Case study: multi-billion pound infrastructure decision making: a regulatory infrastructure asset management assessment.

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Case Study: Multi-Billion Pound Infrastructure Decision Making - A Regulatory Infrastructure Asset Management Assessment

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Abstract

This paper evaluates the effectiveness of a hypothesised asset management decision framework implemented with a High-Speed Railway Infrastructure Asset in the U.K over a three-year period. The physical infrastructure asset(s) consists of a complex assemblage of components and classic engineering fraternities; such as Electrical Transmission & Distribution Systems, Civils Assets, Track Systems, Signalling & Communications, Software, SCADA etc, and Assets. In addition, the asset interacts with many U.K & International suppliers, contractors and service providers. Spanning over 218km with large linear assets the railway provides services for high speed trains connecting the U.K to wider European and domestic services, providing significant economic benefit to the U.K Economy, Social Mobility, Urban Development and National Skills development for many Transportation sectors.

Keywords: Asset management effectiveness; Regulatory asset management; The role of stakeholders in asset management; Infrastructure asset management; Complex adaptive systems

Introduction

As with much safety, national critical infrastructure assets the appointed asset management organisation must as part of its contractual and safety obligations demonstrate a safe, high performing and economically efficient operation of the asset. The U.K Office for Rail & Road (ORR) regulates the Rail network. It does so through extensive assurance processes called periodic reviews. A review can span many years as the regulator assures itself of the plans and asset management effectiveness presented by the asset manager in five-year regulatory review periods. Named, control periods. This paper will evaluate the asset management effectiveness provided through a hypothesised asset management system framework. Both in terms of the reviewed implementation data collected from the implementation and as a result of the measured outcomes associated to its effectiveness in managing holistic and whole life asset decisions. The evaluation topics included in the regulatory review are the performance of the railway infrastructure, the supply chain, safety to staff and members of the public whilst ensuring costs associated with capital; operations and maintenance are demonstrably effective and efficient. In addition there is a large emphasis on confident remaining useful life of assets through condition based management of assets to ensure that expenditure meets the affordability needs of stakeholders. By using publicly published independent review and determination data from the U.K Regulator this paper will now use quantitative performance and qualitative data to assess the asset management system and its completeness as hypothesised, its application in a real-world setting and its overall effectiveness as set out in the methodology provided in of [1].

In summary the purpose of this paper is to

- Assess the findings by which the phenomena of asset decision making was established in the context of a 'real world' infrastructure asset manager
- Review of asset management system framework and assess its effectiveness when implemented in industry
- Assess the role of complex adaptive systems when developing system frameworks for infrastructure asset managers in light of a real world implementation case study
- Establish a 'real world' reference for subsequent mathematical and agent based simulation by using findings from its implementation

System Implementation and Review Context

The Asset Management System began concurrent identification and design during 2016 and implemented concurrently across various departments over five years. The final product of the system framework was assured over a seven-month period as shown in Figure 1, ORR Asset Management Assurance Plan. This assurance investigated each area of the asset management system framework as outlined in (Office for Rail & Road, 2020). This meant that final determination within 2021 given the impact of the COVID-19 Pandemic.

The scope of assurance was categorised into seven areas

- Engineering Assurance
- Asset Management Strategic Context
- Engineering & Strategic Decision Making
- Intervention Volumes
- Control Period Costing
- Long Term Cost and Deliverability
- Customer Expectations

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The regulator

The Office for Rail & Road (ORR) act as an independent regulator, operating within the framework set by UK and EU legislation and is accountable through Parliament and the courts. The Regulator is accountable to Parliament and the public to protect the people, who use, interact or work on the railway; ensure fair access to a rail network; the Regulator also provides railway health, safety, economic and road functions.

The role of the regulator in evaluating the asset management effectiveness

The Regulator ensures the asset owner dispatches its general duties concerning stewardship of the physical railway infrastructure, which means they must secure the operation, maintenance, renewal, replacement and planning and carrying out of upgrades in accordance with best practice and in a timely, efficient and economical manner.

The data sources

The regulatory review process is made public following extensive consultation, review, assurance and challenge by the regulator. For the purposes of this report the following data sources will be utilised.

Annual progress reports: (2016-2019), topics including

- Performance and data monitoring;
- Asset management
- Finance and efficiency
- The 2019 periodic review (PR19)
- Health & Safety records

Final Determination of Regulated Period including special focus on 'Asset Management Findings' covering all topics of asset management, namely:

- Draft Determination published on 30 September 2019
- Final Determination published on 11 December 2019

Measuring the Implementation

Using works from Bruiners the asset management system framework will be measured in the following manners (Figure 1). Identification Strategy Event or Change: Given the novelty of the framework and its implementation as stated [2] over a three-year period, the change and strategy events are established. Further evidence found regarding the organisational achievement of ISO 550001 certification [3] also demonstrates the Industrial effectiveness of the framework in a real world setting as Strategy events and changes were established as business practices. Furthermore the regulator found that, "We found an Asset Management System (AMS) framework, which provides a line of sight between [Objectives] and their AMP".

Stage 1: Establishing the Phenomenon

By mapping the framework to the review of the regulator it is possible to establish the phenomenon in line with research from [1].

Stage 2: Drawing implications from the phenomena

By critically reviewing the findings from the ORR and other timely data sets over the three year period it is possible to evaluate and analyse the impact of the asset management framework, thus setting the basis by which to determine findings both positive and undesirable.

Overall Assessment of the Asset Management System Framework

As shown in Table 1 the overall assessment by the regulator concluded that the asset management review demonstrated significant areas of best practice were achieved 72% of the total findings. Areas where 'likely to be best practice' made up 26% (needing additional clarification) and 2% of topics covered were considered not in line with best practice of or held insufficient evidence.

Asset Management System Framework Overview

This section will review the Asset Management system framework as set out in the hypothesised framework [1]. The subsections related to each of the framework components are highlighted in (Figure 2). The review will use the following structure to ensure traceability back to the framework for later complex adaptive system analysis.

Business objectives

Present in case study: Yes

Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19
Engineering Assurance Meetings with NR(HS)	**Asset Management Strategic Context**	**Engineering & Strategic Decision Making**	**Intervention Volumes**	**Control Period 3 Costing**	**Long Term Cost and Deliverability**	**How HS1 Ltd made changes to meet customer expectations**
Vertex Engineering Assurance Meetings with NR(HS) Professional Heads	Specific Asset Strategies (SAS)'s	Whole Life Cost models	Vertext Engineering Assurance Findings	Asset Decision Support Tool	Deliverability strategy volumes and long term costs	HS1 Ltd satisfaction of General Duty as per Concession Agreement
	Asset Management System	Vertext Engineering Assurance Report.	Review SASs & Single View Of Plan	NR(HS) CP3 Renewals Costs	Annuity costs	Asset Management Excellence Model and improvement roadmap
	Asset Management Documentation (Policy, AMOs, SAMP, Roadmap	CP3 Project Charters / Single View of the Plan Excel Sheet	Long term volumes	NR(HS) Fixed Price to deliver Operator Agreement in CP3	Final Asset Management Excellence Model Report	Key changes or areas for development agreed
	Deliverability Strategy	40 Year Renewals Volumes	CP3 Project Charters (SVOP Excel Sheet)	OMR Effectiveness Study (Rebel Benchmarking		

Figure 1: ORR asset management assurance plan.

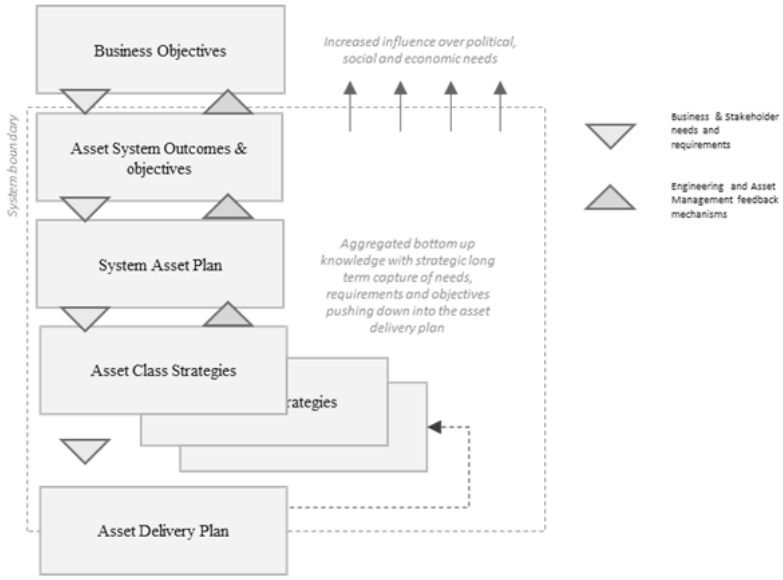

Figure 2: Asset management framework.

Table 1: Summary ORR Asset Management review categories.

Topics founds to be considered in line with 'best practice'	Likely to be in line with best practice but either did not see clear evidence, or identified opportunities for improvement	Not in line with best practice or insufficient
30	11	1

Table 2: Stakeholder aligned objectives with weightings.

Weight	AMO	Weighting	AMO
25%	Safety	15%	cost
20%	punctuality	15%	Passenger satisfaction scores
20%	Availability	5%	Passenger comfort

Description/Findings: The asset management objectives were clearly defined and agreed with stakeholders. The Regulator commented "We found an Asset Management System (AMS) framework, which provides a line of sight between [Objectives] and their AM" [4] & "The overall asset management approach has been tested through the CP3 stakeholder engagement sessions" [3].

Asset system outcomes aligned to business objectives

Present in case study: Yes

Description/Findings: The Regulator concluded that key components of good asset management practice where found, stating that "We found…developed an Asset Management System (AMS) framework, which provides a line of sight…and then cascaded these down to asset management approach for maintenance and renewals" [4] In addition an independent benchmark performed as part of the regulator review and indicates the pre-implementation system effectiveness in planning & strategy vs the implemented asset management framework. Lesly the report concluded that the entire Organisation has distilled each of these into meaningful, weighted objectives, shown in (Table 2).

Overarching System Asset Plan (SAMP)

Present in case study: Yes

Description/Findings: The asset management system found a comparative SAMP document namely, the Strategic Asset Management Plan in accordance with the asset management system framework. The review found that "Strategic documentation such as the Strategic Asset Management Plan (SAMP) and Specific Asset Strategies (SASs) documents that form part of the AMS are stated as being periodically reviewed based on any new information and will be subject to formal review processes to ensure that asset management plans are in line with the most up-to-date understanding" [4].

Asset Class Strategies (ACS)

Present in case study: Yes

Description/Findings: The regulator concluded substantial benefit from the implementation of the asset class strategies (named specific asset strategies in this case study). Stating that "In line with Vertex's findings we concluded that the SASs represents a significant step forward in the development of asset management practice... Broadly we found them to be good high-level documents, which build on existing practices using age as a proxy for replacement frequency. In general, they follow best practice, having to make a number of assumptions for asset degradation based on limited real time data" & "We consider that the SASs contain sufficient information on condition and capability of the assets to be maintained" [4].

Systems Asset Management (SAMP)

Safety & Compliance

Present in case study: Yes

Description/Findings: The SAMP presented safety, compliance

relevant standards requirements. In addition it provided the governance by which the asset management system identified legal safe operation and management of the railway. The regulator concluded that "The SAMP sets out that each discipline… required to demonstrate its compliance with statutory and rail standards through a Safety Management System. Compliance with…Technical and Regulatory Standards is a key aspect of network operations. Compliance is mandatory with a view to the license to operate, relevant stakeholders, interactions and compliance requirements" [4].

Business, organisational & stakeholder information

Present in case study: Yes

Description/Findings: Stakeholder agreement of the asset management objectives, organisation and approach was evidenced, stating that "The overall asset management approach has been tested through the CP3 stakeholder engagement sessions" [4] & AMO's are clearly defined and agreed with key stakeholders.

Asset composition and description

Present in case study: Yes

Description: The asset and its inventory where both determine during the implementation of the asset management system framework with Hierarchies developed to Asset Class Level as standard. However the asset hierarchies are capable of utilising the same objectives as described later on. Meaning that the asset composition is capable of using lower level of asset components as part of its criticality [5].

Asset criticality using the asset system outcomes objectives

Present in case study: Yes

Description/Findings: The organisation builds weighted objectives and risk definitions to ensure that criticality and outcomes where identified, agreed and implemented across the asset management system framework. This intern enabled propitiation and risk/reliability centric approach to be taken for priorities of the business and the asset. Noting that "...aligned the asset condition required in each specific asset strategy with respect to the importance of an asset group or system in delivering the asset management objectives. As with the shift to reliability-centred maintenance has prioritised improvements to asset information collection for higher criticality assets" [3].

Lifecycle management

Present in case study: Yes

Description/Findings: Asset Class Strategies implemented decisions based on the whole life of the asset and across the holistic components in physical (engineering, financial, digital and stakeholder requirements) noting that " suite of SASs aimed at optimising asset performance of key assets through their lifecycle by adopting a structured whole-life cost approach to operations, maintenance, and renewals including asset disposal" [4] The faults chart in (Figure 3) demonstrates reduction in severity 1 & 2 faults during the implementation of the asset management system, notably from 16/17.

Asset Class Strategy (ASC)

The asset class strategies, named SAS's documents, set out the strategy for the management of asset disciplines across the infrastructure for the entire life of the asset. The documents are based the asset portfolio and its condition, performance, risks and associated cost. [4] The following components.

Asset capability

Present in case study: Yes

Description/Findings: Identified in the asset management system framework and determine as sufficient: "We consider that the SASs contain sufficient information on condition and capability of the assets to be maintained".

Asset condition/Reliability

Present in case study: Yes

Description/Findings: Underlying asset reliability was generally good and improved when compared to the average per asset system across for the control period. Asset condition was required to be identified in each asset class Strategy with respect to the importance of an asset group or system in delivering the asset management objectives, noted as "Overall condition of the assets remained good and the infrastructure's capability has remained as originally designed. The severity level of faults has decreased again this year which demonstrated a further improvement…maintenance effectiveness" [3]. Whilst effective there are still areas of improved condition monitoring (namely remote monitoring) to help inform future decisions. Lastly findings were that a shift from cyclical time based maintenance to risk and reliability centered maintenance were achieved [2].

Asset Age Profile & Remaining useful life predictions

Present in case study: Yes

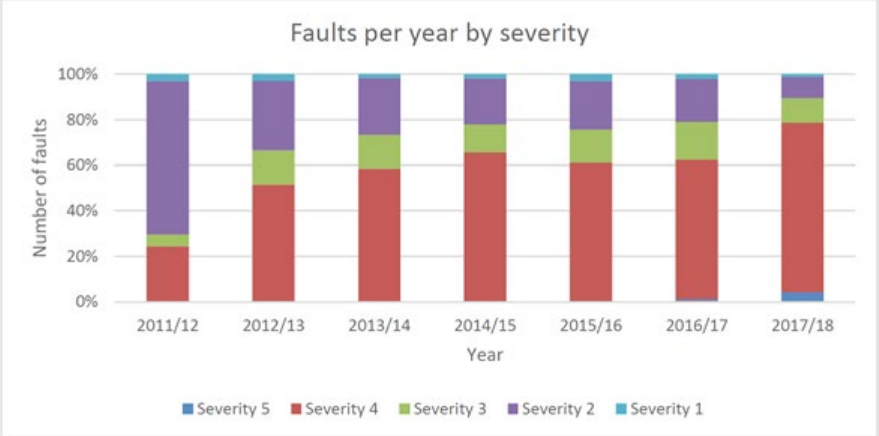

Figure 3: Asset performance (Faults) [2].

Description/Findings: The Asset Management system framework identified the remaining useful life at system level for all assets. Both in terms of the condition, performance and risks but also intern to populate whole life costing models. Noting that "Route asset condition information is held. Asset condition information is relayed into whole life cost model: Additional information such as asset utilisation and predicted asset degradation behaviour is also entered used to support the development of the specific asset strategies, which describe how the assets will be operated, maintained and renewed to deliver the asset management objectives" [4] .

Governance and compliance

Present in case study: Yes

Description/Findings: All areas of compliance associated with the Safety, Competence and Assurance were identified and integrated into the asset management system framework. Noting that, **"**The SAMP sets out that each discipline as required to demonstrate its compliance with statutory and rail standards through a Safety Management System. Compliance with…Technical and Regulatory Standards is a key aspect of network operations. Compliance is mandatory with a view to the license to operate, relevant stakeholders, interactions and compliance requirements".

Expenditure

Present in case study: Yes

Description/Findings: The Asset Manager implemented bottom up pricing thus enabled activity based pricing and planning. Noting that**,** maturing its asset management capability…has improved its cost-capture approach…all the activities that take place on the railway and developed a bottom-up approach to capturing the time it takes to perform them using a Cost Time Resource (CTRs) resource. This has enabled it for the first time to perform activity-based estimates, combining activity-based plans (ABPs) and maintenance unit costs". The same report found that "We found that while it is a recent innovation, it is a positive step towards better transparency and understanding of maintenance costs by providing an enhanced ability to improve efficiency in the planning and delivery of maintenance".

Summary Findings

In each of the categories explored the Regulator found evidence and maturing asset management as a result of the asset management system framework implemented. This section will now summarise this evidence into four areas identified as the report [1] recognising the positive and negative contributions and findings of the system framework.

Summary of positive contribution of the system framework:

- A clear asset management system framework was implemented, with line of sight between Strategy and asset delivery plans
- Asset Management and Business Objectives were well defined and stakeholder agreed
- The System Framework was accepted by Industry, including ISO 55001 certified
- The System Framework identified and integrated the necessary compliance and safety requirements
- Asset Class Strategies considered leading practice
- Financial, Accounting and Physical Alignment assets were significantly improved
- Stakeholder, Criticality and Physical Asset needs were much better identified and utilised throughout the asset management
- 31% 'Asset Management' efficiencies were identified as a result of the implementation of this framework

Summary of areas requiring improvement/negative impact:

- As a result of the Infrastructure being somewhat novel in design and its relatively young age the amount of time bound condition and asset information was limited. This eroded confidence in remaining useful life calculations as still required a large amount of engineering judgment.
- The overall output of the framework was considered by the regulator, in part overly conservative and trended towards earlier life replacement of assets, this may or may not be correct however the need to explain review internal decisions based on 'simulated options' to stakeholders would have helped in demonstrated thorough asset management assurance and thinking
- Unit rates vs Market rates caused 'potentially' excessive risk related costs to be calculated as part of the whole life cost
- The Systems Asset Plan needed a clearer suite of programme milestones at a strategic level and its complexity, impart of a result of its holistic implementation needed work to become more easily visualised by stakeholders
- General over reliance on human based interpretation and needed additional computerised methods of collecting, analysing and simulating data from across the asset management system
- Additional work to bring up better collection/capture of asset data across the asset class strategies was identified

Observations

The framework was implemented over a three year period and thus decisions made during the implementation may have caused time bound constraints to its effectiveness (Figure 4). In short the changes in stakeholder needs may have taken less time to understand in terms of setting objectives than applying those objectives to all areas of the asset management decision making. (Figure 5) illustrated this time bound principle of influence vs understanding the outcomes/outputs. The

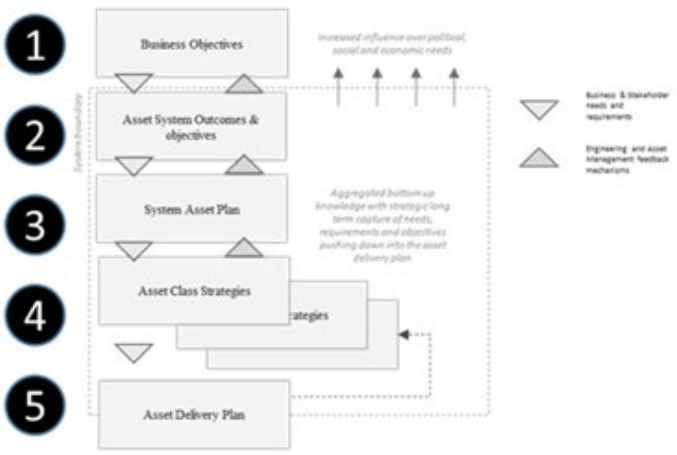

Figure 4: Asset management system (with number referencing).

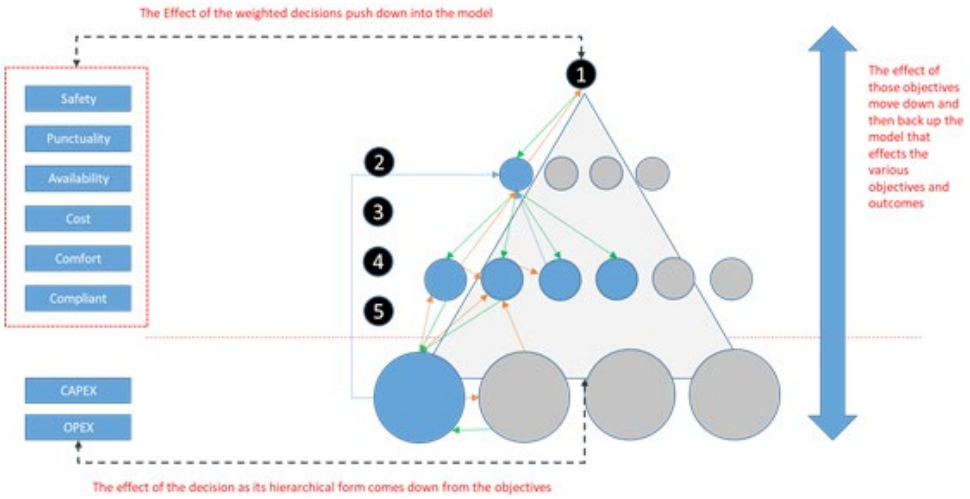

Figure 5: Illustrative agent based interactions.

business objecitves were agreed and stakeholder allingement gains in the beginning of the aset management implementation to faciliate the criticality and engineering assurance to ensure 'line of sigh' between Business Objectives and the asset delivery plan. However the time taken between agreeing the objectives compared to the final asset delviery plan spanned three years. This stakeholder driven top down procress geared with the time it takes to alling phsycial, financial and business decisions to such agree objectives doesn't offer suiffcent time to simulate alternatives. Figure yy below The Asset Class Strategies help to create a time bound interface that helps adapt at greater levels of pace to changing needs of the physical and financial asset. However the total time to cycle from the precession of decisions and interactions within the asset management system needs to be better understood. In this case modelling and simulating various objectives and interactions using complex adaptive systems methods such as Agent Based Simulation could help identify alternative strategies or improvements to the system framework to avoid such manual updates and requirements. Thus bridging the gap between changes in objectives, stakeholder needs, physical performance or condition changes of the asset and the financial outcomes resulting from the above.

Conclusion

The framework as implemented in this case study, offered an improved asset management decision capability, the regulatory concluded that there were move areas associated with 'best practice' in asset management than. In all areas by which it was deployed it had a positive contribution.

- Step change was achieved and good overall benefits in reducing asset risk, maintaining performance of a deteriorating asset, improving economic suitability and incorporating socio-economics into the outcomes of the asset management decision making
- Holistic in the sense it covered all the known angles including socio-economic, physical, financial and digital asset needs to make decisions.
- Difficult to deploy in retrofit situation
- High effort to deploy (internal effort)
- A large issue with multi-stakeholder funding environments are the need to negotiate earlier.

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