Allocation of Function: Yes, no, maybe?

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SUMMARY

This paper summarises the work undertaken to produce an Allocation of Function method in support of a number of client projects in the nuclear sector. This led to the development of an interactive Excel based tool to support the client in Allocation of Function decision making.

KEYWORDS

Allocation of Function, Function Allocation, Method, Strategy, HF Tools, Nuclear

Introduction

The consideration of Allocation of Function is important during the early stages of a project to ensure human capability is accounted for when assigning functions (especially safety functions) to either humans or machines.

The authors were approached by a number of clients in the nuclear sector requesting assistance in the implementation of an Allocation of Function strategy and method early in the lifecycle of their projects.

Although there are a number of Allocation of Function methods and guides that are recognised as good practice, including those made available from organisations such as British Standards (BS), the International Atomic Energy Agency (IAEA) and Electric Power Research Institute (EPRI), it was identified that a degree of adaptation would be required to derive a simplified method that would meet client specific needs.

The authors undertook to devise an Allocation of Function method that could be easily understood and applied by non-Human Factors (HF) professionals with a view to encouraging the engineering teams to consider human capability during the early design development phase.

Method

The work was undertaken in four key phases as outlined in the following sub-sections.

Literature Review

A review of the primary (most referenced) Allocation of Function guidance and methods was undertaken to develop a broad understanding of the context and good practice.

Learning from Experience (LfE)

The authors identified previous work undertaken in the area by both their employing organisation and other organisations in the nuclear sector, including their clients, to inform the development of a method that would meet the specific client's needs.

Understanding Client Need

It was recognised that both clients were at a similar phase in their project lifecycle, and had similar requirements with respect to the development of an Allocation of Function method. Specifically, the key drivers were to develop a method that:

- Could be applied early in the project to support initial design decision making.
- Did not require an extensive understanding of HF or human capability.
- Provided a simple decision-based model that could be applied by non-HF professionals.
- Was scalable or flexible in its complexity to be further developed or of further use as design details emerge.

Allocation of Function Method Development

The initial literature review and LfE identified four key phases or strategic elements to Allocation of Function, these are:

- Identify Functions.
- Characterise Functions.
- Allocate Functions.
- Validation.

The client needs specifically focussed on the method of characterising and allocating functions.

A set of guidance questions and prompts were developed based on the application of understanding of human capability and the role of the operator in the context of the operation or application of the function.

Results

The final method is presented as a semi-automated flow chart within MS Excel (but can be applied in paper form). Guidance is provided at each decision node in the form of yes/no questions and consideration prompts to support the assessor. The logic of the process flow drives the user toward one of the following determinations.

- Implement Fully Automated Solution.
- Implement Fully Automated Solution with Supplementary Monitoring Information Provision.
- Implement Fully Automated Solution with Manual Response to Functional Failure.
- Automation necessary but not feasible. Reconsider functional requirements.
- Manual necessary but not feasible. Reconsider functional requirements.
- Implement Fully Manual Solution.
- Implement Manual Solution with Supplementary Information Provision.
- Implement Blended Solution.

Using the features available within Excel, the tool provides a summary output table in the form of a Dashboard of fundamental factors that influenced the final determination.

Allocation of Function Method

Figure 1 provides an illustration of the decision tree that is used to support options analysis. At each decision box, a number of additional prompts and questions are referred to in support of decision making, these are set out in Tables 1 - 4.

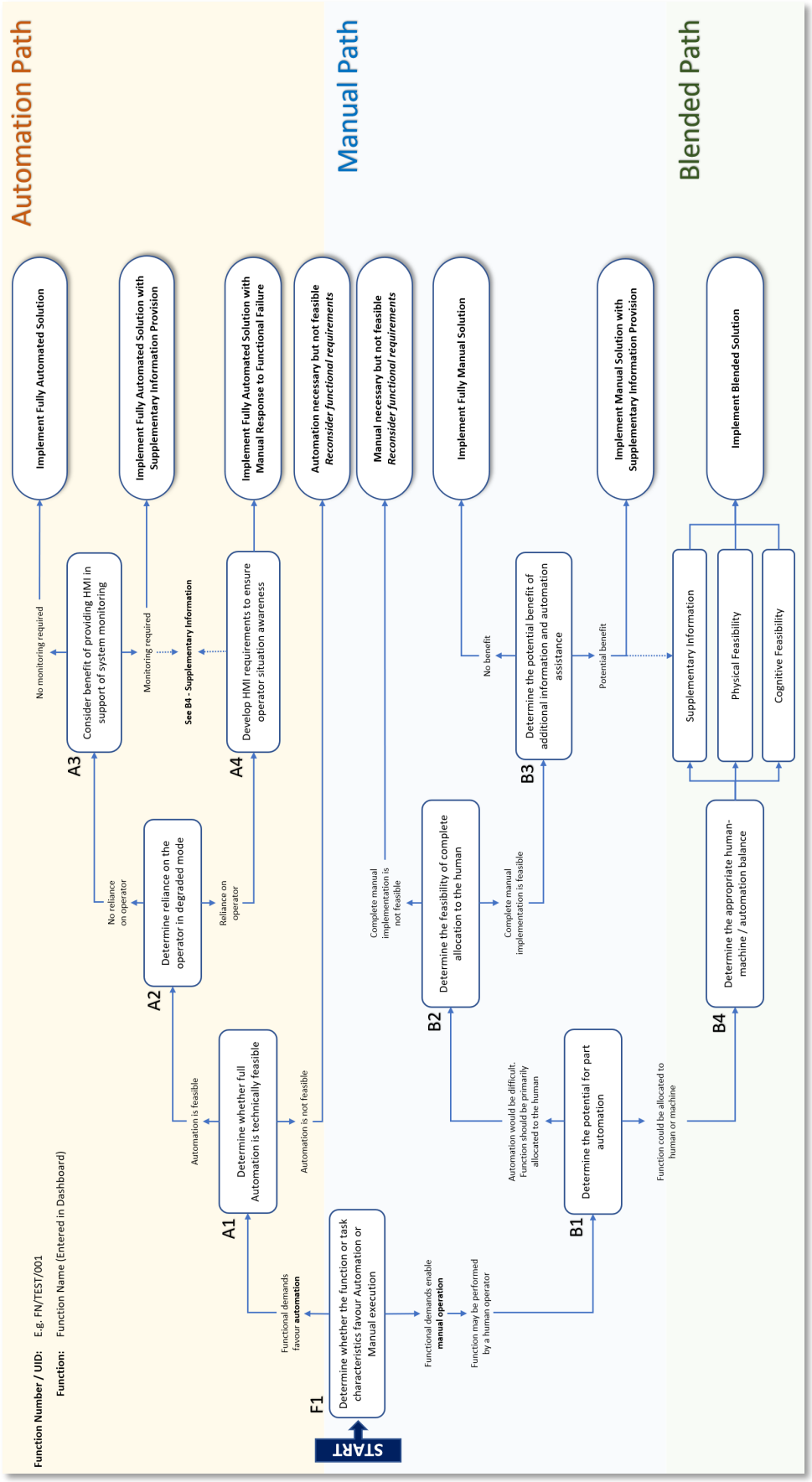

Figure 1: Allocation of Function Decision Tree

Table 1: Primary function prompts

F1: Primary function characteristics or task demands (that would favour automation)	
Legal or statutory requirement	High level of reliability required in support of safety
Operation in an environment hostile to humans	Sustained high intensity operation
Sustained application of high forces	Highly repetitive action
Rapid response to signal or event	Multiple parallel physical operations
Levels of precision beyond normal human capability	Significant data acquisition and processing from multiple sources
High levels of parallel information processing	Retention of a large amount of information
Recording or transferring data to a high level of accuracy	Reliable detection of rare signals or events
Detection of signals beyond human capability	

Table 2: Automation path prompts

A1: Technical feasibility (positive response favours automation)
Are there proven technologies available that can perform this function?
Would the potential cost of developing a bespoke system be acceptable / practicable?
Are anticipated or predictable through-life costs acceptable or sustainable (maintenance | upgrade | replacement)?
Could a solution be implemented within the required timescales?
A2: System robustness (positive response favours automation)
Is there a suitable level of redundancy in the system?
Are (non-human) back-up systems in place?
Are (non-human) further lines of defence in place?
A3: Monitoring requirement (positive response favours supplementary information)
Would monitoring capability favour operator Situation Awareness?
Would monitoring capability favour operator skill-fade?
Would monitoring capability favour operator reaction / response time?

Table 3: Manual path prompts

B1: Technical feasibility (positive response favours manual solution)
Management of novel or unexpected events?
Dynamic adaptation to ever-changing conditions?
Use of heuristics, investigative skills or inductive reasoning?
Decision making based on incomplete or degraded data or information?
Extensive maintenance?
Communication and co-ordination between personnel (on and off site)?
B2: Fully manual feasibility prompt questions (positive response favours manual solution)
Is the function within the physical capability of the operator?
Is the function within the cognitive capability of the operator?
Is the potential human resource cost acceptable?

Table 4: Blended path consideration prompts

B4: Supplementary information consideration prompts

Task prompting.
Task direction / instruction.
Assistance in acquiring information.
Assistance in processing information.
Tasks status information.
Tasks success / failure feedback.
B4: Physical feasibility consideration prompts
Manual handling of large, heavy, complex or fragile items.
Frequency of operation - potential for fatigue.
Poor reach / access / postures.
Duration of effort - potential for fatigue.
Impact / shock / vibration.
Environmental (Noise, light, temperature, humidity, air quality, radiation).
Remote control capability.
B4: Cognitive feasibility consideration prompts
Need to collect data from multiple sources.
High information processing burden.
Frequency of operation - potential for fatigue.
Duration of effort - potential for fatigue.
Parallel information processing.
Potential difficulty perceiving information.
Reliance on memory, retention and recall of information.
Temporal Aspects - absence of time available.
Potential for boredom.
Vulnerable to human biases.
Need for complex error handling.

Application Notes

During the development and early application (trials) of the methodology, the following points were identified that would benefit any practitioner wishing to use, develop or implement a programme of Function Allocation.

- At the start of any large project, especially safety significant projects, a campaign of education and training may be required (typically initiated by HF) to raise the profile and awareness of the need to consider Allocation of Function during optioneering and design development.
- It is important to recognise that although the consideration of Allocation of Function is often championed or led by the HF team, the work requires recognition and collaboration from a number of key stakeholders, including engineering, safety, operations and maintenance. The output cannot be delivered by HF alone and in many cases, it may be preferable for the engineering function to take ownership of the process, recognising the need for support from a HF professional.
- With modern ways of working on large projects, and geographically distributed teams, it is often impractical for professional HF resource to be present at all design reviews or support all optioneering assessments. Awareness training and delegation of responsibility becomes increasingly important, to establish the adoption of a strategy and methodology that encourages consideration of Allocation of Function (and human factors) proportionately. Although there is a risk that HF professionals may have a diminished role in supporting

design decision making, the consideration of human factors (even by others) is fundamentally more important.

- It is tempting to rush ahead with the development and implementation of a method to consider Allocation of Function without first developing and implementing a strategy that determines how the Functions are identified and characterised. This will require collaboration between the key project stakeholders. Many (large) organisations will have their own methods through which Functions are identified (e.g. Functional Analysis, Functional Decomposition, Hazard Analysis, Systems Engineering, Task Analysis). Allocation of Function must be aligned and integrated with the larger programme of work. Specifically, Allocation of Function as both a concept and method needs to be embedded with (or at least used alongside) the core and / or established organisational design decision making processes and arrangements.
- There are many different aspects to Allocation of Function, and it is recognised that there is not one best method that suits all contexts. All models will have limitations and it is likely that any specific approach set out will be adapted for use. The method proposed can be used and / or adapted as required, but provides a robust basis for development, focussing on identifying the key aspects (and human performance shaping factors) to be considered as prompts.
- Proportionality and timing are important aspects to Allocation of Function that are often linked. At the start of the project, specific details may not be available, and the Functions may be loosely defined. However, the consequences of error may be no less severe, and the importance of considering human factors at an early stage may be pivotal to design progression. Once the designs are more developed and specific Safety Functions are being defined, the method of Allocation of Function may need to be adapted, and consideration of human factors should be embedded in the decision-making process.
- In line with design development and option selection, consideration of Allocation of Function may need to be undertaken iteratively, as information becomes available.
- A key aspect to the adoption of an Allocation of Function method is the improved level of rigour and robustness it provides. Through the consistent use of a systematic approach, the rationale for decision making can be captured – which is often poorly documented. The Allocation of Function method should include the means of ensuring that all decisions are captured and recorded.
- There is often a temptation to ‘score’ or add a quantitative element to the assessment of design options. Although there are valid methods of doing this it often adds unnecessary complexity and ambiguity (e.g. how to validly apply weighting to each parameter). The focus of Allocation of Function assessment should be qualitative.

Summary

The Allocation of Function method developed, and Excel-based tool provides the user with a simplified means of considering human capability in order to make a determination early in the design of the system as to whether the function should primarily be allocated to the human, the machine or a blended approach is required. The methodology is adaptable and flexible enough to be applied proportionately, depending on the stage of the project. The tool provides a mechanism for the decision-making process to be clearly recorded.