User centred approach to developing a Concept of Operations

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SUMMARY

The paper describes a user centred approach to the development of a Concept of Operations and its application to the Synthetic Environment, which is a digital signalling design tool that will be used to develop seamlessly integrated scheme designs for Network Rail.

KEYWORDS

Concept of Operations, Use Cases, User Needs, Digital Solutions

Introduction

There are many examples of systems being procured, or infrastructure designed and built without really considering how it is going to be used, the operational or task goals that need to be achieved, or how maintained. This results in a design or system where the users must 'fit' into the system, and this failure to consider the usability and operation fully can result in re-design, higher operational costs long term, dissatisfaction or reduced levels of safety as operators have to cope with a system or environment that doesn't really meet their goals. Development of a detailed and comprehensive Concept of Operations that places the users at the heart of the design can produce real benefit in ensuring that a full suite of user and system requirements are developed.

What is a 'Concept of Operations' Document?

The Concept of Operations (ConOps) is intended to be a user-oriented document that describes the characteristics of the desired future-state of a system from the viewpoint of all stakeholders, including users, developers, maintainers, passengers, business leaders and any other affected parties. The Concept of Operations document aims to:

- Serve as a tool to engage stakeholders;
- Identify the users of the proposed management system;
- Describe the context of the proposed system;
- Provide a view of how the proposed system will function through scenarios/user stories;
- Explore new ways of working;
- Support the integration of new technologies;
- Provide high level descriptions of the activity;
- Operational requirements;
- Descriptions of functionality of area / process.

There are many benefits to a Concept of Operations document, and it is a core Systems Engineering activity. Development of the document provides an opportunity to benchmark design with current and future industry best practice, creating a structured plan for how the system will ideally operate, and supports the development of the 'Basis of Design'.

There is tendency with Concept of Operations documents to focus on either the operational, infrastructure or technology changes, and not consider or engage with the end-users, or focus on only the operational element with no concern for maintenance or customers. This can result in a disjointed ConOps which is based on 'work as imagined' rather than 'work as done'.

Systems Engineering and Human Factors are complementary disciplines; Human Factors can provide the user perspective for a system or operation, creating user requirements that informs system and safety requirements. By bringing these together into one unified set of requirements, the usability of the system can be fully integrated throughout design development through to testing, and commissioning into use.

Developing a User Centred Concept of Operation

The Concept of Operations should be utilised as a living iterative document that is used to engage the end-users from the start till the end of any project rather than just a designers document. The steps towards creating an effective document are described below:

1. **Personas:**

Personas provide meaningful archetypes that can be used to describe user interaction with systems or environments that can be referred to at all stages of service innovation, development, and delivery. They represent significant groups of end-users and their different goals, needs, characteristics, and expectations. The focus on different user viewpoints can help inform decision-making in the design of services and the user experience. They also support the development of an understanding of the roles and functions that will interact with the system, the inputs and outputs, and key challenges. Current pain points and opportunities for efficiency can be captured at each stage in the design e.g., difficulties with design integration, points at which re-work normally occurs; opportunities to capture design information for other purposes or streamlining processes and checking. It is key to do proper research, gathering information about the current or intended users. Data collection methods include interviews or workshops with end-users and user-facing roles.

2. **Operational Scenarios or Use Cases:**

The Concept of Operations should be based on Operational Scenarios or Use Cases, (depending on which is most relevant to system that is being described) to define what the envisioned system provides or how it functions throughout the timeline of a scenario or design stages. These should include the range of scenarios that the system can be used within, including normal or optimal performance, degraded and emergency modes. The Use Cases should describe all of the modes or configurations that the system may need to have in order to deliver its intended purpose throughout its life cycle. This may include modes needed in the development of the system, e.g. testing or training, as well as operational modes and system decommissioning [Ref 1].

3. **User Stories:**

User stories are stated ideas of requirements that express what users need to perform their specific goals within the Operational Scenario or Use Case. User stories are brief, with each element often containing fewer than 10 or 15 words each. User stories are "to-do" lists that help determine the user needs for a project or system, and support their translation to user and system requirements.

4. **User Story Boards:**

User Story Boards or 'stakeholder explainers' - which can be either static and interactive visualisations bring the concept of the system or product to life. They can incorporate key elements from the ConOps work including the User Stories and identified scenarios to explain to the wider stakeholder what a system or product may look like and how the users will interact with along the timeline of the Operational Scenario or Use Case.

5. **Requirements Development:**

If the Concept of Operations is developed effectively, then the system and user requirements for the system or project should be clearly identifiable and easily extracted to support design development, or definition of operations and performance requirements. By taking the user centred approach in the Concept of Operations document, the requirements should retain the user needs at their core and result in systems and infrastructure that is easy to use, fit for purpose and can be operated and maintained safely while meeting the needs of customers.

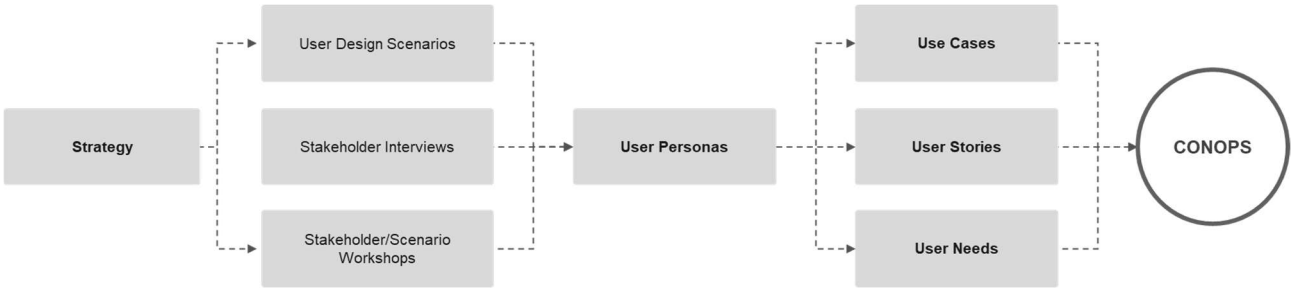

Figure 1 Illustration of a user centred approach to Concept of Operations Development

Application of the user centred approach

A user centred approach was taken to develop the Concept of Operation for a new digital tool that will allow designers to develop and deliver fully integrated, tested designs for digital signalling such as European Train Control System (ETCS). These digital components are collectively termed Future Command Control and Signalling (F-CCS) solutions. These future Digital Signalling solutions will replace traditional lineside signalling with movement authorities and speed information that is relayed to the driver via an in-cab display. The data driven design approach offers the ability for design standardisation to bring efficiency and reduce the overall cost of replacing traditional signal design with F-CCS solutions.

Network Rail are developing a strategy for the Design and Validation of F-CCS designs, that will feature a set of digital design tools at its heart. The central design tool, called the Synthetic Environment, forms a central component for a Network Rail strategy for achieving cost reductions in the design and delivery of future digital signalling schemes by harnessing technology solutions that supports fully integrated, consistent designs [Ref 2]. Synthetic Environments are computer simulations that provide a high level of realism to a physical environment, and are developed to support design and testing. Synthetic Environments are not a new concept, they are widely used in other sectors and industries [Ref 3], but they are new to the Rail Industry in the UK.

Where a complex technical solution is needed, there is a tendency to focus on the digital tool, delivering the functional capability of the tool, rather than resulting in a solution that meets end users' needs. However, to achieve a result that meets the needs of a range of users, the client realised that they needed to put the user perspective foremost. By placing the user goals and needs

at the heart of the Concept of Operation, it provided a basis for developing the requirements for the solution, with the intention to create an output that is intuitive and fully supports the design process.

Concept of Operations development

There are a range of engineers, designers and end user representatives that would need to interact with the Synthetic Environment to create an F-CCS design. As this is a new concept for the Signalling design community, it was important to establish how designs are developed using current systems and processes, and how these will change for the future i.e., establish the 'as is' and the 'to be' for the signalling design process.

Stakeholder workshops were held with representatives from a range of technical disciplines who are involved in developing conventional and digital signalling designs. These workshops mapped out the range of users involved in design and assurance at each stage of the design process. This mapping included identifying the user goals and information needs using the current design tools and processes, and the future vision for using the Synthetic Environment.

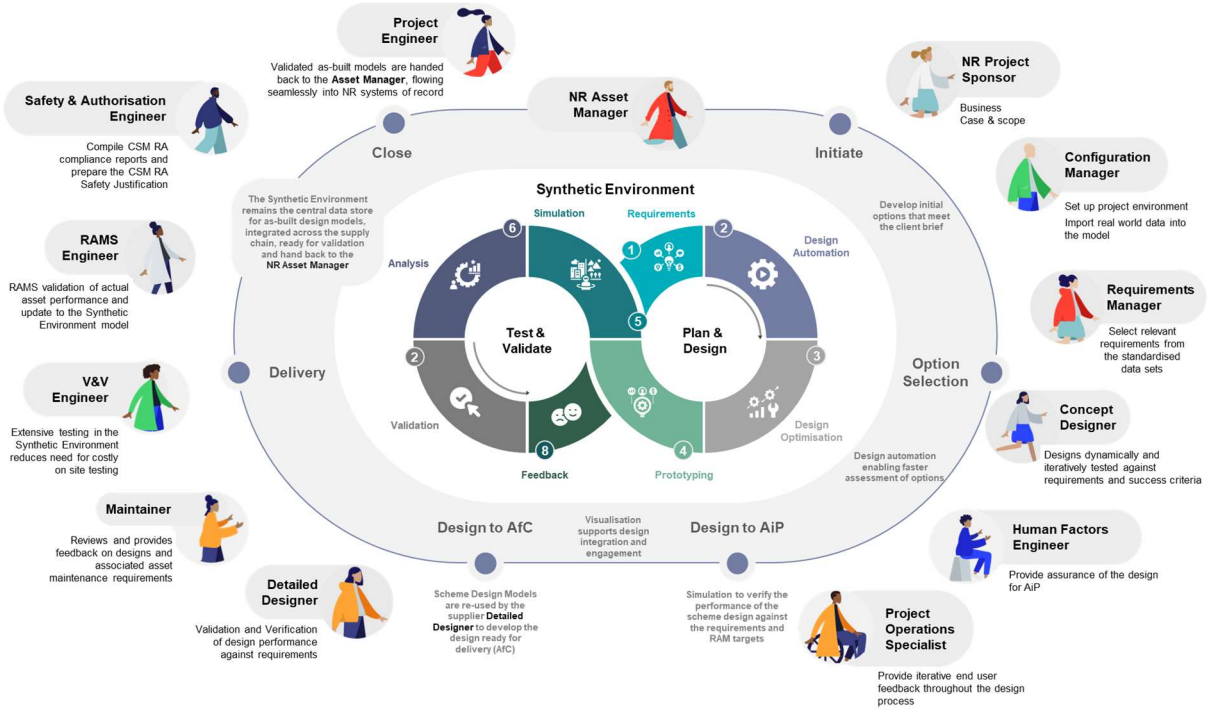

Figure 2 User interaction with the Synthetic Environment at each stage of the project delivery lifecycle

The goals and user need for the primary users of the tool were expanded to create a detailed view of user interaction at each stage of design. A set of Use Cases provided the mechanism to convey the complexity of multiple users interacting with the Synthetic Environment in parallel to perform specific tasks in order to achieve detailed design goals. In conventional signalling designs, multiple designers or disciplines would be working simultaneously on design activities before integrating the designs together. The analysis identified that the conventional approach to design was error prone due to the reliance on these design integration activities to identify any inconsistencies or lack of compatibility between disciplines. Therefore, the benefits of the Synthetic Environment to provide a single view of the design that highlights inconsistencies could be stated as part of the Concept of Operations.

The primary set of Use Cases for each stage of the design were developed, describing the user's interaction with the tool, and how the interaction changes as the design develops through the lifecycle. The Use Cases provided a basis to work with Digital Developers to develop a System Architecture that could support the functional goals for the tool.

End User Engagement

One of the limitations of the current signalling design process is the limitations for engaging with end users such as Train Drivers, Maintainers and Signallers. The conventional signalling design engagement is delivered via the Signal Sighting process, which relies on the expert user groups interpretation of signalling scheme drawings to identify any potential clashes for signal sighting.

ETCS has been delivered across a relatively limited number of schemes such as Cambrian Line, Thameslink, West Coast, Elizabeth Line, and in most cases has been delivered as ETCS Level 2 Overlay where ETCS is provided alongside conventional lineside signals. Future ETCS schemes will replace conventional lineside signals, and therefore there is an increased need to review and validate ETCS designs. In ETCS schemes, the transition between conventional and ETCS has been identified as an area of potentially increased workload for Train Drivers [Ref 4], and therefore early engagement with end users is critical to ensuring that schemes are developed to reduce the potential for overload.

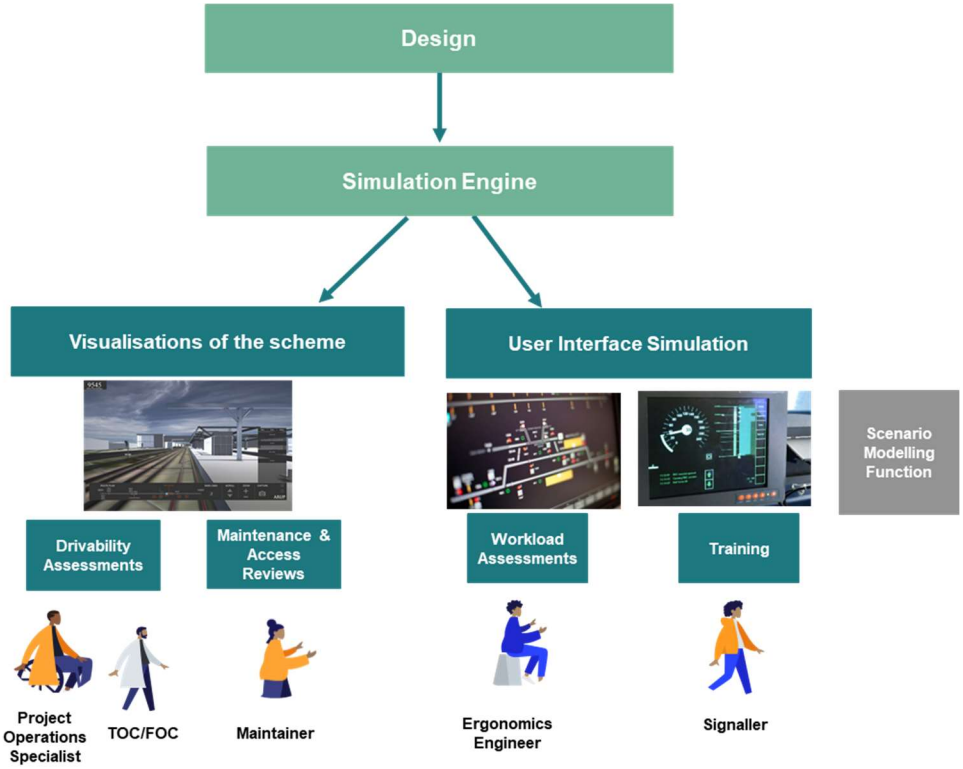

Figure 3 Examples of how visualisations and simulation will engage end users to capture early input and assurance of scheme design

The Synthetic Environment will provide a visualisation element to support engagement with end users to evaluate the impact of design and support assurance processes carried out by Human Factors Specialists. These include Driveability assessments of the route, allowing the End User representatives the opportunity to visualise the external route with the changes to the ETCS Driver Machine Interface displayed. This will support early analysis of the impact of the transition on driver workload, and any conflicts.

The impact of the changes on the Signaller role, and the change in workload associated with the scheme, could also be modelled at a much earlier stage in the design. The ability to simulate and model Signaller interaction and decision making at an earlier stage would provide confidence about the impact of the scheme and system interaction changes to provide assurance about the management of the network.

The visualisation would also provide opportunity for early engagement with the maintenance community relating to the positioning and access to equipment for maintenance.

Value of the User Centred Approach

The User Centred approach to developing the concept for the Synthetic Environment supported the engagement with a wide variety of stakeholders and the wider supply chain on the new approach to design development. By creating personas to describe the user interaction with the system in support of the Concept of Operations, this created a deeper level of engagement and discussion with the vision for the Synthetic Environment than a traditional style document. It allowed readers to visualise and engage with the users of the tool, their different perspectives, and requirements. The client was able to engage with the potential end users more widely to gain feedback on the vision.

The Concept of Operations will be iterated in parallel with the F-CCS Design and Validation process and the Synthetic Environment system development so that the Concept becomes aligned with the system as it matures.

References

NASA Systems Engineering Handbook. (2019) Appendix S: Concept of Operations Annotated Outline | NASA (accessed 17/02/2023)

Future F-CCS Strategy, T190/GEN/ADM/005

Innocenti, M., Pollini, L. (1999) A synthetic environment for simulation and visualization of dynamic systems. Proceedings of the 1999 American Control Conference (Cat. No. 99CH36251)

Monk, A., Cross, M-E., & Collis, L. (2016) Number and frequency of transitions to/from ERTMS operation - impact on railway operations (T1091) Rail Safety and Standards Board Limited.