Getting it right…the earlier, the better

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SUMMARY

There's always criticism about projects going over budget and over time. Cost increases are often due to scope changes during the later stages of a project when detailed design starts. It is widely known that a scope change later in a project will be more expensive than scope changes early in a project. In the UK, Mainline railway projects are defined in eight GRIP (Governance for Railway Investment Projects) stages. This paper will explore the GRIP stages for the UK. The author will look at whether these stages are still suitable and will look specifically at GRIP stages 1-4. Then the author will explore why the scheme development stages are so important to build in resilience at an early stage and avoid costly scope changes at a later stage. It will also look at how the stages for signalling compare with other disciplines, and the challenges that the signalling stage gates have compared with these disciplines. The author will also briefly explore the importance of stakeholder identification and capturing requirements comprehensively and as early as possible. Finally, the author will compare the GRIP stages with other industries processes and understand what the UK has done more recently to improve the technical aspects of the stages. The paper will conclude with questions that the author suggests everyone takes away and thinks about for their own specific country and/or project.

1 INTRODUCTION

Delays…overruns…over budget…cancellations…cutbacks. These are some of the words that you see and hear for railway projects all the time in press in the UK and throughout the world. Railways around the world are critical networks; transporting freight and people for commuting, business and leisure, removing cars and lorries from the roads and can have a certain nostalgia in people's minds. Therefore, it is no wonder that emotions run high and as a result cause frustration when things don't go to plan. But why don't things go to plan and why do we see these cost overruns and delays?

This is a question where there is no one all-encompassing answer. However, this paper will look at one of the aspects that the author deems to be a major reason for these delays. The paper will look at the early stages of a project (scheme development), before any detailed design is started and a long time before construction is started and ask if the current structure of these railway project stages is suitable. These are known as GRIP stages (Governance for Railway Investment Projects) in the UK and apply to Mainline railway projects. The author will also look at other industries and note the similarities and differences. Finally, the author will conclude and pose questions for anyone working in the railway sector across the world to think about.

2 RAIL PROJECT EXECUTION

2.1 UK Rail Network

The Mainline Rail Network in the UK is extensive and has almost 16,000km of route serving over 2500 individual stations. In 2017, Great Britain transported 66 billion passenger kilometres and transported 17 billion tonne kilometres of freight in 2017-2018 (which was 9% of all domestic freight moved in 2017). All data is from the *Williams Rail Review*: *The rail sector in numbers* published by the UK Government [1]. These figures are staggering but still pales to the route kilometres of countries around the world where the UK only has the 14th biggest railway [2]. However, Great Britain has one of the most congested railways in Europe as shown in *Figure 1* [1] and therefore has committed to spend over £50 billion on the railways between 2019 and 2024 (not including large infrastructure projects for example HS2 (High Speed 2)). The highly congested UK rail network and the large sums of money being spent can also cause problems for projects, with limited time available to complete work and the possibility of rushing the earlier stages of a project to "use up" the money before it runs out.

Figure 1: Railway Congestion in Europe figure from [1]

To add to these statistics, the UK also has the oldest railway in the world that developed during the Georgian age and into the Victorian age (~1825 -~1901), so projects often have to deal with older infrastructure that was built in the Victorian age (for example: the Severn Tunnel, which is the Tunnel that runs under the River Severn between England and Wales, was built between 1873 and 1886 and is currently being electrified). Projects also have to deal with varying signalling technologies across the country from mechanical signalling installed in the 1800s through to ETCS with ATO installed in 2017.

All of these problems showcase the importance of developing a scheme and therefore the design from an early stage and ensuring that all of the relevant stakeholders are involved as soon as possible. The more information that is obtained earlier in the project then the easier it will be, generally, to implement this project.

A relatively well-known graph is the cost vs time graph for a project (as per *Figure 2*). Just search for cost vs time on Google and you get a page full of exactly the same graphs, which shows the importance of understanding this is key to a successful project. This graph shows the project stages across the x-axis. The purple line shows the opportunity for influencing the outcomes of a project, whereas the orange line shows the cost of making a change. The earlier that the requirements are captured and pinned down precisely means there is less likely to be change at a later date, and therefore the less change the lower the cost of an overall project. It is generally known that the projects with the largest amount of change are the ones that have gone over budget and time. Why is this the case? Do people really understand the importance of the early stages for a project? Or are the early design stages seen as a tick box exercise so that money can be released and the "real work" can begin?

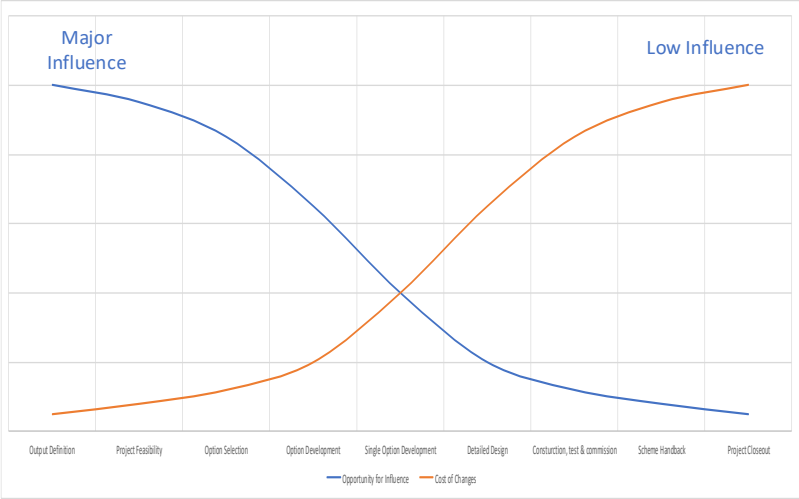

Figure 2: Cost vs influence graph

2.2 GRIP Stages

Let's now look at what these GRIP stages are all about and the outputs at each stage.

The GRIP stages are defined as the Governance for Railway Investment Projects [3] and is specified in Network Rail Standards as the process for Network Rail to manage and control projects that enhance or renew the national rail network. All projects must adhere to this GRIP process, which is split into eight stages (shown in *Figure 3*).

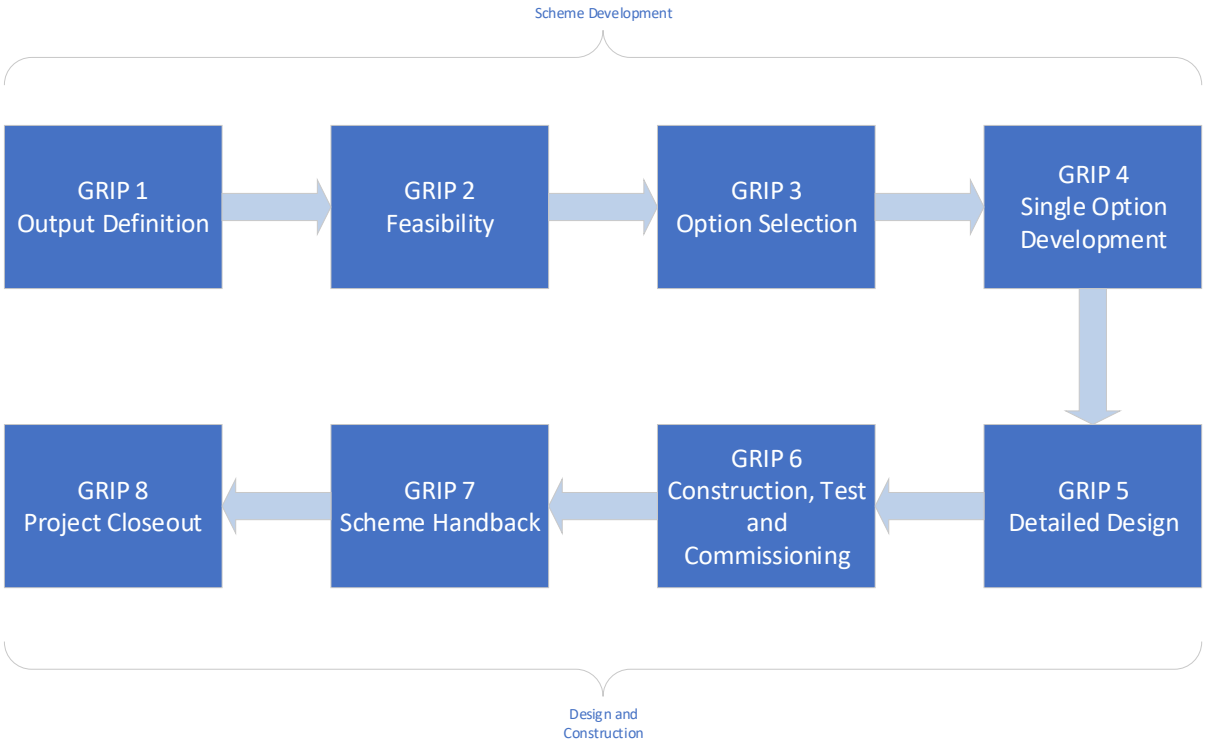

Figure 3: GRIP Stages

The scheme development stages are GRIP 1 – 4 and often projects are packaged as either GRIP 1-4 or GRIP 5-8 projects. This means that different contractors often complete GRIP 1-4 and GRIP 5-8.

The standards cover the GRIP stages in significant detail over multiple modules, however the manuals are project management biased and only briefly cover the technical and engineering aspects of a project. This is because the GRIP process is used to reduce the reputational and financial risk of the delivery of projects. If the GRIP process is followed properly then it is generally successful in reducing the risk of a project. It is noted that many projects get to GRIP 4 but only a few will then move onto GRIP 5. The GRIP process is logical however there are a few difficulties: one being the fact that the GRIP process is more aligned to the investment process and less to the technical risks (later in this paper, the author will discuss what has been done more recently to capture the technical risks) and the other is that the GRIP process is often internal to an infrastructure owner, and so as a supplier it can be difficult to understand exactly what deliverables are required from each stage (or what should have been produced at a previous stage). The next few paragraphs present the author's overview of each GRIP stage and a summary of the suggested deliverables.

2.2.1 GRIP 1

This is invariably an internal infrastructure owner activity and is used to define the output for the project from a high level. It is used to define what is needed from the project – i.e. increase train service, new trains, reduce delays etc. It is largely linked to the investment portfolio and so will look at the funding for the project. The output of this stage should be a requirements document – looking at the problem or opportunity and defining the problem. It is important that the Common Safety Method for Risk Evaluation and Assessment (CSM-RA) is initiated at this stage. This method is defined within European Regulations [15] and is a framework that describes a common mandatory

European risk management process for the rail industry. This paper will not go into the detail of CSM-RA but notes that it is important and should be initiated at the start of a project and is applicable to each further GRIP stage.

Stakeholder consultation is important at this stage and all stakeholders need to sign up to the requirements for this project. If they are consulted at a later GRIP stage, then they might not agree with the requirements or might want to introduce new requirements. As shown in *Figure 2* the earlier the influence the lower the cost; if stakeholders are only consulted at GRIP 2, 3 or later than the cost of change will start to ramp up significantly.

2.2.2 GRIP 2

This stage develops the requirements further and starts to look at viable solutions in response to the requirements. Scheme sketches and/or layout modelling are likely to be produced at this stage showing a multitude of options that would give the required output. This stage will also start to look at the operational requirements and a specification will be produced to define what the scheme is required to do from an operator's perspective. At this stage, it is important to understand who the operators will be once the scheme has finished and therefore buy in of the stakeholders is again critical. The better the requirements the better the final output will be and the smaller the change. The output of this stage will need to be a feasibility report that includes:

- the relative outputs/sketches/modelling,
- costs,
- feasibility,
- funding
- business case
- Risk Register (through application of CSM-RA).

No option will be chosen at this stage as not enough detail will have been gathered to allow an option to be chosen.

2.2.3 GRIP 3

This stage develops the options recommended at GRIP 2 and ensures that they address the constraints and definition of GRIP 1. This is therefore dependent on clearly defined requirements. At this stage each option will be developed, and the most appropriate option will be selected that delivers the stakeholder requirements, also ensuring that it can be delivered economically and safely. As the GRIP stages are driven by investment then sometimes the option chosen is the cheapest option, which might not actually be the option that delivers all of the requirements. An output of this stage should be an option selection report, which defines each option in detail and should include:

- the cost (whole life and value for money),
- timescales,
- appropriate technical assessments,
- constructability,
- maintenance strategy,
- operations and control strategy
- outline testing strategy
- scheme plan.
- Updated Risk Register
- Any other details to help justify the chosen option.

Based on all the assessments produced during GRIP 3 then the chosen option can be justified. From a signalling perspective then the signalling scheme plan should achieve Approval in Principle at this stage.

2.2.4 GRIP 4

This stage develops the option chosen at GRIP 3 and builds upon all of the strategies and assessments produced; turning them from strategies to plans. The aim of this stage is to produce outline designs and to fully understand the project with all of its constraints, issues and risks. The more information that is available and agreed with all stakeholders at this stage then the more accurate the cost for the next stages and the more likely that the project will succeed. All other disciplines should receive approval in principle at this stage and within signalling then the signalling scheme plan should be Approved for Construction.

2.2.5 GRIP 5

The development phases are now over, and the project moves into detailed design. This means that a complete, robust engineering design will be produced at this stage that will be approved for construction by the end of the phase. Costs increase significantly at this stage and therefore implementing change becomes more difficult and a lot more costly.

2.2.6 GRIP 6

The project is constructed, tested and commissioned into use at this stage. Based on the detailed designs produced at GRIP 5.

2.2.7 GRIP 7

At this stage the assets are handed over from the project team to the maintainer and/or operator. The assets and scheme should match the requirements produced at GRIP 1.

2.2.8 GRIP 8

The project is closed out in an orderly manner and all accounts are settled.

It is noted that in all the GRIP 1 – 4 stages, stakeholders must be consulted throughout with accurate requirements specified. Without agreement from all stakeholders at early stages then it is more likely that something will change when it is more expensive to change it. The best place to ensure that the final output is resilient and future proofed is to ensure that these are captured in the requirements from GRIP 1. Trying to make a fully resilient design at GRIP 5 or even GRIP 3 or 4 starts to become too difficult and the costs can easily spiral; so, any extra resilience built in will be reduced to save cost.

Th author's experience is that when the GRIP process is used well, and full consultation has happened throughout then the project is more successful. However, more often than not the early GRIP stages are seen as tick box exercises and reports are produced that "tick the boxes" but aren't detailed enough to allow for a good set of design deliverables (with minimal change) at GRIP 5. Sometimes it is just not possible because costs are squeezed at the early stages and so the finer details are pushed into later GRIP stages. The difficulty for signalling is that more detail is required at an earlier stage then other disciplines, as effectively signalling requires approval in principle by GRIP 3 whereas other disciplines don't need approval in principle until GRIP 4. In the UK, the signalling scheme technical approval process is a mandatory Network Rail Standard [4]. Therefore, it can be a challenge to produce signalling deliverables that require input from other disciplines when the other disciplines are not as advanced in their design as signalling. Why is this the case? Can the Approval in Principle of all disciplines become more aligned?

2.2.9 Stakeholder Identification

It has been identified that in all the GRIP stages, stakeholder consultation is very important. But who are the stakeholders? How do you identify them? And when do you get them involved? The challenge is to get the right stakeholders involved as early as possible; the more stakeholders involved in the early stages then the better the project will end up. However, there is a limit because as more are involved then there are more differing opinions

and a project could end up with too many requirements to have to deal with that conflict with each other. The old UK saying of *too many cooks spoil the broth* is important to note; this expression alludes to many cooks adding something to a soup, which in the end tastes awful. This is true of the railway, too many stakeholders all adding their own differing opinions that don't always align will in the end create a project that is over budget, over time or simply doesn't fulfil any sensible criteria.

So how can you get the "best tasting broth" of just enough of the right stakeholders to ensure a successful project?

This can be completed through stakeholder management techniques alongside accurate requirements definition. However, it must be remembered that stakeholders are ultimately people with different personalities and characters and so a stakeholder process is only the starting point. Therefore, the process (suggested by the author below) must always go hand in hand with consideration, understanding and a good proportion of people skills. Stakeholder management is a well-known project management tool; for a railway this should start at GRIP 1 and continue through all of the GRIP stages. The CENELEC railway application standards [8] are a good place to start; the aim of these European Union standards is to create a consistent approach to the management of reliability, availability, maintainability and safety (RAMS) on railways across the European Union. BS EN 50126-1:2017 defines stakeholders into five main categories, which is a good starting point:

- Railway undertakings (for example Train or Freight Operating Companies)
- Infrastructure managers (for example Network Rail in the UK)
- Maintainers/operators
- Railway supply industry
- Safety authorities

One (or more) of these stakeholders will have overall responsibility for the project and will be the one initiating the GRIP process. However, this doesn't always mean that this stakeholder will be the final operator or customer. It is also important to identify and remember throughout the process that the ultimate customer for any rail project is those using the rail network i.e. the passengers (me and you!). This can sometimes be forgotten amid a project.

The stakeholders identified should be named, categorised and logged but only for the purpose of this process to understand who these stakeholders i.e. people are. Now that the stakeholders have been identified, how should they be effectively managed. It is again noted that stakeholders are people and the best way to manage stakeholders is to understand who they are as people, to build a relationship and to keep communication channels open. There are many different management methods that can be used as a starting point, but the author will only discuss one here. This method is an amalgamation of multiple stakeholder management grids ([9], [10]) and so splits the stakeholders into:

- Those who can influence a project
- Those who are interested/affected by the project
- Those who are involved in a project

To truly acknowledge these then a three-dimensional grid needs to be used that encompasses all of these factors.

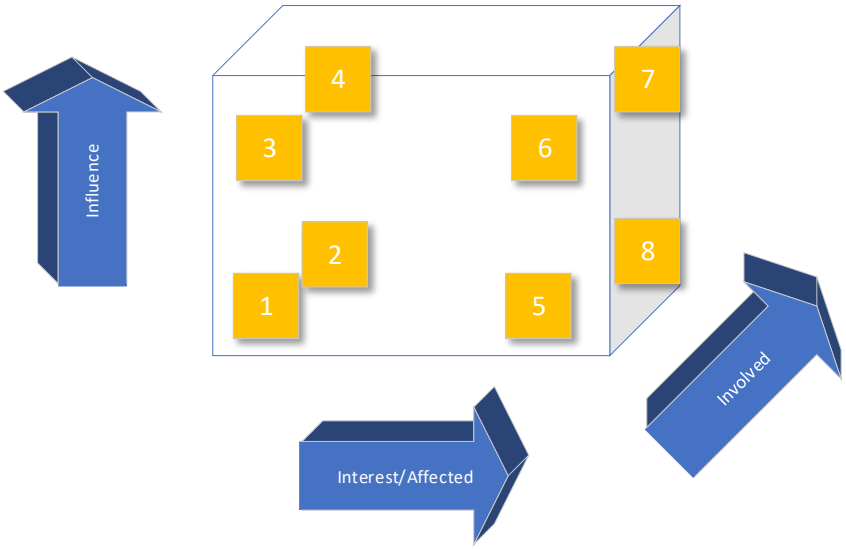

Figure 4: Diagram to show an example stakeholder identification 3D Grid

1) Low interest, low influence, low involvement: this could be for example a different project team that will be completing a new project in the same area but at a later timescale.
2) Low interest, low influence, high involvement: this is an unlikely category but could be a designer who is heavily involved in the project but is just following a scope of works
3) High influence, low interest, low involvement: this could be for example a government entity that can significantly influence a project but is not necessarily involved or interested in the specific outcomes.
4) High influence, low interest, high involvement: this is an unlikely category but could be a designer who is heavily involved in the project through writing the scope of works.
5) High interest, low influence, low involvement: this could be for example a general member of the public
6) High interest, high influence, low involvement: this could be for example a train or freight operating company
7) High interest, high influence, high involvement: this is likely to be the initiator of the project
8) High interest, low influence, high involvement. This is likely to be a supplier or contractor working on the project and so is interested in seeing it completed but doesn't necessarily have high influence.

These categories can be used to understand how much involvement and consultation each stakeholder should have in a project. Each category can have multiple stakeholders.

It is noted that any stakeholder of high influence should be involved as early as possible in the project and kept involved throughout the project. As has been noted multiple times in this section, stakeholders are people and so should be understood in that light i.e. it maybe that the person who "shouts louder" is the person who makes the biggest difference to a project, even though they might not be the correct person to identify the change. This must be managed sensitively and is where people skills are critical to anyone managing stakeholders.

It is likely that the stakeholders are identified by the initiator of the project, but these details are not always shared with those implementing the project – which means that stakeholders could be missed during later stages but will suddenly reappear near the end of the project. This is when change can happen that is often too late to implement efficiently.

This stakeholder process is a starting point and a whole paper could be written on stakeholders, however for this specific paper the author notes that it is important, should be identified as early as possible, a way of identifying and managing stakeholders should be used, these details should be shared and managed throughout the lifecycle of the project and in the end stakeholders are people so people skills is critical to effective management.

2.3 GRIP vs V&V

The author has discussed the GRIP process, its positives and negatives and the importance of correctly identifying stakeholders. Now the author will look at other examples of well-known project processes and compare these to the GRIP process.

The first process is the Verification and Validation process ("V Cycle") that has come from the software industry but is moving into the railway sector and is included within the CENELEC railway application standards [8].

There are multiple variations on the V Cycle, this paper gives the authors representation of the cycle. ***Figure 5*** shows the V Cycle and imposes the GRIP stages. It is noted that at each stage verification should be completed to ensure that it still matches the requirements of the previous stage; then validation is completed during the implementation stages to ensure that the system actually validates the requirements, definition and ultimately the concept.

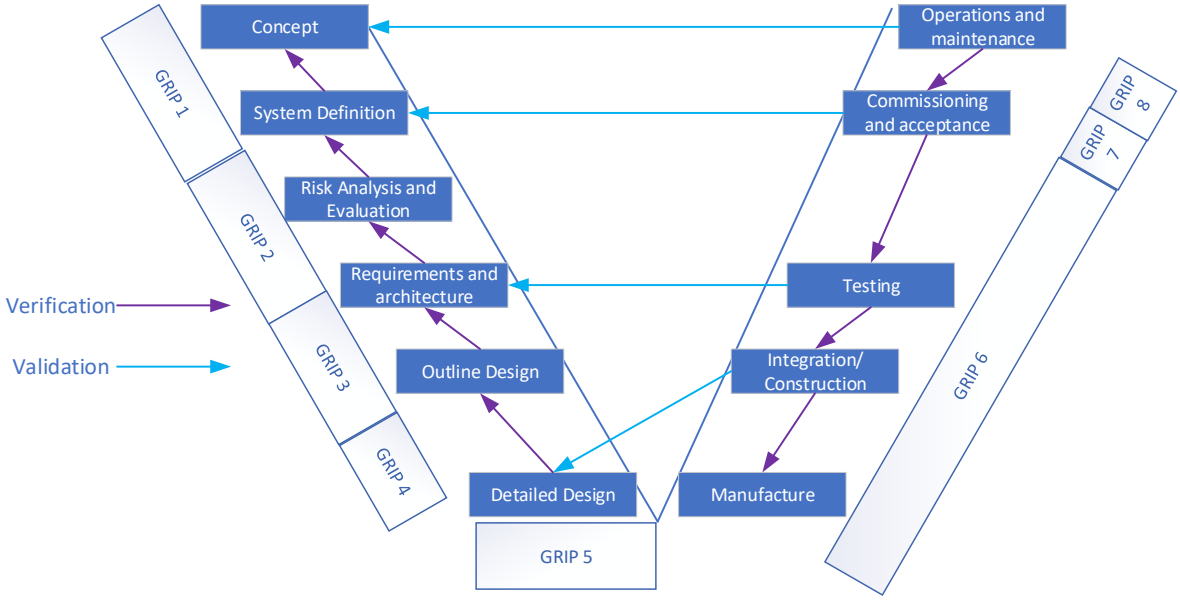

Figure 5: The V cycle and GRIP process superimposed

It is difficult to fully compare as the V Cycle is more technical whereas the GRIP process is more managerial. A specific item that the GRIP process doesn't consider as a stage, in its own right, is the operational and maintenance part of the cycle. These are important aspects of all projects and so should be considered in every GRIP stage and therefore there should be a validation exercise once the project is complete (i.e. GRIP 7 or 8) to ensure that operations and maintenance is validated against the concept. Unfortunately, this step is not always completed sufficiently as it is often the case that the handover process ends up being overtaken by commercial issues. Should there be an extra step on the GRIP process to consider the validation of operations and maintenance?

The V cycle shows the importance of identifying requirements as early as possible and then using these requirements at each stage to verify that they still meet the required output; then validating these requirements during the implementation and testing stages.

Capturing the full suite of requirements is not an easy process but should start at GRIP 1. By GRIP 3 the requirements should be finalised and frozen. This will mean that from GRIP 4 onwards no changes should be made to these requirements. Returning to the authors main point of getting it right…the earlier the better: the earlier a good and complete set of requirements are produced and frozen the better the project will be.

There have been many recent papers and conferences on requirements, including a joint conference between the IRSE and INCOSE in the UK on Requirements Management (see the article in the July/August 2018 edition of IRSE News for further details [11]). For this paper the author notes the importance of capturing, finalising and freezing the requirements as early as possible to avoid changes at the later stages of a project.

2.4 GRIP vs other industries

How do the GRIP stages within the mainline railway industry compare to other industries in the UK?

There are lots of different processes used within different industries in the UK. The author has observed the processes used within Highways England for major projects (Highways England is a UK government company charged with operating, maintaining and improving England's motorways and major A roads) as well as the Royal British Institute of Architects (RIBA) processes and produced a comparison as shown in ***Figure 6***.

Figure 6: Comparison of three different project processes

Generally, the GRIP stages align with the two other processes identified. However, it is interesting to note that the RIBA Plan of Work includes an 'In Use' stage and as noted in the section on the V Cycle, could the GRIP process add an extra stage to validate the project once it is in use? Or is the GRIP process too much of a financial tool and so this extra stage will not fit with the main scope of the process?

2.5 Technical Stagegates

So, the author has considered that the GRIP stages are adequate if followed properly but they aren't technical in nature.

Around 2014, it was noted that many projects (particularly) signalling projects were over budget and running late. But more significantly were the concerns that there were several incidents in which the design was found to have safety critical errors. Therefore, as described in an article by Francis How in the IRSE News from June 2015 [6] a working group was set up with Network Rail, IRSE and the signalling supply industry in the UK. The recommendations for short term actions from this group were:

- Apply technical stage-gates to all signalling projects, with any non-compliance to this requirement being very much the exception to the rule and treated with the seriousness it deserves.
- If the agreed date for passing a stage-gate cannot be met, the implications (including safety) for the planned commissioning date(s) and other critical milestones must be identified and addressed.
- Any change to the agreed/approved specification during the detailed design, construction, testing and commissioning phases should be avoided. Where change is absolutely necessary, both supplier and client must agree that it can be managed safely
- The non-sequential application of signalling design/development processes should be the exception, not the norm
- Rigorous change control processes must be applied to all designs issued for construction purposes.

Reading these recommendations again four years later, the author notes that there are still significant incidents happening in the UK and across the world (Collision at London Waterloo in August 2017 – described in the January 2019 edition of IRSE News [5] is one of many examples). So, do we still remember these recommendations and the reasons for them? Have they been forgotten about? Are these recommendations applied to projects in 2019?

These were significant recommendations, but it is unclear whether the UK signalling industry fully took these recommendations onboard. The biggest change was the addition of technical stage gates, which would sit alongside the more project management GRIP stage gates. These stage gates are further discussed in Jon Shaw's article in the December 2015 edition of IRSE News [7]. These stage gates are part of the Engineering Project lifecycle and they document the design development process and engineering assurance activities required throughout the GRIP stages. To move onto the next design phase (end of GRIP 1, end of GRIP 3, end of GRIP 4 and during GRIP 5) then hard technical stage gates must be passed where the project details are independently peer-reviewed within the infrastructure owner using defined checklists and specific deliverables.

Some of the deliverables are optional depending on the scheme and most are either pass or fail, i.e. to proceed to the next stage then the document must be produced of sufficient quality. But how do you define sufficient quality?

These stage gates have the potential to significantly improve the scheme development process and add to the GRIP stages a more technically biased process. This ensures that the technical and safety aspects of a project are considered along with the cost and programme – these must always be hand in hand for a project to succeed and for the requirements to be met.

2.6 Technical Assurance Process

The trouble with the technical stage gates is that they were only issued as a technical instruction and so are not covered directly in standards unlike the GRIP process. It has been previously noted that the GRIP stages needed to be tied together with project engineering activities. Therefore, a new UK Mainline standard has been introduced (with compliance date of September 2019) which introduces the Integrated Engineering Lifecycle for Projects (IELCP) [14]. The next few paragraphs are the authors own brief overview and summary of this lifecycle. The lifecycle provides an integration, assurance and control layer between the more commercial GRIP stages and project engineering activities. These basically ensure that there is consistency, that the right engineering activities are completed at the right time and the risks are managed and reduced for the integrated engineering activities.

This process adds six discrete phases each with a technical stage gate that broadly aligns with the GRIP stages.

These new phases are largely focused on requirements:

- The initial requirements document is developed to define the required output.
- The options are investigated and evaluated against the initial requirements document.

- The various technical options are further defined using appropriate option selection criteria and a more substantial requirements document is produced that expands upon the requirements defined at earlier stages.
- The design is developed further and allows the final detailed requirements document to be produced.
- The design is developed to allow construction to be undertaken.
- Construction is completed, tested and validation activities are undertaken to ensure that the assets meet the design and the requirements developed at the initial phase.

The phases have similarities with the V Cycle and allow verification and validation activities to be completed throughout the lifecycle. It is also noted that the requirements are always verified against the original requirements from the initial phase and are frozen at a specific point (i.e. GRIP 4).

So, it seems that the UK Mainline railway industry is moving in the right direction, the addition of mandatory technical gates that align with the GRIP stage gates is significant progress and should enhance the good practice already being done. The danger is that this turns into another tick box exercise, another process that everyone has to follow, something else that adds time to the programme and items could get missed because the gates are pushed through. As with everything else, the good processes are in place, however it is the author's view that projects are not yet fully implementing the technical stage gates, originally recommended four years ago and if they are then they are not implemented with the intended context considered. In the end it is down to people to understand the importance of the stage gates and having the confidence to challenge project managers and "tick box" attitudes. Therefore, is a culture change required to undo any corporate memory loss and allow these processes to be followed with their intended meanings of providing suitable assurance (both technically and commercially)?

3 CONCLUSION

The main aim of this paper is to show that the best way to get a project right is to spend time on the scheme development stages and ensure that the design has been sufficiently assured against the original requirements. The paper has suggested that allowing sufficient scheme development phases will significantly reduce the risk of overrunning and over budget projects. The author has looked at the GRIP stages, comparing them to different industries and looking at how the GRIP stages have been enhanced with more technical assurance processes. The author has briefly looked at the importance of stakeholder and requirements management.

It is the authors view that the UK mainline railway has procedures in place that will ensure a project is delivered successfully. There are similarities in the overall GRIP stages with other industries, however the author would suggest that the UK has good scheme development stages compared to other industries. Nevertheless, we could learn from others about the final operations and maintenance stage, not closing out a project too early but adding an additional stage to understand how the project has met the original requirements. Yet, a good process is only as good as the people involved and as good as the requirements captured. It must be remembered that comprehensive capture of the requirements from every relevant stakeholder must be undertaken and well recorded.

Therefore, the author's challenge is whether we have forgotten the outputs of the past? Do these processes end up being tick box exercises? Is a culture change required? Are requirements properly captured from all required stakeholders? Do projects know the required stakeholders? Are they adequately consulted? Are stakeholders understood as people with different personalities and characters? And are the right people capturing the correct requirements (not just an opinion from a meeting)?

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