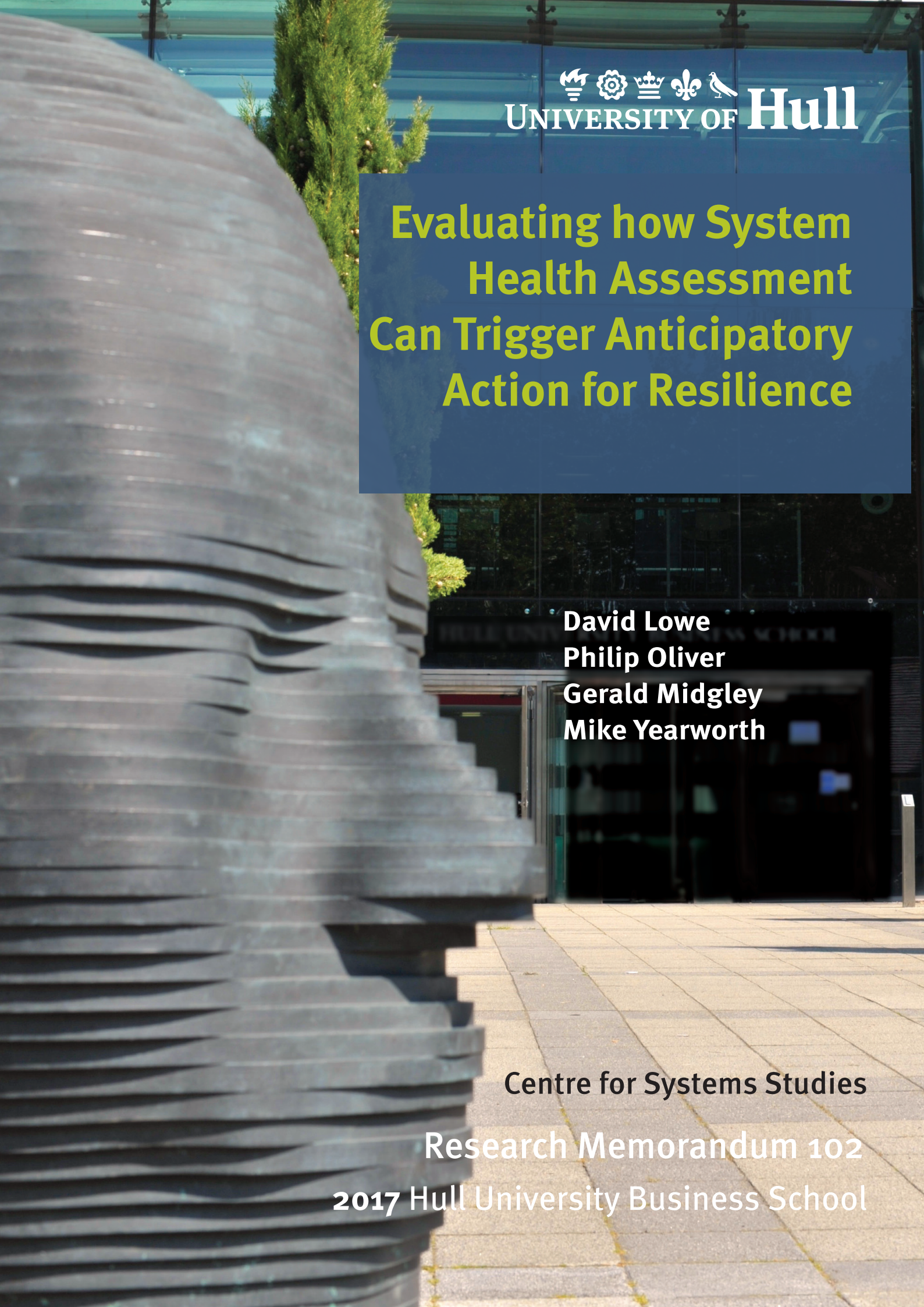

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Centre for Systems Studies

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Evaluating how System Health Assessment Can Trigger Anticipatory Action for Resilience

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Abstract

In 2014 the Defence Science and Technology Laboratory developed and implemented a novel approach to assess the system by which the United Kingdom Ministry of Defence delivers infrastructure projects and services. This approach brought together existing methods to constitute a hybrid problem structuring method that offered the potential to trigger anticipatory intervention by focusing on the health as opposed to the performance of this system. This paper revisits the initial assessment to examine whether use of the method has led to increased system resilience, and in particular to understand what it was about the method that helped to deliver benefits. Insights with regard to the structures and processes necessary to enable anticipatory action for resilience are presented.

Keywords: Systems Thinking; Resilience; System Health Monitoring; Anticipatory Systems

1. Introduction

This paper follows up on a system health assessment conducted within the United Kingdom (UK) Ministry of Defence (MOD) in 2014 to guide anticipatory intervention within its Defence Infrastructure System.

The Defence Infrastructure System boundary encompasses the Defence Infrastructure Organisation (DIO) together with the elements of MOD Head Office that provide governance for the operation of the DIO ('Governor' role) and the Armed Forces and other elements of MOD that provide infrastructure requirements for the DIO to deliver against ('Customer' role). The DIO was created in 2011 to *"coherently manage delivery against MOD's infrastructure requirements"* [1] and is responsible for building, maintaining and servicing the infrastructure necessary to enable MOD personnel – both military and civilian – to live, work, train and deploy both in the UK and overseas.

In order to drive further efficiency and effectiveness, in 2014 MOD decided to introduce a strategic business partner within the DIO to act as the senior management team and inject knowledge and expertise developed in the private sector. As part of the preparations for this introduction, the Defence Science and Technology Laboratory (Dstl) were tasked to assess the health of the Defence Infrastructure System in order to identify major strengths, weaknesses and uncertainties, and also to make recommendations to be implemented as part of a broad reform programme [2].

This work identified eight key actions that should be taken with the purpose of improving the health (and consequently long term performance and resilience) of the Defence Infrastructure System that were taken forward in the Defence Infrastructure System Programme. Immediate feedback was very positive, but in November 2016, almost exactly two years after the results were briefed, the UK National Audit Office published a report [3] which found that whilst MOD *"has started to improve its management of the defence estate … the department has not yet set out how it will fully address the significant challenges it faces sustaining the whole of its estate and the resulting risks to military capability"* and went on to make

a number of recommendations for further intervention. This suggests that the original health assessment failed to trigger all the changes necessary – because not all appropriate actions were identified by the initial assessment and/or because their implementation is not yet complete.

It is well established that most change programmes fail, with failure rates as high as 70% (Kotter [4]). This paper examines the reasons why the identified actions seemingly have failed to achieve the desired outcomes in terms of two dimensions – desirability and feasibility – following Peter Checkland's criteria for identifying purposeful actions as part of his Soft Systems Methodology [5]. In terms of desirability, this paper considers where the actions have had a positive effect (i.e. as designed); where the actions have had a negative effect (i.e. where unintended consequences have come into play – as per the 'fixes that fail' systems archetype [6]); where they have had no effect at all (i.e. the action was not necessary); and where additional actions should have been recommended (i.e. the action set was not sufficient). In terms of feasibility, this paper considers which actions proved straightforward to implement and which actions proved difficult (such that implementation was significantly compromised or failed altogether) in order to better understand barriers and enablers to progress.

Taken together, the results will help provide answers to the research question posed recently as part of a movement to advance Anticipation as a multi-disciplinary research field: What structures and processes are necessary for anticipatory action? [7]. The paper now proceeds to:

- Detail why anticipatory action is important for a resilient system and how internal health assessments can be used to trigger such action (see 2. Literature Review);
- Revisit the assessment that was conducted in 2014 and the recommendations that were made (see 3. Initial Assessment);
- Evaluate the desirability and feasibility of the outcomes that followed from these recommendations in the light of events that have followed via stakeholder interviews (see. 4. Evaluation);

- Discuss the insights generated by the evaluation and identify areas for further work (see. 5. Discussion); and
- Summarize the findings and highlight the key points (see 6. Conclusions)

2. Literature Review

The term ‘resilience’ stems from Latin (resiliens) and originated from the physical sciences where it is commonly used to refer to the *“ability of a substance or object to return to its original shape after being bent, stretched, or pressed”* [8]. Resilience has been the subject of much scholarly debate in the systems literature since Holling [9] first introduced the concept in a systems context in 1973 where he defined resilience of an ecosystem as “the measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters and still persist”. In particular, a competing ‘engineering resilience’ paradigm has emerged that is distinct from Holling’s ‘ecological resilience’. Where ecological resilience (also referred to as static resilience or robust resistance) involves maintaining the existence of function and is typically measured in terms of the system’s ability to resist disturbances, engineering resilience (also referred to as agile adaptability or dynamic resilience) involves maintaining efficiency of function, including by taking action to achieve a more desirable state in advance of a disturbance, and is typically measured in terms of speed of return to a state of efficiency [10].

In the public sector, where threats to existence are rare (whilst a government department may be sanctioned for a lack of efficiency it almost always persists, and especially a Department of State such as MOD), it is the concept of ‘engineering resilience’ that is the more relevant. Moreover, it is vitally important that government departments such as the UK MOD continue to deliver essential services regardless of changes in operating conditions and that they take pre-emptive action to ensure this. In particular it is important for the defence and security of the UK that MOD is able to deliver the outputs specified in a set of Military Tasks: defending the UK and its overseas territories; providing strategic intelligence; providing nuclear deterrence; supporting civil emergency organizations in times of crisis; defending our interests by projecting power strategically and through expeditionary

interventions; providing a defence contribution to UK influence; and providing security for stabilization [11].

In order to maintain efficiency of function under the engineering resilience paradigm it has been suggested that a system should have the ability Anticipate, Monitor, Respond and Learn [12]. The collation and processing of information is critically important for each of these cornerstones and the impact of introducing information systems on an organization's resilience has been identified as a fruitful direction for research in this area [13]. Such information systems should enable the collation and processing of contextual information that is both external and internal to the system if they are to enable pre-emptive anticipatory action [14] [15] that will ensure resilience in the engineering resilience sense. Whilst MOD has a number of structures and processes dedicated to the collation and processing of external information, there is less dedicated to the collation and processing of internal information. It is postulated here that system health assessments can provide a useful complement to existing performance, risk and audit reporting and make for a more complete set of internal contextual information from which MOD can take anticipatory action.

In the field of organizational management, health is being increasingly recognized as a lead indicator for performance – "Performance is about delivering (financial) results in the here and now. Health is about the ability to do it year in, year out" [16] – that has the potential to transform management approaches from reactionary to anticipatory. Whilst a number of approaches have been developed to enable health assessment in public, private and third sectors – see previous CSER paper for a description of these [17] – there appears to have been no attempt to evaluate their effectiveness in a longitudinal sense.

This paper revisits the initial assessment conducted in 2014 to understand why the action that was recommended has not fully achieved the benefits that were anticipated. Of particular interest is what it was about the method that was developed and implemented that could be improved. For example, did the apparent failure stem from the way in which the process was managed (i.e. building

commitment of individuals, establishing multi-organizational teams) or how the content was managed (i.e. summary visualization enabled ready appreciation of key issues, hierarchical representation enabled linking of point issues in wider context) or both [18]? In this way insights are offered against the research question highlighted earlier: What structures and processes are necessary for anticipatory action? [7]

3. Initial Assessment

The initial assessment in 2014 involved the development and implementation of a hybrid Problem Structuring Method (PSM) that combined Hierarchical Process Model (HPM) with Viable System Model (VSM) methods in a pluralist [19] (or multi-methodological [20]) design.

HPM was developed at the University of Bristol based on a strong process-based view of system description [21]. The HPM tree structure provides a conceptual schema for establishing the processes required to achieve a transformation. Leaf processes are described using gerund form to stimulate a degree of creativity in the modelling (gerund forms have no subject and the performer is not specified) and are scored using an Italian Flag scale that details what is known to be good about a process (green), what is known to be bad about a process (red) and what is uncertain or unknown (white). These scores are then typically aggregated using sufficiency and necessity conditions drawing upon a variation of the interval probability theory implemented in what is termed the Juniper algorithm [22].

Eliciting the hierarchical system structure typically proceeds from a top-level transformational process through repeated questioning of how? until there is no longer a process answer to these how? questions. However, in this application the HPM structure was developed through the application of VSM at two different levels to examine the Defence Infrastructure System in the wider context of the Defence Enterprise (see Figure 1). The VSM was developed by Beer [23-25] by applying cybernetic theory (regarding the flow and use of information for regulation and control) to the management of organizations. He established that the viability of an

organization in its environment is dependent on the capacity of, and strong links between, five key system elements – Identity (S5), Intelligence (S4), Control (S3 including Audit S3*), Coordination (S2) and Operations (S1). These 'invariances' provide a functional framework for the design of a new system and/or the assessment of an existing system and can be applied recursively to model organizational scale and complexity.

However, the application of VSM in its standard form was found to be problematic. Stakeholders had difficulty in discriminating between Beer's S3 (control), S3* (audit) and S2 (coordination) because they regarded these functions as largely indistinguishable within the role of management. Consequently, these functional requirements were collapsed into a single layer to yield an adapted VSM focused on four key functions (with associated sub-functions):

- Strategic Leadership (Beer's S5): Setting strategic direction; Setting strategic incentives; and Managing strategic performance and risk.
- Strategy Formulation (Beer's S4): Capturing inputs and constraints; Setting strategy; and Monitoring strategy implementation.
- Operational Management (Beer's S3, S3* and S2): Setting management direction; Managing performance and risk; Assuring delivery coherence; and Assuring and auditing performance.
- Operational Delivery (Beer's S1): Understanding user requirements; Understanding supplier capabilities; Delivering projects and services; and Managing delivery performance and risk.

The assessments were undertaken via two workshops: one focusing on 'Defence Enterprise Operational Management' (function E3) related to infrastructure delivery and the other focusing on 'Infrastructure Delivery System' (functions S1-S4). The workshop participants were those stakeholders identified as having responsibility for and/or experience of, delivering key elements within functions E3 and S1-S4, as well as those with experience of setting requirements and receiving services as a customer (principally the Armed Forces). Eight actions were identified based upon five key weaknesses and three key areas of uncertainty (see Table 1). These

recommended actions were readily accepted by the senior customer (who was not party to any of the workshop discussions) and used to define the forward work plan for the Defence Infrastructure System Programme.

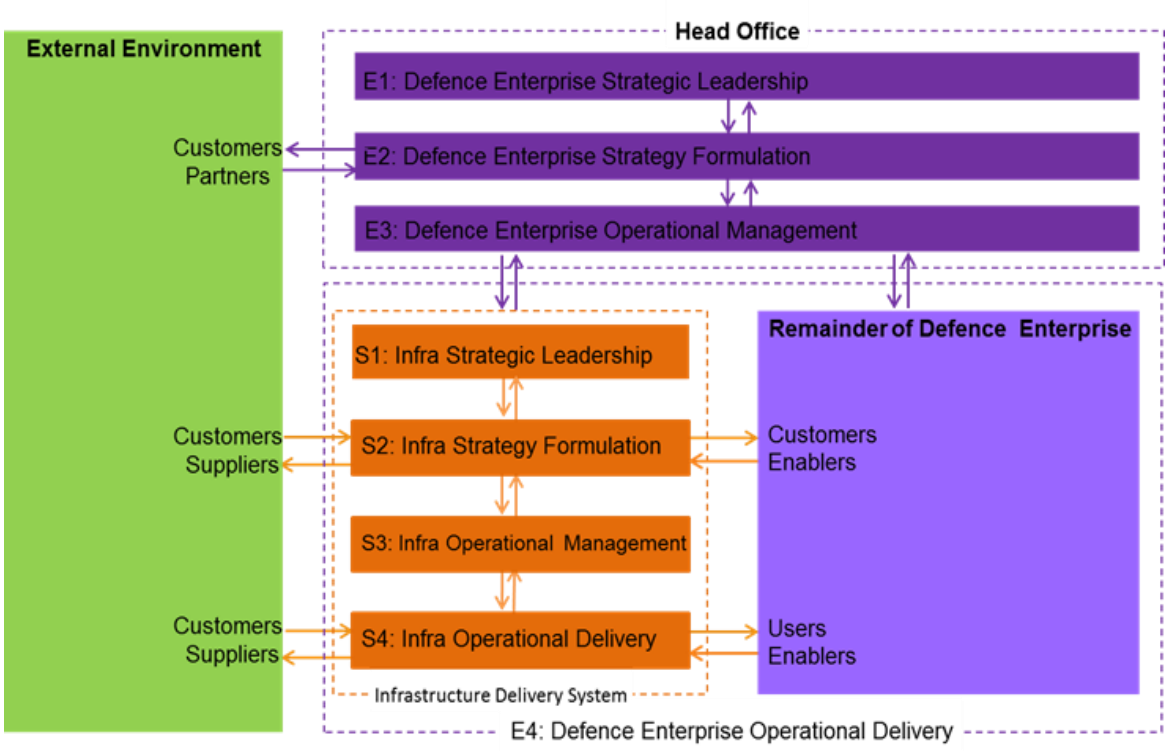

Figure 1 – Assessing the Infrastructure Delivery System in the context of the Defence Enterprise

The immediate cross-sectional evaluation conducted using the framework developed by Gerald Midgley and his co-authors [26] revealed very positive stakeholder views, with two main benefits being identified from the perspective of follow on work to establish a maturity model and track progress of actions being taken. First, the work had brought the stakeholders together to understand the system:

> *"The Dstl work made a real difference in the success of the Defence Infrastructure System Programme definition stage. In particular, it enabled us to arrive at an agreed maturity model much more quickly than would otherwise have been the case as many of the key stakeholders had already*

been through the thought process that led them to understand the functions within the system".

Second, the work identified key areas for intervention:

> *"In addition, your work with them around the Italian Flag assessment resulted in a common understanding of system weaknesses. This enabled us to reach a rapid and robust consensus as to the current state of the Infrastructure System and priorities for corrective action"*.

#	**Recommended Actions**	**Systemic Problem**
1	Define scope of Infrastructure Delivery System	Uncertainty
2	Test, formalise and communicate internal interfaces	Uncertainty
3	Test, formalise and communicate external interfaces	Uncertainty
4	Accelerate roll-out of management information systems	Weakness
5	Link Infrastructure delivery to Defence objectives	Weakness
6	Establish incentives for 'Defence first' behaviours	Weakness
7	Manage Infrastructure Delivery System as a whole	Weakness
8	Develop Intelligent Customer status (Head Office and Armed Forces)	Weakness

Table 1 – Recommended action for intervention within Defence Infrastructure System

4. Evaluation

The research question posed here – What structures and processes are necessary for anticipatory action? – has necessitated the design and implementation of a longitudinal evaluation method. This method draws upon the principles of Realistic

Evaluation [27] in that it considers an Outcome (O) to be the result of the application of a given Method (M) in a given Context (C), or C + M = O for short. This construct provided the basis for six structured interviews with stakeholders drawn from all aspects of the Defence Infrastructure System – two from Head Office, two from Armed Forces and two from DIO – where the interview team asked a set of open questions relating first to Context, then to Outcome and lastly to Method. Of these six interviews, four were conducted with staff who were involved in the initial assessment and two were conducted with staff who were new in their posts (both in the Armed Forces).

In response to the opening set of questions, stakeholders reported that the Context over the intervening two years had been challenging in three key aspects and these had limited the implementation of the actions identified in 2014. First, it was noted that the DIO had experienced service provision issues at the Infrastructure Operational Delivery level where Customers were dissatisfied with the service delivered through a number of related contracts and that this had led to relationships with the Armed Forces to become strained. Second, and as a direct result of these service provision issues, it was highlighted that Head Office had been unable to maintain a broad system-wide perspective at the Infrastructure Strategic Leadership level and instead had typically focused in one or two areas. The fact that this occurred despite MOD establishing a dedicated change programme highlights the acute nature of these service provision issues. Third, it was observed that the installation of a Strategic Business Partner at the Infrastructure Operational Management level had yet to realize all of the expected benefits and had in some areas led to significant additional complications. More positively though, the stakeholders reported that, compared to the assessment made for September 2014, there were now reduced levels of uncertainty owing to the work conducted by the Defence Infrastructure System Programme.

The way in which this work had/had not delivered Outcomes was the subject of the next section of the interviews which examined how the actions detailed above in Table 1 had been progressed (recall that each was designed to be both feasible and desirable). It was established that seven out of these eight actions – #1, #3, #4,

#5, #6, #7 and #8 – had been progressed substantially and that each had delivered a positive Outcome (i.e. they were indeed both feasible and desirable). For example, it was evidenced that improvements in the collation, processing and dissemination of management information has directly led to improvements in decision making with specific reference to estate lifecycle, maintenance backlogs and footprint rationalization. Whilst feasible, Action #2 had proven to be less desirable than the other recommended actions and so had been deprioritized within the Defence Infrastructure System Programme. It was also established that the recommended actions were a comprehensive set and this was attributed to the broad nature of the actions that meant that even with the benefit of hindsight nothing additional could and should have been recommended. It was acknowledged however that not all of the actions identified as both desirable and feasible had yet to fully pay off – primarily due to the challenging context described above but also due to their long-term nature.

The final section of each interview examined what it was about the Method that had delivered a comprehensive set of actions that had proven to be largely both desirable and feasible. The interviewees identified three key aspects. First, the interviewees found that by engaging and gathering together a broad range of stakeholders to exchange views, and from their unique perspectives on the current ‘as is’ operating model, the Method yielded high levels of stakeholder engagement that persisted over time. Second, the interviewees found comparing the intended ‘to be’ operating model against a pre-established framework in a structured way to be helpful in identifying important areas of uncertainty where more definition was required. Third, the interviewees found that conducting the baseline assessment that identified both strengths and weaknesses (in addition to these uncertainties) to be helpful in establishing a common stepping off point from which direction could be set with confidence.

5. Discussion

Whilst cross-sectional evaluation is useful, in that it provides benefit to researchers by accessing different perspectives other than their own, longitudinal evaluation

goes further to provide complementary benefits (as acknowledged by Midgley and his co-workers [26]. Longitudinal evaluations have benefits both for researchers and for participants. For researchers, such evaluations can reveal the blockers and enablers for long term impact that follow from their initial work. For participants, such evaluations provide a useful stimulus to revisit original issues, reflect and perhaps reinvigorate or at least maintain momentum. Both types of benefits were realized in this case.

This longitudinal evaluation confirms the key finding from the cross-sectional evaluation of just how suited Problem Structuring Methods are to guiding intervention in messy, problematical situations involving Multi-Organizational Groups [28-30]. This stems from enabling a social process where multiple stakeholders are engaged, and they are encouraged to contribute from their perspectives whilst simultaneously providing a structure for handling content that supports effective discussion and/or dialogue. The benefits that stem from the simultaneous management of process and content are well known [18] (sometimes with the injection of substantive expertise [31]). In this instance stakeholders particularly valued the structure provided by the VSM as it provided a useful handrail for guiding discussion and assessment.

Both this longitudinal evaluation and the initial cross-sectional evaluation highlighted the potential for Italian Flag assessments to act as powerful boundary objects where the model provides a number of affordances [32] that enable Multi-Organizational Groups to constructively focus on the assessment and what actions to take rather than argue from entrenched positions – it was interesting to record one interviewee characterizing this in their own terms as *"corralling whinging for use as a basis for action"*. In particular, the stakeholders appreciated the way in which this assessment scheme provides for the visualization of uncertainty – the white on of the Italian Flag – in addition to the balance of strengths (green) and weaknesses (red). In some instances, this represented situations where insufficient information was available and in others it represented situations where participants agreed to disagree but in all instances, there was a commitment to work to reduce the uncertainty where it was assessed to have significant impact on decision-

making. The identification and treatment of uncertainty is recognized as a key aspect of strategic decision making [33] and it was interesting to note that work subsequent to this assessment used a maturity model approach to track progress against benchmark levels set on a five point Likert scale against a number of functional requirements – see [34] for a review of maturity model approaches. Whilst such approaches are well-suited to setting targets and tracking progress they do not provide for recording and treatment of the uncertainty.

This focus on health as opposed to performance was found to be helpful in that it somewhat distanced participants from the symptoms in the here and now to focus on the underlying causes. In particular, it enabled the senior leaders involved to 'step back' and to reflect on the effect that actions were having and so to identify the need for alternative and/or additional intervention that otherwise would not have been brought about. The areas identified through the assessment have been welcomed as evidence-based interventions that, when fully implemented, will increase resilience by reducing the likelihood of risks materializing as issues.

Such a systems approach has since been applied elsewhere in MOD to good effect, most notably for Acquisition but also for Permanent Joint Head Quarters and Head Office organizations. As the UK government continues its move towards commissioning the delivery of public services, it appears that opportunities for adding value via this type of assessment will continue to expand. Further, the flexible nature of this approach to assessment means that it lends itself to examination of a broad range of interface types (contractual, inter-organization or intra-organization) and so could provide the basis for a wide spectrum of use in organizational settings.

It should be noted that the development and implementation of this novel approach to health assessment took place during a period of extreme change in Defence Infrastructure System. Whilst initial exploration of the broader adoption of this approach in other organizational settings (and in particular public sector organizations) has shown great potential, in order to realize maximum benefit, the organization in question needs to be stable enough for the senior managers to take

on responsibility for delivering broad-based systemic change as opposed to being limited to addressing pressing issues that are narrow in scope. The inability of senior managers to act systemically proved to be a major blocker in this particular case.

6. Conclusions

This paper has revisited the initial assessment carried out for the United Kingdom Ministry of Defence in 2014 with regard to the way in which it delivers infrastructure projects and services to evaluate whether it has led to increased system resilience through the triggering of anticipatory action. The analysis of a number of interviews conducted with stakeholders suggests that whilst seven of the eight actions identified in 2014 have brought positive outcomes the extremely difficult operating context – with the MOD having to deal with a number of pressing performance issues as detailed in the NAO report [3] – has limited MOD's ability to drive systemic change and fully realise the associated health benefits.

This paper has identified a number of insights with regard to the structures and processes necessary to enable anticipatory action for resilience that appear to be readily transferrable to other settings. These comprise the needs to: (i) Step back to consider system health (and not system performance) in order to identify actions necessary to address the underlying systemic issues; (ii) Engage and bring stakeholders together to exchange views and jointly identify necessary actions in order to engender trust and commitment; (iii) Provide a means for enabling stakeholders to critique both the 'as is' and 'to be' and to summarize this is a meaningful way that can be readily accessed by others in order to help communicate what needs to be done; (iv) Recognize uncertainty where it exists in order to ensure that action is taken to reduce it (in addition to action to address weakness); and (v) Revisit assessment over time to maintain momentum in implementation.

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