A Report for
Network Rail and ORR
from
Asset Management Consulting Limited (AMCL)

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3rd June 2013

Assessment of EAU Charge Proposals
PR13 Review

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AMENDMENT HISTORY		
Version	Sections	Amendment Details
Draft A	All	Initial draft for review of factual accuracy
Draft B	All	Updated following ORR and Network Rail Comments
1.0	Exec. Summ.	Updated following Draft B Comments

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Executive Summary

AMCL (Asset Management Consulting Limited) is the *Independent Reporter - Part B: Asset Management* to Network Rail and the Office of Rail Regulation (ORR) in the United Kingdom. As part of that role AMCL was commissioned to complete a technical review of Network Rail's work on the proposed Control Period 5 (CP5) Electrified Asset Usage (EAU) charges. The findings of this review will contribute to the ORR's Periodic Review 13 work to determine the EAU charge for CP5.

The objective of this review was to establish if a robust engineering approach had been taken by Network Rail in its proposals and calculation methodology for determining the EAU charge. The mandate was to review if the work provided a clear rationale and whether the calculations and assumptions were sensible. The pre-defined scope for AMCL was to review Network Rail's assumptions, basis of proposal and calculation methodology as follows:

- Review of technical rationale; do the assumptions contained within the supporting documents seem sensible, are they justified and, where engineering judgement has been applied is it reasonable? Two key areas need to be reviewed:
  - Proportion of costs impacted by utilisation; and
  - Level of asset degradation impacted by utilisation.
- Computational Accuracy. Network Rail has developed a charging model, are there any computational issues that could lead to inaccuracy?

AMCL was specifically requested not to give a view on any charging policy proposed by Network Rail in its consultation on charges, input costs or output costs as these were assessed as part of the ORR's wider Periodic Review 13.

To facilitate the review AMCL undertook a series of desktop studies and interviews with key Network Rail stakeholders to assure the understanding of the end-to-end process for establishing the EAU charge proposals for AC and DC electrification systems.

Following completion of the review summarised in this report, AMCL has identified a number of key conclusions as follows:

- Overall Methodology:
  - Network Rail stated that the charge calculation methodology is broadly the same as that in CP4 but with the cost window extended to 35-years to provide consistency with the approach used for the variable usage charge (VUC).
  - As Network Rail could not produce any information evidencing the decisions behind the CP4 assumptions on variability AMCL cannot judge whether the new approach is more detailed or where it has improved.
  - The Network Rail EAU charge panel are the leading Network Rail experts and in AMCL's opinion have the appropriate experience to assess the traffic impacts on costs.
  - The logic of the V1/V2 methodology, using the statements provided by Network Rail, appears to be reasonable when applied to the renewals elements. However, we challenge if this is the most appropriate methodology for calculating the maintenance elements of cost. A potentially different approach would be to try and prove a relationship between unplanned maintenance and traffic volumes using Fault Management System (FMS) and Ellipse data.
- Technical Rationale:
  - There appears to be inadequate justification for the assumptions as there is no formal record explaining the discussions and decisions from the expert panel or any written record of the detail of any analysis that was quoted as taking place. As there has been no quantitative evidence to analyse, AMCL has looked to challenge the assumptions only where an alternative logical case can be put forward. It was only in written response to AMCL questions that further information was documented. The inadequate written justification will make it difficult to repeat this exercise in the future and justify the results, especially where there are changes in opinion between Control Periods.
  - 'Wear and tear' costs associated with electrically powered trains occur due to the passage of train current collectors along Network Rails contact systems. Therefore in our opinion it is not thought appropriate that 'wear and tear' costs should be considered to arise due to load current flow in the electrification system other than that at the current collector / contact system interface. The electrification system should be managed and operated within rated capacity and maintained in accordance with the appropriate Network Rail Company Standards.
  - AC planned maintenance costs will change with traffic due to the risk based nature of the inspection categories but this is not a linear relationship and on many lines

significant traffic increases could take place with no change in inspection regime. Therefore we challenge the appropriateness of including this in the charge.

  - AC and DC unplanned maintenance logically has a relationship to traffic volumes for certain assets. Network Rail should be able to demonstrate how unplanned maintenance varies with traffic volumes by analysing information from the FMS and Ellipse systems which would allow it to apply a single variability figure to the unplanned maintenance costs.

- Computational Accuracy:
  - In the calculation of the CP5 EAU charges the model appears to have no computational errors.
  - There were errors in the conversion to 12/13 prices of the CP4 charge for comparison. The error in the first model release was corrected but a secondary error was then introduced by reversing the conversion figure.
  - The second release of the model during the review process introduced a significant number of changes within the charging model but upon inspection, for the CP5 calculation, these have only affected the manipulation of the input costs and had no material impact on the model's computational accuracy.
- Long Term:
  - The extent of un-recorded expert judgement in the determination of CP5 EAU Charges may make it more onerous to demonstrate continuous improvement and refinement in later Control Periods.

Based on the overall review and the conclusions documented above, we propose a number of recommendations which should be completed prior to the agreement of EAU charges for CP5:

1) Network Rail should remove the 'Transformer Rectifier Unit Renewal' activity from the proposed EAU charge as these should be managed and operated within rated capacity.
2) Network Rail should remove the AC planned maintenance factor from the proposed EAU charge as there is not a linear relationship between traffic and spend and on review of the figures put forward by Network Rail the costs appear to be minimal.
3) Network Rail should determine whether it is feasible to carry out an analysis of unplanned maintenance to produce a single percentage figure for how unplanned maintenance varies with traffic, which should then be applied to the predicted unplanned maintenance costs. If this is not feasible using current data this should be included in the next review process.

4) Network Rail should reverse the error introduced through the conversion of the CP4 figures from £/vehicle mile & £/KGTM to £/vehicle km & £/KGTkm in the second release of the EAU charge model.

The following recommendations are longer term and should be completed before any review of the EAU charge for CP6:

5) Network Rail should establish revised cost categories that enable 'wear and tear costs' to be recorded as this would enable a reduced reliance on engineering judgement in future.
6) Where judgement is still required, this should be documented such that it can support statements on EAU Charges referenced in future periodic reviews.

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1 Introduction

1.1 Background

Network Rail manages and operates Great Britain's national rail network under the terms of its Network Licence and is regulated by the Office of Rail Regulation (ORR) in five-year Control Periods (CPs). The current Control Period is CP4.

As part of the charges levied on the users of the railway, the Electrification Asset Usage (EAU) charge is aimed at recovering the maintenance and renewal costs associated with electrification assets that vary as a result of utilisation.

In CP4 this amounts to a recovery of approximately £8 million, which is just over 0.1% of Network Rail's total £6 billion revenue requirements.

Network Rail is proposing a revised methodology as part of the 2013 Periodic Review for the calculation of the EAU charge with a move from a 5-year cost calculation window to a 35-year calculation in an effort to smooth future forecasts.

In support of the proposed change, Network Rail has produced a suite of documents and a calculation tool to recommend and justify the level of charges. The principal method employed is to assess what portion of an activity's cost can be attributed to utilisation-related degradation and the likely impact of changes in the level of utilisation.

In September 2012 the proposed charges were put out to consultation with the industry as part of a wider consultation looking at a proposed approach to developing the EC4T and EAU charging framework for implementation from the start of CP5.

To support and inform this consultation process, Network Rail and the ORR commissioned AMCL (Asset Management Consulting Limited) as the *Independent Reporter - Part B: Asset Management* to complete a technical review of Network Rail's work on the proposed charges.

1.2 Purpose

The objective of this review was to establish if a robust engineering approach has been taken by Network Rail in its proposals and calculation methodology for determining the EAU charge. The mandate was to review if the work provided a clear rationale and whether the calculations and assumptions were sensible. AMCL has been specifically requested not to give a view on any charging policy proposed by Network Rail in its consultation on charges.

The finding of this review will contribute to the ORR's Periodic Review 13 work to determine the EAU charge for CP5.

1.3 Scope

The pre-defined scope for AMCL was to review Network Rail's assumptions, basis of proposal and calculation methodology as follows:

- Review of technical rationale; do the assumptions contained within the supporting documents seem sensible, are they justified and, where engineering judgement has been applied is it reasonable? Two key areas need to be reviewed:
  - Proportion of costs impacted by utilisation; and
  - Level of asset degradation impacted by utilisation.
- Computational Accuracy. Network Rail has developed a charging model, are there any computational issues that could lead to inaccuracy?

Exclusions: AMCL was not expected to comment on:

- Any charging policies (including charging horizon) proposals by Network Rail;
- The level of final charging proposed in the model; and
- Input costs.

1.4 Methodology

In accordance with the mandate, AMCL reviewed the technical rationale based on establishing Network Rail's justification for each activity impact. The onus was subsequently with Network Rail to clarify confidence limits and technical justification for each activity impact.

To facilitate this AMCL undertook a series of interviews with key Network Rail stakeholders. AMCL also conducted desktop studies which consisted of the review and analysis, as appropriate, of documents and models provided by Network Rail, plans, processes, data and further evidence.

2 Technical Rationale

2.1 Charge Methodology

The EAU charge was developed to recover the 'wear and tear' costs associated with AC and DC networks. These have been determined by Network Rail using a methodology based on two variability percentages for each selected EAU charge activity. Network Rail states that this is broadly the same approach as used in CP4.

The two variability percentages are defined by Network Rail as follows:

- V1 – '*the % proportion of the cost category which varies with traffic*'; and
- V2 – '*the level of variability, which describes the extent to which Network Rail costs increase with traffic*'.

Following further discussions with Network Rail AMCL believe that V1 & V2 can be explained as follows for renewal categories:

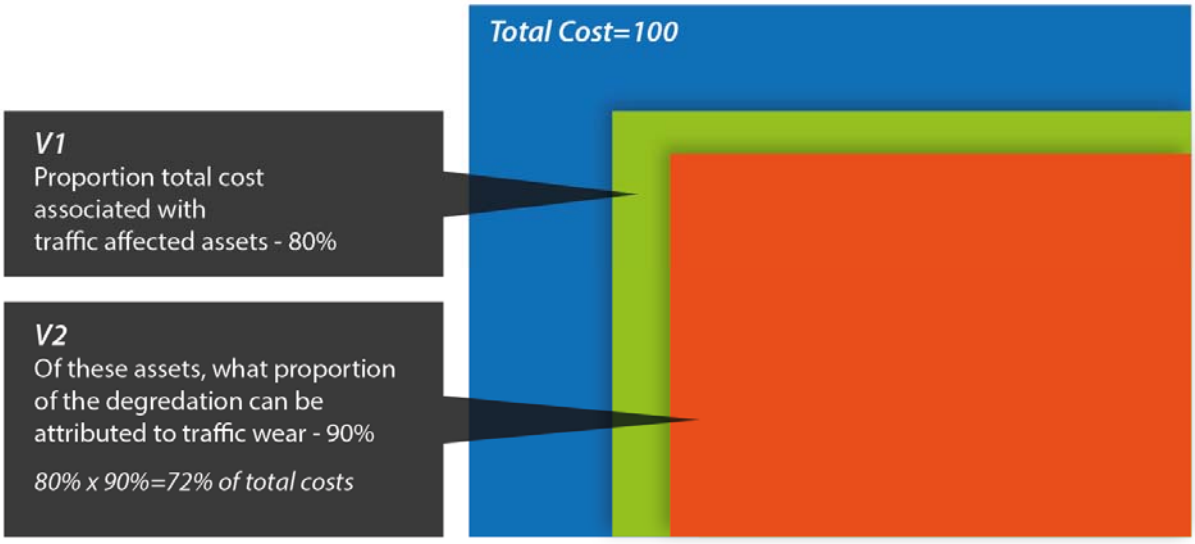

Figure 1 V1 and V2 concept

One of the key changes in Network Rail's cost estimation methodology for CP5 EAU charges is that costs are now based on long-run averages over 35-years rather the 5-year period used in CP4. This is consistent with the approach used for the CP5 variable usage charge and will allow a smoothing of variations in future spend.

2.2 EAU Charge Activities and Variability Percentages

Initially Network Rail carried out a desktop review of the AC and DC systems identifying all cost areas which may be affected by traffic from the grid supply point through to the Network Rail train interface. This cost activities where then subject to a peer review and challenge session using the panel of Network Rail experts listed in Table 1 below:

Name	Title
Matt Skinner	Development Manager, Asset Management Services
Richard Stainton	Professional Head (Electrical Power), Asset Management Services
James Taylor	Infrastructure Maintenance Development Manager, Network Operations
Mark Proctor	Technical Lead E&P CP5, Asset Management Services
Nigel Wheeler	Wessex Route Asset Manager E&P, Network Operations
Ben Worley	Senior Regulatory Economist, Group Strategy
Gabriela Weigertova	Regulatory Economist, Group Strategy

Table 1 Network Rail EAU Charge Panel

From this review the following activities have been proposed by Network Rail as chargeable within the scope of EAU and against these the following variability percentages have been proposed by Network Rail. These are shown in Table 2 and Table 3 for AC and DC respectively, along with the corresponding percentages from CP4. Also included are Network Rail's comments on the CP5 charges which were presented to the Traction Electricity Steering Group meeting hosted by ATOC at which ORR was present on 11th March 2013.

Activity	CP4 Variability (V1/V2)	Proposed CP5 Variability (V1/V2)	Network Rail Comments
OLE contact / catenary wire renewal	40% (50%/80%)	72% (80%/90%)	Very strong link between asset degradation and traffic. Significant scope of this work activity is linked to traffic.
OLE mid – life refurb.	N/A	42% (60%/70%)	New intervention for OLE as per asset policy. Scope includes elements that will vary with traffic (contact wire, catenary, insulators, registration equipment, etc.)
Full renewal	N/A	10.5% (15%/70%)	No impact on charge due to timescales for intervention activities

Activity	CP4 Variability (V1/V2)	Proposed CP5 Variability (V1/V2)	Network Rail Comments
Component change	N/A	10% (25%/40%)	Includes renewal of some components degraded by pan passages e.g. neutral sections
OLE Maintenance	5% (50%/10%)	12% (80%/15%)	Risk based maintenance regime – planned and reactive activities influenced by category (pan passages & lines speed)

Table 2 AC Electrification

Activity	CP4 Variability	Proposed CP5 variability	Network Rail Comments
Conductor rail renewal	40% (50%/80%)	54% (60%/90%)	Re-assessed based on better understanding of degradation rates and assessment of scope of renewal activities
Transformer Rectifier Unit Renewal	N/A	4% (40%/10%)	Considers increase in traffic accelerating end of life
Electric traction equipment (ETE) Maintenance	N/A	21% (40%/52%)	Maintenance regime more reactive than OLE – identified reactive activities

Table 3 DC Electrification

The variability percentages were determined using engineering judgement taking into account documents such as the Electrical Power Asset Policy, Network Rail Company Standards and the scope of works for renewal projects. These were then subjected to peer review by the same panel listed in Table 1.

Network Rail has provided some justification of the rationale used[1], which are presented and reviewed in sections 2.5 and 2.6 for AC and DC respectively. No substantive further written evidence was submitted to AMCL to support the variable percentages proposed, however Network Rail stated that considerable effort was made to check that the percentages proposed were of the right order prior to peer review. This is understood to have been carried out through liaising with maintenance engineers, reviewing maintenance spend and taking into

[1] SBPT3274 - supporting doc - Consultation on EC4T and EAU in CP5; and
Response to Independent Reporter (AMCL) Questions of 27th March 2013

consideration documentation such as the Electrical Power Asset Policy, particularly section 5, which details in some depth the electrification asset degradation mechanisms.

2.3 Justification of EAU Charge Activities Proposed

The identification of activities to be included in the EAU charge has been based on those which are required to address degradation modes arising from utilisation, or 'wear and tear'. In AMCL's opinion ‘wear and tear’ costs associated with electrically powered trains occur due to the passage of train current collectors along Network Rails contact systems.

In AMCL's opinion it is not thought appropriate that ‘wear and tear’ costs should be considered to arise due to load current flow in the electrification system, other than that at the current collector / contact system interface, as the electrification system should be operating within rated capacity and maintained in accordance with the appropriate Network Rail Company Standard.

On the above basis it is not considered appropriate that the activity ‘Transformer Rectifier Unit Renewal’ should be included as an EAU charge activity. Other than this AMCL identified no substantive reason to dispute the inclusion of the other activities.

2.4 Justification of Variable Percentages Proposed

As the variability percentages are based on expert judgement with limited supporting evidence it has not been possible for AMCL to comment in great detail on the adequacy of the variability percentages proposed based on any kind of quantitative review of data. The Network Rail review panel consists of leading experts in this field and therefore in the next sections AMCL's comments on the appropriateness of the percentages are based on a combination of expert subject matter opinion and an assessment of the logic contained in of Network Rail's justifications as repeated in sections 2.5 and 2.6.

For each of the stated activities and percentages, Network Rail's rationale is repeated, followed by AMCL's opinion of its validity.

2.5 AC Electrification

2.5.1 OLE Contact / Catenary Wire Renewal

Network Rail Justification (for 72%)

This is a stand-alone contact / catenary wire renewal. Contact / catenary wire degrades due to the following factors: number of pantograph passages, contact force between pantograph and contact wire, train speed, traction current being drawn by the train, collector strip material and contact wire material. Network Rail studies have found published references stating a wear rate of 1 mm2 per 10^5 pantograph passages as a rule of thumb for predicting contact wire lifetime. Internal analysis also found a relationship between the number of pan passages and conductor wear.

The contact wire / catenary wire is 80% (V1) variable based on the very strong link between an increase in traffic and asset degradation. If traffic increases expect increased conductor wear, increased hard spots and increased faults, which would lead to the need to renew the contact wire and/or catenary. Given other factors affect wear and not just pan passages the variability is proposed at 90% (V2).

AMCL Opinion

In AMCL's technical opinion the value of V1 appears reasonable as there is clearly a strong link between traffic and asset degradation based on the stated references. The value of V2 is also considered reasonable, as there are not believed to be many 'other factors' that would affect asset degradation to a significant degree. AMCL therefore has no substantive reason to challenge the percentages put forward.

2.5.2 OLE Mid-life Refurbishment

Network Rail Justification (for 42%)

Mid-life refurbishment of the OLE system includes combinations of renewal of contact wire, catenary wire, droppers and jumpers, insulators and registration equipment. As noted above all of these components degrade, to varying degrees, as a direct result of traffic movements causing electrical and mechanical stresses on the components. Network Rail has identified a first generation of degradation relationships where the category of line (i.e. the utilisation) affects the rate of change of the condition of the OLE system asset. This is supported by the output from the OLE MACRO project, which sets differentiated maintenance interventions for different category of line. The output of the OLE MACRO project is summarised in Network Rail/L2/ELP/21087.

A significant proportion of the scope of works for a mid-life refurbishment is traffic related (as defined in the Unit Rate work book) and so it is estimated that, on average across the different refurbishment activities, there is circa 60% (V1) of the activity that is affected by traffic. Of this,

like contact wire, a large percentage of the cost varies with traffic - this has been estimated to be 70% (V2).

AMCL Opinion

In AMCL's technical opinion increased train paths will lead to increased wear through mechanical movement of a significant number of the Mid-Life refurbishment assets and so AMCL has no substantive reason to challenge the logic or percentages put forward.

2.5.3 OLE Full Renewal

Network Rail Justification (for 10.5%)

Full renewal of the OLE system includes renewal of structures, contact wire, catenary wire, droppers and jumpers, insulators, registration equipment and along track conductors. As noted above all of these components degrade, to varying degrees, as a direct result of traffic movements causing electrical and mechanical stresses on the components. Network Rail has identified a first generation of degradation relationships where the category of line (i.e. the utilisation) affects the rate of change of the condition of the OLE system asset. This is supported by the output from the OLE MACRO project, which sets differentiated maintenance interventions for different category of line. The output of the OLE MACRO project is summarised in Network Rail/L2/ELP/21087.

A significant proportion of the scope of works for a full renewal is non-traffic related i.e. structures and so it is estimated that there is circa 15% (V1) of the activity that is affected by traffic. Of this, like mid-life refurbishment, a large percentage of the cost varies with traffic - this has been estimated to be 70% (V2). Note - There are no costs with this activity yet but in future CPs full renewals will begin to appear in line with the OLE Lifecycle model as set out in the EP asset policy.

AMCL Opinion

In AMCL's technical opinion a low proportion of the assets involved in a full renewal are affected by traffic. The majority of the assets involved are long life and not affected by traffic volumes (for example the supporting structures). Therefore the timing of full renewals is likely to be planned around the degradation of these assets and would only vary slightly due to the degradation of the traffic-affected assets as these can be replaced through the other interventions mentioned in this section. As a result, in AMCL's opinion this percentage would appear to be potentially higher than expected. However, as noted above, there are no planned full renewals in CP5 and

hence this does not have any effect on the proposed CP5 EAU charge rates as there are no input costs related to this in the model.

2.5.4 OLE Component Change

Network Rail Justification (for 10%)

The scope of this activity includes renewal of assets such as neutral sections, section insulators and other key OLE components. These are degraded, in part, by pan passages - most notably sectioning devices.

There are a number of other factors such as obsolescence that are impacting the renewal activities in this category hence only 25% (V1) has been estimated to be affected by traffic and 40% (V2) proposed for the element that varies.

AMCL Opinion

In AMCL's technical opinion there are a number of OLE components that will logically degrade with traffic and this is an area which via a small change to Network Rail's cost recording approach could, in the future, be proved quantitatively. Within the constraints of this review, AMCL has no substantive reason to challenge the logic and percentages put forward.

2.5.5 OLE Maintenance

Network Rail Impact and Justification (for 12%)

Section 5.2.1 of the Electrical Power asset policy describes the degradation mechanisms for OLE systems. Utilisation is a key factor of degradation - as pan passages increase there is an increase in contact wear and frequency of contact forces on the OLE wire run assets. This will cause additional mechanical and electrical fatigue, which can contribute to the speed at which defects emerge on the system. These defects are managed by reactive maintenance or as part of planned maintenance activities where access times allow. The E&P MACRO risk based studies identified the need for a different inspection and maintenance regime based on two key parameters - pan passages and line speed. It follows then that as traffic increases OLE maintenance will increase both for planned and reactive activities. The regime is set out in Network Rail/L2/ELP/21087 'Specification of Maintenance and Defect Prioritisation of 25kV Overhead Line Electrification Equipment'.

The majority of OLE maintenance costs (inspections, intrusive maintenance and reactive works) are sensitive to traffic variations. This has been estimated as circa 80% (V1). Of this some 15%

(V2) varies due to traffic. This is made up of 5% that is related to pan passage increases and the impact on planned maintenance works and 10% related to reactive works. The former has been assessed by looking at the impact of change of pan passages on the OLE line category and therefore maintenance costs while the latter has been assessed by considering the wire run reactive works cost percentages compared to the overall maintenance budget.

Network Rail determination of 80% (V1): The V1 figure for this intervention activity was taken from a qualitative analysis of the inspection and maintenance regime for OLE Network Rail/L2/ELP/21087. This analysis estimated the percentage of inspection and maintenance activities that are variable with increases in traffic – the majority of these relate to proactive foot patrol inspections and intrusive maintenance activities, which vary by line category. It also takes account of the volumes of defect and fault management, which are also prioritised by line category. This was estimated at 80% and this was supported by analysis of historic work volume activity.

Network Rail determination of V2: The figure for V2 is broken down into two parts. The first relates to an assessment of variability by considering increases in pan passages whilst the second relates to the expenditure related to reactive works for certain OLE standard jobs which were considered to be influenced by traffic increases.

Network Rail determination of 5% (part 1 of V2): When assessing the impact of pan passages the line categorisation shown in Network Rail/L2/ELP21087 was considered to determine the impact of transitioning from one OLE category to another.

The average annualised cost for an OLE wire run (tension length) maintenance was estimated as follows:

- *Category (Cat) 1 OLE - £2100 / annum*
- *Cat 2 OLE – £1500 / annum and*
- *Cat 3 OLE - £900 / annum.*

Given that the maintenance of the 'do minimum' Cat 3 regime is circa £900/annum then we are interested in the impact of the cost of moving from a Cat 3 to Cat 2 and Cat 2 to Cat 1.

The cost per pan passage changes in Cat 3 wire runs may be calculated by dividing the cost of maintenance by the number of pan passages Cat 3 covers i.e. 49.

So £900/49 = £18.36 per pan passage increment.

The cost difference between Cat 1 wire runs and Cat 2 wire runs is circa £600/annum. If we consider this as the difference between the boundary areas of Cat 2 and Cat 1 then £18.36 represents a 3.1% change per pan passage increment. This semi-quantitative analysis was rounded up to 5% to take account of the fact that presently there is no upper limit on the Cat 1 pan passages. This means that there is no increase in proactive costs but the reactive costs would increase in proportion to traffic increases.

Network Rail determination of 10% (part 2 of V2): When considering the impact of increases in traffic (pan passages) on reactive maintenance an assessment of the costs associated with reactive defect related standard jobs was made. Only costs relating to the OLE wiring (contact, catenary, droppers, jumpers, insulators, neutral sections, etc.) were included. The analysis determined that this related to circa 10% of the overall annual cost of OLE inspection and maintenance.

AMCL Opinion

Network Rail did not produce written evidence of the 'analysis of historic volume activity' referenced above with respect to the determination of V1. However, in AMCL's opinion the value of V1 appears reasonable as the majority of OLE maintenance costs are considered to be sensitive to traffic variations, therefore AMCL has no substantive reason to challenge the percentages put forward for V1.

Network Rail/SP/ELP/21087 graphically shows OLE Category 3, Category 2 and Category 1 in terms of pan passages per day and in terms of line speed.

The logic behind Network Rail's determination of the 5% figure for variability in Maintenance is unclear to AMCL. It refers to standard NR/L2/ELP/21087 which contains the following rules for allocating the Maintenance regime for a section of OLE, based on the pan passages (per day) and the line speed.

Ref:	NR/L2/ELP/21087
Issue:	5
Date:	05 March 2011
Compliance date:	04 June 2011

- 115 mph and 151 pan passages is Category 1;
- 60 mph and 200 pan passages is Category 1;
- 60 mph and 100 pan passages is Category 2;
- 60 mph and 40 pan passages is Category 3.

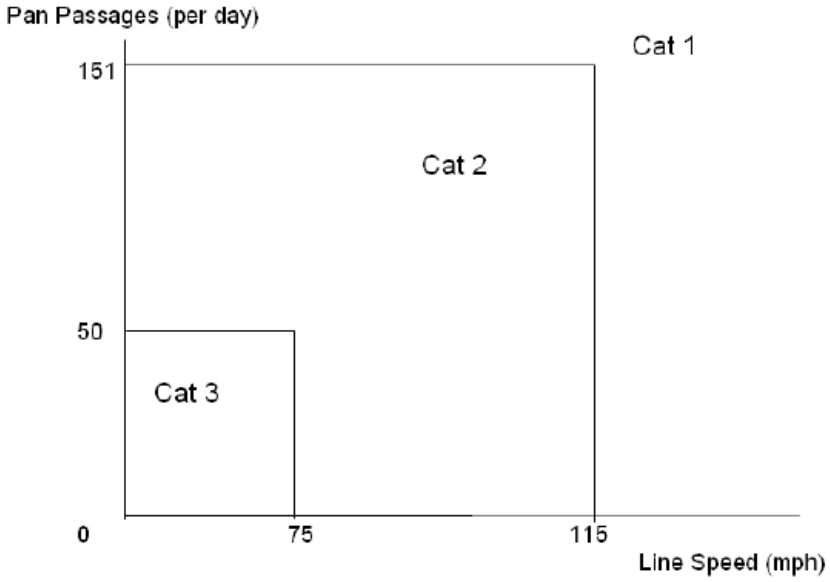

Figure 2 OLE Risk Based Maintenance Categories (extracted from NR/L2/ELP/21087)

The banding of the categories has not been fully explained. It would be expected that the cost for each Category would consist of a fixed amount and a variable amount. Of the variable amount, some will be attributable to line speed and some to utilisation (pan passages). Network Rail's analysis appears to try to estimate the impact of the 'Pan Passages' factor, but this does not take into account linespeed and it is not clear why the analysis is working from the above chart output rather than the underlying relationship between Pan Passage and the required maintenance activities. Given Network Rail's work in its modelling for the SBP it would be expected that these underlying relationships would be available.

AMCL has some further concerns about how Network Rail's logic is then translated into the overall percentage figure used for V2. The percentage of the overall charge which is attributable to usage varies by category, but there does not appear to have been an attempt to calculate how much of the overall network is in each category and use this to estimate the overall variability.

It is therefore recommended that this analysis is revisited and more clearly justified, or that this term is dropped from the variable charge until it is better demonstrated.

Network Rail did not produce evidence of the 'assessment of the costs associated with reactive defect related standard jobs' referenced above with respect to the determination of the second part of the V2 percentage but stated that this was based on expert judgement. AMCL has no substantive reason to challenge this percentage.

2.6 DC Electrification

2.6.1 Conductor rail renewal

Network Rail Justification (for 54%)

The wear of conductor rail by collector shoes on electric trains is the primary degradation mechanism for conductor rail. As a result of increased traffic volumes the wear rate will accelerate and lead to earlier replacement of conductor rail. Section 5.6.1 of the electrical power asset policy describes how conductor rail degrades which includes load creep (increase electrical loads and traffic volumes), wear/erosion (due to current collector shoes) and corrosion. The 'web' of the conductor rail corrodes due to environmental conditions while the head of the rail degrades due to the passage of trains. There is a first generation linear degradation rate for conductor rail that varies by type of rail from 0.27% per year through to 0.97% per year. This rate increases linearly in proportion to traffic increases.

The scope of works for conductor rail renewal activity includes elements that are not directly affected by traffic e.g. guard boards, insulators etc. As a result the renewal activity affected by traffic is 60% (V1) while the element that varies due to traffic is considered to be 90% (V2).

AMCL Opinion

It is well accepted that the major cause of wear is due to current collector shoes passing over the third rail. Therefore AMCL has no substantive reason to challenge the logic or percentages put forward.

2.6.2 Transformer Rectifier Unit Renewal

Network Rail Justification (for 4%)

Section 5.4.2 of the Electrical Power asset policy describes how transformers degrade due, amongst other things, to loading / utilisation. Electrical power assets' useful or remaining life is

affected by the utilisation/demand that is place on them. As new electrical traffic is introduced the assets work harder and research has shown that there is a direct link between load (transformer temperature) and remaining life such that remaining life doubles for every 6 degrees C below 98 degrees C i.e. the more load the less remaining life is available to the transformer. Transformer life is affected by load and there are standard models that cover this such as IEC 354-1991. The IEC model requires a case-by-case assessment and detailed loading input data. In addition traction rectifier transformers are subject to thermal stresses as a result of the high levels of fluctuating loads.

It is estimated that 40% (V1) of the transformer renewal activity is affected by traffic but, again, only a small percentage of the activity varies with organic growth. This is estimated at around 10% (V2).

AMCL Opinion

As stated in section 2.3, in AMCL's opinion it is not thought appropriate that 'wear and tear' costs should be considered to arise due to load current flow in the electrification system other than that at the current collector / contact system interface. The electrification system should be managed and operated within rated capacity and maintained in accordance with the appropriate Network Rail Company Standard.

On the above basis it is not considered appropriate that the activity 'Transformer Rectifier Unit Renewal' should be included as an EAU charge activity.

2.6.3 ETE Maintenance

Network Rail Justification (for 21%)

The 40% (V1) figure is taken from the assessment of reactive costs for conductor rail when compared to the overall spend profile for electrical traction equipment maintenance. 52% (V2) has been identified from the ratio of costs for activities that are sensitive to traffic increases against the overall expenditure for conductor rail reactive maintenance activities.

The present maintenance regime for ETE is more reactive than the comparable regime for OLE (however, this is currently under review as part of the RBM/RCM programme for E&P assets). As a result the figure for V1 for this intervention type was based on an assessment of historic costs pertinent to ETE maintenance and in particular conductor rail maintenance (planned and reactive). The amount identified for the year analysed (10/11) was some £2.44m out of a total expenditure of circa £6m i.e. 40%.

The determination of the V2 percentage was made following a similar approach. The standard jobs that were most directly linked to traffic were identified (using expert judgement) and the total expenditure calculated. The standard jobs that were analysed were those that summated to the £2.44m figure and of those some £1.28m was considered as pertinent to the derivation of V2. This provides the figure of 52%.

AMCL Opinion

Network Rail did not provide written evidence of the 'assessment of historic costs' undertaken in the determination of V1 or of the 'standard jobs that were analysed' that were most directly linked to traffic with respect to the determination of V2.

Based on the above and further clarification from Network Rail, planned maintenance costs were not considered to be included in this charge as this is a time based regime and is not variable by traffic. Therefore in AMCL's opinion taking 40% of the total ETE maintenance expenditure (planned and unplanned) would be appear to be potentially high. AMCL would also consider that stating 52% of all unplanned ETE maintenance is due to traffic appears high, particularly when it is considered that the equivalent figure put forward for OLE unplanned maintenance was 10%.

3 Computational Accuracy

3.1 Original Model

Appendix A sets out AMCL's understanding of the process flow for Network Rail's original EAU charge model. No errors were found in the computational accuracy of the calculation methodology for the CP5 rates and the model is consistent with the explanation set out in 'SBPT3274 - supporting doc - 2012 12 19 EAU CHARGE MODEL (DEC 2012) - note' which was provided by Network Rail as part of the suite of documents for this review.

AMCL questioned the validity of using only 14/15 forecast traffic as a basis to set the charge for the whole of CP5 and that using the CP5 average forecast traffic would provide a more accurate result. Network Rail agreed with this statement but stated that using only the 14/15 forecasts was consistent with the methodology used in calculating the variable usage charge.

AMCL found that there was an error in the conversion of the Freight element of the CP4 rates from 11/12 prices to 12/13 prices. However, the converted CP4 figures are used for comparison purposes only and do not have an effect on the proposed CP5 charge rates. The model process stated that these had been converted to 12/13 prices and then from miles to km; but in the conversion from 11/12 to 12/13 prices these were also erroneously divided by an extra miles to km conversion factor. The original numbers from the model are set out in Table 4.

	CP4 RATES (£/vehicle mile for pass or £/KGTM for freight, 11/12 prices)		**CP4 RATES (£/vehicle mile for pass or £/KGTM for freight, 12/13 prices)**		**CP4 RATES (£/vehicle km for pass or £/KGTkm for freight, 12/13 prices)**	
	AC	**DC**	**AC**	**DC**	**AC**	**DC**
Franchised Passenger	0.0118	0.0045	0.0122	0.0046	0.008	0.003
Freight	0.1120	0.0597	0.1857	0.0990	0.115	0.061

Table 4 Network Rail Conversion of CP4 rate

The actual rates should be as set out in Table 5.

	CP4 RATES (£/vehicle mile for pass or £/KGTM for freight, 11/12 prices)		CP4 RATES (£/vehicle mile for pass or £/KGTM for freight, 12/13 prices)		CP4 RATES (£/vehicle km for pass or £/KGTkm for freight, 12/13 prices)	
	AC	DC	AC	DC	AC	DC
Franchised Passenger	0.0118	0.0045	0.0122	0.0046	0.008	0.003
Freight	0.1120	0.0597	0.1154	0.0615	0.072	0.038

Table 5 Correct Conversion of CP4 rates

3.2 Changes Following 11th April 2013 Update

At the initial meeting with Network Rail, AMCL was informed that Network Rail had found that the renewals input numbers did not match with the current Tier 0 model (strategic forecasting model) numbers and that these were to be updated and the model would be reissued.

Network Rail released the updated model on Thursday 11th April 2013. This update contained a number of changes, not just an update to Tier 0 model renewal input numbers. Network Rail listed out all but one of the changes in the model. The changes are summarised and discussed in Table 6.

Nature of Update	Worksheet	AMCL Comments
26 March 2013 update: cells w19 and x19 corrected (now converted to km once)	EAU charge (Apr '13)	This is has corrected the original error in converting the CP4 charges to 12/13 prices
26 March 2013 update: Renewals numbers a99: ab122 updated (CP6-CP11 updated so consistent with tier 0)	Renewals (26-03-13)	New input number used. This is as Network Rail originally stated would be updated
26 March 2013 update: RPI uplift made consistent with billing approach i.e. Nov - Nov (W13)	EAU charge (Apr '13)	11/12 to 12/13 conversion rate has been changed from 1.03 to 1.052. Network Rail stated that this is consistent with billing but it is not consistent with SBP uplifts.
3 April 2013 update: maintenance breakdown (maintenance summary sheet, cells C17 - P18) 49% for OLE maintenance and 8.5% for con rail maintenance.	maintenance summary (030413)	Network Rail stated that the maintenance figures were overstated as they contained variable and non-variable charges and that this corrected this error.

Nature of Update	Worksheet	AMCL Comments
4 April 2013 update: addition of new rows in Renewals (26-03-13) tab for conductor rail to rectify mapping of costs such that only conductor rail renewal costs are included in the charge.	Renewals (26-03-13)	Network Rail stated that upon analysis not only were Tier 0 model input figures incorrect but that there were a number of costs which should not have been included in that activity line. This addition was to create accurate input numbers.
4 April 2013 update: addition of new rows in Renewals (26-03013) tab for OLE Other and Mid Life Refurbishment activities to rectify mapping issues such that only appropriate elements are included in the charge.	Renewals (26-03-13)	Network Rail stated that upon analysis not only were Tier 0 model input figures incorrect but that there were a number of costs which should not have been included in that activity line. This addition was to create accurate input numbers.
10 April 2013 update: costs now divided by annual average forecast traffic across CP5 (instead of 2014/15 forecast traffic). See TABS 'TF P elec veh km' (cells AK1405:AL1406) and 'EF F elec KGTkm' (cells AH216:AI216)	TF P elec veh km EF F elec KGTkm	This is in line with AMCL's comments on the computational accuracy of the original model.

Table 6 Network Rail's noted Model Changes

Further to the above stated changes there was also one further change which AMCL has noted and which has resulted in an error being introduced to the CP4 comparison rates. This is summarised and discussed in Table 7.

Nature of Update	Worksheet	AMCL Comments
Conversion factor for £/vehicle mile & £/KGTM to £/vehicle km & £/KGTkm switched from divided by to multiplied by.	EAU charge (April'13)	This is an unstated change which introduces a conversion error.

Table 7 Additional Model Changes

The overall effect of these changes on the proposed CP5 EAU charge rates is significant, as can be seen when comparing the original rates (as stated in Network Rail's consultation response) listed in Table 8 with the new rates in Table 9.

	CP5 Rates (pence per vehicle mile for pass or £/KGTM for freight, 12/13 prices)	
	AC	DC
Franchised Passenger	1.96	2.08
Freight	0.3662	0.2300

Table 8 Original CP5 proposed EAU Charge rates

	CP5 Rates (pence per vehicle mile for pass or £/KGTM for freight, 12/13 prices)			
	AC	**% change**	**DC**	**% change**
Franchised Passenger	2.59	32.5%	0.88	-57.7%
Freight	0.4637	26.6%	0.0858	-62.7%

Table 9 New CP5 Proposed EAU Charge Rates

The above changes to the CP5 rates are due to significant changes to the input costs in the EAU charge model and the way these are derived from the original Tier 0 model numbers for renewals and stated maintenance costs. These are not due to any changes to the way in which the model works and so fall outside of the scope of this work and so have not been subject to any further analysis by AMCL.

4 Conclusions

Following completion of the review summarised in this report, AMCL has identified a number of key conclusions. These are grouped and documented in the following sections.

4.1 Overall Methodology

The key generic conclusions on the overall methodology are as follows:

- Network Rail stated that the charge calculation methodology is broadly the same as that in CP4 but with the cost window extended to 35-years to provide consistency with the approach used for the variable usage charge (VUC).
- As Network Rail could not produce any information evidencing the decisions behind the CP4 assumptions on variability AMCL cannot judge whether the new approach is more detailed or where it has improved.
- The Network Rail EAU charge panel are the leading Network Rail experts and in AMCL's opinion are appropriately qualified to assess the traffic impacts on costs.
- The logic of the V1/V2 methodology using the statements provided by Network Rail appears to be reasonable when applied to the renewals elements. However, AMCL would challenge if this is the most appropriate methodology for calculating the maintenance elements of cost. A potentially different approach would be to try and prove a relationship between unplanned maintenance and traffic volumes using Fault Management System (FMS) and Ellipse data.

4.2 Technical Rationale

The key conclusion identified by AMCL relating to the technical rationale behind Network Rail assumptions, justification and use of engineering judgement are as follows:

- There appears to be little justification for the assumptions as there is no formal record explaining the discussions and decisions from the expert panel or any written record of the detail of any analysis that was quoted as taking place. As there has been little quantitative evidence to analyse, AMCL has looked to challenge the assumptions only where an alternative logical case can be put forward. It was only in written response to AMCL questions that further information was documented. The lack of written justification will in AMCL's opinion make it difficult to repeat this exercise in the future and justify the results, especially where there are changes in opinion between Control Periods.

- In AMCL's opinion, 'wear and tear' costs associated with electrically powered trains occur due to the passage of train current collectors along Network Rails contact systems. Therefore in AMCL's opinion it is not thought appropriate that 'wear and tear' costs should be considered to arise due to load current flow in the electrification system other than that at the current collector / contact system interface. The electrification system should be managed and operated within rated capacity and maintained in accordance with the appropriate Network Rail Company Standards.
- AC planned maintenance costs will change with traffic due to the risk based nature of the inspection categories but this is not a linear relationship and on many lines significant traffic increases could take place with no change in inspection regime. Therefore AMCL would challenge the appropriateness of including this in the charge.
- AC and DC unplanned maintenance logically have a relationship to traffic volumes for certain assets. Network Rail should be able to demonstrate how unplanned maintenance varies with traffic volumes by analysing information from the FMS and Ellipse system which would allow it to apply a single variability figure to the unplanned maintenance costs.

4.3 Computational Accuracy

The key conclusions identified by AMCL with respect to the computational accuracy of the model are as follows:

- In the calculation of the CP5 EAU charges the model appears to have no computational errors.
- There were errors in the conversion to 12/13 prices of the CP4 charge for comparison. The error in the first model release was corrected but a secondary error was then introduced by reversing the conversion figure.
- The second release of the model during the review process introduced a significant number of changes within the charging model but upon inspection, for the CP5 calculation, these have only affected the manipulation of the input costs and had no material impact on the model's computational accuracy.

4.4 Longer Term

The key conclusion identified by AMCL for the longer term calculation for the EAU charge is as follows:

- The extent of un-recorded expert judgement in the determination of CP5 EAU Charges may make it more onerous to demonstrate continuous improvement and refinement in later Control Periods.

5 Recommendations

5.1 Immediate Actions

The following recommendations should be completed prior to the agreement of EAU charges for CP5:

1) Network Rail should remove the 'Transformer Rectifier Unit Renewal' activity from the proposed EAU charge as these should be managed and operated within rated capacity.
2) Network Rail should remove the AC planned maintenance factor from the proposed EAU charge as there is not a linear relationship between traffic and spend and on review of the figures put forward by Network Rail the costs appear to be minimal.
3) Network Rail should determine whether it is feasible to carry out an analysis of unplanned maintenance to produce a single percentage figure for how unplanned maintenance varies with traffic, which should then be applied to the predicted unplanned maintenance costs. If this is not feasible using current data this should be included in the next review process.
4) Network Rail should reverse the error introduced through the conversion of the CP4 figures from £/vehicle mile & £/KGTM to £/vehicle km & £/KGTkm in the second release of the EAU charge model.

5.2 Longer Term

The following recommendations are longer term and should be completed before any review of the EAU charge for CP6:

5) Network Rail should establish revised cost categories that enable ‘wear and tear costs’ to be recorded as this would enable a reduced reliance on engineering judgement in future.
6) Where judgement is still required, this should be documented such that it can support statements on EAU Charges referenced in future periodic reviews.

Appendix A Original EAU Charge Model Process Flow