Subject	CCR – Summary of Project QA Procedures		
Date	4 October 2013	Job No/Ref	227755-00

1 Introduction

This note has been prepared at the request of Network Rail to provide a summary of the QA procedures used by Arup on the Capacity Charge Recalibration (CCR) project.

The following areas are covered:

1. Summary of Arup's overall Quality Assurance process on the project;
2. Summary of checks in the data development stage of the project; and
3. Summary of approach and checks undertaken in the tariff calculations stage;

Additional analysis or checking of datasets has been not been undertaken to support this technical note. As such, this technical note should not be considered a full independent audit of the analysis.

2 Overall Quality Assurance Process

Quality assurance on the CCR project has followed Arup's company-wide combined management system (Arup Management System or AMS) approved by Lloyds Register Quality Assurance. This sets the parameters for quality control. This system is routinely audited by independent auditors on both project and system levels. AMS concentrates on defining responsibility levels and powers available to each layer of management, and defines the checks and balances which one layer imposes on another (for example, the preparation, checking and approval of deliverables).

Our AMS includes a series of Operating Procedures that have been followed. Those relevant to the CCR project are:

- Commission: This ensures that the project is correctly registered within our business system, and that the correct staff, with appropriate skills and experience are assigned to the project tasks. Arup's formal proposal, including the proposed approach, was accepted by Network Rail and can be made available for review as required;
- Project Inception Review: The review concentrates on understanding the Client's requirements and clarification through discussion. Any changes to the scope of work, compared to the proposed approach in the commission stage, are formally recorded. Arup issued a formal inception report to Network Rail on the 7th December 2012;
- Project Plan: As part of the Inception Review, a Project Plan (PP) and programme was prepared. The project plan defined the project procedures and the work to be undertaken;
- Project Input Requirements: Collating input data and information was an important part of the project. Data requirements were documented in the inception report, including information on the owner and status of data. The data table was subsequently used to ensure that Arup received all the required information to complete the recalibration;
- Project Verification: These procedures are used to ensure that our output meets client requirements. Reviews of reports and analysis were completed at each stage of the project to

coincide with issuing each major deliverable. In addition to checking by each major deliverable is approved by the Project Manager or Director;

The table below provides a list of the project deliverables that have been subject to Arup's project verification procedures. Network Rail, ORR and Industry stakeholders (via the Capacity Charge Working Group) have been given had the opportunity to provide feedback on these deliverables.

Deliverable	Date Issued
Stakeholder Presentation 1	22nd November 2012
Inception Report	7th December 2012
Progress Report	21st December 2012
Draft Report	19th January 2013
Stakeholder Presentation 2	13th February 2013
Stakeholder Presentation 3	7th March 2013
Draft Capacity Charge Pricelist	5th April 2013
Final Report	24th May 2013
Updating the Tariff User Guide and Tool ISSUE 1	26th July 2013
Final Capacity Charge Pricelist (Incorporating final Schedule 8 Payment Rates)	22nd August 2013
Updating the Tariff User Guide and Tool ISSUE 2 (Incorporating final Schedule 8 Payment Rates)	26th July 2013
Capacity Charge Pricelist for missing service codes	10th September 2013

3 Data Development

Developing the underlying Capacity Utilisation (CUI) and Congestion Related Reactionary Delay (CRRD) dataset for the project is an important aspect of the analysis and underpins the recalibration. This section provides a summary of the checks undertaken to ensure the quality of the underlying data. The summary here is based on documentation provided in the Draft and Final reports. Please refer to these reports for technical definitions and detailed explanations of the overall approach.

3.1 Coding the Constant Traffic Section (CTS) Network

The CTS network coding was based upon the adaptation of an existing CTS dataset provided by Network Rail. The dataset was extended by Arup to include recent additions to the railway network (e.g. the East London Line component of London Overground and Airdrie – Bathgate), and also expanded to include additional fields, such as CTS length (converting from miles, chains and yards to miles expressed as decimals for the purposes of subsequent calculations) and the number of tracks in a CTS.

The extent of the CTS network coding precluded a full, independent check within the budget and timescales of the project. We therefore adopted a sampling approach to checking the CTS data for errors or inconsistencies. In the event of a discrepancy being found, the records for adjacent CTSs were also checked and amended as necessary. Using this method approximately 50% of the CTS data records were checked. This is a significant proportion of the data and considered appropriate to demonstrate that the coding exercise had been carried out accurately.

3.2 Assigning CRRD to the CTS Network

The method by which link-based delay data records are allocated to the railway network is such that single delay records are often allocated across multiple CTSs (i.e. there are two or more CTSs between the start and end locations allocated to the delay). In agreement with Network Rail, we adopted three alternative approaches to the allocation of delay: (i) all delay allocated to the first CTS included in a delay record; (ii) all delay allocated to the last CTS included in a delay record; and (iii) delay divided equally between all CTSs included in a delay record. (Note: for node-based delays, the delay was allocated to the link(s) immediately 'downstream' of the node in all cases.) To ensure the maintenance of data integrity delay data to the CTS network, the total values of delay allocated by each method were compared with each other, and with the total delay included in the original delay data supplied by Network Rail, and checked for consistency.

Using the techniques described, 96.2% of overall CRRD minutes were assigned directly to the CTS network. The remaining 3.8% was distributed across the network proportionately. Prior to distributing the 3.8% of remaining minutes analysis was undertaken to test that unassigned delay minutes were representative, and apportioning them was an adequate assumption.

3.3 Calculating Capacity Utilisation Indices (CUIs)

The algorithm used for the calculation of CUIs across the network is based upon the methodology described by Gibson et al. in their 2002 paper entitled *Developments in Transport Policy: The Evolution of Capacity Charges on the UK Rail Network*, and by AEA Technology Rail in their 2005 *Capacity Utilisation Indices Methodology* document. When the algorithm was being implemented in the Perl script written for the calculation process, results produced by the script for a range of different scenarios (varying numbers of tracks, including bi-directional services on single tracks; different combinations of trains; alternate time periods; etc.) were tested and verified against manually-produced results for the equivalent scenarios.

The resulting CUI outputs were also sense-checked, and unusually high (>90%) or low (0%) results were individually reviewed to ascertain their cause. For the very high values, the cause was typically found to be a freight train entering a CTS, and then stopping in a branch or loop within the CTS for several hours before leaving the CTS again: such results were excluded from the subsequent analysis. Some values close to 100% were found to be due to intensive train services at peak times at known 'pinch points' such as Cannon Street – London Bridge, and were retained. Low values were found to reflect very infrequent or no train services on some parts of the network, particularly during the night. This is accurate and these records were retained in the analysis.

All CUI calculations were implemented by the analytical team. High level sense checks were undertaken by the Project Manager and Lead Analyst.

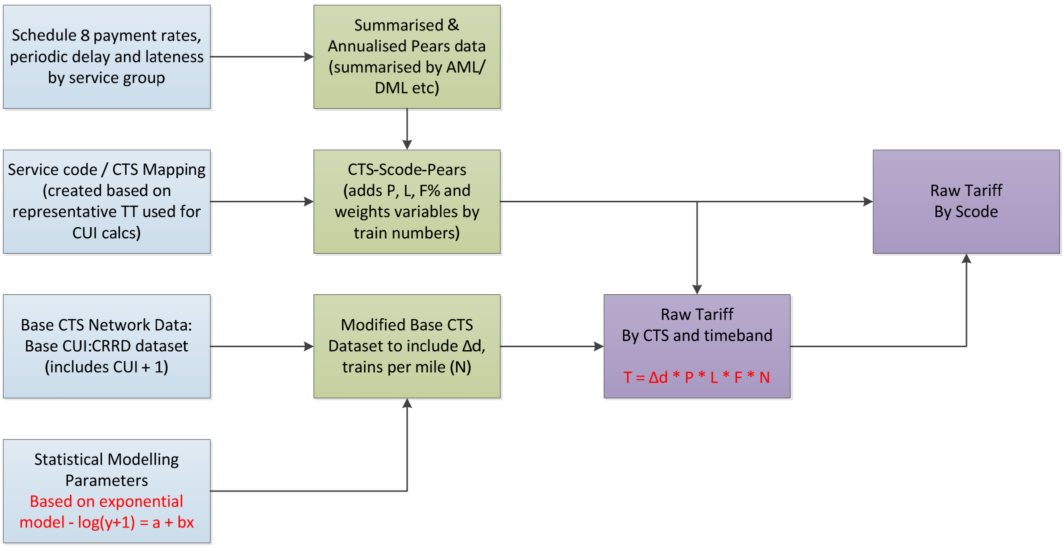
4 Tariff Calculations

Calculating the capacity charge tariffs required the following steps to be undertaken:

1. Application of the CUI:CRRD Relationship;
2. Deriving the cost per minute of delay to Network Rail;

3. Applying the "trains per mile" parameter;
4. Raw tariff calculation for each CTS and timeband;
5. Tariff calculation for service codes;

The diagram below provides a process map of the tariff calculation process and shows how different datasets come together to create raw tariffs for each CTS and timeband and subsequently tariffs by service code. Process mapping of calculations form an important part of ensuring that calculations are specified and implemented correctly.



Tariff calculations were specified and agreed with Network Rail prior to implementation. The approach is based on the approach taken in the previous calibration, which was provided to Arup by Network Rail. Throughout the process, and as part of regular progress meetings, the overall approach to implementing calculations was presented to Network Rail.

All calculations were implemented by the analytical team. As part of implementing calculations checks are built into the process. For example, a check is undertaken to ensure that the number of records in each dataset is accurate and no data is lost. Totals are also checked at intermediate stages to ensure that the number of trains, and delay minutes, are consistent between intermediate datasets.

Once the analytical team have implemented calculations all datasets were reviewed by the Project Manager or Lead Analyst to ensure that a second person (who did not undertake the initial implementation) reviews the calculation.

4.1 Estimated Relationship between CUI and CRRD

A key input to the tariff calculation model is the estimated relationship between CRRD and CUI. This relationship was initially estimated by Imperial College working for Arup. Further sensitivity testing was undertaken by Arup and, in recognition of a degree of uncertainty around the central estimates, a conservative relationship was ultimately used for tariff calculations in order to avoid over-charging. Following publication of draft pricelists in April 2013, Network Rail appointed FTI consulting to critically review the work undertaken by Imperial College, and to re-estimate the relationship. We understand that the FTI work confirmed that the relationship used for tariff calculations was conservative, and that the 'true' relationship between CRRD and CUI is likely to be stronger than that assumed for calculating capacity charge tariffs for CP5. Further information on the FTI work is available from Network Rail.