cut-off point below which, the function can no longer operate,(i.e. higher than 0), which may be specified for physical components, and observed in human agents.
- The data suggests that the human operated function may in fact be much more tolerant to off spec quality due the innate adaptability of the human operator.
- This is counterintuitive to the accepted wisdom that the human operator is less reliable.

Factor	Parameter	Key	Value	Comments
Environment Factor	Probability of the environment affecting performance	E	FMV input from Tabulated range	Could be a standard Metadata algorithm random number generator to explore variability effects
Agent Factor	Probability that Agent ability to perform	A	FMV input from Tabulated range	Could be a standard Metadata algorithm random number generator to explore variability effects
Task Factor	Probability that task details will affect performance	T		Could be a standard Metadata algorithm random number generator to explore variability effects
Function aberration	Endogenous Probability of the Function failing	Pfend	FMV input from Tabulated range	Could be a standard Metadata algorithm random number generator to explore variability effects
Effect of all the factors	Overall Probability of function failing	Pfail	E x A x T X Pfend	Standard algorithm
Function Specification	Probability of the Function firing	Pfun	1 - Pfail	Sum of probabilities is 1
Aspect presence	Probability of Aspects linking	Pa	Pi, Pp, Pr, Pc, Pt, etc.	These are the output probabilities of the upstream linking functions.
	Probability of Function output	Po	Aprd Pa x Pfun	Standard algorithm
Effect of all the factors	Probability of no Function output	Pno	1 - Po	Sum of probabilities is 1
Adaptability	Probability limit of Function's Tolerance for impaired Aspects	Pt	FMV input from Tabulated range	Could be a standard Metadata algorithm random number generator to explore variability effects
Failed function identity	Function failure from impaired Aspects	Pf	Activate = Amin Pa >= Pt? 1: 0	Highlights the failed function (s) in that instantiation

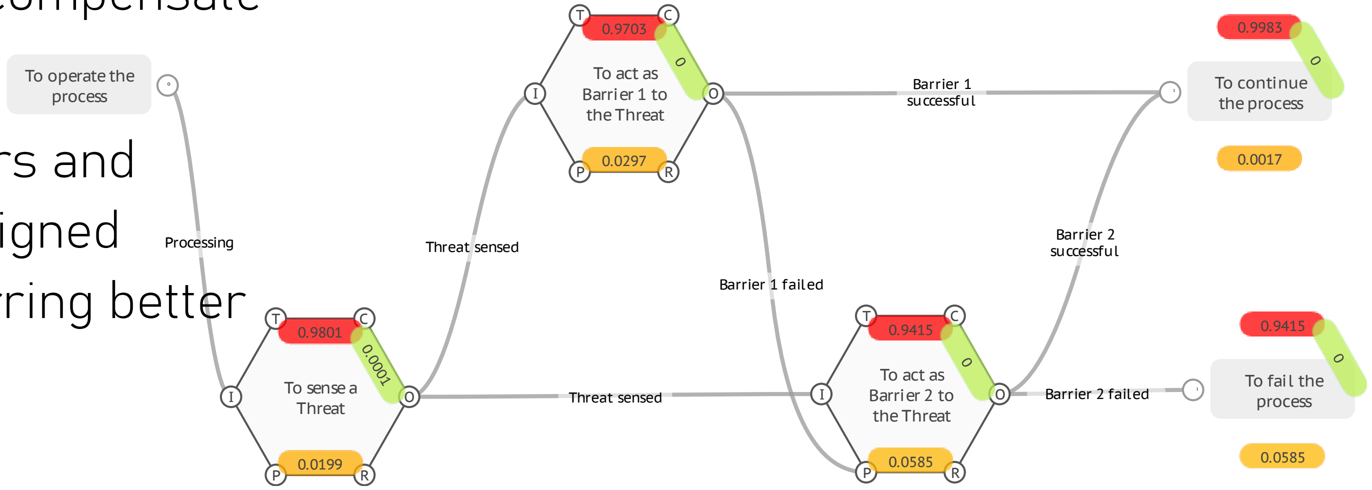
WHAT HAPPENS IF THE FUNCTIONS FAIL?

Cycle = 0



- This is the final defining benefit of the FRAM approach. Illustrated well by the restaurant real world response to unexpected emergent variability.
- Observation of work teams in construction, emergencies and healthcare in particular show that there are many more "just in case" work around functions available on the menu in real life.
- The FMV now has the capability to reroute the process through the mix of functions to compensate or work around emerging issues.
- Not only that it can learn these behaviours and anticipate response, including better designed systems as a continuous process, conferring better resilience as well as understanding.

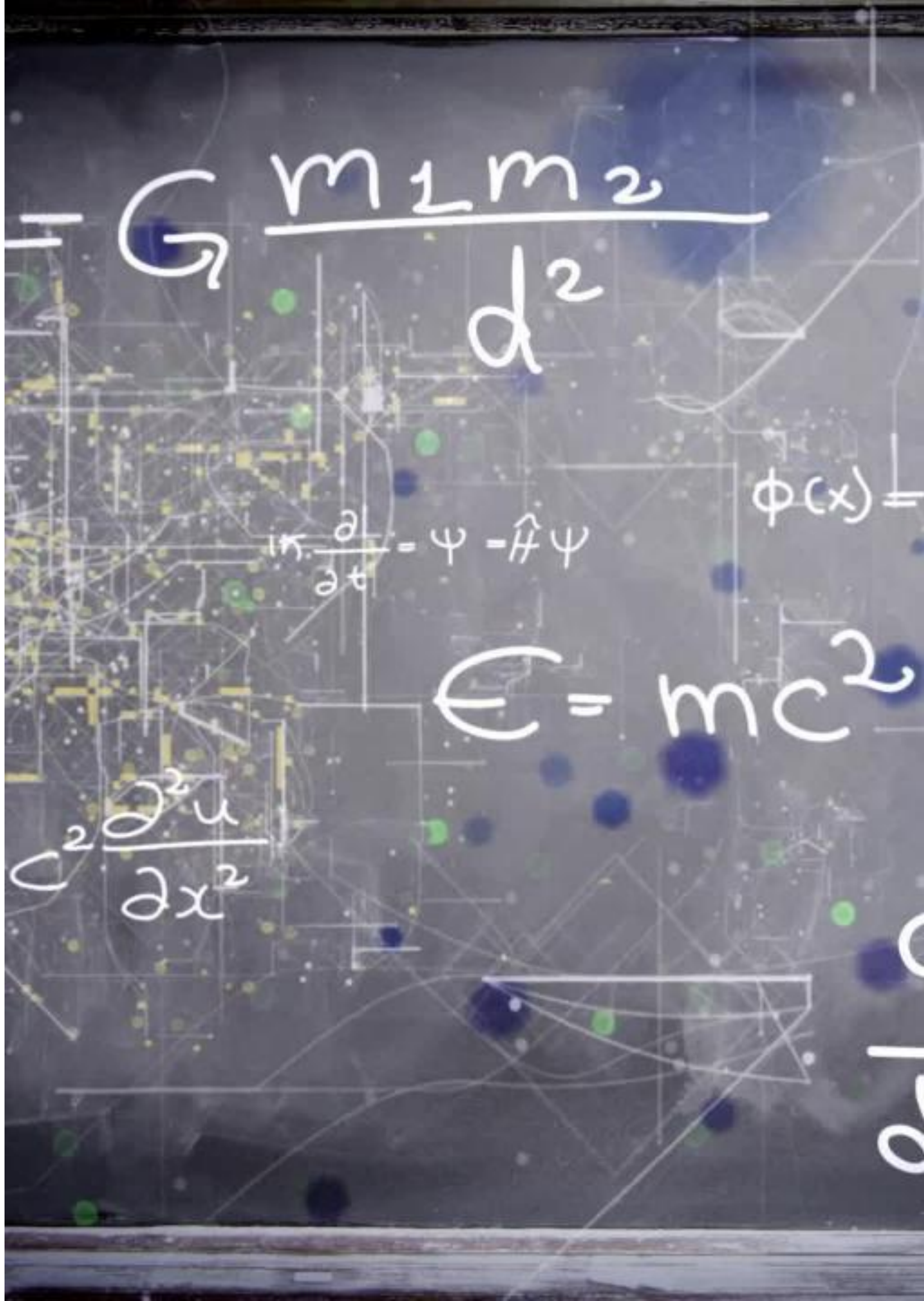
Cycle = 6



Summary – What are FUNCTIONS in a FRAM?

- A storm of "Snowflakes" or a system scenario?
- A mental "mind map" or a mathematical model?
- Yes – all of the above?

- The FRAM is used to build a visualisation of the interacting functions in a system.
- It is a method to build that model – how the analyst uses it depends on the application.
- But it is a legitimate system metamodel, if only used as a visual aid.



Discussion?