A Case Study in Operational Readiness

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Abstract This paper discusses a unique approach for evaluating operational readiness in an acquisition project. The case study involves an operational metro railway in the US undergoing a major asset replacement, including rail cars, rail control system, and control centre. The project was conducted on behalf of the asset owner to ensure operational readiness for the transition to the new system. A Systems Engineering methodology was applied to identify the complex series of changes that would occur between the current operations and the planned future operations. Once identified, changes could be classified as document, business, or physical, thus providing an understanding of the potential impact on people, processes, and assets. This information was then translated into a visual risk-based roadmap to identify the actions necessary to achieve operational readiness. The project achieved the intended aims of the task through the identification of areas that had not received sufficient consideration. These were primarily non-technical items such as: human factors; training requirements of staff; and document updates to capture the establishment of new processes for the management of new assets.

Keywords: Operational Readiness, Rail, Transport

1 Introduction

1.1 Background

This case study introduces an innovative approach to identifying and guiding activities necessary to achieve operational readiness for an acquisition project. The approach involved re-purposing tools and techniques developed within the Systems Engineering community for tackling early-stage conceptual design, and applying these to the unique challenges of achieving successful operational readiness. But what is operational readiness? Operational readiness can be defined as '*the process of preparing the custodians … of an asset under construction (and the supporting organisation) such that, at the point of delivery/handover, that organisation is … fully prepared to assume ownership of the asset'* (Powell, 2012). The asset at the centre of this case study, an operational metro system in the United States, is undergoing a major upgrade with the primary purpose of modernising the ageing railcar fleet and train control system for improved passenger comfort and better service reliability. The key physical changes include:

- replacement of 30-year old railcar fleet;
- introduction of new Communications-Based Train Control (CBTC) system; and
- installation of Digital Communications System (DCS) in the field.

With the physical scope defined and work underway to commence delivery of the physical changes, the operator of the metro system began to ask themselves "will we be ready"? This demonstrated a high degree of self-awareness and ensured that they started their operational readiness journey sooner, rather than later.

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1.2 The operational readiness challenge

Achieving operational readiness to a satisfactory level for small engineering projects can be difficult. Risks can be downplayed; time schedules are short; budgets are tight. It can be easy to overlook the value of successful handover. By contrast, achieving operational readiness for large and complex acquisition projects is almost always recognised as critical and yet can still be overlooked. Different factors come into play: organisations are consumed with the sheer scale of design and construction activities; time schedules span years, creating a feeling of “there’s plenty of time”, and; lines of accountability can become blurred between the asset owner, the operator, and the construction company. Fortunately, in this case an operational readiness task was clearly defined by the metro operator relatively early[4], which encouraged a sense of urgency within the organisation. This meant that the authors work could commence unimpeded on analysing the implications of the changes on the metro’s processes, people and assets. Owing to the significant scale of the task (from both a physical and organisational perspective), the authors adopted an information-centric approach to this task, rather than a more traditional document-centric (i.e. producing flow-charts and reports that are intrinsically disconnected) approach.

1.3 Overview

The approach involved the capture of information in a Model-Based Systems Engineering (MBSE) tool to enable effective review and analysis of functional changes that the project introduces to the metro system. This is referred to as the Information Model. This methodology was based on 3 primary success factors:

- **Iterative development approach**
  Due to the complexity of the operating environment and the significance of the upgrade project, there were a variety of uncertainties that affected the capture of information during the task. As a result, an iterative approach was used for information capture and analysis to ensure accuracy, and to maintain an acceptable rate of development.
- **Model-based information management**
  The nature of many independently defined elements within a single operational environment can give rise to significant disconnects in information. This can be overcome via a single source of truth information base which captures all operations and project information. A relational database was used with a specifically tailored schema to ensure that the right information would be captured and linked in an appropriate way. This is the Information Model.
- **Regular and clear stakeholder engagement**
  To develop and sustain the Information Model detailed above, and to ensure that relevant and clear data was managed in the Information Model, key stakeholders were taken on the journey through the life of the task. This included a variety of workshops and meetings with key personnel, both in-person and via teleconferencing.

1.4 Implementation of the methodology

There were 6 major facets to the operational readiness task that were conducted in an iterative manner:

1. **Understanding of guidance material**
   It was important for this task to first understand the guidance information that was being used by the metro to perform their operations, maintenance and capital works. The primary sources of information analysed and included in the Information Model were: operating rules; process and procedure documentation; organisational information; asset management plans; and the upgrade project design documentation.
2. **Functional analysis**
   Based on the guidance documentation and stakeholder discussions, a functional model of the existing metro system was developed. This model included all functions performed to in the operation of the railway, for example, drivers reporting for duty, execution of work orders, and development of maintenance strategies. This analysis was captured using Enhanced Functional Flow Block Diagrams (EFFBDs) and reviewed through multiple iterations with stakeholders.
3. **Physical system analysis**
   All identified functions were allocated to physical items in the Information Model to develop an understanding of the impact of functional changes on physical assets and vice-versa.

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[4] Still during the preliminary design stage

4. **Organisational and people analysis**
   In addition to physical assets, the functions were allocated to elements within the organisation to develop a rich understanding of the impacts that the functional and physical changes would have on the people within the metro organisation.
5. **Change analysis**
   Once the current state functions had been captured and adequately modelled, an analysis of the upgrade project was conducted to identify specific changes to the functional and physical system.
6. **Risk analysis**
   With any change, there is a level of uncertainty. With uncertainty, there is risk. The risks associated with the changes to be introduced were assessed using an initial course assessment method and refined as further information become available. This risk assessment allowed for a level of priority and focus to be given to different changes.

Ultimately, the Information Model consisted of thousands of entities connected in thousands of ways. This would have been impossible to accurately analyse or visualise without the use of the MBSE tool.

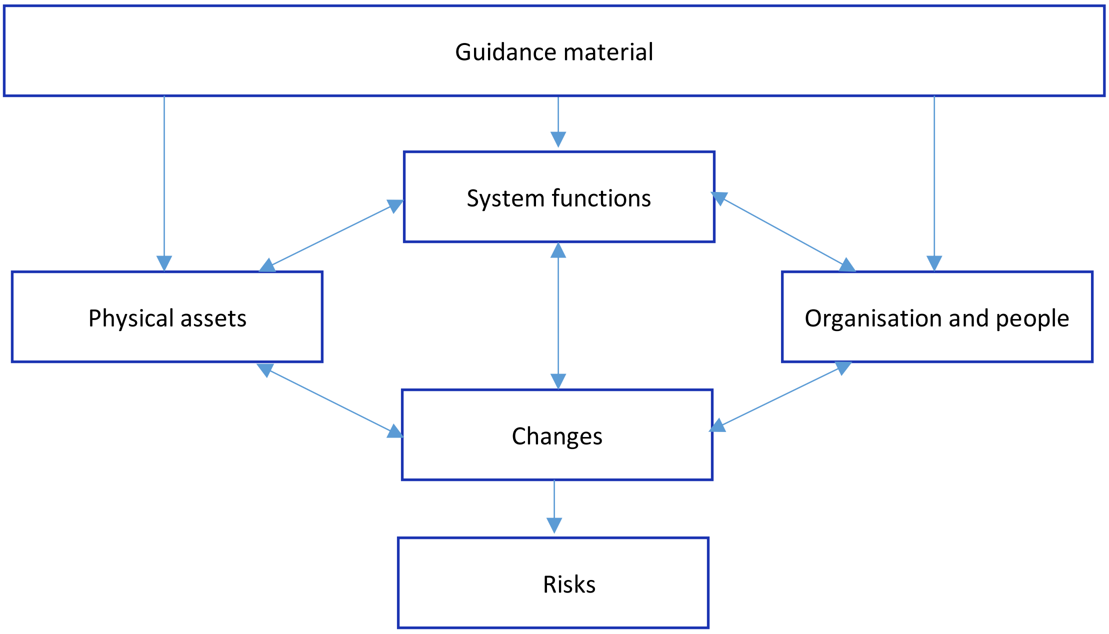

Figure 1. Information model structure

2 Assessing operational readiness

2.1 Understanding current operations

Capturing the current operations was primarily based on the functional analysis using EFFBDs (an example of which is shown in Figure 2). The development of the current operational model clearly showed that there was a much deeper level of understanding within the metro staff than that documented in the guidance material. This level of detail was elicited through stakeholder workshops where staff were guided through each EFFBD to establish whether they were a true representation of the operations, and if not, to identify what changes were needed.

2.2 Understanding future operations

The authors had initially intended to conduct a full functional analysis of the future system for comparison with the current system. However, after preliminary analysis it was found that this approach would be unnecessarily constrained by requiring inputs from the design milestones. Hence, it was considered a more effective use of resources to focus on the changes being introduced and how they would affect specific functions, assets and people. The identification of these changes allowed for connections to be made in the Information Model that articulated how the changes affected: system functions; physical assets; and people.

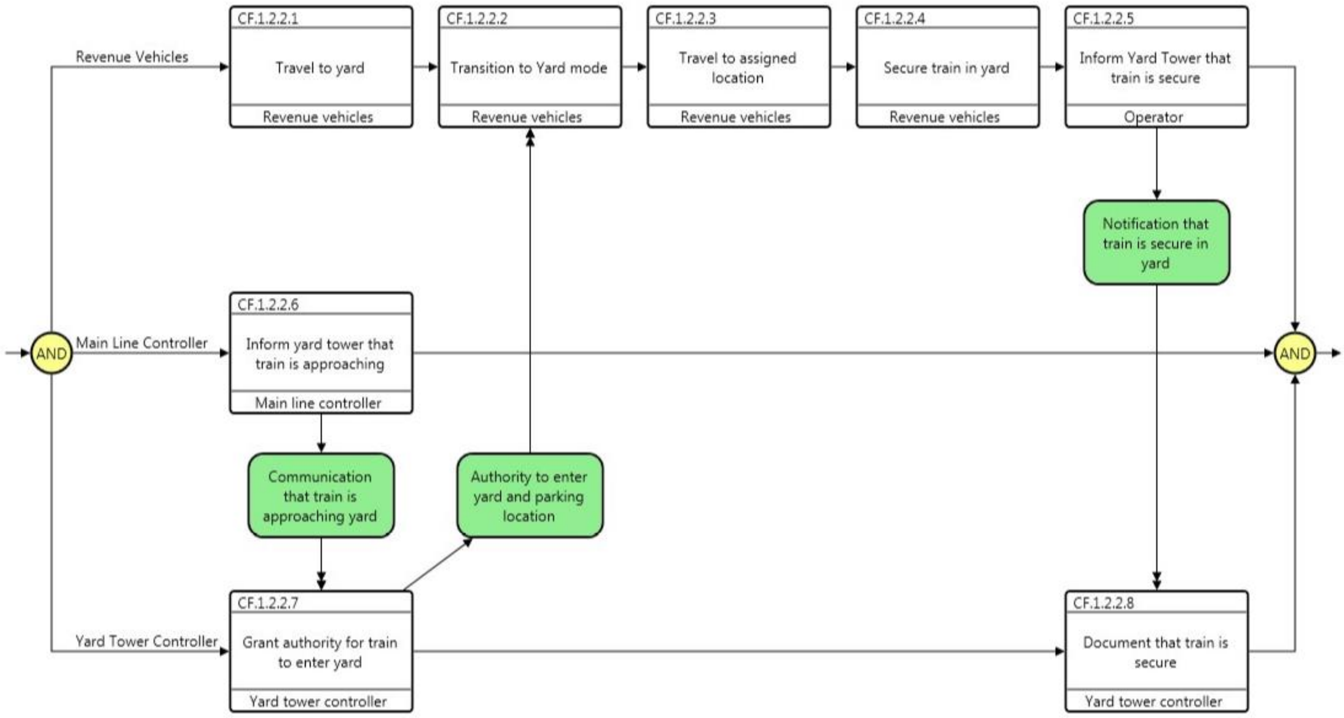

Figure 2. Example EFFBD (storing a train at the end of the day)

2.3 Assessment of operational changes

For each of the changes that were identified, they were assessed for their impact on:

- **Documentation**
  All identified changes were assessed as impacting some form of documentation. As all of these entities were captured in the Information Model, a documentation view could be produced to show all changes that were impacting specific documents or procedures. For example, there were sections within the operating rules where no changes would be required, and others where >20% of rules would be impacted.
- **Organisation and people**
  If there were to be a functional change in the operations, then the element of the organisation responsible for that function would also need to change. For some personnel, the changes were reasonably minor, for example, maintenance strategists would need to develop strategies for different assets but the process used for this remained unchanged. For other personnel, the changes were significant, for example, controllers would be required to understand how to coordinate operations and troubleshoot problems for an entirely new control system. In some instances, the changes could require a complete change in roles, for example, certain maintenance roles would be significantly changed due to the change in lowest replaceable unit.

3 The risk-based roadmap

3.1 Purpose

As all the changes were being identified and analysed, it became clear that a means of prioritising them would be required. For this reason, a risk-based roadmap was developed to enable the metro agency to focus on specific changes that either posed the greatest risk to the organisation and/or were the most urgent.

3.2 Information translation

Each change that was required was assessed based on:

- **Consequence**
  Using a scenario of ‘do nothing’ in response to the change that was to occur, what would be the consequent of continuing operations? For example, if there was a process document that required update, the

consequence of operating without that process document being updated was assessed. A simple 5-tiered logarithmic scale was used.

- **Urgency**
  Urgency was based on how long the change would take to implement, and when the change was required to be implemented. The resulting value was a date which represented the last date at which work on the change needed to commence. For example, if maintenance personnel were required to be trained in repairs to the new railcars before the end of 2021 and it would take 6 months to train them, the urgency would result in a date of 30 June 2021.

The resulting graph (see Figure 3) plotted the risks (and some opportunities) for the metro's consideration. The risks towards the upper left corner were the highest priority.

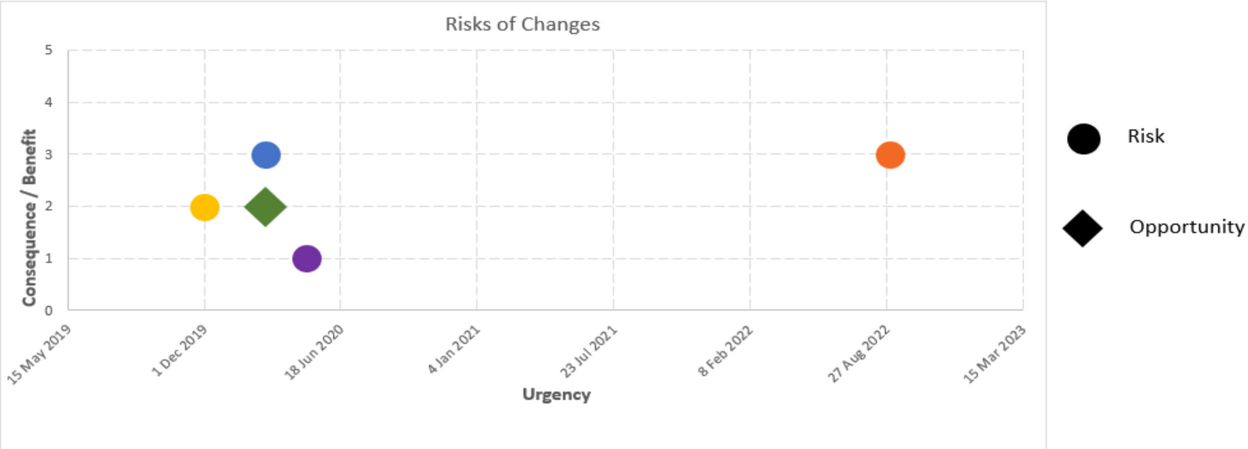

Figure 3. Risks of changes (Urgency vs Consequence) - REDACTED

3.3 Achieving operational readiness

The result of this operational readiness task was a clear roadmap for the metro authority which detailed:

- the changes that the project would be introducing;
- the impact that these changes would have on their documentation;
- the impact that these changes would have on their people;
- the risks that were present if these changes were not addressed; and
- the relative risk-based priority and urgency of the changes to be addressed.

From this information, the metro authority was able to commence preparations for the significant upgrade to its rail network with clear rationale to substantiate assignment of budget and resources. This task shifted the focus of the metro operator from being equal parts excited and overwhelmed by the new system that was under construction, to tangible actions necessary for ensuring that the intended benefits can be realised from 'day one'.

4 Conclusion

This case study demonstrates how applying Systems Engineering techniques can successfully direct the effort towards achieving operational readiness. Fundamental to the success of this approach is the Information Model coupled with an iterative approach to development, and clear and consistent stakeholder communication. It is the author's opinion that starting the journey towards operational readiness should occur during the early (i.e. pre-tender) stages of concept design to be able to feed into, and influence, early decisions. Although this task was ultimately successful in achieving the intended aims of the task, opportunities were missed to optimise the design that could have simplified, and/or reduced the cost of change on the organisation.

5 References

Powell, D. C., 2012. *Operations Readiness & Assurance (OR&A), A Guide for Practitioners.* 1st ed. United Kingdom: Operations Readiness & Assurance Ltd..