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Dear Emily

Response to the Morgan Tucker report reviewing our Variable Usage Charge estimates and freight caps

Purpose

The purpose of this letter is to set out Network Rail's response to the Morgan Tucker report which reviews and comments on our initial estimate of Control Period 5 (CP5) variable usage costs. It is also a response to the request in ORR's consultation document on the variable usage charge and a freight-specific charge for us to use reasonable endeavours to improve our estimates of cost variability with respect to civils structures. We have written to you separately in relation to embankment renewals, culverts renewals and metallic underbridge renewals[1].

We welcome the Morgan Tucker report and continued engagement from stakeholders in relation to refining our variable usage cost estimates, where appropriate.

This letter has been copied to colleagues who attend the monthly variable track access charging meeting for their information.

All terms in this paper are in 2011/12 prices and at end CP4 efficiency unless stated otherwise.

[1] Letter from NR to ORR, 'Top down' cost variability assumptions applied to embankment, culvert and metallic underbridge renewals, 18 December 2012

Background

Network Rail 'freight cap' consultation and conclusions

To inform any decision by ORR in relation to placing any early cap on freight variable usage charges (VUCs) we calculated an initial estimate of freight variable usage costs. We consulted on our initial cost estimate in November 2011 and, following careful consideration of consultation responses, concluded on our consultation to ORR in March 2012.

A summary of the variable usage cost estimate included in our conclusions letter is set out in Table 1, below:

Table 1: Updated variable usage cost estimate

Asset type	**Costs (£M per year)**
Track:	**242.4**
Track maintenance and renewals	242.4
Civils:	**25.5**
Embankments renewals	1.9
Metallic underbridge renewals	9.7
Brick and Masonry underbridge renewals	13.3
Culverts renewals	0.5
Signalling:	**13.6**
Maintenance	8.2
Minor works points renewals	5.4
Total	**281.5**

Response to Morgan Tucker report

In its report, Morgan Tucker makes a number of detailed comments in relation to our initial estimate of variable usage costs, particularly brick and masonry underbridge renewals. Below, we have summarised these comments before setting out our response.

Impact of traffic growth on brick and masonry arch structures

Morgan Tucker states that we suggest that there is a directly proportional relationship between costs and an increase in traffic on the network. It notes that the relationship between traffic growth and cost is particularly complex and that it is not appropriate to assume a direct linear relationship between the two. Morgan Tucker considers that we should have taken into account the following factors:

- traffic constitution;
- geographic spread;
- quality of existing assets; and
- age of the structure, etc.

Furthermore, Morgan Tucker suggest that we should undertake further investigative research in order to understand the complex effects of traffic growth on brick and masonry arch structures.

We agree with Morgan Tucker that the relationship between traffic growth and cost is a complex one and that there would be considerable merit in undertaking further research in this area, particularly for brick and masonry underbridges. As discussed in more detail, below, we are also progressing workstreams that seek to improve our overall understanding of masonry structures. Also, as part of our Strategic Business Plan (SBP) work programme we are carrying out degradation modelling for structures and our work on masonry arches is being incorporated in the form of increased probabilities relating to defect occurrence. However, absent the tools, at present, to model 'bottom up' the cost variability for brick and masonry underbridges, we consider that it was reasonable and pragmatic to assume a linear relationship between marginal changes in traffic and cost to reflect the physical degradation evidence under freight loading.

Quality of existing civils assets and the age of the structures

In relation to the quality of existing civils assets and the age of the structures, we assumed anticipated asset condition across the network as at the end of CP4. We consider that it is important for cost reflectivity purposes that our cost variability estimates reflect the actual condition of structures on the network, rather than a less relevant, theoretical, alternative scenario.

In addition, although our brick and masonry underbridge variable usage cost estimate was informed by recent expenditure on the Settle and Carlisle Line, we estimated variable costs on a national average basis. Therefore, we did not assume that expenditure on the Settle and Carlisle Line was representative of network-wide expenditure more generally.

We also consider that it is important to note that for track costs, which account for the vast majority of variable usage costs, we did not make a high-level assumption that there is a directly proportional relationship between traffic growth and cost. Instead, we modelled 'bottom up' three increased traffic scenarios (+5%, +10% and +20%) to determine the relationship between traffic growth and cost. This modelling confirmed that the relationship between track costs and marginal traffic increases was broadly linear. Track variable usage costs ranged from £242m to £249m depending on the

traffic scenario used. For the avoidance of doubt, our track variable usage cost estimate was based on the +20% traffic scenario.

Traffic constitution and geographic spread

Morgan Tucker notes a number of factors such as future traffic constitution, geographic spread and zone of influence that it considers are likely to change overtime and result in a reduction in the average axle load operating on the network. Whilst we acknowledge the forecast changes in the constitution and location of future freight traffic, our methodology was designed to establish the extent to which costs vary in response to relatively small hypothetical traffic increases. Because these traffic scenarios were hypothetical they were never intended to reflect the specific growth rates in the different freight market sectors or parts of the GB rail network. The hypothetical traffic scenarios assumed that network-wide traffic increased by +5%, +10% and +20%.

'Top down' engineering judgement

Morgan Tucker do not believe that it was appropriate for us to use 'top down' engineering judgement in order to estimate the variable usage costs associated with non-track assets.

We recognise that, where possible, it is preferable to apply a 'bottom up' approach to estimating cost variability. Indeed, we have applied a 'bottom up' approach to estimating track variable usage costs, which account for 86% of total variable usage costs.

In relation to non-track assets, as stated above, at present, we do not have the tools to model 'bottom up' the level of cost variability. Therefore, we have applied a 'top down' approach. Whilst we accept that our 'top down' variable cost estimates are likely to be more uncertain than 'bottom up' estimates, we continue to consider that these costs should be recovered through VUCs. We strongly consider that the civils and signalling costs identified in Table 1, above, vary with traffic and thus if they were excluded from the VUC it would make the charge less cost reflective. Furthermore, it would also result in costs not being recovered from those who cause them to be incurred and could potentially provide us with a disincentive to accommodate additional traffic on the network.

We note that Morgan Tucker do not contend that the non-track variable usage costs that we have identified are not variable with traffic. Nor does it propose alternative cost variability assumptions.

Modelling techniques – track costs

Morgan Tucker expressed concern that the models that we used to estimate track variable usage costs (Vehicle Track Interaction Strategic Model (VTISM) and the Strategic Route Section Maintenance Model (SRSMM)) have not yet had enough time to be validated and tested.

We welcome the fact that Morgan Tucker recognises the development of VTISM and the SRSMM as a positive move. We do not, however, share its concern that the models have not had enough time to be validated and tested. VTISM, which calculates the majority of track variable usage costs, has been developed as part of a significant research programme led by the Vehicle/Track System Interface Committee (V/T SIC) and managed by the Rail Safety Standards Board (RSSB). VTISM (stage 1) was released in 2006 and has been used by the industry to manage changes around the vehicle / track interface. For example, it has been used by the Department for Transport (DfT) to evaluate new rolling stock bids and routes for cascading trains.

VTISM and the SRSMM were also used to estimate track maintenance and renewal costs in the Initial Industry Plan (IIP) and are currently being used to develop our Strategic Business Plan (SBP). Therefore, using VTISM and SRSMM to estimate track variable usage costs is consistent with our wider approach to modelling track costs.

We strongly disagree with Morgan Tucker that VTISM and SRSMM are only capable of dealing with increased traffic scenarios. In fact, in our March 2012 conclusions letter to ORR[2] we estimated the cost impact associate with a 10% reduction in traffic. We noted, however, that the track policy for CP5 and beyond has been designed to accommodate increasing traffic (consistent with traffic forecasts) and thus the increased traffic scenarios were more relevant.

Variability assumptions – brick and masonry arch structures

Morgan Tucker does not agree with our methodology for estimating the cost variability of brick and masonry underbridges and suggests that further investigative work needs to be undertaken. It considers that we should have taken into account the following technical factors:

- vibration and resonance;
- train velocities;
- high speed passenger trains;

[2] Available at: http://www.networkrail.co.uk/PeriodicReview2013.aspx

- construction materials;
- maintenance history;
- traffic constitution;
- design parameters;
- ultimate limit state; and
- serviceability limit state.

We agree with Morgan Tucker that it is not appropriate to treat brick and masonry underbridges in the same way as metallic underbridges. Hence, in our March 2012 conclusions letter to ORR we proposed a refined approach. We consider that this refined approach gives rise to a better estimate of brick and masonry underbridge variable usage costs than previously set out in our November 2011 consultation. Following review we continue to consider that our estimate of brick and masonry underbridge variable usage costs (£13.3m) remains appropriate. We have also sought to improve our estimate by providing further information, below.

We do not agree with Morgan Tucker's view that our estimate of annual renewal expenditure on the Settle and Carlisle Line should be reduced by more than 85% to reflect its extreme topography. An 85% reduction would imply an annual renewal spend, on a 70 mile 'new' heavy freight route, of £525,000. At current prices, strengthening a metallic underbridge costs approximately £300,000, where a few isolated strengthening web and flange plates or stiffeners are required. However, to significantly strengthen a masonry arch requires either a reinforced concrete saddle (which involves possession and track removal) or the production of a relieving arch beneath the structure (providing headroom is available). These methods are costly relative to the simple strengthening of a steel structure described, above. Based on recent expenditure on masonry structures (see below), we strongly consider that the £525,000 figure implied by Morgan Tucker would be insufficient.

<u>The cost of refurbishment, reconstruction and temporary strengthening</u>

Set out, below, is a range of examples of the value of remedial works on masonry structures that we have carried out in response to heavy freight traffic. We consider that these values support the above statement that the £525,000 figure implied by Morgan Tucker would be insufficient to remedy the traffic impact on a 70 mile 'new' heavy freight route:

- **Enterkin Burn and Crawick viaduct refurbishments**. The refurbishment cost for these two structures was approximately £6m. However, this cost includes £1m associated with track lowering which does not typically form part of a viaduct refurbishment. If, as we consider appropriate, the cost of track lowering is excluded, the average refurbishment cost of these two structures

equates to approximately £2.5m each. Figure 5.5 of the Spandrel Walls report attached to the cover email accompanying this letter illustrates this refurbishment[3]. Both of these structures were medium sized multi-span stone viaducts that required significant strengthening and refurbishment to restore their integrity and prevent the rapidly increasing severity of defects. Crawick viaduct was six 11 metre spans and Enterkin Burn viaduct was four 15 metre spans.

- **Settle and Carlisle viaduct refurbishment**. The cost of the simple saddle refurbishment was approximately £1.2m for a six span viaduct of approximately 10m spans.

- **Single span refurbishments on the LNW route**. The cost of a single span saddle refurbishment to masonry structures on our LNW route range from approximately £300,000-£500,000. Therefore, a mid-point estimate for this type of refurbishment would be approximately £400,000.

- **Masonry underbridge major reconstructions**. In our experience, the cost of major reconstruction for a masonry underbridge ranges from approximately £600,000 to £1,000,000. Therefore, a mid-point estimate for this type of refurbishment would be approximately £800,000.

- **Temporary strengthening in the form of tie rods restraint**. The cost of a tie rod is approximately £10,000. On average, we consider that five tie rods would be required per masonry structure and thus the average cost per structure would be £50,000. Figure 5.1 of the Spandrel Walls report attached to the cover email accompanying this letter illustrates the use of temporary strengthening work in the form of tie rods on Crawick viaduct in Scotland[4].

The, above, cost estimates show that, with the exception of minor works such as tie rods, remedial costs typically range from approximately £400,000-£2,500,000 per masonry structure. The large range reflects the fact that where structures can be strengthened externally without closing the railway it can be relatively low cost; but where the structure requires reconstruction or significant internal strengthening the cost is materially higher. Hence, the £525,000 figure implied by the Morgan Tucker report would only be sufficient to finance one single span refurbishment per annum similar to that on the LNW route and certainly not sufficient for any significant multi-span strengthening works. We strongly consider that, on a 70 mile 'new' heavy freight route, £525,000 materially understates the cost of remedial work in response to heavy freight traffic.

[3] Mott Macdonald / Network Rail "Spandrel Walls – Managing the Risks lessons learnt, Figure 5.5.
[4] Mott Macdonald / Network Rail "Spandrel Walls – Managing the Risks lessons learnt, Figure 5.1.

In our March 2012 conclusions letter we estimated that brick and masonry underbridge variable usage costs, on a 70 mile 'new' heavy freight route, to be £2.1m per annum. We continue to consider that this is a reasonable estimate of brick and masonry underbridge variable usage costs. Based on the cost estimates set out, above, this would be sufficient to carry out one of the following per annum:

- one large viaduct refurbishment; or
- three masonry underbridge major reconstructions; or
- five single span refurbishments.

We consider that this quantum of work in respect of a 70 mile 'new' heavy freight route is not unreasonable and does not overstate variable costs.

Frequency of masonry structures per mile

As a further sense check, we have confirmed the number of masonry underbridges on a sample of different freight routes and estimated the implied number of structures on a 70 mile route, see below:

	Route			
	Settle - Carlisle	**Glasgow & South Western**	**West Coast Main Line (LNW)**	**West Coast Main Line (Scotland)**
Route miles	72.5	82.5	311	90
Number of underline bridges – masonry	139	90	365	46
Implied number of underline bridges per mile	1.9	1.1	1.2	0.5
Implied number of underline bridges on a 70 mile route	134	76	82	36

The, above, analysis shows that for the routes considered the number of masonry underbridges, for a 70 mile track section, ranges from 36-134. Based on total route miles and underbridges for the, above, regions we can estimate, on average, a 70 mile track section will have 81 masonry underbridges[5]. Therefore, we do not consider the three major reconstructions or five single span refurbishments per annum estimated, above, is excessive.

We have also confirmed that the, above, routes contain 134 viaducts and, at least, 40 of these are masonry. This gives rise to an average of 0.07 masonry viaducts per route mile[6] and thus equates to approximately five structures for a 70 mile track

[5] 81 = ((139+90+365+46) / (72.5+82.5+311+90))*70
[6] 0.07 = 40 / 556

section[7]. We consider the fact that a 70 mile track section typically contains 81 masonry underbridges and five viaducts supports our view that either one major viaduct refurbishment per annum or three to five masonry underbridge refurbishments and / or reconstructions in response to heavy freight traffic is broadly reasonable. We note that in the late 1970s a new flow of bulk stone freight traffic from the Mendip quarries to Southampton docks resulted in six masonry arches being reconstructed including one viaduct strengthening over a period of approximately 2 years on a thirty mile length of route. However, given the knowledge at the time, this was assumed to be a masonry material issue in that some of the bridges were constructed with early locally produced bricks.

In our March 2012 conclusions letter we estimated that brick and masonry underbridge variable usage costs, on a 70 mile 'existing' heavy freight route, to be £200,000 per annum. Based on the cost estimate set out, above, this would equate to the temporary strengthening with tie rods of four masonry structures in response to heavy freight traffic. We continue to consider that this estimate is broadly reasonable and not excessive.

We do not agree with Morgan Tucker's conclusion that because vulnerable arches on 'existing' heavy freight routes will have already been strengthened, total variable usage costs should be limited to spend on 'new' heavy freight routes. We consider that masonry and brick underbridge renewal costs on 'existing' routes are variable with traffic, however, to a lesser extent than those on 'new' routes. This difference in the level of cost variability is reflected in our variable usage cost estimate.

Recent research

We also consider that the Mott Macdonald / Network Rail "Spandrel Walls – Managing the Risks" lessons learn report, referenced above and attached to the covering email accompanying this letter, supports our view that brick and masonry underbridge renewal costs vary with traffic. We note that one of the key lessons learnt set out in the report is:

"The type and tonnage of the rail traffic can have an effect on the loads imposed onto a spandrel wall. The inter-relationship between the structural configuration and axle patterns and loading is critical with respect to the load being transferred to the spandrel wall. It has been demonstrated through analysis that the HTA freight wagon is significantly more aggressive than the other types of freight traffic operating on the network." [8]

[7] (40/556) * 70
[8] Mott Macdonald / Network Rail "Spandrel Walls – Managing the Risks lessons learnt, page i.

We would also like to highlight the following workstreams that demonstrate that we are seeking to improve our overall understanding of masonry structures:

- The 2006 Ciria report C656 titled “Masonry Arch Bridges: Condition Appraisal and Remedial Treatment” (attached to the covering email accompanying this letter). This work was commissioned by the Bridge Owners’ Forum, of which we are a member, with the aim of promoting better understanding of the condition and management of masonry arch bridges. The report provides a recent state of the art reference on remedial treatments for bridge owners and maintenance engineers. It has provided support for Engineers and Bridge Owners including Network Rail in providing a modern view of the condition assessment and repair techniques in a single document.

- The ongoing University of Bath masonry arch durability research that we have sponsored. This is a three year sponsored PhD which extends the work on spandrel walls and also looks at and tests the masonry material properties

- The ongoing UIC project P/0134 on the assessment of masonry arch bridges. The project will be completed in 2014 and includes work packages on susceptibility to degradation, dynamic behaviour, assessment of damaged arches and assessment of serviceability.

- UIC Report 778 -3 1995 (second edition 2011) Recommendations for the assessment inspection and maintenance of masonry arch bridges. (Precursor to the project above).

Moving load effects

Broadly speaking, we do not agree with Morgan Tucker that the effect of moving loads on structures is extremely complex. Railway bridges are, in the main, simple structures and, with some exceptions, the load distribution generally follows theory. Masonry arches are particularly illustrative of this in that the defects occur precisely as one would predict from theory and, most notably, under the track that freight trains run loaded. In addition, the detailed finite element studies carried out demonstrated that the distribution within the structure and highlighted high stress concentrations where known defects occur.

Vibration and resonance

We note that the Morgan Tucker report states that vibration and resonance has not been taken into account. Masonry arches are high mass soil filled structures that have considerable natural damping against vibration. Vibration and resonance was, considered during the west coast modernisation programme and we found that

resonance did not occur in our masonry arch bridges because the applied loading frequencies of both freight and passenger traffic differed considerably from the natural frequencies of the structures at normal operating speeds and loading. Moreover, the Spandrel Wall research that we commissioned recently looked at this issue as part of a parametric study and concluded that it was not relevant to the damage being incurred. We, therefore, do not consider that vibration and resonance are relevant considerations when assessing the cost impact of traffic on brick and masonry underbridges.

Train velocities and high speed passenger trains

In relation to masonry arches, the main consideration is the bogie spacing not the velocity of the vehicles which is a secondary consideration; the velocity is not relevant to the damage incurred unless there is a serious fault reducing support to the track and causing impact from every axle. However, it should noted that as damage to the structure occurs it does increase the likelihood of impact becoming a factor that will then accelerate the damage.

Traffic constitution

As set out above, our methodology was predicated on establishing the extent to which costs vary in response to relatively small hypothetical traffic increases. Hence, it was never intended to reflect the specific growth rates in the different freight market sectors or parts of the GB rail network.

Construction materials, maintenance history and design parameters

As noted above, we consider that it is important for cost reflectivity purposes that our cost variability estimates reflect the actual condition of structures on the network, rather than a less relevant, theoretical, alternative scenario. We can confirm that when estimating the appropriate level of cost variability, we assumed construction materials, maintenance history and design parameters representative of reality across our portfolio of masonry underbridges. We note, however, that serviceability failure is largely independent of the construction materials and, possibly with the exception of structures constructed from high strength blue engineering brick, stone / brick arches are equally at risk of serviceability failure from increased loading.

Ultimate limit state and serviceability limit state

We do not consider that ultimate limit state is a key consideration when estimating brick and masonry underbridge variable usage costs. Arches rarely, if ever, suffer ultimate collapse other than through river scour of foundations. Therefore, the failure

in almost all cases is a rapid increase in the formation of defects and an accelerating loss of serviceability leading to load restriction and ultimately route closure if no remedial action is taken.

Variability assumptions – minor works points renewals

Morgan Tucker consider that the 44% variability assumption that we applied to minor works points renewals seems overly excessive and that it is unclear why this track asset is being assessed using a 'top down' methodology. It also believes that we have made a number of mathematical errors in the calculation process.

We continue to consider that our 44% variability assumption is reasonable and that it is appropriate to treat these cost categories separately from track costs. We note that this assumption has been reviewed by the Independent Reporter, Arup, who gave it a 'yellow' rating. This means that Arup had no major concerns in relation to method, data or assumptions. We also note that Morgan Tucker has not provided any evidence to substantiate its view that our proposed variability assumption should be reduced by at least 50%.

We have reviewed our variable cost estimate and do not consider that it contains any mathematical errors. However, the exact natures of the mathematical errors alleged by Morgan Tucker were not clearly articulated in its report.

Conclusion

Morgan Tucker considers that there is insufficient information in our consultation documents to justify the increase in variable usage costs. Ultimately, it suggests that existing VUCs should be frozen for CP5 in order to allow a thorough research programme to be completed, specifically on brick and masonry arch structures.

We do not agree with Morgan Tucker that there is insufficient information in our consultation documents to justify recalibrating VUCs for CP5. The vast majority of variable usage costs have been estimated 'bottom up' using established models that have been reviewed by an Independent Reporter. Whilst we recognise that our 'top down' variable usage cost estimates are likely to be more uncertain than 'bottom up' estimates, we consider that these cost categories vary with traffic and, for the reasons set out above, that our variability assumptions are reasonable. In our opinion, freezing VUCs in CP5 would reduce cost reflectivity, result in costs not being recovered from those who cause them to be incurred, and potentially provide us with a disincentive to accommodate additional traffic on the network. We also note that Morgan Tucker do not contend that the non-track variable usage costs that we have identified are not variable with traffic. Nor does it propose alternative cost variability assumptions. Therefore, we consider that it is appropriate to retain the brick and

masonry underbridge, track and signalling variable usage cost estimates set out in our March 2012 conclusions letter to ORR. We will update these cost estimates to take into account the latest cost and traffic data (set out in our Strategic Business Plan) when we conclude to ORR by the end of March 2013.

We recognise the importance of continuing to improve our understanding of civils assets, including the relationship between cost and traffic. As noted above, as part of our SBP work programme we are adjusting our cost models using probabilities that reflect the degradation found in practice on the assets. We are also undertaking further work that will contribute to improving our overall understanding of masonry structures. This involves working with leading universities both here and abroad as part of the research projects listed above and as a participating partner the benefits of outputs can often be ascertained and applied before project completion of final reports.

Finally, we consider that it is important to be clear that our work to date has focused on estimating variable usage costs. The variable usage charges that operators will pay for access to the network have not yet been determined by ORR. These charges are likely to incorporate an efficiency overlay and uncertainty surrounding the level of this overlay means that it is not yet clear whether charges in CP5 will be higher or lower than those in CP4.

If you would like to discuss any aspect of this letter please do not hesitate to contact me.

Yours sincerely,

Ben Worley

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