Challenges in implementing current track standards into the existing ageing infrastructure

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hallenges in Implementing Current Track Standards Into the Existing Infrastructure

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Abstract

The rail industry in the United Kingdom is constantly investing in its infrastructure to make a better experience for passengers by providing more frequent and faster journeys. Large parts of this investment are the renewal of infrastructure that needs upgrading and introduction of new rolling stock which requires strategic and operational planning, multi-disciplinary design input and approvals from Network Rail Route Asset Managers (RAM). With the evolving standards set out by Network Rail it is becoming increasingly difficult to design track alignments without derogations to these standards. The aim of this paper is to gauge industry professionals' opinions on aspects surrounding track design such as their industry experience, their experience on working with software tools, as well as to highlight areas of design difficulty with regards to the Network Rail standards. Furthermore, this paper will explore a case study where the existing and proposed alignments have been analysed and an alternative proposed alignment has been designed in an attempt to eradicate the derogations encountered in the original design. Qualitatively collected data showed that 63% of sites designed by the respondents contain derogations, mainly connected to the restrictions and limitations in the design standards, as well as the changes to the scope during the project life cycle. Following on from this, the results of the case study highlighted the original accepted proposed design contained six derogations which, in the second proposed alignment, were reduced to three more serious derogations which resulted in the design being rejected.

Keywords: permanent way, track design, derogation, design standards, railways

1 Introduction

The rail industry in the United Kingdom is constantly investing in its infrastructure to make a better experience for passengers by providing more frequent and faster journeys. Large parts of this investment are the renewal of infrastructure that needs upgrading and introduction of new rolling stock which requires strategic and operational planning, multi-disciplinary design input, and approvals from Network Rail (NR) Route Asset Managers (RAM). With the evolving standards set out by NR [1-4], it is becoming increasingly difficult to design track alignments without derogations to these standards and without the use of appropriate design methods. The aim of this paper is to gauge industry professionals' opinions on aspects surrounding track design such as their industry experience, their experience on working with software tools, as well as to highlight areas of design difficulty with regards to the NR standards. Furthermore, this paper will explore a case study where the existing and proposed alignments have been analysed and an alternative proposed alignment has been designed in an attempt to eradicate the derogations encountered in the original design.

2 Materials and Methods

2.1 Expert opinion survey

The quantitative element of this study was addressed by a questionnaire sent out to industry professionals of varied experience levels, with an aim of collating data in a simplistic number format by the use of factual questions and opinion questions where a Likert scale will be applied to the question. In the qualitative element of the survey, the respondents were encouraged to give their view on certain design elements *via* open-ended questions, as an attempt to determine additional blockers that designers regularly come up against.

2.2 Case study

The quantitative method used in this study was case study research method to fulfil the aim and objectives. The case study addressed a descriptive question, allowed the study of the phenomenon in real-world context, and provided an evaluation [5]. The case study was a detailed design of Elderslie Station in Liverpool with two new proposed alignments: the first was a fully compliant design to [3], while the second was a design that meets most standards with exceptional circumstances which have arisen from designs done in the past, and also looked to highlight issues that current standards have on the re-design of existing infrastructure.

3 Results and analysis

3.1 Expert opinion survey

Thirteen track design experts were surveyed and provided response to the questions set in the expert opinion survey. Figure 1 shows that 23% of he respondents have over 20 years' experience in the design industry which is an indication that they may have been involved with all techniques that have been available to the present date. 30% of the respondents sit in the 16 – 20 years' experience range, which gives an indication that they should have been exposed to the majority of available design techniques.

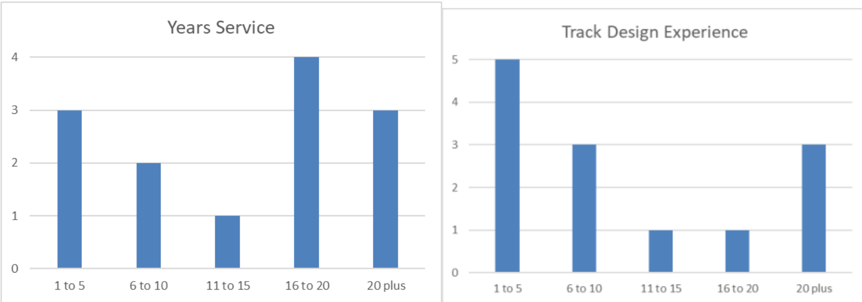


Figure 1. Experience of the respondents

Only 7% of respondents sit in the 11 – 15 years' experience, exposing a potential skills gap in the industry. The remaining 46% of respondents are in the 1 – 5 and 6 – 10 years' experience range and these respondents will most likely never have been involved in Hallade design [6-8]. Figure 1 also shows that knowledge gap and experience gap may be relatively high, despite the recent efforts in recognising this and increasing the number of jobs available in this area.

Based on the responses to the survey questions, it can be seen that there are mixed views on the traditional (e.g. Hallade) design methods. These methods, in the opinion of the industry, lack accuracy especially over long distances and through complex sites but is still an industry proven method of design. On the other hand, the overwhelming majority of the respondents use design software [6,7] for which they think there is room for improvement especially because there is a perceived over-reliance on the software with a lack of "First Principles" appreciation, further highlighting the knowledge gap that is developing within the rail design industry.

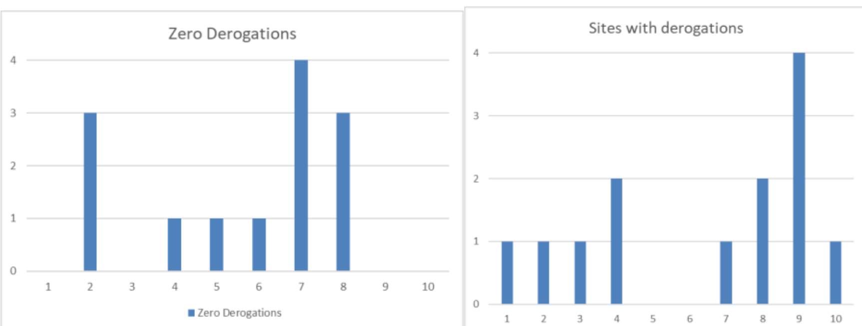
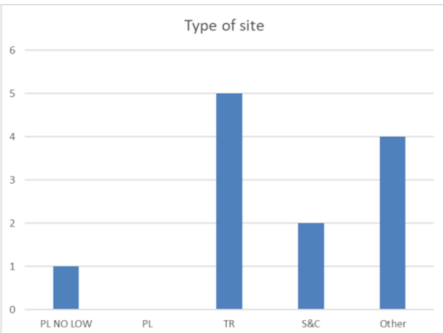


Figure 2. a) How easy is to implement NR design with zero derogations (1- very difficult; 10-very easy). b) Sites with x10% of derogations.

Similarly, 70% of respondents indicated that they have some experience in traditional gauging methods, and 92% in the use of modern gauging techniques which include the use of ClearRoute 2 and the lasersweep [6]. These figures show that there is a relatively good appreciation of the importance of gauging and route clearance role in the track design.

Less experienced designers find it difficult to design to the current standards and mid-experienced designers find it slightly easier (Figure 2a). 77% of respondents rated at 5 or higher for difficulty to implement current standards with only 23% rating it lower than 5. This could indicate that standards have advanced so much that experienced designers who are so used to designing a certain way are finding it difficult to implement these methods to current standards. This could also indicate that perhaps there is an issue with the current standard design software tool [6,7] that more experienced designers have problems adapting to. This potentially explains the results shown in Figure 2b - out of 130 sites designed by all respondents, 63% contain derogations which is an alarmingly high. This statistic alone shows just how difficult it is to fully comply with the current standards [1-4].



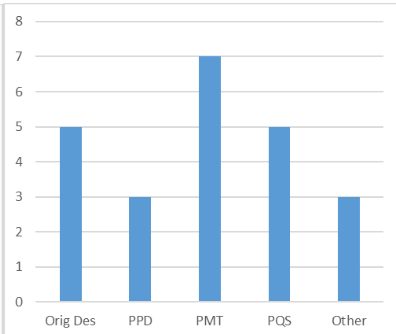


Figure 3. a) Type of site designers find most difficult to design. PLNOLOW - Plain Line Re-alignment (Track Lowers NOT Allowed), PL-Plain Line Renewal (Track Lowers Allowed), TR-Track Re-alignment through Structures (Track Lowers NOT Allowed), S&C-S&C Renewal (Track Lowers Allowed), Other. b) Factors contributing to derogation. OrigDes-Original Design that was completed to different standards; PPD-Poor previous design, PMT-Poor maintenance of track; PQS-Poor Quality survey; Other.

When asked about the type of site/project most difficult to design and, hence, most likely to contain derogations from the standards, 38% of the respondents selected the 'track re-alignment through a structure' where there are no track lowerings allowed (Figure 3a); 15% selected 'switch and crossover renewal (S&C)'; 8% find difficulty in plain line re-alignments with no track lowerings allowed, while 31% opted for the 'other' response and gave the following answers:

- *“2-second-rule is almost impossible to abide by”*
- *“Plainline renewal where lowers not permitted, and maximum lift specified”*
- *“Multi-staged complex S&C junctions with Platform/Structure interfaces”*
- *“Those in Wessex and Anglia route where older forms of S&C are being renewed with modern form with varying geometries.”*

The majority of responses (including the 'other' responses) indicate that designers find most challenges on sites where there are constraints on altering the vertical alignment. This specification is generally put in contracts, however, without taking the track out, digging a hole, and then putting the track back it is impossible to lower the track. Every time there is any maintenance carried out on a length of track, the track must be lifted out of its designed position so sometimes trying to put a design on a track where the client wants it back in its original position cannot be accomplished.

Figure 3b) shows that the most recognised factor contributing to derogations was poor maintenance of the track (30% of the respondents), followed by original design and poor quality survey with 22% of the responses. The respondents could identify more than one answer due to the many different factors that could affect any design, and these were as follows:

- *“Generally it is the scope of the job and the tight nature of the track. Construction methods also have a huge impact. If you slue a lot, you require more ballast excavation. If you lower a lot, you will also require more ballast excavation. If there is not the capacity in the wagons ordered for the job then it is not possible to implement the large slues or big lowers. This means that you have to stick to the existing footprint which is difficult whilst making things compliant. If the scope is a like for like renewal, generally moving S&C greater than 5m from its existing position will require other parts of the infrastructure to be moved. If that means a new OLE mast, or a signal move, they are expensive and generally the client (RAM) does not have the budget to implement such changes. The most common derogation that is applied to designs within S&C is network rails 'two second rule' (Clause 8.3.1 of [3]).”*
- *“Poor Specifications at inception and at GRIP4 stage”*
- *“Scope changes, financial constraints (no new OLE structures for example), staging being pre-determined, limited site access (during survey/design phase), limited access for installation, not adhering to a systems engineering approach (integrated designs), unrealistic programme, unrealistic budget, interfaces with internal disciplines, interfaces with external projects”*
- *“Especially when the Victorian railway was built around structures, bridges etc. which now present great restrictions”*
- *“Note Merseyrail where existing track in poor condition and platforms are out of gauge”*

Based on the responses, it would appear that poor track maintenance poses most of the challenges for designers. However, it would be unfair to tie the cause of not being able to implement current standards solely to that and, based on the other responses above, it is apparent that many factors can impact how a track design is undertaken. It is very clear that finance can play a large part in the process of failing to meet standards, and this is potentially connected to the age and history of the tracks. The United Kingdom Rail Network is largely Victorian in age, with significant amount of grand structures incorporated in it, many of which are listed and protected. Even if the funds were available to build a new bridge or station, sometimes there are still blockers that are outwith the control of the client, contractor or designer.

3.2 Case study

To illustrate the issues identified through the expert opinion survey, an attempt was made to compare two designs for Elderslie Station: one submitted to and accepted by the client (porposed desing) and an alternative one produced in an attempt to minimise the number of derogations (Tables 1 and 2).

The Elderslie Station is located 3 km SW of Liverpool, oriented N-S, and comprises a cutting between two tunnels (Figure 4).

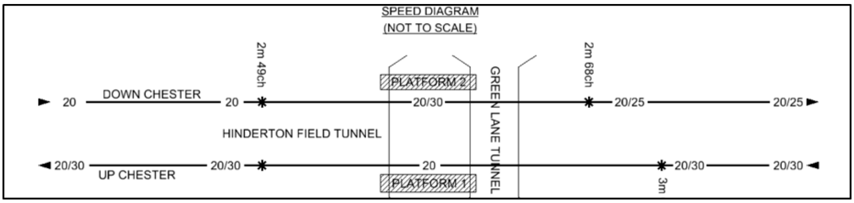


Figure 4. Schematic representation of the Elderslie station.

The design task from NR included adjustments to the proposed track alignment design to achieve 'standard' platform X and Y dimensions (730mm – 745mm and 890mm – 915mm) in accordance with GI/RT7016 (issue 5) & GC/RT7073 (issue 1). Additionally, clearance had to be provided for the new Merseyrail vehicle as well as any aspirational vehicles as listed in the NR Route Gauge Capacity Database. The existing gauging information showed that there are several clearances less than normal values with the smallest being 66mm between the Class 507/508 and another Class 507/508 vehicles. The proposed design was accepted with derogations on: virtual transition, lower SD Values (Table 1), short transition lengths, short vertical curves, lower six-foot values, lower clearance values (Structure & Passing, Table 2). The impact of these derogations will be relatively low, however the comfort and the riding experience of the passenger would be compromised with passengers potentially feeling like they are on a rollercoaster due to the multiple changes of direction and short element lengths.

Table 1. Comparative parameters for the Proposed and the Alternative design.

Track	Cat.	Const. Toler.. Band 2	Req'd Track Quality Stand.	Design SD Output		Expected Post Installation SD		Track Quality	
				Prop.	Alt.	Prop.	Alt.	Prop.	Alt
Up	AL35	1.800	2.700	4.312	2.121	6.122	3.921	Very Poor	Satis'y
Down	WT35	2.600	4.300	1.561	1.533	4.161	4.133	Good	Good

Table 2. Minimum clearance for the proposed (including interim) and alternative design

Stage	Deflated			Inflated		
	Ch. (m)	Min. Clear. (mm)	Vehicle	Ch. (m)	Min. Clear. (mm)	Vehicle
Interim	4520	73	Class 507, 508	4520	38	W6a 3rd Gen
Proposed	4455	71	Class 507, 508	4455	40	W6a 3rd Gen
Alter.	4455	93	Class 507, 508	4455	58	W6a 3rd Gen

In the alternative design that tried to address the number and effect of derogations, the following derogations were unavoidable: lower SD Values, lower six-foot values, and larger relative values (Figure 5). However, the cause of these derogations is not the design that has been carried out on the Down line, but the fact that no design has been carried out on the Up line or the six-foot, while the relative measurements are the measurements between the tracks.

4 Discussion and conclusions

Due to the country-specific nature of the topic of this study, the research presented in this paper identified a lack of published literature on the subject area which can be considered one of the limitations of this study. The existing literature comprises and is limited to the existing standards and in-house reports which sometimes contain commercially sensitive information. Considering the extent and the age of the UK railway network, it is clear that future investment in the industry and railway development will have to be tied to the dissemination and measurable impact of the research associated with the investment.

The number of track design experts surveyed for this study was limited to the designers within one large international, multi-disciplinary, consultant house which may be interpreted as too narrow and not representative. The authors tried to address this potential limitation with targeting a spectrum of professionals with various degree of experience who may have worked in other companies, albeit in the same field, in the past. Future studies would be focussed on surveying experts from a number of companies of varying sizes as well as experts who work (or worked) in a range of stakeholders: clients, contractors, engineers in order to obtain more representative and holistic view form the industry.

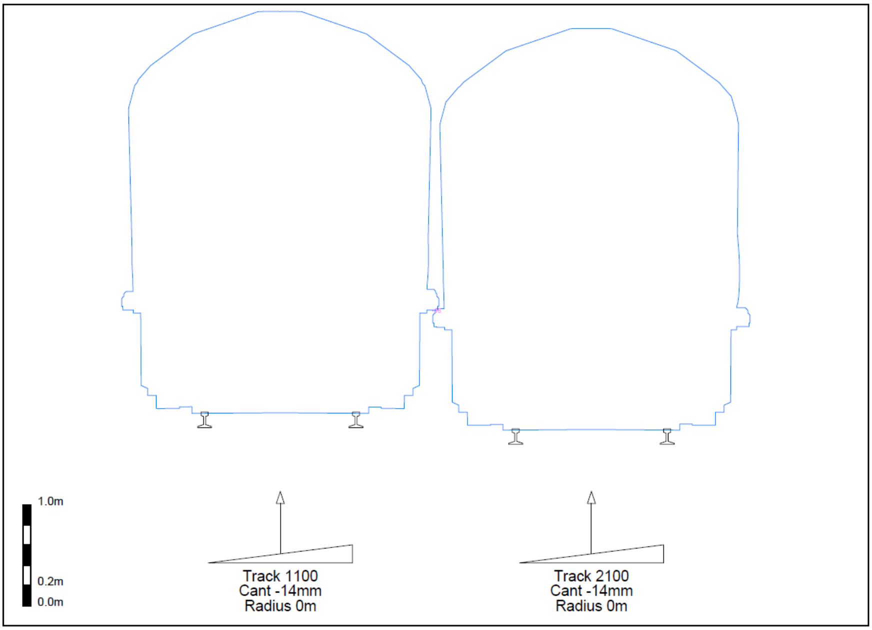


Figure 5. Alternative design for the case study with minimum number of derogations form the standards.

Another potential source of subjectivity in this study is the alternative design for the illustrative case study. This design was carried out by the first author and represent their subjective view on the topic. However, this design attempt showed that the required track design was unable to be completed without derogation on two occasions (the originally proposed design accepted by the client and the alternative design produced in attempt to eradicate the derogations and asses the effect of these derogations). This supports the expert view of design in cases when, unless a large-scale remodelling were to take place, the design will always have derogations due to the original layout which was designed to different standards. In this case, the removal of some derogations only resulted in further derogations.

This study only focused on one single case study of plain line re-alignment through structures with track lowering not allowed which, based on the responses from the questionnaire, proved to be the type of site that designers find most difficult to design. For the future, it would be worthwhile to investigate the other combinations of sites in a similar fashion, involving experts with different levels of experience and using different design methods. The responses provided to the questionnaire would suggest that there are more to derogations in certain sites than just the style and original scope would suggest. Case studies on specific sites where large changes of scope, which have caused designers to radically change designs and introduce derogations, would be welcome addition to the existing body of knowledge.

The comments made by some of the respondents appear to suggest that the software that is used as the industry standard would appear to be outdated and further analysis should be undertaken to verify this. It is the understanding of the authors that this is the only software that is available to the track design industry in the UK. The developments in the design software, however will have to be guided towards integrated design tool functionality i.e. a package that will allow all design work and requirements to be done under one tool.

The responses from the surveyed experts hinted at a potential skill gap developing in the industry, with larger percentage of experienced designers and relatively inexperienced designers who appear to be over reliant on software for design. It would be beneficial to carry out a study across the majority or all railway design houses to assess if this is common across the industry. Such study would also include an insight into the one aspect that was missed in the present study: assessing the site experience of the designers. This experience can be extremely helpful when designing and an investigation into this area could help understand the link between designers who may be over reliant on the software and designers who understand the ground conditions and the nature and magnitude of loads coming from the new proosed railway construction or upgrade.

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