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Assessing Network Rail's delivery of Network Availability in CP6

25/05/18



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ORR

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1 Executive Summary

1.1 Introduction

The Office of Rail and Road (ORR) as the regulator of Network Rail's (NR) performance is seeking to implement a strategy for monitoring performance with respect to Network Availability during Control Period 6 (CP6). The measure used during CP5 has proven to be ineffective for a number of reasons. Although it is still reported for regulatory purposes, it is understood not to be actively used by any stakeholders. However, the ORR considers the need for a metric that can be monitored and that will influence behaviour as a key element of their role in CP6.

The concept of Network Availability refers to how much of the network is available to run services, i.e. not taken as a possession by NR. The impact of a possession on train operators and ultimate users varies by the location and length of track possessed, and the time of day, week and year. Typically, passenger services are impacted by possessions over weekends, while freight services are affected by night-time works.

The various industry stakeholders will experience Network Availability differently, and not all Network Non-availability should necessarily be counted as equal. For example, possessions that affect more trains, or trains with more passengers aboard, or that are taken at short notice can all be more disruptive. For passengers, disruption that includes bus replacement services is considered particularly undesirable. Furthermore, possession disruption can be measured in terms of the volume or quantum of disruption occurring, or viewed through the lens of an efficiency measure, e.g. how much disruption is required to deliver a certain amount of work.

Throughout CP4 and CP5, the regulatory stance to Network Availability has been based on the measurement and reporting of the Possession Disruption Indicator (PDI). There are two PDI measures, PDI-P and PDI-F, intended to measure disruption to passenger and freight services respectively.

According to industry parties, PDI-P and PDI-F have been plagued by issues with implementation. The metrics are calculated four weeks in arrears, are not consistent when service groups are re-mapped, and the Network Availability Reporting System (NARS) used to calculate the metrics contained errors in implementation. There has therefore been a loss of confidence across the industry in the usefulness of the PDI metrics. Indeed, NR have commented that the PDI metrics have never been valued by the industry.

1.2 Context

In order to clarify the objectives of the study and help drive a measure of success, we have agreed with the ORR the following problem / opportunity statement for the project.

“To meet its duty as an economic regulator, ORR has sought to measure the efficiency of Network Rail in its delivery of a) reliable performance and b) network availability.

The concept of measuring and monitoring Possession Disruption goes back to CP4 and yet has neither caught the imagination of the industry nor drives its behaviours in spite of widespread belief in the utility of measuring the issue. Indeed with the latest index deemed “broken” there is a need to reappraise the metric.

With ever bigger and longer running possessions being used to create economically efficient and timely delivered programmes there is a risk that Train Operators, their customers and local economies will take an ever higher burden



from the impact of possessions. In such a context the measurement of possession disruption seems urgent and necessary.”

Network Availability is likely to become an important issue over the course of CP6 and beyond. Looking forward, there are several trends that will continue to put pressure on NR to perform in its delivery of Network Availability. These include:

- Increased demand and traffic, in terms of greater service frequency and service loading;
- Greater maintenance, renewal and enhancement requirements;
- Government Policy such as de-carbonisation of traction power by 2040, which may require enabling infrastructure works;
- Increasing stringency of health and safety requirements;
- Increasing demand for earlier first and later last trains, leaving less time to take non-disruptive possessions; and
- An increasing pressure on NR to deliver value for money.

The net effect is that NR will have fewer non-disruptive hours to do more work. There is therefore a risk that the ultimate user, or the wider economy, will be adversely affected by an increasing number of disruptive possessions. There is also a need for those possessions that are taken to be utilised effectively, and to be seen to be used effectively.

1.3 Stakeholder Perspective

A critical success factor for the regulatory stance towards Network Availability is acceptance by the industry. Understanding the needs and fears of industry participants is a vital step in determining a regulatory stance that will find acceptance.

Throughout the study, we took the views of a variety of stakeholders, including Government, NR, TOCs and Freight Operating Companies (FOCs). The stakeholder views regarding the regulation of Network Availability had some important common themes.

1.3.1 Network Rail

Network Rail’s National Systems Operator team were engaged throughout the project and had a strong view the PDI-P and PDI-F do not add value to the decision making for the industry. Prior to this study, in May 2017, NR proposed a number of metrics as an alternative to PDI that they believe would influence behaviour and, as they are already calculated, can be implemented quickly and efficiently.

The proposed indicators were dubbed Early Warning Indicators (EWIs).The two EWIs proposed by NR are presented in the table below.

EWI	Description	Reason proposed
Level of Access Disputes	Level of access disputes escalated to Access Disputes Committee (ADC) through the engineering access planning process, or after the Confirmed Period Possession Plan. This is a leading indicator.	To assess whether the access planning processes are working as they should. TOCs and FOCs are incentivised to look after the best interests of the end customers, and if Network Rail are getting the access plans wrong, and disadvantaging the end customer, they have the clear opportunity to dispute the access plans.
Notification Discount Factor	To encourage early notification of Restrictions of Use and better timetable planning, Network Rail is incentivised by notice periods which attract discounts on the Schedule 4 payment rates. This is a lagging indicator.	This information will provide reassurance that Network Rail is developing access plans in line with industry processes and that late change is not increasing over time.



A number of views were expressed as part of the consultation including a suggestion that any approach to assessing Network Availability should rely on customer needs or existing metrics used internally by NR and that inform NR's decisions today.

1.3.2 The Office of Rail and Road

The ORR believes that there can be some improvement to the EWIs proposed by NR. Ideally, a possession disruption measure should:

- reflect passenger experience;
- be easy to comprehend throughout the industry; and
- be easy to understand how to influence.

In addition, a number of other criteria were agreed that have fed into the evaluation.

1.3.3 Train Operating Companies

Network Rail proposed that measuring Network Availability was not a key issue for the industry as TOC's had not raised this as an issue. In order to determine the validity of this assumption we reviewed responses to ongoing consultation work by the ORR on the subject of Network Availability. We have reviewed responses from 9 of the 25 UK TOCs, 36% of the total.

All of the responding TOCs claimed to have been affected by the issue of Network Availability. The majority of respondents were of the view that NR is mindful of the impact it has on passengers when taking possessions. However, there was a sense that improvements were possible despite the challenging trade-offs between maintenance, renewal and enhancement cost and disruption to TOC services and passengers.

1.3.4 Freight Operating Companies

In order to ascertain the views of FOCs, we reviewed responses to ongoing consultation work by the ORR on the subject of Network Availability. We have reviewed responses from four of the seven UK FOCs.

There are concerns that NR is more focused on its TOC customers than its FOC customers, especially in the context of alliancing, where the Alliance is focused on the relationship between the Route business and the dominant local TOC.

Diversions routes are crucial for FOCs to provide the level of reliability that their customers expect. Diversions that pass through multiple Routes are often not coordinated. There are also issues with the provision of W9/W10 freight gauge clearance.

1.3.5 Other stakeholders

In addition to the above, we had conversations with the Department for Transport (DfT) and Transport Scotland. We also engaged the passenger representation organisation Transport Focus. A key point raised was that passengers naturally want the minimum timetable impact, and to minimise the time spent on bus replacement services

1.3.6 Summary of stakeholder needs

Based on a review of the stakeholder engagement, we have identified the following concerns as key issues for the monitoring of Network Availability in CP6.

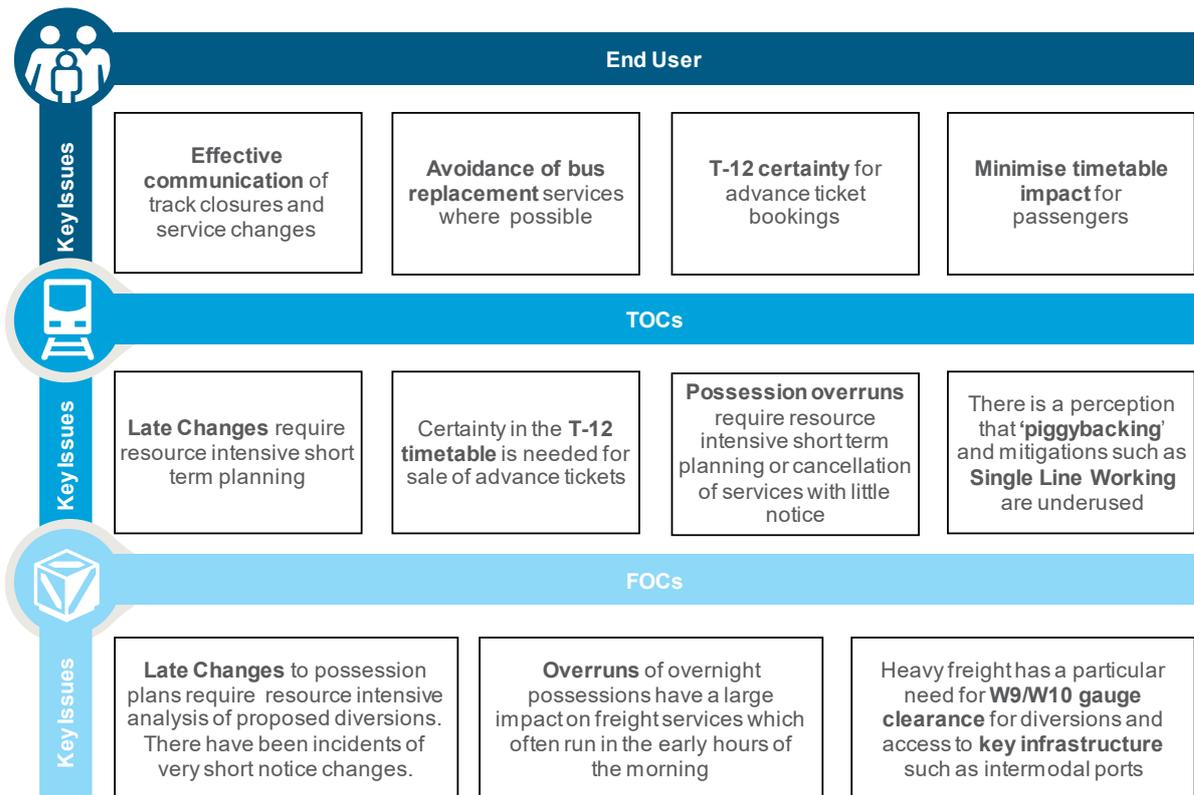


Figure 1: Key issues for NR's customers.

Taken as a whole, we believe the views presented here give sufficient evidence to the notion that possession disruption is an issue that requires some level of measurement and monitoring in principle.

1.4 Efficient use of possessions

Productive efficiency is the production of outputs (maintenance, renewal and enhancement works) by the combination of input factors, in this case financial expenditure and possession disruption.

NR reports transparently on its financial expenditure, but without appropriate regulation it is not fully incentivised to minimise disruption to the ultimate user or wider economy, as discussed above.

A graphical representation of the framework for assessing productive efficiency in this setting is shown in Figure 5. The curve linking A to B shows the possible combinations of inputs (financial cost and disruptive cost) required to achieve a set level of outputs (a certain portfolio of maintenance, renewals and enhancements).

Firstly, the regulator will want to monitor if NR, due to the pressures on Network Availability, moves its strategy from A to B (arrowed). This represents a

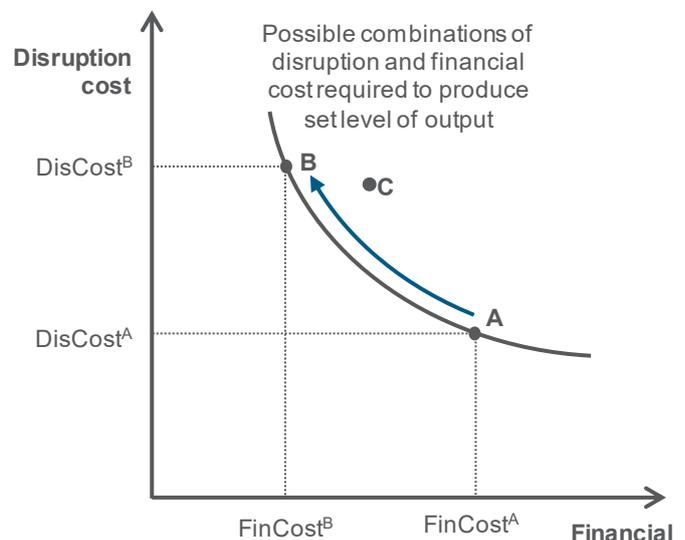


Figure 2: Productive efficiency

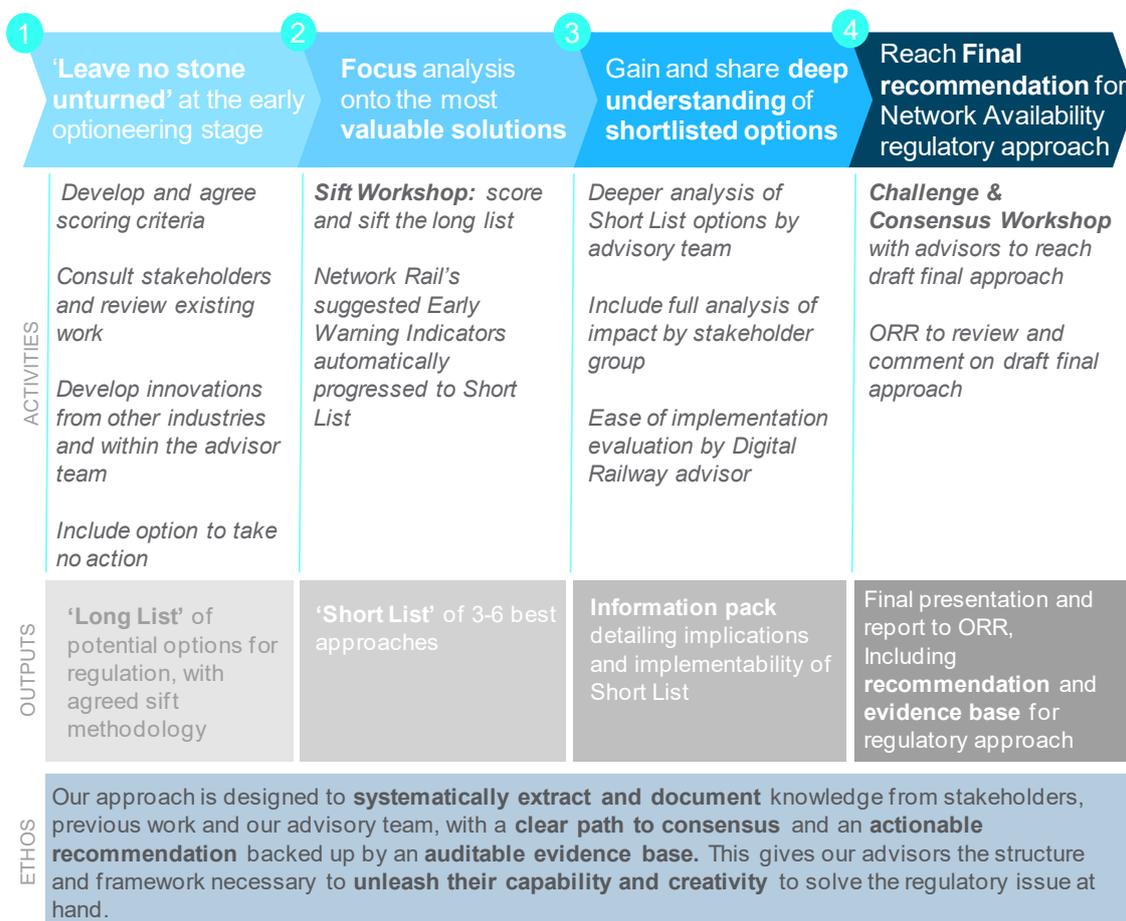


reduction in financial cost traded off against an increase in disruption costs. The preferred position on the curve will be determined by relative weightings of disruption cost and financial cost in the eyes of the regulator, taking all stakeholder consideration into account.

Secondly, the regulator will want to be assured that, in the absence of competitive pressures, NR is not producing at a point such as C, to the right and above of the curve. This would reflect inefficient use of spend or disruptive possessions. Route-level comparisons or benchmarking may allow the regulator to monitor if such a situation arises.

1.5 Methodology

Our approach was to develop a Long List of potential options for measuring and regulating Network Availability, and then score these options against pre-agreed criteria. The options that are deemed most promising were then further developed and discussed with the ORR, DfT, and NR. Lastly, the results consolidated into a recommended suite of measures for understanding the delivery of Network Availability CP6. Our methodology is outlined in the figure below.



1.6 Optioneering & Sift

The primary aim of the Sift process was to move from a Long List of options for regulatory metrics to a plausible shortlist for detailed examination and was undertaken by assessing each option against a set of agreed criteria. The Long List metrics were categorised by the type of insight into Network Availability that they bring.



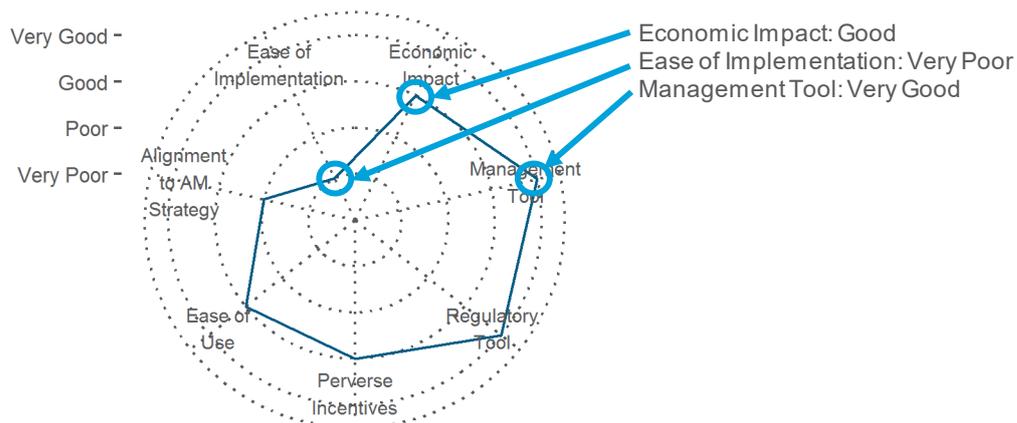
- **Actual vs Planned Availability** – These measures, of which PDI-P and PDI-F are examples, measure the (weighted) average level of the network that is available to run trains.
- **Possession Efficiency Measures** – These measures are loosely defined as ratio of output achieved to disruption caused. For example: metres of track renewed per passenger delay minute.
- **NR Early Warning Measures** – We considered the two EWIs proposed by NR as a distinct category. We also considered a further option, the Possession Value Indicator. This measure was proposed and evaluated by NR, then later withdrawn.

Mitigations and Customer Services and **Approaches from other Industries** were considered on their merits as adjacent measures to provide insight on aspects of possession disruption other than the level of possession disruption and the efficiency of delivering output in possessions. They were not scored according to the same sift criteria of the first three categories.

- **Mitigations and Customer Services** – These measures do not directly measure disruption, but serve as adjacent metrics that offer additional insight into how the network is performing.
- **Approaches from other Industries** – While the challenges facing the rail industry are unique, we have reviewed the approaches taken to Network Availability in other regulated network industries.

The results of the long list assessment are presented in “**spider**” charts. The six criteria are Economic Impact, Management Tool, Regulatory Tool, Perverse Incentives, Ease of Use, Alignment to AM Strategy, and Ease of Implementation. Each criterion is marked on a four point scale: Very Poor, Poor, Good, Very Good.

The solid line indicates the score for each labelled criteria. If the solid line is closer to the centre of the chart, it indicates poor performance against that criterion, and if it is closer to the edge it represents good performance against that criterion. The following example chart provides an example of how to interpret the scores.



1.7 The Shortlisted Options

There were four key metrics that passed the assessment and made the shortlist. In addition, there were four further options that were assessed as adding a valuable contribution to a comprehensive suite of metrics.



1.7.1 The four key metrics

1. Schedule 4 Related Measure

Description: Schedule 4 of the Track Access Agreements incentivises NR to minimise network disruption and insulates TOCs and FOCs from the commercial impact of that disruption.

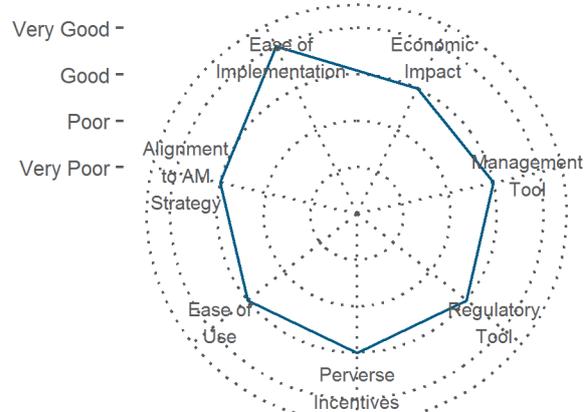
TOCs are compensated for the loss of future revenue from disenfranchised passengers, the cost of operating bus replacement services, costs relating to the cancelled or late amended possessions, and costs relating to a change in train mileage. If train mileage is reduced, the Schedule 4 payments to the TOC will reduce, as they have incurred less cost themselves. Long term possessions attract increased levels of disruption, while giving advance notice to operators attracts a discount via the Notification Discount Factor.

FOCs are compensated a set amount determined by the severity of disruption and the advance notice given. In cases of severe disruption, the FOC may be able to claim for actual costs/losses and liquidated damages.

This metric would simply report the value of Schedule 4 payments in each period at a Route level.

Analysis: Schedule 4 alone is not a sufficient mechanism for incentivising NR to take an efficient level of possessions from the point of view of the passenger and the wider economy. Nevertheless, the systems used to calculate the payments are the most obvious source of data for a possession disruption metric. For example, some components of PDI are drawn from Schedule 4.

By publishing S4 payments a reputational, as well as the existing financial, incentive on NR is created. Although the calculation of Schedule 4 payments is somewhat convoluted, the end result is expressed in currency, which is easy to interpret despite having some disadvantages: payments are made in nominal terms, hindering trend analysis; the currency values could unfairly be seen as a 'fine' paid by NR; and the payment rates are commercially confidential and subject to periodic renegotiation.



2. Comparison of Corresponding Day Timetable against Plan of Day

Description: The Corresponding Day Timetable (CDTT) is a reference timetable with no 'baked-in' possessions. It represents the services operators would run without any restrictions. The Plan of Day (PoD) is the latest timetable planned for each day of operations. It therefore includes all planned, but no unplanned, disruption relative to the CDTT.

This metric would compare the sum of train-minutes scheduled to run in the CDTT with the sum of train-minutes scheduled to run in the PoD. Cancellations should be accounted for using the same methodology as the established Schedule 8 approximation:

Cancellation minutes for service i ≈ 1.5 × service interval for service i

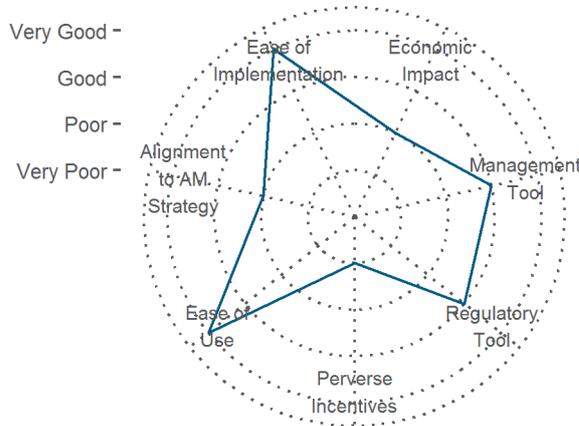
The metric could be expressed as a percentage, to allow consistent inter-temporal comparisons as the timetable is changed.



$$Availability = \left[\frac{\sum_{SG} \sum_D \{EJT_{SG,D} + CM_{SG,D}\}}{\sum_{SG} \sum_D CDTT_{SG,D}} \right]$$

Analysis: While not capturing additional factors such as journey type mix, early notification and impact of bus replacement services, this is a simple measure essentially treating all train-minutes as equal. It is intuitive to understand as the percentage increase in total train journey time across the network due to planned disruption.

As it focuses purely on delay and cancellations, it would be suitable as part of a suite of measures that each focused on a different aspect of possession disruption impact.



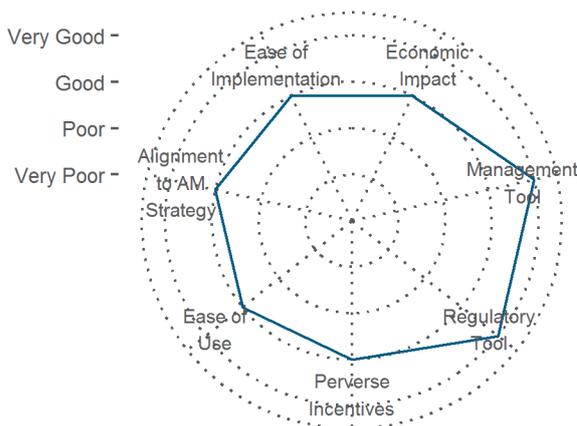
3. PDI enhancement 1: disruption minutes

Description: One of the weaknesses of PDI identified by our early analysis is the unintuitive nature of it being expressed as an index. This metric would be a modification of the current PDI-P and PDI-F, such that it:

- could be reported at a Route level, and
- can be expressed directly as the lost customer minutes / hours in each period, rather than an index.

The benefits of these changes would be the ability to benchmark at a route level, and to have a metric that is customer-focused and easier to comprehend while making use of much of the work and research carried out to produce NARS and PDI.

Analysis: This approach to measuring possession disruption would allow benchmarking of Route performance with suitable normalisation (such as the scheduled train-km used in the current system), and by quoting the metric in easily understood terms such as delay per km sidesteps some of the ease of use issues with PDI. However, it would require a rebuild of NARS, for which NR is not currently funded.



4. Dutch / LUL Lost Customer Hours approach

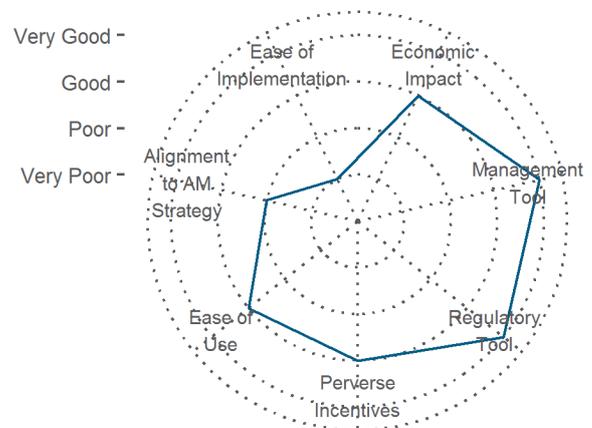
Description: Taking inspiration from the Dutch approach to managing Network Availability, Transport for London currently uses a Lost Customer Hours (LCH) metric. A total lost time impact per hour is modelled and assigned to each section of the network using estimates of train loadings, service frequencies, and time of the week. It is then possible to express the cost, in terms of LCH, incurred for taking possession of any given part of the network.



The Nominally Accumulated Customer Hours (NACHs) database provides a ‘reasonable pre-estimate’ of the passenger time impact of individual incidents on the tube network. It is then possible to provide a granular post-hoc estimate of the actual causes of delay, and therefore identify the worst performing areas to efficiently target investment and resources. The data inputs include: network information such as line geometry, station capacity, and rolling stock; service frequency and transit time; signalling data and fallback plans; and economic and demographic data.

The system has been widely accepted within TfL as a significant contributing factor to improved performance levels and a cultural shift towards becoming a customer-oriented, rather than engineering-oriented organisation. It has been used extensively in the performance framework for PPP contracts. It is also used in business case development to understand the trade-off between works disruption and the benefits of a scheme, prioritise asset maintenance and reliability projects, setting performance targets internally and for contractors, assessing the impact of closures and other operational scenarios, and calculating staff performance-based bonuses.

Analysis: The Lost Customer Hours approach represents a best-practice approach to planning, managing, and contracting Network Availability. It is passenger-focused, and incentivises access planners, train planners, engineers and frontline staff to collaborate on improving customer service. However, its disadvantages are high implementation cost and data requirements. Furthermore, bedding-in the measure across NR, TOCs and FOCs and achieving a cultural shift towards customer service may take several years to achieve.



1.7.2 The additional supplementary metrics

1. Rail Replacement Bus Vehicle-Hours

Description: This metric is the number of vehicle-hours of bus replacement services run each period. Our review of stakeholder needs suggests that passengers typically do not like using bus replacement services, although there are exceptions where higher quality vehicles have been used, or in cases where a passenger’s journey is more closely aligned to the coach diversion route than the rail network.

Analysis: The number of vehicles in a bus replacement service that a TOC is required to run depends on the typical passenger loading of the train services it is replacing. Therefore, bus vehicle-hours are a reasonable reflection of the overall level of passenger inconvenience suffered by passengers on the network. Reducing the number of bus vehicle-hours required incentivises NR and TOCs to find solutions that keep passengers on trains, which is desirable.

2. Late Notice Possession Changes

Description: This metric is calculated as the number of new, cancelled, curtailed or extended disruptive possessions agreed between the issue of the Confirmed Period Possession Plan (CPPP) and issue of the Weekly Operating Notice (WON) that caused the disruptive element of the possession to change (increase or decrease) in length. The CPPP is issued at T-26.

Analysis: Currently reported as part of NR’s Possession Indicator Report, this simple measure gives valuable insight into how well NR is planning its possessions. Unlike the



Notification Discount Factor which is based on the prevailing Schedule 4 regime, the count of late notice possession changes is easy to interpret by stakeholders within and outside of the industry.

FOCs and TOCs have both commented that re-planning services around late changes is resource intensive and, depending on how late the changes are, sometimes disruptive to the ultimate customer. We propose the following alterations:

- T-26 is a 'cliff-edge' cut-off, with all late changes post T-26 being counted equally. However, changes post T-12 (informed traveller, where TOCs may begin selling Advance tickets) or post T-6 (at which point re-planning services becomes more challenging) are evidently more disruptive to operators and passengers alike. *We therefore recommend that late changes post T-12 and T-6 are reported in the same way that late changes post CPPP are currently reported.*
- We noted from conversations with NR that not all late changes cause disruption to services. An example of a non-disruptive change would be the curtailment or a cancellation of an overnight possession, where the original possession did not affect any services in the CDTT. *For the purposes of regulating Network Availability, only disruptive late changes should be reported.*
- Given the increased importance of Route-level devolution, we recommend that, if possible, *late changes should be reported at a Route level.*

3. Delay / Cancellation Minutes & Unplanned TSRs due to Possession Overrun

Description: These metrics assess the impact of possession overruns. They comprise the train delay minutes attributed to possession overruns, the cancellation minutes attributed to overruns, and the count of unplanned temporary speed restrictions (TSRs) put in place as a result of possession incidents. Together, they offer insight into how possessions are being managed on the day of possession.

Analysis: These metrics focus on an aspect of possession disruption not covered in any of the metrics: the disruption due to the management of possessions not going to plan on the day. This can be due to mistakes in judging the amount of contingency time in the work plan, unexpected on-site conditions, or occasionally errors by track workers. While it may not be possible to eradicate the occurrence of possession overruns, TOCs, FOCs, and the ultimate freight and passenger customer can be heavily impacted by them particularly on a congested network such as in the UK.

The current approach used by NR in the Possession Indicator Report is a useful indicator of trends in delay and cancellation minutes. We recommend that if possible the delays and cancellations be reported at a Route level, and the count of overruns is reported alongside total delay and cancellation minutes. This would give sight of if overrun disruption is occurring often, or if disruption impacts are accruing from a small number of isolated incidents.

4. Critical Freight Infrastructure

Description: If industry can come to consensus on a list of critical infrastructure for freight, the count and average duration of incidents of non-availability should be reported.

Analysis: We note that the availability of critical infrastructure such as freight interchanges and major ports are naturally crucial for operation of freight services. In addition, the availability of W9/W10 gauge cleared diversions has been reported as an issue in CP5. We therefore propose

1.7.3 The additional supplementary metrics

The following diagram summarises the metrics retained through the optioneering and sift process. Each retained metric has been mapped to a specific aspect of possession disruption impact and relevant stakeholder group.

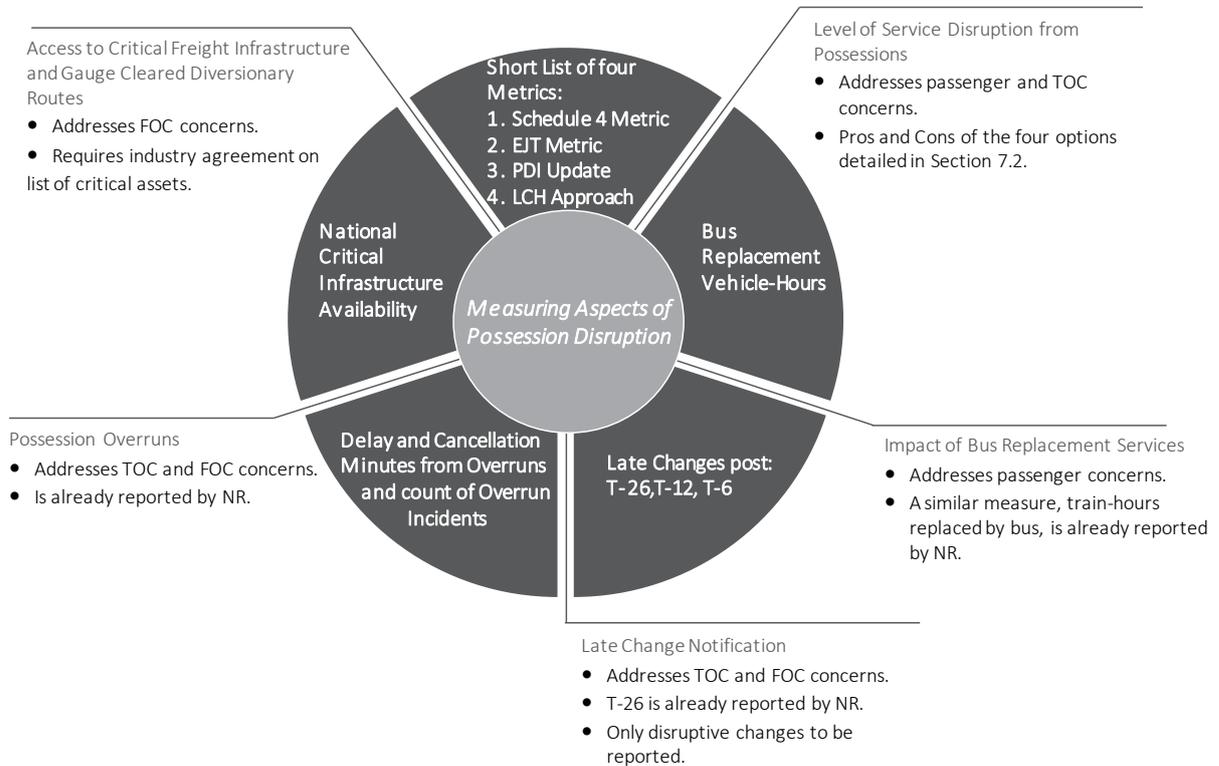


Figure 3: Suite of measures emerging from Sift Workshop.

1.8 Defining possession disruption metrics

We have considered in detail a Short List of the four possession disruption metrics defined above. These metrics are:

1. A Schedule 4 Measure;
2. An Excess Planned Journey Time Measure;
3. An Update to PDI;
4. A 'Dutch' Lost Customer Hour Approach.

Options 1-3, and possibly option 4, would make use of the existing Schedule 4 systems and infrastructure.

1.8.1 Schedule 4 metric

The Schedule 4 metric would report the total Network Rail Schedule 4 payment made in each period.

1 S4 Measure

Definition:	Level of Schedule 4 payments
Unit:	£ GBP
Timeframe:	Periodic
Route-level to national level aggregation:	Sum of payments for each route

Schedule 4 payments are calculated via a complex system of equations. The payments from NR to operators mitigates the loss of present and future revenue, the cost of running replacement buses, the change in train operating costs relative to the non-disrupted timetable, and costs relating to cancelled / late amended possessions. The payments are discounted if early notification is given.

Strengths	Weaknesses
<ul style="list-style-type: none"> ▪ Already an accepted industry measure. ▪ A potential path of least resistance. ▪ If TOC revenue is a good proxy for passenger experience, it is a sophisticated measure that captures many elements of lost revenue. 	<ul style="list-style-type: none"> ▪ As an existing metric, it fails to sufficiently incentivise good possession planning as reported by operators. ▪ It does not effectively incentivise balancing works cost against the wider economic costs of possession disruption. ▪ As a nominal GBP measure it is not independent of inflation. ▪ Payment rates are reset periodically, hindering trend analysis. ▪ Quoting the impact of Network Availability as a monetary quantity could be perceived as ‘fining’ Network Rail for taking necessary possessions in their day-to-day operations.

1.8.2 An Extended Journey Time metric

The Extended Journey Time (EJT) metric is a cut-down version of the Schedule 4 measure. It captures the increase in journey time and Cancellation Minutes in the Plan of Day compared to the Corresponding Day Timetable. This metric was developed out of Option 4: Comparison of Corresponding Day Timetable against Plan of Day from the optioneering and sift process.

2 Excess Planned Journey Time Definition

Definition:	Relative / absolute increase in the Corresponding Day Timetable total journey time
Unit:	Relative / absolute increase in journey time over CDTT total journey time
Timeframe:	Periodic / weekly
Route-level to national level aggregation:	Dependant on Service Group Weighting (SGW)

The EJT metric represents an effort to ‘strip down’ the Schedule 4 payment mechanisms to create a simple, comprehensible and focused measure of the level of possession disruption occurring on the network.

It is derived from the existing Schedule 4 mechanisms. We believe implementation will be possible at a lower cost than rebuilding NARS, given that the component expressions are already computed for the purpose of calculating Schedule 4 payments.



$$\text{Absolute Extended Journey Time Metric} = ((\text{WACM} + \text{NREJT}) \times \text{SGW})$$

$$\text{Relative Extended Journey Time Metric} = \sum \left(\frac{(\text{WACM} + \text{NREJT})}{\text{AJT}} \times \text{SGW} \right)$$

With the following definitions for the component expressions:

WACM and NREJT are the Weighted Average Cancellation Minutes and the Network Rail Extended Journey Time Schedule 4 components described in Section 7.1 above;

AJT is the average scheduled running time (Average Journey Time) for a Service Group in the Corresponding Day Timetable.

SGW is a Service Group Weighting which could be one of the following:

- Number of trains in the Service Group;
- Proportion of total train-hours in the Service Group;
- Proportion of total passenger-hours in the Service Group;
- Typical passenger loadings.

Strengths	Weaknesses
<ul style="list-style-type: none"> ▪ Should capture all planned, but no unplanned, disruption on the network. ▪ Relative increase in journey time / cancellation minutes can be used to benchmark disruption levels across routes. ▪ Absolute increase in journey time / cancellation minutes can be used to track total disruption over time. 	<ul style="list-style-type: none"> ▪ Does not capture negative experience of bus replacement. ▪ Does not capture early notification. ▪ Does not capture overruns. ▪ The passenger-focused service group weightings have cost and resource requirements, and would need remodelling if there is a significant change in passenger demand or service offering.

1.8.3 A revisited PDI metric

This metric is an enhancement to PDI, fixing the implementation issues and allowing Route-level reporting. The calculation methodology would be tweaked to allow the expression of passenger-delay minutes per km.

3 PDI v2 Definition

Definition:	An updated PDI, expressed in delay-minutes and disaggregated to Route level
Unit:	Delay minutes per train-km
Timeframe:	Periodic
Route-level to national level aggregation:	Mean average, weighted by scheduled train-km in each Route

$$EPJwVT = \frac{\sum_{SG} \left[\sum_d \{ (\text{NREJT}_{SG,d} + \text{WACM}_{SG,d}) \bullet \text{BF}_{SG,d} \bullet \text{PASS}_{SG,d} \bullet \text{ToDW} \} \right]}{\sum_{SG} PT_{SG}}$$

The equation reflects an estimate of the additional journey time for passengers, divided by scheduled train kilometres. The inputs are:

- Extended journey time (**NREJT**) for the service group (**SG**), by day (**D**). This is a component of Schedule 4.



- Weighted average of cancellation minutes (**WACM**) for service group, by day. This is a component of Schedule 4.
- Busyness factor (**BF**) measuring the frequency of services, for service group, by day. This is a component of Schedule 4.
- Average passenger train kilometres scheduled by service group (**PT**).
- **PASS** is the daily average number of passenger journeys per day for the relevant service group. This weighting is in NARS, but may require updating.
- Time of Day Weighting (**ToDW**) is a pre-determined fraction representing the percentage of passenger journeys for the relevant Service Group during the time of day (average values for each hour of the day) and day of week. This weighting is in NARS, but may require updating.

Strengths	Weaknesses
<ul style="list-style-type: none"> ▪ It may be possible to make use of the existing NARS work ▪ Is sophisticated enough to capture the customer experience well given current data sources 	<ul style="list-style-type: none"> ▪ Possibly would retain 'toxic' connotations of PDI ▪ May not be independent of service group changes ▪ Does not reflect that passengers do not (dis)value all delay minutes equally ▪ Would need a re-branding exercise ▪ Stakeholders have strongly hinted that the money to rebuild NARS is not available

1.8.4 A Lost Customer Hours metric

This metric would involve modelling a 'reasonable pre-estimate' of the delay and cancellation minutes / hours for any piece of infrastructure that may be taken as a possession, for all times of day and year. The modelling could conceivably go to a very detailed level; for example, on London's tube network, TfL has assigned estimates of lost customer walk time within stations for non-availability of escalators. However, a workable system could be envisaged where the most frequently taken possessions were modelled in a first phase, with additional updates to the system being implemented over time.

4 'Dutch' Lost Customer Hour Approach Definition

Definition:	Track modelled disruption due to unavailability of all relevant network assets
Unit:	Lost Customer Hours
Timeframe:	Periodic / weekly
Route-level to national level aggregation:	Sum of Lost Customer Hours for each Route

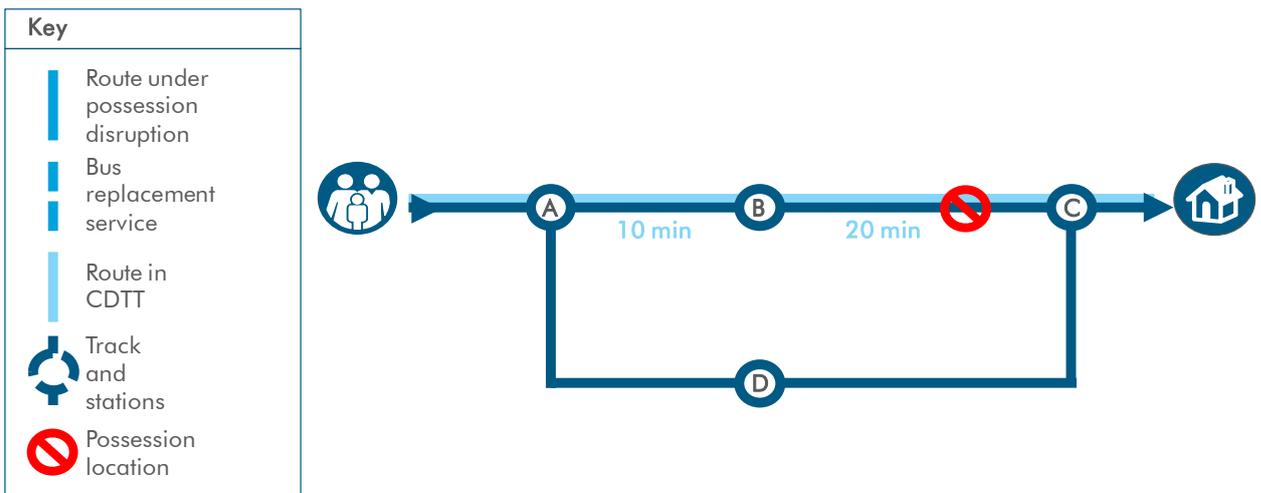
An appealing aspect of this metric is that the database of reasonable pre-estimates of disruption for any possession can be accessed by engineers, works planners and train planners, allowing for coordinated and informed decisions to be made across NR and the wider industry regarding the impact of possessions. This has helped drive to a transformation of culture within TfL, moving from an engineering-focused to a customer-focused outlook from inception in the mid 1990's to today.

This forward-looking approach can be used by NR to hold third parties to account when e.g. developers or utility companies require possessions. Understanding of the impact of the third party schemes is a first step to negotiating compensation or possession patterns with less impact on services.

Strengths	Weaknesses
<ul style="list-style-type: none"> ▪ Proven international record. ▪ Proven ability to change organisational focus as in LUL. ▪ Effectively captures customer experience by acknowledging the various values for different types of customer (dis)benefit. ▪ GJT for all OD pairs on the national network is already calculated. 	<ul style="list-style-type: none"> ▪ Requires expenditure and time on modelling work to set up. ▪ Would require work to adjust methodology to specifics of National Rail network, and account for greater heterogeneity. ▪ Attribution of LCH to Routes may be non-trivial. ▪ Passenger impact of potential bus replacement services would need modelling work to understand. ▪ Data requirements may be spread across industry organisations. ▪ LENNON data not as granular as Oyster taps.

1.9 Assessing the possession disruption metrics

In order to give a more detailed understanding of how the shortlisted possession disruption metrics perform under different types of network disruption. We have identified six major types of possession disruption, which are described in the following diagram and table (see key below).



Disruption Type	Description
Type 1: Bus diversion with extended journey time	Train scheduled to service A-B-C. Bus replacement operates between B-C, increasing journey time by 10 minutes.
Type 2: Rail diversion with missed station	Train scheduled to service A-B-C. Train is re-routed via D, skipping stop at B. There is no extension of journey time from A to C.
Type 3: Rail diversion with interchange	Train scheduled to service A-B-C. Train is re-routed to D, skipping stop at B. Passengers change to connecting service to C onward. There is no extension of journey time from A to C.
Type 4: Rail diversion with extended journey time	Train scheduled to service A-B-C. Train is re-routed via D, skipping stop at B. There is a 10 min extension of journey time from A to C.
Type 5: Customer chooses not to travel	Train scheduled to service A-B-C. Train is re-routed via D, skipping stop at B. There is a 20 min extension of journey time from A to C. Many passengers are deterred from travelling.



Type 6: Customer unable to travel
 Train scheduled to service A-B-C. Train terminates at B, and no feasible alternative arrangements for B-C are provided (This is relatively uncommon on the UK railways).

The results of the analysis of the six disruption types are summarised in the following table.

Metric	Type 1: Bus diversion with extended journey time	Type 2: Rail diversion with missed station	Type 3: Rail diversion with interchange	Type 4: Rail diversion with extended journey time	Type 5: Customer chooses not to travel	Type 6: Customer unable to travel
1. Schedule 4	Yes	Yes	Partial	Yes	No	No
2. EJT Metric	Partial	Yes	Partial	Yes	No	No
3. PDI v2	Partial	Yes	Partial	Yes	No	No
4. LCH Approach	Yes	Yes	Yes	Yes	Yes	Yes

The LCH approach can be configured to capture any disruption type, but its implementation is costly to achieve such a level of detail. It is possible that a phased introduction would not capture all disruption types in an initial version.

Schedule 4 has complex caveats to capture the impact of bus transfer, but has drawbacks as a regulatory measure due to reliance on bilaterally negotiated commercially sensitive payment rates.

The EJT Metric and PDI have a similar performance, as they both draw on the same elements of Schedule 4: NREJT and WACM. However, the EJT Metric is significantly less costly if it can be computed without a refresh of the Network Availability Reporting System (NARS) on which it relies.

1.10 Recommendations and next steps

Based on the analysis in this report, our recommendation for a measure of the level of possession disruption on the railway network is to develop the EJT metric, by carrying out a cost-benefit evaluation of reporting A-EJT and R-EJT. Ideally a passenger-focused Service Group Weighting should be used, but we expect that the train-focused alternative will have lower implementation costs.

In the longer term, the industry should consider the feasibility of moving to a Lost Customer Hours approach.

In aggregate, the regulatory stance for Network Rail’s delivery of Network Availability in CP6 should reflect the following.

- Network Availability should be monitored above and beyond the Schedule 4 mechanism, which is not alone sufficient to balance possession disruption against the impact on passengers or the wider economy.
- Possession disruption has several aspects that impact different stakeholders. These should be monitored separately with a suite of measures, to better understand the full picture of Network Availability. The suite of measures should comprise:



- *The A-EJT and R-EJT metric:* if feasible, a passenger-focused approach should be adopted, using the passenger-focused service group weightings presented in Figure 9. Alternatively, the train-focused metrics could be used, which have less demanding data requirements.
- *Delay and Cancellation Minutes due to Possession Overrun metric:* NR should continue to report this existing metric.
- *A Bus Vehicle-Hours metric:* Train-hours replaced with bus service are already reported. If possible, the more passenger-focused Bus Vehicle-Hours should be reported.
- *Disruptive Late Changes post T-26, T-12 and T-6:* Late changes post T-26 are already reported by NR. Changes post T-12 and T-6 should be reported as these very late changes are disruptive to operators and ultimate users.
- *Critical Freight Infrastructure:* If industry can agree on a list of critical infrastructure for freight, the count and average duration of incidents of non-availability should be reported.

These metrics can all be reported at a Route level, to facilitate performance benchmarking in addition to trend analysis.

- The level of possession disruption will vary depending on the output requirements of NR. Major enhancements may, for example, cause huge disruption but deliver yet greater benefits. The suite of measures should therefore be used to generate informed discussion on the topic of Network Availability, with the understanding that disruption from possessions may sometimes increase with good reason.
- The response of operators to possession plans can impact the disruption experienced by the end user. The metrics could therefore be considered to be jointly owned by the infrastructure owner and operators.
- In the long term towards CP7 and beyond, consideration should be given to moving towards a 'Dutch' Lost Customer Hours approach to delivering Network Availability, used as a tool to help shift industry culture towards a focus on the ultimate customer.



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2 Glossary of Abbreviations and Acronyms

Abbreviation	Description
A-EJT	Absolute Extended Journey Time
ADC	Access Disputes Committee
BiDi	Bi-Directional
CPPP	Confirmed Period Possession Plan
CP4 / 5 / 6	Control Period 4 / 5 / 6
CDTT	Corresponding Day Timetable
DfT	Department for Transport
EWI	Early Warning Indicators
EJT	Extended Journey Time
FOC	Freight Operating Company
HLOS	High Level Output Statement
LCH	Lost Customer Hours
NARS	Network Availability Reporting System
NR	Network Rail
ORR	Office of Rail and Road
OPA	Overall Performance Assessment
PoD	Plan of Day
PDI	Possession Disruption Index
PDI-F	Possession Disruption Index - Freight
PDI-P	Possession Disruption Index - Passengers
R-EJT	Relative Extended Journey Time
S4	Schedule 4 of the Track Access Agreements
SLW	Single Line Working
SRN	Strategic Road Network
TSR	Temporary Speed Restriction



TOC	Train Operating Company
TfL	Transport for London
TS	Transport Scotland
WICS	Water Industry Commission for Scotland
WON	Weekly Operating Notice

3 Introduction

The Office of Rail and Road (ORR) as the regulator of Network Rail (NR) performance is seeking to implement a strategy for monitoring performance with respect to Network Availability during Control Period 6 (CP6). The measure used during CP5 has proven to be ineffective for a number of reasons. Although it is still reported for regulatory purposes, it is understood not to be actively used by any stakeholders. However, the ORR considers the need for a metric that can be monitored and that will influence behaviour as a key element of their role in CP6.

In January 2018, SNC-Lavalin were commissioned by the ORR to advise on options for the regulatory approach to NR's delivery of Network Availability in CP6.

The concept of Network Availability refers to how much of the network is available to run services, i.e. not taken as a possession by NR. The impact of a possession on train operators and ultimate users varies by the location and length of track possessed, and the time of day, week and year. Typically, passenger services are impacted by possessions over weekends, while freight services are affected by overnight works.

The various industry stakeholders will experience Network Availability differently, and not all Network Non-availability should necessarily be counted as equal. For example, possessions that affect more trains, or trains with more passengers aboard, or that are taken at short notice can all be more disruptive. For passengers, disruption that includes bus replacement services is considered particularly undesirable. Furthermore, possession disruption can be measured in terms of the volume or quantum of disruption occurring, or viewed through the lens of an efficiency measure, e.g. how much disruption is required to deliver a certain amount of work. This report focuses on Network Availability defined as the volume of possession disruption taken. However, we believe that understanding the volume of disruption can in turn be useful for gaining insight on possession efficiency in conjunction with other factors such as maintenance and renewals expenditure.

Our findings recommend that a suite of measures is used to oversee possession disruption on the network. We feel that given the varying ways in which people experience possession disruption, no single measure can give the full picture.

Throughout CP4 and CP5, the regulatory stance towards Network Availability has been based on the measurement and reporting of the Possession Disruption Indicator (PDI). There are two PDI measures, PDI-P and PDI-F, intended to measure disruption to passenger and freight services respectively.

Schedule 4 of the Track Access Agreements provides a financial incentive to NR to minimise the disruptive effect of possessions on Train Operating Companies (TOCs). It aims to hold operators broadly revenue-neutral to changes in the level of Network Availability. To do this, it is necessary to compute a genuine estimate of the revenue impact of possessions on operators. The total revenue impact therefore provides a measure of disruption due to possessions. However, Schedule 4 suffers from some weaknesses as a tool for assessing Network Availability. First, it is not the case that the revenue impact of disruption on train operators is representative of the cost to the ultimate user or the total cost to the economy. Second, a public-facing measure expressed in terms of currency may appear to be a 'fine' or monetisation of non-performance of NR, which Schedule 4 is not. Third, to the extent that it holds TOCs neutral it can cease to incentivise TOCs to manage 'down' possessions taken.

According to industry parties, PDI-P and PDI-F have been plagued by issues with implementation. The metrics are calculated four weeks in arrears, are not consistent when service groups are re-mapped, and the Network Availability Reporting System (NARS) used to calculate the metrics contained errors in implementation. There has therefore been a loss



of confidence across the industry in the usefulness of the PDI metrics. Indeed, NR commented that the PDI metrics have never been valued by the industry.

NR will continue to publish PDI figures until the end of CP5. However it is understood not to drive behaviour in the NR possession planning process and we have feedback from TOCs (as part of a wider ORR consultation on Network Availability in CP5) that they have not used this measure in CP5. This represents a missed opportunity to have an effective performance measure for Network Availability that drives continuous improvement in the following ways:

- Incentivises Network Rail to find a balance between the time that the network is **available for customers** (passenger and freight) while **delivering the required maintenance, renewals and enhancements** e.g. by finding the most efficient **way of taking** possessions, and the most **effective timing** for those possessions;
- Reflects Network Rail's role as system operator, incentivise Network Rail to understand and **manage the impact** of possessions on **key passenger and freight flows** (e.g. not closing both East and West Coast mainlines simultaneously);
- Supports other incentives on Network Rail **to plan within an appropriate timeframe** to enable customers (passenger and freight operators) and end users (passenger and freight) to also plan ahead (aligning as necessary with other incentives such as **Schedule 4**).

In this report we address the following questions.

- Why would it be necessary or desirable to measure and monitor possession disruption?
- Are the initial proposals from NR (the Notification Factor and the Count of Access Disputes) not an optimal solution? If not, why so?
- Is Schedule 4 of the Track Access Agreements a sufficient mechanism for monitoring / incentivising NR to take the optimal amount of possessions? If not, why so?
- What other options might there be to monitor possession disruption?

Given the scope of this assignment, there remain many other questions to consider around the topic of managing and regulating possession disruption. Despite this limitation we hope that the contents of this report can be used as the basis of an ongoing conversation between NR, the ORR, and wider industry. We note that the following questions are considered out of the scope in this report. However, future research could return to these issues.

- What are detailed costs of implementing our proposed metrics?
- Are the proposed metrics generally supported by industry?
- What are the next practical steps to implementing the proposed metrics?

Any regulatory measure would require extensive industry consultation and consensus before implementation. In writing this report, we have undertaken limited industry consultation on the status quo in CP5 and our proposals for CP6. However, we note that further consultation and refinement of our proposals would be required, which could be the focus of next steps.

4 Context

In this section we present a problem / opportunity statement for this project, and discuss the pressures bearing down on Network Availability for CP6. We also summarise our stakeholder consultation and discuss the role of Schedule 4 and the concept of efficiency in taking and using possessions.

4.1 Problem / opportunity statement

In order to clarify the objectives of the study and help drive a measure of success, we have agreed with the ORR the following problem / opportunity statement.

“To meet its duty as an economic regulator, ORR has sought to measure the efficiency of Network Rail in its delivery of a) reliable performance and b) network availability.

The concept of measuring and monitoring Possession Disruption goes back to CP4 and yet has neither caught the imagination of the industry nor drives its behaviours in spite of widespread belief in the utility of measuring the issue. Indeed with the latest index deemed “broken” there is a need to reappraise the metric.

With ever bigger and longer running possessions being used to create economically efficient and timely delivered programmes there is a risk that Train Operators, their customers and local economies will take an ever higher burden from the impact of possessions. In such a context the measurement of possession disruption seems urgent and necessary.”

4.2 Pressures on Network Availability

Network Availability is likely to become an important issue over the course of CP6 and beyond. Looking forward, there are several trends that will continue to put pressure on NR to perform in its delivery of Network Availability. These include:

- Increased demand and traffic, in terms of greater service frequency and service loading
- Greater maintenance, renewal and enhancement requirements;
- Government Policy such as de-carbonisation of traction power by 2040, which may require enabling infrastructure works;
- Increasing stringency of health and safety requirements;
- Increasing demand for earlier first and later last trains, leaving less time to take non-disruptive possessions; and
- An increasing pressure on NR to deliver value for money.

The net effect is that NR will have fewer non-disruptive hours to do more work. There is therefore a risk that the ultimate user, or the wider economy, will be adversely affected by an increasing number of disruptive possessions.

There is also a need for those possessions that are taken to be utilised effectively, and to be seen to be used effectively. This need can be conceived as the feeling of frustration a motorist might experience upon have a journey disrupted by coned-off motorway lanes with no apparent work taking place.

4.3 Stakeholder Consultation

Throughout the study, we took the views of a variety of stakeholders, including Government, NR, TOCs and Freight Operating Companies (FOCs). We used telephone interviews and

face-to-face interviews to gather primary evidence. We also reviewed responses to ongoing consultation work carried out by the ORR.

The stakeholder views regarding the regulation of Network Availability had some important common themes. In this section we give an overview of who was consulted, and present some summary findings that are relevant to the regulation of Network Availability in CP6. The following comments are concise summaries of extensive conversations and written consultation responses, intended to be easy for the reader to digest. The full text of written responses to an ORR industry consultation regarding Network Availability in CP5 is available at <http://orr.gov.uk/rail/consultations/pr18-consultations>.

4.3.1 Network Rail

We met representatives from the NR National System Operator throughout the project. Prior to this study, in May 2017, NR proposed a number of metrics as an alternative to PDI that they believe would influence behaviour and, as they are already calculated, can be implemented quickly and efficiently.

The proposed indicators were dubbed Early Warning Indicators (EWIs). The two EWIs proposed by NR are presented in the table below.

EWI	Description	Reason proposed
Level of Access Disputes	Level of access disputes escalated to Access Disputes Committee (ADC) through the engineering access planning process, or after the Confirmed Period Possession Plan. This is a leading indicator.	To assess whether the access planning processes are working as they should. TOCs and FOCs are incentivised to look after the best interests of the end customers, and if Network Rail are getting the access plans wrong, and disadvantaging the end customer, they have the clear opportunity to dispute the access plans.
Notification Discount Factor	To encourage early notification of Restrictions of Use and better timetable planning, Network Rail is incentivised by notice periods which attract discounts on the Schedule 4 payment rates. This is a lagging indicator.	This information will provide reassurance that Network Rail is developing access plans in line with industry processes and that late change is not increasing over time.

In addition, we met and spoke with representatives from NR throughout the assignment. Some of their views on Network Availability are summarised in the following table.

Comment
NR highlighted that from engagement with stakeholder to develop the System Operator scorecard, monitoring Network Availability was not considered a priority.
The PDI measures are not fit for purpose and do not drive behaviour.
At the onset of the project, SNC-Lavalin understood that a third EWI, the Possession Value Indicator, was proposed by NR. We now understand that the Possession Value Indicator EWI is in fact not recommended by NR as a metric for CP6.
Highlighted that works planners do take anticipated Schedule 4 payments into account, and that this may be a sufficient incentive for NR.
Highlighted the high levels of industry confidence in the Access Dispute Committee.
Suggested that any approach to assessing Network Availability should rely on customer needs or existing metrics used internally by NR and that inform NR's decisions.

4.3.2 The Office of Rail and Road

We have had several meetings and discussions with representatives of the ORR throughout the project in order to understand their success criteria for the regulation of Network Availability in CP6.

Comment

Ideally, a possession disruption measure should:

- reflect passenger experience;
- be easy to comprehend throughout the industry; and
- be easy to understand how to influence.

The ORR believes that there can be some improvement to the EWIs proposed by NR.

There is interest in the ORR to understand the how efficiently NR is making use of the possessions it takes.

The ORR understands that the access planning process is complex, with several internal and external roles. It is therefore crucial to assign targets to the most appropriate business units. The Route access planning teams have the most control over the volume of possessions taken, but works planners have significant control over how they coordinate with other projects ('piggy-backing') on other possessions.

Laying down certain rules – such as never closing the ECML and WCML simultaneously - is an important part of good possession planning. Rules are in the Access Planning Frameworks, which are owned by the System Operator.

It is understood that the NR work planning teams feel that staged work causes unnecessary cost increases.

As contractors are procured after applying for track access, the final scope of work may not match the original pattern of possessions.

4.3.3 Train Operating Companies

In order to ascertain the views of TOCs, we reviewed responses to ongoing consultation work by the ORR on the subject of Network Availability. We have reviewed responses from 9 of the 25 UK TOCs, 36% of the total:

- Arriva Rail London
- Arriva Trains Wales
- c2c
- CrossCountry
- Govia Thameslink Railway
- Greater Anglia
- Heathrow Express
- London Midlands
- Northern

All of the responding TOCs claimed to have been affected by the issue of Network Availability. The majority of respondents were of the view that NR is mindful of the impact it has on passengers when taking possessions. However, there was a sense that improvements were possible despite the challenging trade-offs between maintenance, renewal and enhancement cost and disruption to TOC services and passengers. Some of the specific points raised are listed in the following table.

Comment

Access Planning has, in some instances, been less well-resourced and coordinated since the responsibility was devolved to the route level.

Works are not always planned optimally in the sense that some chances to share access in a given possession are missed.

Works contractors are appointed after access is planned with operators. Therefore, as the contractors fully scope and plan their work, significant costs are incurred as disruption, re-planning, or contract variations.

It is felt that sometimes single-line working opportunities are missed as NR is unwilling to resource.

Some TOCs highlighted the impact of late changes on their business and customers:

“It is critical that Network Rail remains incentivised to have a 100% success rate in avoiding late notice changes to possessions beyond the T-12 informed traveller date.”

“Outside of major projects we have complained to Network Rail about them making late changes to possession times. Network Rail produces the CPPP with possession details at T-24, and we are obliged to spot bid any revised changes at T-18 which is a contractual deadline to enable bids to be processed, offered back at T-14 and uploaded at T-12. An ongoing concern is the ‘tinkering’ of possession times after T-22. We need more discipline in the planning process.”

The Access Frameworks developed as part of the Industry Access Plan (IAP), at significant effort, are not being utilised.

Maintenance and Renewals are seen to be better planned than major projects and Enhancements.

Several operators monitor the Early Notification Discount Factors; however there is a suspicion that NR partly circumvents Schedule 4 Early Notification Discount Factors by booking possessions early, then cancelling or amending them closer to the time.

There is overall a good level of confidence in the Access Dispute Committee process.

In addition, we have been in discussions with the Performance Director at Arriva. Arriva is a TOC owning group, which runs five UK franchises in addition to the concession Arriva Rail London (London Overground). He raised the following:

- *The impact of possessions on customers is something that matters. Arriva doesn't really use the PDI measures as they stand, which supports the view that the metric does not work for its intended purpose.*
- *Arriva has developed its own alternative metric for the train planning dashboard – using Schedule 4 data to look at what percentage of the train plan is actually delivered based on missed calling points. Any TOC with a revenue profile to achieve really cares about this – the example given was Cross Country. Delivery of weekend timetables that are competitive with other routes or other modes in terms of the % of the timetable offered as a train (as opposed to a bus replacement) and the journey times offered is key.*

4.3.4 Freight Operating Companies

In order to ascertain the views of FOCs, we reviewed responses to ongoing consultation work by the ORR on the subject of Network Availability. We have reviewed responses from four of the seven UK FOCs:

- *DB Cargo UK*
- *Colas Rail*
- *Freightliner*
- *GB Railfreight*

Comment

There are concerns that NR is more focused on its TOC customers than its FOC customers, especially in the context of alliancing, where the Alliance is focused on the relationship between the Route business and the dominant local TOC. There are also general fears of degrading coordination between devolved access planning teams.

Some possessions are booked by NR as a 'nice-to-have' rather than to make room for specific work. This can take the form of overnight possessions out of passenger service hours. These issues, although usually resolved when raised, block the operation and growth of rail freight services.

As many freight services run overnight, the late hand backs of overnight possessions can be very disruptive to FOC operations.

Diversions routes are crucial for FOCs to provide the level of reliability that their customers expect. Diversions that pass through multiple Routes are often not coordinated. There are also issues with the provision of W9/W10 freight gauge clearance.

FOCs are often impacted by late notice changes to possessions. These burden the FOC with re-planning services and checking the proposed diversion.

There is overall a good level of confidence in the Access Dispute Committee process, although there are some issues including the affordability of legal representation for FOCs, and the lack of time to challenge disruptive late notice changes.

4.3.5 Other stakeholders

In addition to the above, we had conversations with the Department for Transport (DfT) and Transport Scotland. We also summarise comments by the passenger representation organisation Transport Focus.

Department for Transport

We held two face-to-face meetings with representatives from the DfT. The points arising in the discussion are summarised in the following table.

Comment

Reiterated a lack of confidence in the PDI metrics and the Possession Indicator Report, but supported a new measure(s) to ensure industry focus on managing disruption effectively, including communications with customers.

The DfT did not view Schedule 4 payments alone as being a sufficient proxy for disruption to users caused by possessions.

Highlighted a concern with TOC behaviour toward the end of franchises, where they may choose to receive Schedule 4 payments rather than work to solutions that would maximise long-run revenue.

Highlighted a need for closer working between Network Rail and operators and shared responsibility to manage disruption in the interest of end-users: for example, through the allowing for and provision of diversionary services.

There is a need for shared industry responsibility: for example, TOCs can choose to divert or cancel services, and may cancel for Schedule 4 benefits when the end-user may prefer diversionary routes.

Need to keep sight of the necessity of works, and of delivering them efficiently (which often means needing to cause a lot of disruption).

Early notification is important to operators. End-users are willing to suffer major disruption for major works if the reasons for the disruption are communicated clearly and in advance, including the benefit work will deliver.

Transport Scotland

We held three telephone interviews with representatives from Transport Scotland. We spoke to the Contract Mangers of the ScotRail and Caledonian Sleeper franchises, and a Rail Freight Policy Advisor.

Comment

The ScotRail franchise has recently been affected by possession overruns.

Network Availability is not an issue for the Caledonian Sleeper, due to slack in the timetable and good quality available diversions.

The availability of cross-border routes, keeping the Scotland Route coordinated with the remainder of the UK railways, is important for Scottish freight.

The Scotland Route High Level Output Statement (HLOS) mentions the need to keep at least one Scotland to London route available to passenger, freight and sleeper services.

Transport Focus

Transport Focus is the independent transport user watchdog. They represent passengers, some road and motorway users, and pedestrians and cyclists. A summary of their comments follows:

Comment

Passengers naturally want the minimum timetable impact, and to minimise the time spent on bus replacement services.

It would be possible to categorise sections of track, in order to focus attention on possessions that affect the most important areas of the network.

There should be a default assumption that the two routes for accessing e.g. Southend or Cambridge should not be closed simultaneously.

For large multi-million pound projects, a relatively small budget could be set aside to investigate less disruptive ways of delivering the work.

A critical success factor for the regulatory stance towards Network Availability is acceptance by the industry. Understanding the needs and fears of industry participants is a vital step in determining a regulatory stance that will find acceptance.

4.3.6 Summary of stakeholder needs

Based on a review of the stakeholder engagement, we have identified the following concerns as key issues for the monitoring of Network Availability in CP6.

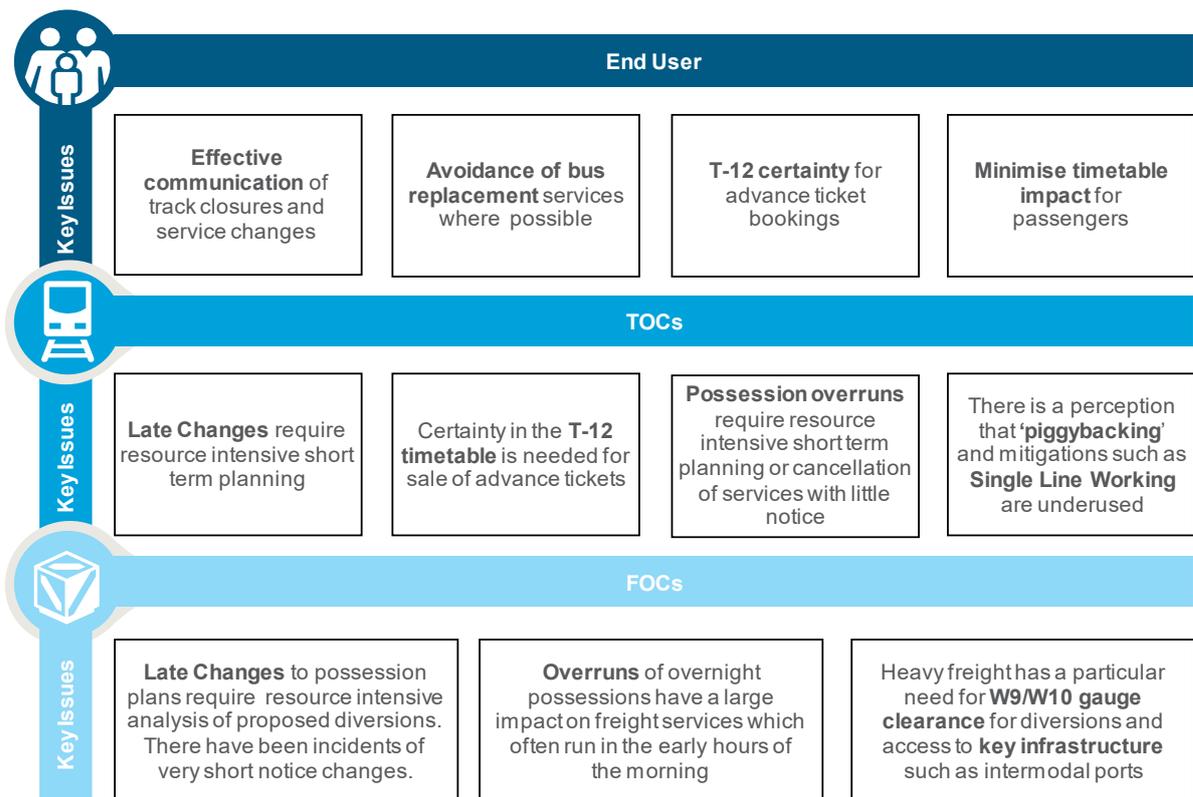


Figure 4: Key issues for NR's customers.

Taken as a whole, we believe the views presented here give sufficient evidence to the notion that Network Availability, insofar as it is a function of possession disruption, is an issue that requires some level of measurement and monitoring in principle. We note that a limitation of this report is that extensive stakeholder consultation on our specific proposals, presented in Section 8, is out of scope and should be a priority of future work.

4.4 Understanding Schedule 4 as a Measure of Network Availability

Schedule 4, the part of the Track Access Agreement that aims to hold operators broadly revenue-neutral to changes in the level of disruptive possessions on the network is a potential measure of Network Availability but with the weaknesses shown below.

Schedule 4 is based on parameters and weightings (the Network Rail Payment Rates) agreed by industry players that do not necessarily reflect all the relevant costs; neither all the cost to end users, nor some costs incurred by non-users. For example, approximately half of all fares are regulated increases from a baseline level reflecting British Rail fares, which may not reflect end-user demand for or the cost of running a particular service.

Indeed, by being held revenue-neutral to the impact of disruptive possessions, operators are insulated from the pain of passengers and are therefore not always best placed to represent the passenger through the possession planning process. TOCs first responsibility is to their shareholders, and while keeping trains running is typically within their interest as it contributes to their reputation and returns, there are situations when this is not the case. For example, towards the end of a franchise the emphasis may be on squeezing out short run returns at the expense of reputation.

Schedule 4 holds operators broadly revenue-neutral to changes in the level of network disruption via NR compensation; NR is therefore incentivised to act to minimise the sum of disruption impact in terms of revenue loss.

Conceivably, an alternative set of weightings could be used to represent the total passenger and operator loss in terms of generalised cost from network disruption. This would be equal to the loss of revenue to the operator plus the loss of surplus to the passenger. The various extra inconveniences experienced by the passenger would be included here, the greatest of which would be loss of time. Given the proportion of time and revenue benefits typically calculated for railway enhancement schemes, we would expect the lost time element to be at least as large as the revenue element.

Lastly, disruption might be weighted by the impact on the wider economy. In practice this might be done using economic multipliers. This would be equal to the loss of revenue to the operator plus the loss of surplus to the consumer, plus the indirect loss to business and the wider economy due to potential journeys not being made (including impacts on health, the environment etc. as well as other economic activity per se). A recent example of this was the £100million quoted for the economic loss to Devon and Cornwall after the collapse of the sea-wall and the railway at Dawlish in 2015 where, for instance, tourism expenditure was reduced as holidaymakers could not access the region by train. However, more recent attention to wider economic (and agglomeration) benefits suggests that these figures may be significant in a wider range of situations than previously considered.

To balance the benefits of possession disruption against the costs to the wider economy, consistent with its vision,¹ NR should balance possession planning against the total economic cost of disruption. It is clear that weightings representing the generalised cost to the wider economy would yield much larger payments than the currently used weightings that reflect the only the revenue impact on operators. Therefore, although Schedule 4 is a necessary mechanism for insuring operators against changes in the level of network disruption, it is not sufficient to incentivise the optimal level of possession taking from the perspective of the economy as a whole.

Further details on this argument are given in Appendix A.

4.5 Defining efficient use of possessions

Before progressing to the analysis of how NR can be encouraged to achieve efficient use of possessions, it is useful to distinguish between *allocative* and *productive* efficiency. Allocative efficiency considers the question of what should be produced and for whom, while productive efficiency considers how those outputs should be produced.

Allocative Efficiency	Productive Efficiency
<ul style="list-style-type: none"> ▪ How much should be invested in rail vs other modes? ▪ How much public funding should be invested in transport vs other areas? (HLOS, SoFA) ▪ What rail projects should be undertaken? (Transport Business Cases) ▪ What safety / maintenance standards should be upheld? 	<ul style="list-style-type: none"> ▪ Is value for money being achieved? ▪ Is value for disruption cost being achieved? ▪ Is the most appropriate combination of disruption cost and financial input being used to deliver the required maintenance, renewal and enhancement outputs?

At a high-level, allocative efficiency might be concerned with the level of investment in the railway, and what railway projects should and should not be carried out. These questions are out of the scope of this study.

¹ "It's our role at Network Rail to provide the best possible service to everyone who relies on the railway – passengers, the train and freight operating companies and businesses nationwide." - <https://www.networkrail.co.uk/who-we-are/our-role>, accessed 24/05/18

Productive efficiency in this setting is the production of outputs (maintenance, renewal and enhancement works) by the combination of two input factors, financial expenditure and possession disruption.

NR reports transparently on its financial expenditure, but without appropriate regulation it is not fully incentivised to minimise disruption to the ultimate user or wider economy, as discussed above.

A graphical representation of the framework for assessing productive efficiency in this setting is shown in Figure 5. The curve linking A to B shows the possible combinations of inputs (financial cost and disruptive cost) required to achieve a set level of outputs (a certain portfolio of maintenance, renewals and enhancements).

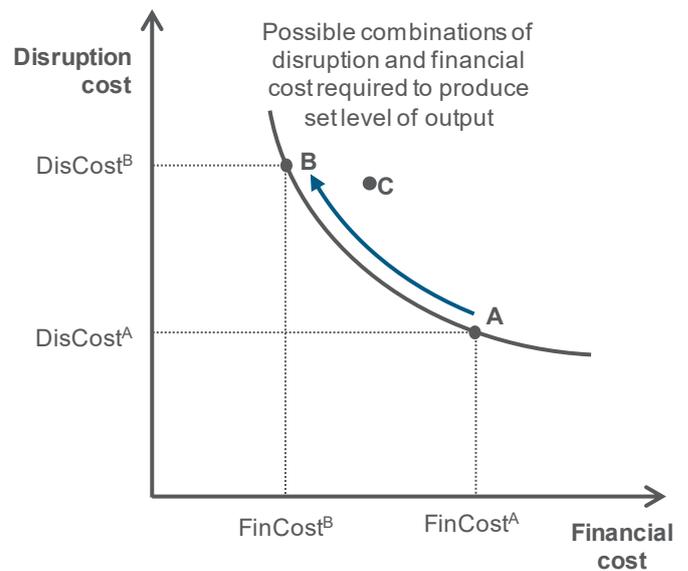


Figure 5: Productive efficiency

Firstly, the regulator will want to monitor if NR, due to the pressures on Network Availability outlined in 4.2, moves its strategy from A to B (arrowed). This represents a reduction in financial cost traded off against an increase in disruption costs. The preferred position on the curve will be determined by relative weightings of disruption cost and financial cost in the eyes of the regulator, taking all stakeholder consideration into account.

Secondly, the regulator will want to be assured that, in the absence of competitive pressures, NR is not producing at a point such as C, to the right and above of the curve. This would reflect inefficient use of spend or disruptive possessions. Route-level comparisons or benchmarking may allow the regulator to monitor if such a situation arises.

This static framework does not take into account dynamic effects over time. There are some key considerations here:

- technology and innovation will shift the grey curve towards the origin as new ways of working allow more to be done with less, and
- increasing traffic and demand for the network increases the disruption cost to passengers, given a fixed network capacity.

Ideally, the regulator would have sight of the level of output produced, the financial costs incurred, and the disruption cost, in order to understand the efficiency of NR's delivery of Network Availability. In this sense, Network Availability can be seen as one side of a trade-off between disruption costs, financial costs, and the amount of output produced.

Output	Disruption metric	Financial cost
<ul style="list-style-type: none"> • Measured through delivery of project milestones • Sometimes measured (by proxy) as financial spend on maintenance, renewals, and enhancements 	<ul style="list-style-type: none"> • Measured through PDI-F and PDI-P • Incentivised by Schedule 4 • Supported by other measures including notification discount factors, counts of access disputes, and 	<ul style="list-style-type: none"> • Reported through a variety of measures including the Financial Performance Measure (FPM)

4.6 Summary

Before introducing methodology, analysis, and results, we summarise the introduction.

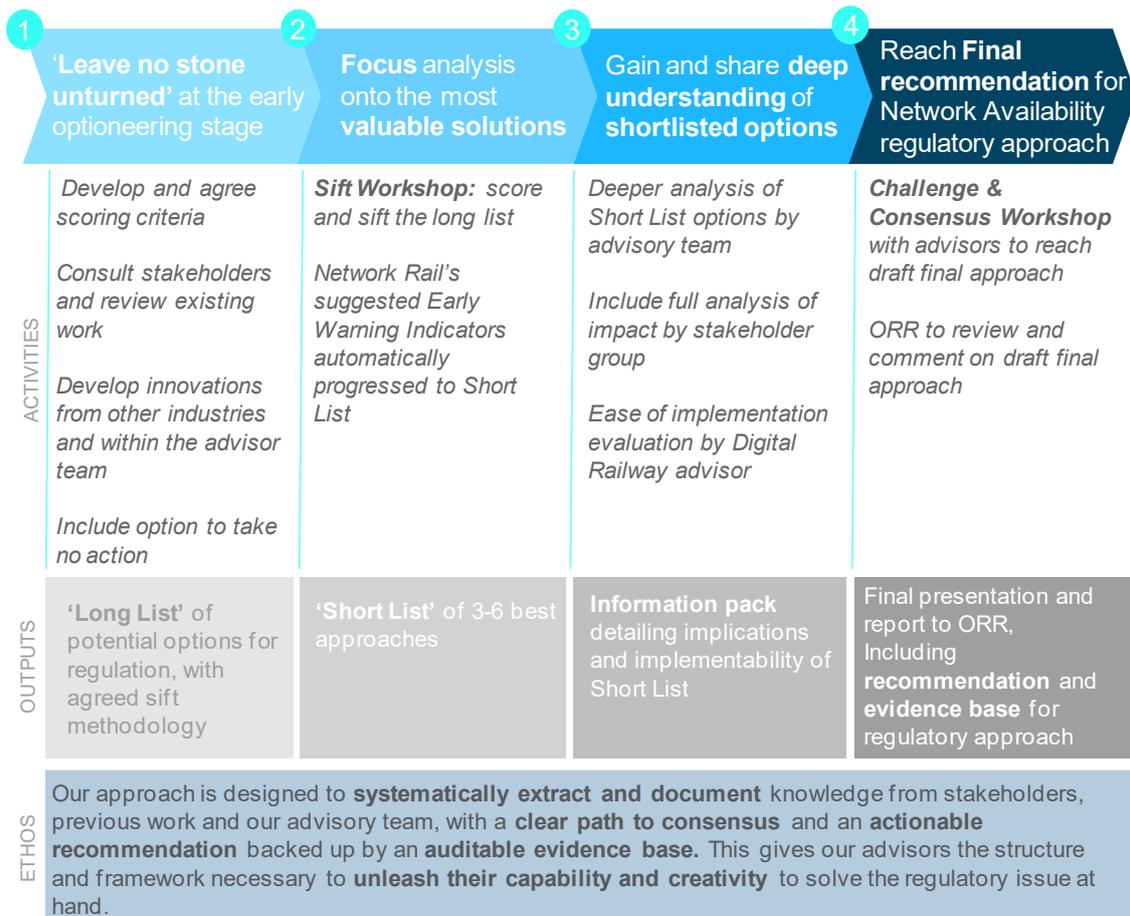


1. **Problem / Opportunity Statement:** ORR has a requirement to monitor NR's delivery of Network Availability in CP6, and the existing measure is deemed "broken". This limits the ORR's ability to assure itself that a Network Availability is being suitably managed.
2. **Pressures on Network Availability:** increased traffic, fewer opportunities for overnight working, and financial pressure on NR, and the need to deliver transformative enhancements mean that Network Availability may be a crucial issue in CP6.
3. **Stakeholder Consultation:** Engagement with industry and Government has told us that possession disruption is an important issue for TOCs that hold revenue risk in their franchise. FOCs are concerned with obtaining specialist gauge clearance and the impact of possession overruns. Passengers naturally dislike all service disruption regardless of the cause, but are particularly concerned about the impact of bus replacement services on their journeys.
4. **Understanding Schedule 4 as a Measure of Network Availability:** Schedule 4 payments are valuable as a commercial framework to reduce operator's exposure to possession disruption, and the infrastructure used to compute the payments is an accessible source of data that can be used to measure Network Availability. However, there are reasons why it is alone an insufficient mechanism to incentivise NR in their delivery of Network Availability.
5. **Defining Efficient Use of Possessions:** In order to fully understand the productive efficiency of NR in using its possessions, a regulator requires aggregate measures of
 - a. NR's output in terms of work delivered,
 - b. the level of disruption from possessions,
 - c. the financial cost of delivering its output.

While the financial costs are well understood and this research suggests a suite of measures for the level of possession disruption, it has still proven challenging to find suitable data to observe the amount and quality of output NR delivers in a given possession.

5 Method

Our approach was to develop a Long List of potential options for measuring and regulating Network Availability, and then score these options against pre-agreed criteria. The options that are deemed most promising were then further developed and discussed with the ORR, DfT, and NR. Finally, the results consolidated into a recommended suite of measures for understanding the delivery of Network Availability CP6. Our methodology is outlined in the figure below.



The Sift Workshop took place on 19/2/18, and the Challenge and Consensus Workshop took place on 22/3/18. Section 6 presents the optioneering and sift process, based primarily on the outputs of the Sift Workshop. Section 7 gives a detailed analysis of four metrics for understanding the level of service disruption on the rail Network, and Section 8 provides our recommendations.

6 Optioneering and Sift

The primary aim of the Sift process was to move from a Long List of options for regulatory metrics to a plausible shortlist for detailed examination. The Long List options were assessed against a sift score criteria, which is described in Appendix B. The Long List metrics were categorised by the type of insight into Network Availability that they bring.

- **Actual vs Planned Availability** – These measures, of which PDI-P and PDI-F are examples, measure the (weighted) average level of the network that is available to run trains.
- **Possession Efficiency Measures** – These measures are loosely defined as ratio of output achieved to disruption caused. For example: metres of track renewed per passenger delay minute.
- **NR Early Warning Measures** – We considered the two EWIs proposed by NR as a distinct category. We also considered a further option, the Possession Value Indicator. This measure was proposed and evaluated by NR, then later withdrawn.

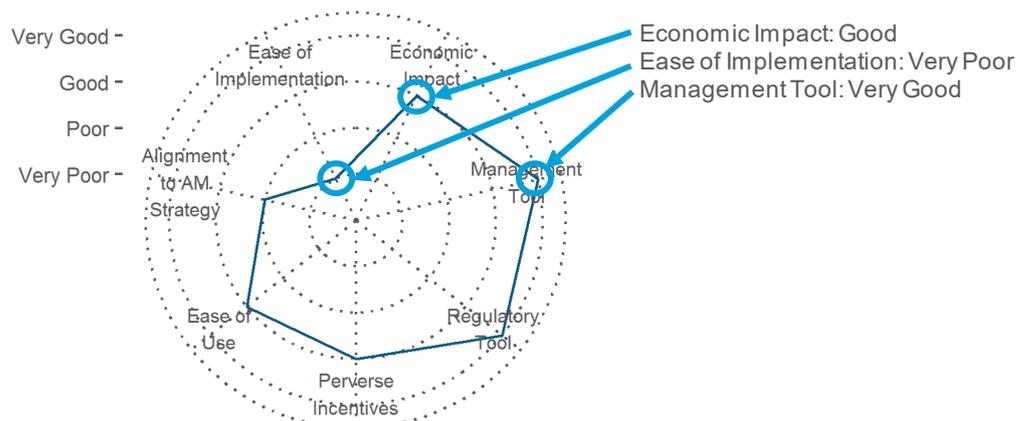
Mitigations and Customer Services and **Approaches from other Industries** were considered on their merits as adjacent measures to provide insight on aspects of possession disruption other than the level of possession disruption and the efficiency of delivering output in possessions. They were not scored according to the same sift criteria of the first three categories.

- **Mitigations and Customer Services** – These measures do not directly measure disruption, but serve as adjacent metrics that offer additional insight into how the network is performing.
- **Approaches from other Industries** – While the challenges facing the rail industry are unique, we have reviewed the approaches taken to Network Availability in other regulated network industries.

The scoring summary and associated “spider” chart for each Network Availability Metric is shown below with some general commentary on Mitigations and Customer Services and Approaches from other Industries.

The results of the long list assessment are presented in “**spider**” charts. The six criteria are Economic Impact, Management Tool, Regulatory Tool, Perverse Incentives, Ease of Use, Alignment to AM Strategy, and Ease of Implementation. Each criteria is marked on a four point scale: Very Poor, Poor, Good, Very Good.

The solid line indicates the score for each labelled criteria. If the solid line is closer to the centre of the chart, it indicates poor performance against that criterion, and if it is closer to the edge it represents good performance against that criterion. The following example chart provides an example of how to interpret the scores.



6.1 Actual vs Planned Availability

1. Current PDI-P and PDI-F

Description: The current PDI-P and PDI-F measures are calculated by NR's Network Availability Reporting System (NARS). PDI-P is the additional journey time for passengers, converted via a value of time to a generalised cost to passengers. This value is then normalised by the total train kilometres run.

The generalised cost includes the impact of 'baked-in' possessions in the WTT, accounts for average passenger loadings, time of day, and uses a value of time differentiated by estimated proportions of passenger journey types (leisure, business, commuting).

PDI-F is a simpler metric, at least in terms of the number of inputs. It is essentially the total track-km hours unavailable by day and service group weighted by average freight volume, normalised by the total track-km hours for the relevant day and service group, also weighted by average freight volume.

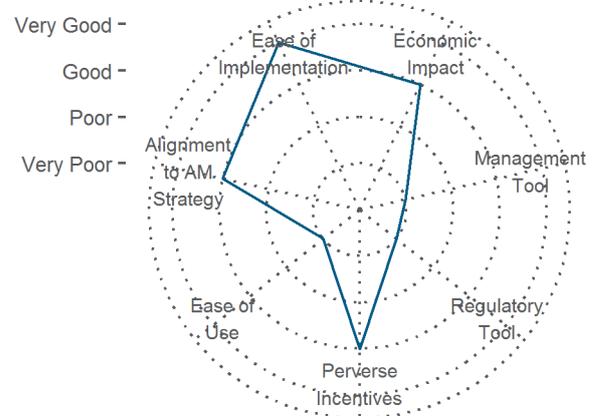
Both metrics are expressed as an index with the base being actual possession disruption at the end of CP3.

Analysis: PDI has a well-thought through design, combining data sources to model most of the typical aspects of disruption in traditional transport models. However, through the inclusion of so many factors, it is not easily comprehensible. This is compounded by being expressed as an index on a base year, giving it an arbitrary feel.

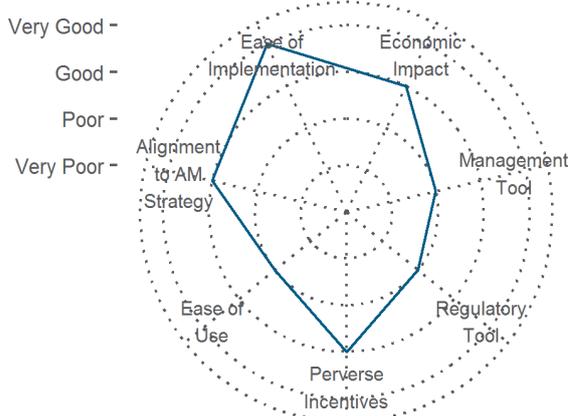
Weighting the output by journey types necessitates value judgements on the relative worth of different passenger groups, which adds potentially unnecessary complication; journey purpose splits are easily disputable, and a change in journey purpose over time would render the index invalid.

The greatest drawback to PDI is that it has failed to attract industry buy-in, partly due to a mistake in the implementation in NARS. This is why it scores poorly for *Management Tool* and *Regulatory Tool* despite a thoughtful design.

For these reasons, PDI will be **discarded** as a potential option for CP6.



2. PDI at a Route level



Description: It is our understanding that the PDI-P and PDI-F metrics calculated by NARS cannot be disaggregated to a Route level. The PDI at a Route level metric would simply be the existing PDI approach, adjusted to allow comparisons between the devolved Route businesses.

Analysis: By implementing PDI at a Route level, and taking the opportunity to fix the implantation issues with the original PDI, it would be possible to make a more effective

benchmarking and management tool and create a chance to gain the industry buy-in that the original PDI has lost.

However, such a tool would still suffer from poor ease of understanding from its many component factors and index format. We further understand that a rebuild of NARS is considered too costly by stakeholders, and therefore this option will be **discarded** as a potential option for CP6.

3. Schedule 4 Related Measure

Description: Schedule 4 of the Track Access Agreements incentivises NR to minimise network disruption and insulates TOCs and FOCs from the commercial impact of that disruption.

TOCs are compensated for the loss of future revenue from disenfranchised passengers, the cost of operating bus replacement services, costs relating to the cancelled or late amended possessions, and costs relating to a change in train mileage. If train mileage is reduced, the Schedule 4 payments to the TOC will reduce, as they have incurred less cost themselves. Long term possessions attract increased levels of disruption, while giving advance notice to operators attracts a discount via the Notification Discount Factor (see metric 11. Notification Discount Factor).

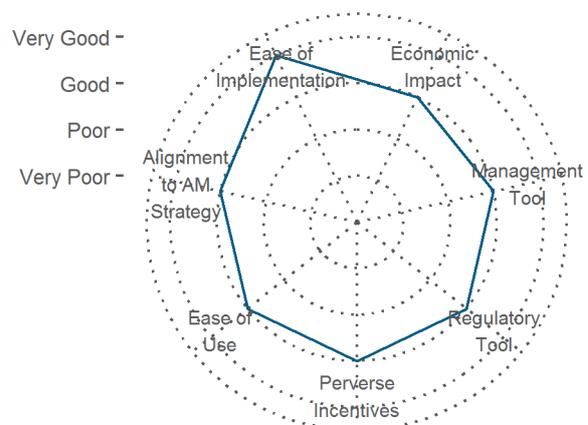
FOCs are compensated a set amount determined by the severity of disruption and the advance notice given. In cases of severe disruption, the FOC may be able to claim for actual costs/losses and liquidated damages.

This metric would simply report the value of Schedule 4 payments in each period at a Route level.

Analysis: As outlined in Section 4.4, Schedule 4 alone is not a sufficient mechanism for incentivising NR to take an efficient level of possessions from the point of view of the passenger and the wider economy. Nevertheless, the systems used to calculate the payments are the most obvious source of data for a possession disruption metric. For example, some components of PDI are drawn from Schedule 4.

By publishing S4 payments a reputational, as well as the existing financial, incentive on NR is created. Although the calculation of Schedule 4 payments is somewhat convoluted, the end result is expressed in currency, which is easy to interpret despite having some disadvantages: payments are made in nominal terms, hindering trend analysis; the currency values could unfairly be seen as a 'fine' paid by NR; and the payment rates are commercially confidential and subject to periodic renegotiation.

We therefore **retain** Schedule 4 as an option for CP6, and give a more detailed analysis of its calculation steps in Section 7.1.





4. Comparison of Corresponding Day Timetable against Plan of Day

Description: The Corresponding Day Timetable (CDTT) is a reference timetable with no ‘baked-in’ possessions. It represents the services operators would run without any restrictions. The Plan of Day (PoD) is the latest timetable planned for each day of operations. It therefore includes all planned, but no unplanned, disruption relative to the CDTT.

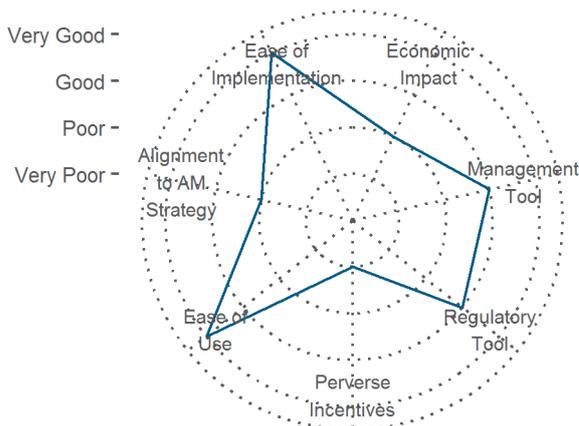
This metric would compare the sum of train-minutes scheduled to run in the CDTT with the sum of train-minutes scheduled to run in the PoD. Cancellations should be accounted for using the same methodology as the established Schedule 8 approximation:

$$Cancellation\ minutes\ for\ service\ i \approx 1.5 \times service\ interval\ for\ service\ i$$

The metric could be expressed as a percentage, to allow consistent inter-temporal comparisons as the timetable is changed.

$$Availability = \left[\frac{\sum_{SG} \sum_D \{EJT_{SG,D} + CM_{SG,D}\}}{\sum_{SG} \sum_D CDTT_{SG,D}} \right]$$

Analysis: While not capturing additional factors such journey type mix, early notification and impact of bus replacement services, this is a simple measure essentially treating all train-minutes as equal. It is intuitive to understand as the percentage increase in total train journey time across the network due to planned disruption.



As it focuses purely on delay and cancellations, it would be suitable as part of a suite of measures that each focused on a different aspect of possession disruption impact.

We therefore **retain** a comparison of CDTT against Plan of Day metric as an option for CP6. We developed the concept into the EJT metric detailed in Section 7.2.2.

5. Dutch / LUL Lost Customer Hours approach

Description: Taking inspiration from the Dutch approach to managing Network Availability, Transport for London currently uses a Lost Customer Hours (LCH) metric. A total lost time impact per hour is modelled and assigned to each section of the network using estimates of train loadings, service frequencies, and time of the week. It is then possible to express the cost, in terms of LCH, incurred for taking possession of any given part of the network.

The Nominally Accumulated Customer Hours (NACHs) database provides a ‘reasonable pre-estimate’ of the passenger time impact of individual incidents on the tube network. It is then possible to provide a granular post-hoc estimate of the actual causes of delay, and therefore identify the worst performing areas to efficiently target investment and resources. The data inputs include: network information such as line geometry, station capacity, and rolling stock; service frequency and transit time; signalling data and fallback plans; and economic and demographic data.

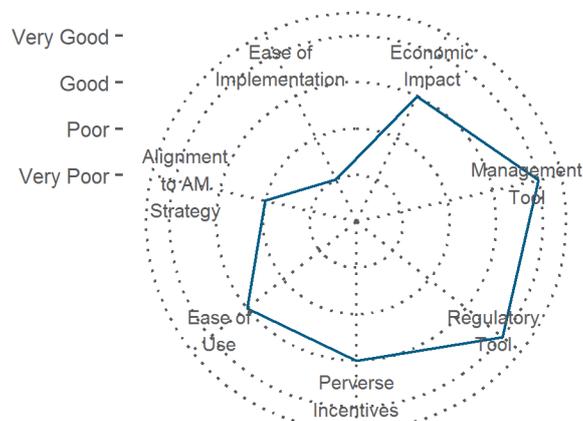
The system has been widely accepted within TfL as a significant contributing factor to improved performance levels and a cultural shift towards becoming a customer-oriented, rather than engineering-oriented organisation. It has been used extensively in the performance framework for PPP contracts. It is also used in business case development to



understand the trade-off between works disruption and the benefits of a scheme, prioritise asset maintenance and reliability projects, setting performance targets internally and for contractors, assessing the impact of closures and other operational scenarios, and calculating staff performance-based bonuses.

Analysis: The Lost Customer Hours approach represents a best-practice approach to planning, managing, and contracting Network Availability. It is passenger-focused, and incentivises access planners, train planners, engineers and frontline staff to collaborate on improving customer service. However, its disadvantages are high implementation cost and data requirements. Furthermore, bedding-in the measure across NR, TOCs and FOCs and achieving a cultural shift towards customer service may take several years to achieve.

We **retain** the Lost Customer Hours approach as an aspirational target for CP7 if not CP6.

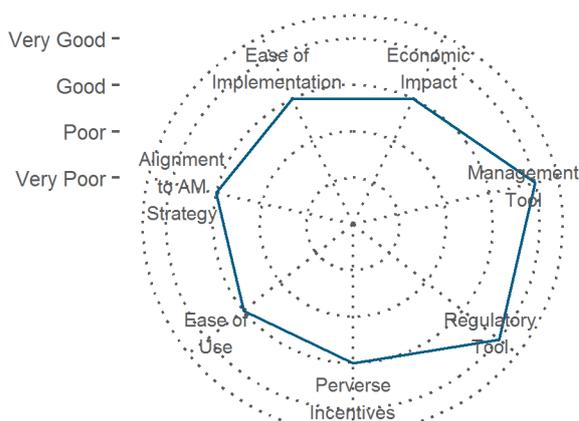


6. PDI enhancement 1: disruption minutes

Description: One of the weaknesses of PDI identified by our early analysis is the unintuitive nature of it being expressed as an index. This metric would be a modification of PDI described in Option 1: Current PDI-P and PDI-F, such that it:

- could be reported at a Route level, and
- can be expressed directly as the lost customer minutes / hours in each period, rather than an index.

The benefits of these changes would be the ability to benchmark at a route level, and to have a metric that is customer-focused and easier to comprehend while making use of much of the work and research carried out to produce NARS and PDI.



Analysis: This approach to measuring possession disruption would allow benchmarking of Route performance with suitable normalisation (such as the scheduled train-km used in the current system), and by quoting the metric in easily understood terms such as delay per km sidesteps some of the ease of use issues with PDI. However, it would require a rebuild of NARS, for which NR is not currently funded.

We therefore **retain** PDI enhancement 1 as a recommended option for CP6.



7. PDI enhancement 2: disruption in £

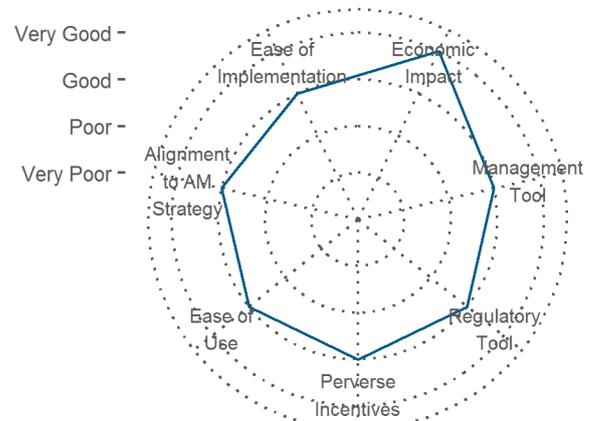
Description: One of the weaknesses of PDI identified by our early analysis is the unintuitive nature of it being expressed as an index. This metric would be a modification of PDI described in metric 1. Current PDI-P and PDI-F, such that it:

- could be reported at a Route level, and
- can be expressed directly as the lost value of customer time in each period, rather than an index.

The benefits of these changes would be the ability to benchmark at a route level, and to have a metric that is customer-focused and easier to comprehend while making use of much of the work and research carried out to produce NARS and PDI.

Analysis: Expressing the metric in universally understood monetary terms lends itself to use in business cases by enabling a direct comparison of customer disruption with the generalised benefit of schemes or projects. However, this approach shares the same disadvantages of reporting Schedule 4 payments, while requiring a rebuild of NARS and a duplication of effort in monetising possession disruption alongside the existing Schedule 4 mechanism.

We therefore **discard** PDI enhancement 2 as a recommended option for CP6.

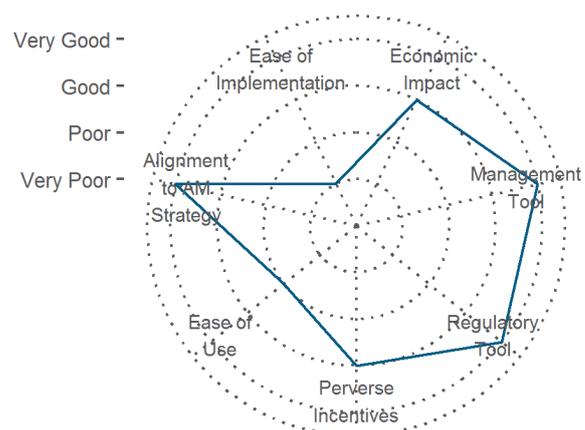


8. Schedule 4 Measure with Macroeconomic Weightings

Description: This metric is as metric 3. Schedule 4 Related Measure, with a different set of weightings. As discussed in Section 4.4, the traditional Schedule 4 weightings are set with the objective of holding operators approximately revenue neutral to changes in the level of Network Availability. The proposed weightings for this metric would instead reflect the cost of disruption to operators, passengers, and the wider economy. Estimates of this impact could be ascertained using economic multipliers.

This metric would simply report the value of Schedule 4 payments, reweighted with so-called macroeconomic weightings, in each period at a Route level.

Analysis: While this option is ideal for capturing the impact of possession to the wider economy, a concept explored in Section 4.4, and weightings could be calculated through an analysis of economic multipliers, the results would incentivise possessions to be taken in certain geographic areas of the economy over other. This could make the weightings politically unpopular. In addition, this measure could unfairly be interpreted as an amount of monetised damage NR is causing to the wider economy.



We therefore **discard** the Schedule 4 with Macroeconomic Weightings as a recommended option for CP6.

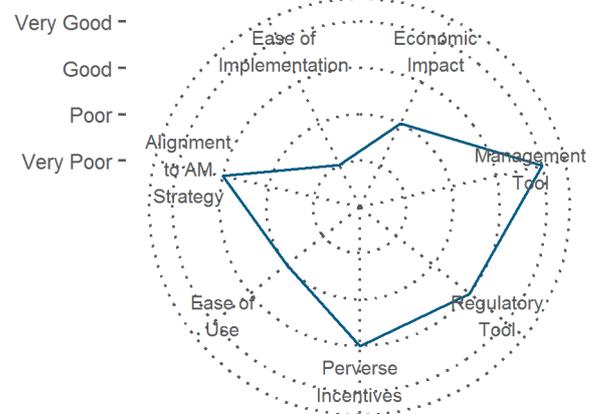
6.2 Possession Efficiency Measures

9. Possession Efficiency Indicator

Description: This conceptual metric is defined as the level of network disruption normalised by the level of work output. A likely proxy for network disruption is Schedule 4 payments, while the level of work output could be determined by assigning a points-based value to different activities. For example, X points for renewing a set length of track, and Y points for electrifying a set length of track.

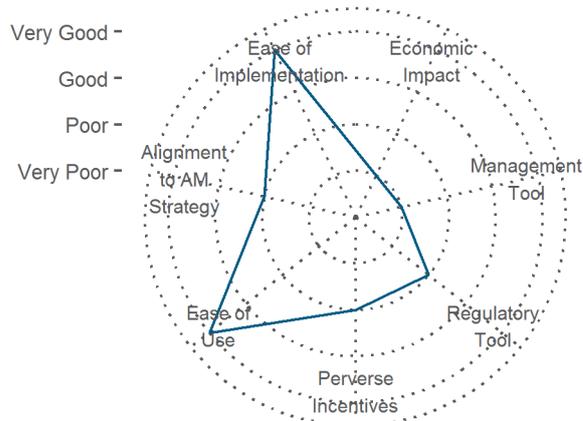
Analysis: This measure is an attempt to capture the amount of output undertaken by NR in the course of a possession, in order to give oversight of the concept of productive efficiency in possession taking as explored in Section 4.3. However, given the variety in work tasks carried out in possession, from survey and track replacement to bridge-strengthening works or one-off transformative enhancements, it is unlikely to be possible to devise a point value for each type of work that does not perversely incentivise certain types of activity.

We therefore **discard** the Possession Efficiency Indicator as a recommended option for CP6.



6.3 NR Early Warning Indicators

10. Count Access Disputes



Description: This metric tallies the access disputes escalated to the Access Disputes Committee (ADC) during the access planning process, or after the Confirmed Period Possession Plan.

The aim of this metric is to assess the possession planning process. It assumes TOCs and FOCs are incentivised to act in the best interest of the ultimate user, and will escalate disputes if and only if they feel NR's access planning process is not aligned to the needs of ultimate users.

Analysis: From engagement with NR we understand that there are many categories of Access Dispute. Some in particular, such as FOC disputes based on unavailability of critical infrastructure, be that access to a freight interchange or lack of gauge cleared diversionary routes, are valuable for understanding if operators are satisfied with the planing process.



As disputes can be raised early in the possession planning process, they are a leading indicator of planning problems that can be consulted before the day of disruption, in contrast with many of the backward looking or ‘rear-view mirror’ metrics explored here.

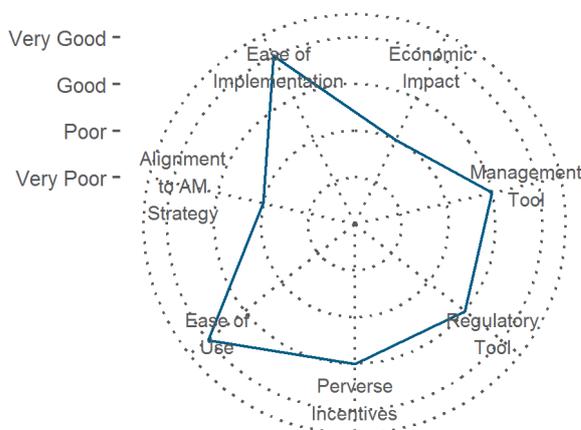
However, we understand that operators often strategically raise disputes to ‘cover themselves’ in case they want to negotiate access at a later date, inflating the number of true disputes. Meanwhile, others see use of the Access Dispute Committee as a last resort, and may be dissatisfied with a possession but not lodge a dispute, masking the number of true disputes. Conversely, a high count of access disputes may represent NR pushing back at unreasonable demands from TOCs.

We therefore **discard** Count of Access Disputes for CP6 because it is too subjective and therefore not suitable for trend analysis or Route-level benchmarking, while recognising that it has an important role in NR’s own management of its processes.

11. Notification Discount Factor

Description: This metric is the average Schedule 4 Notification Discount Factor over all possessions occurring in a period. It is our understanding that an unweighted average is being proposed.

In order to assist timetable planning, NR is incentivised via discounts to Schedule 4 payments if they give notice within specified periods. The earlier notification is given, the greater the discount factor applied. While these discount factors do not directly measure possession disruption, they give some indication of the quality of communication to end users.



Analysis: Our review of stakeholder needs suggested that operators are particularly impacted by the resource requirements of re-planning services in response to late changes. However, as it uses a commercial indicator from Schedule 4, and a more easily understood and comprehensive alternative is available in the form of Option 16: Late Notification Changes, we **discard** the Notification Discount Factor as an option for CP6.

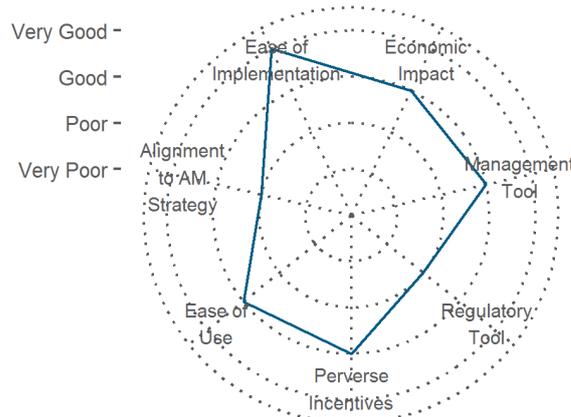
12. Possession Value Indicator

Description: This metric was proposed by NR but is now understood to be dropped from their proposal for assessing possession disruption in CP6. It is the level of Schedule 4 payments normalised by renewals spend. In this case renewals spend is being used as a proxy for work output, so the measure gives an indication of network disruption per unit of work output.

Schedule 4 payments are calculated taking into account estimated train loadings, delay minutes and cancellation minutes.



Analysis: We understand that since commencing work on this project, this Early Warning Indicator has been dropped by NR as it was not driving behaviours. This measure attempts to capture the concept of productive efficiency in possession taking as outlined in Section 5, which requires understanding of output delivered in a possession, the financial cost that output and the level of possession disruption caused. While Schedule 4 payments are a reasonable proxy for the level of possession disruption, and the financial cost of possessions are captured in other metrics, using expenditure on renewals as a proxy for the amount of output delivered misses the key outputs of maintenance and enhancements and incentivises overspend on renewals.



We therefore **discard** the Possession Value Indicator as a recommended option for CP6.

6.4 Mitigations and Customer Service

The Mitigations and Customer Service metrics do not attempt to capture the overall level of possession disruption or possession productive efficiency, and are therefore not scored according to the sift scoring criteria. Instead, they are assessed on their merit as adjacent measures that capture aspects of possession impacts other than possession disruption and efficiency. They could be published by NR or the ORR as preferred.

13. Rail Replacement Bus Hours

Description: This metric is the number of hours of timetabled train services that are replaced by a bus service each period.

Analysis: This metric is currently reported in NR’s Possession Indicator Report. Our review of stakeholder needs suggests that passengers typically do not like using bus replacement services, although there are exceptions where higher quality vehicles have been used, or in cases where a passenger’s journey is more closely aligned to the coach diversion route than the rail network.

However, we suggest that an improvement on this measure would be to report bus vehicle-hours run, rather than train-hours replaced by buses, as detailed below. We therefore recommend discarding Rail Replacement Bus Hours as an option for CP6.

14. Rail Replacement Bus Vehicle-Hours

Description: This metric is the number of vehicle-hours of bus replacement services run each period. Our review of stakeholder needs suggests that passengers typically do not like using bus replacement services, although there are exceptions where higher quality vehicles have been used, or in cases where a passenger’s journey is more closely aligned to the coach diversion route than the rail network.

Analysis: The number of vehicles in a bus replacement service that a TOC is required to run depends on the typical passenger loading of the train services it is replacing. Therefore, bus vehicle-hours is a reasonable reflection of the overall level of passenger inconvenience suffered by passengers on the network. Reducing the number of bus vehicle-hours required



incentivises NR and TOCs to find solutions that keep passengers on trains, which is desirable.

We therefore **retain** Rail Replacement Bus Vehicle-Hours as part of a recommended suite of measures in CP6.

15. Count of Planned Disruption Mitigation Interventions

Description: This metric is the count of Disruption Mitigation Interventions such as single line working (SLW) and bi-directional operations (BiDi). These interventions generally increase the financial cost of carrying out works, but allow services to run albeit with reduced capacity on the line.

Analysis: These mitigations allow reduced services to run during a possession, which can help fulfil the objective of keeping passengers on trains and off buses. However, the impact disruption mitigation interventions, if effective, should be apparent in the results of a possession disruption indicator.

We therefore **discard** count of disruption mitigation interventions as part of a recommended suite of measures in CP6.

16. Late Notice Possession Changes

Description: This metric is calculated as the number of new, cancelled, curtailed or extended disruptive possessions agreed between the issue of the Confirmed Period Possession Plan (CPPP) and issue of the Weekly Operating Notice (WON) that caused the disruptive element of the possession to change (increase or decrease) in length. The CPPP is issued at T-26.

Analysis: Currently reported as part of NR's Possession Indicator Report, this simple measure gives valuable insight into how well NR is planning its possessions. Unlike the Notification Discount Factor which is based on the prevailing Schedule 4 regime, the count of late notice possession changes is easy to interpret by stakeholders within and outside of the industry.

FOCs and TOCs have both commented that re-planning services around late changes is resource intensive and, depending on how late the changes are, sometimes disruptive to the ultimate customer.

We therefore **retain** the late notice possession changes indicator as part of a recommended suite of measures in CP6, with the following alterations:

- T-26 is a 'cliff-edge' cut-off, with all late changes post T-26 being counted equally. However, changes post T-12 (informed traveller, where TOCs may begin selling Advance tickets) or post T-6 (at which point re-planning services becomes more challenging) are evidently more disruptive to operators and passengers alike. *We therefore recommend that late changes post T-12 and T-6 are reported in the same way that late changes post CPPP are currently reported.*
- We noted from conversations with NR that not all late changes cause disruption to services. An example of a non-disruptive change would be the curtailment or a cancellation of an overnight possession, where the original possession did not affect any services in the CDTT. *For the purposes of regulating Network Availability, only disruptive late changes should be reported.*



- Given the increased importance of Route-level devolution, we recommend that if possible, late changes should be reported at a Route level.

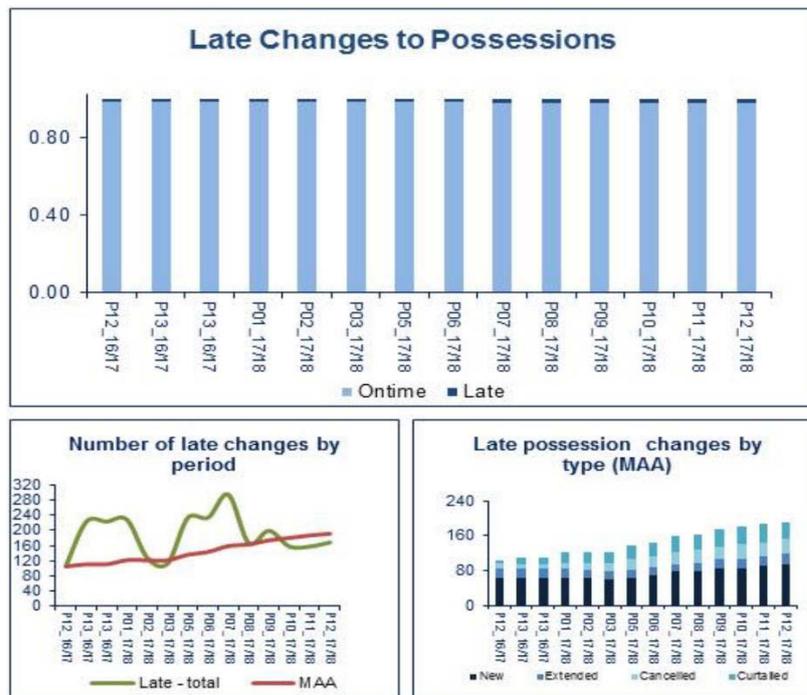


Figure 6: Charts extracted from NR's Possession Indicator Report, showing changes in the count and type of late changes post T-26.

17. Delay / Cancellation Minutes & Unplanned TSRs due to Possession Overrun

Description: These metrics assess the impact of possession overruns. They comprise the train delay minutes attributed to possession overruns, the cancellation minutes attributed to overruns, and the count of unplanned temporary speed restrictions (TSRs) put in place as a result of possession incidents. Together, they offer insight into how possessions are being managed on the day of possession.

Analysis: These metrics focus on an aspect of possession disruption not covered in any of the metrics: the disruption due to the management of possessions not going to plan on the day. This can be due to mistakes in judging the amount of contingency time in the work plan, unexpected on-site conditions, or occasionally errors by track workers. While it may not be possible to eradicate the occurrence of possession overruns, TOCs, FOCs, and the ultimate freight and passenger customer can be heavily impacted by them particularly on a congested network such as in the UK.

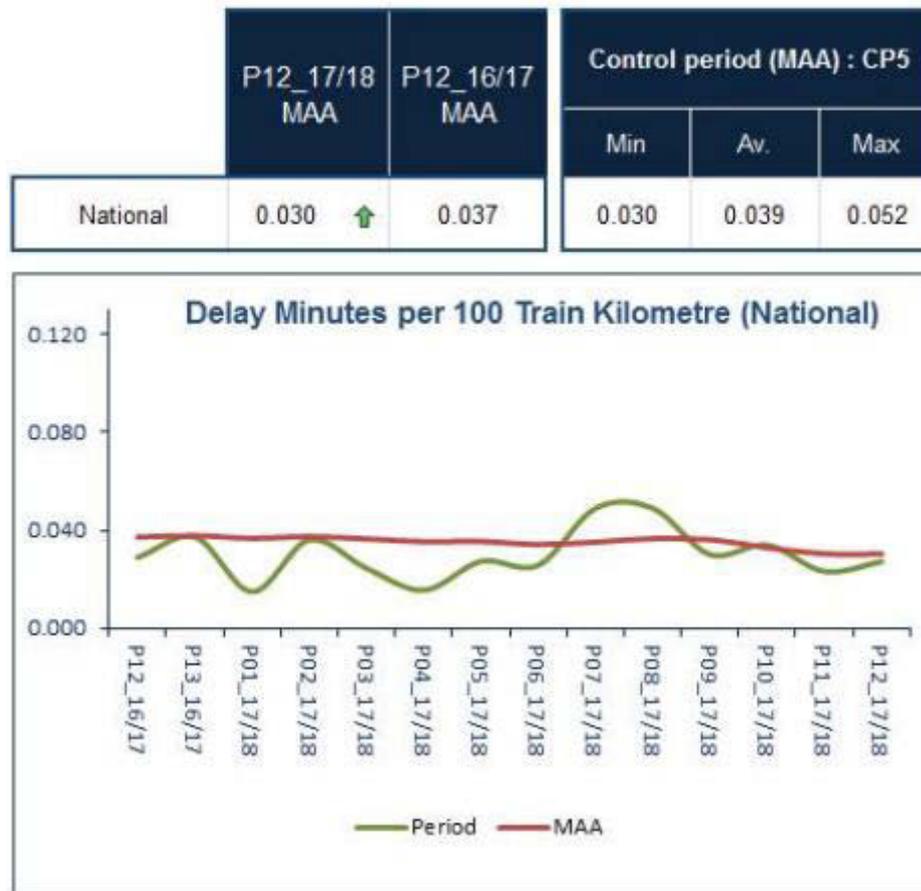


Figure 7: Chart extracted from NR's Possession Indicator Report, showing Delay Minutes due to Possession Overrun per 100 scheduled Train Kilometres.

The current approach used by NR in the Possession Indicator Report is a useful indicator of trends in delay and cancellation minutes. We therefore **retain** late notice possession changes as part of a recommended suite of measures in CP6, with *the recommendation that if possible the delays and cancellations be reported at a Route level, and the count of overruns is reported alongside total delay and cancellation minutes*. This would give sight of if overrun disruption is occurring often, or if disruption impacts are accruing from a small number of isolated incidents.

6.5 Approaches from other Industries

We carried out some research into availability measures for other regulated network industries in the UK. Although the challenges facing these industries do not directly mirror those of the railways, there is some insight to be gained by considering the approaches of other economic regulators.

18. Highways-style availability measure

Description: To assess the disruption caused by their program of maintenance, renewals, and enhancements, Highways England report on a Network Availability performance indicator for the Strategic Road Network (SRN). The metric is simply the percentage of lane-km-days that are not closed to traffic for works. The target for the first five year Road Period is 97% availability within each of the five years.

Lanes are considered available if there are speed restrictions or a narrowed carriageway. Lanes closed for reasons other than planned works are not included in the calculation.



Analysis: Highways England's Network Availability measure is very simplistic compared to any metric that could be used for the rail network. This is suitable for their purposes as road users are not reliant on operators to provide vehicles, and there are typically a greater number of diversionary routes available. For the rail network, we judge that a similar approach, e.g. the number of km-hours of track taken in possessions would be too blunt an instrument to understand the impact of possession taking.

19. Power and gas transmission

Description: Ofgem monitor the performance of the electricity and gas Distribution Network Owners (DNOs) via reliability and availability metrics. The primary measures are the number of customer supply interruptions per 100 customers, and the average duration of customer interruptions.

Analysis: These two simple measures elegantly break down the total hours of disruption into the number of incidents (managed by preventative maintenance / resilience projects) and the average duration of incidents (managed by incident response). This could be applied to the rail sector by reporting the count and average duration of possessions taken or possession overrun incidents. We have therefore recommended the count of possession overruns to be reported as part of Option 17: Delay / Cancellation Minutes & Unplanned TSRs due to Possession Overrun.

20. Water supply – England

Description: OFWAT measures reliability and availability measures for water suppliers in England and Wales. The availability measure is a sum of the total hours of interruption from incidents lasting over three hours. There is no weighting to account for e.g. households with differing numbers of members, or for households considered more 'vulnerable'.

Analysis: This metric uses a threshold of three hours of disrupted service before an incident is recorded. In the context of a congested network where small deviations from timetable can have large impacts on delay, particularly in peak hours, we do not judge such an approach could be usefully deployed in the rail sector.

21. Water supply – Scotland

Description: The headline performance measure for Scottish Water, monitored by the Water Industry Commission for Scotland (WICS), is the Overall Performance Assessment (OPA). The OPA is a score out of 418.75, calculated by summing seventeen sub-metrics. While this is not a Network Availability measure per se, it contains sub-metrics that relate to the quality of provision of the water main network. An overview of the OPA is given in the following table.



	Indicator	Maximum score
	Inadequate pressure	37.50
	Unplanned supply interruptions	37.50
	Hosepipe restrictions	12.50
Water supply	Security of Supply index absolute	12.50
	Security of Supply index variance against target	12.50
	Water quality	50.00
	Water pollution incidents (Category 1 & 2)	12.50
	Leakage	12.50
	Sewer flooding incidents due to inadequate capacity	25.00
	Sewer flooding incidents due to other causes	37.50
Waste-water service	Sewer flooding, properties at risk	12.50
	Wastewater pollution incidents (Category 1 & 2)	25.00
	Wastewater pollution incidents (Category 3)	12.50
	Sewage sludge disposal	12.50
	Non compliant waste water treatment works	50.00
Customer service	Customer contact	18.75
	Assessed customer service	37.50
Total	Overall Performance Assessment	418.75

Analysis: The OPA is a suite of measures scored separately and summed to reach a total score. There are potentially perverse incentives coming into play by measuring e.g. Water Quality and Customer Contact on the same scale; it may not necessarily be desirable to trade off a two point decrease in Water Quality for a three point increase in Customer Contact. However, a key advantage of a metric that is easily disaggregated into components is that it is easy for managers or regulators to understand the root cause of a deterioration in performance and implement a suitable response. We therefore propose in our final recommendation that a suite measures are used, each focusing on a distinct aspect of possession disruption.

6.6 Conclusions from the Sift Workshop

The following diagram summarises the metrics retained through the optioneering and sift process. Each retained metric has been mapped to a specific aspect of possession disruption impact and relevant stakeholder group.

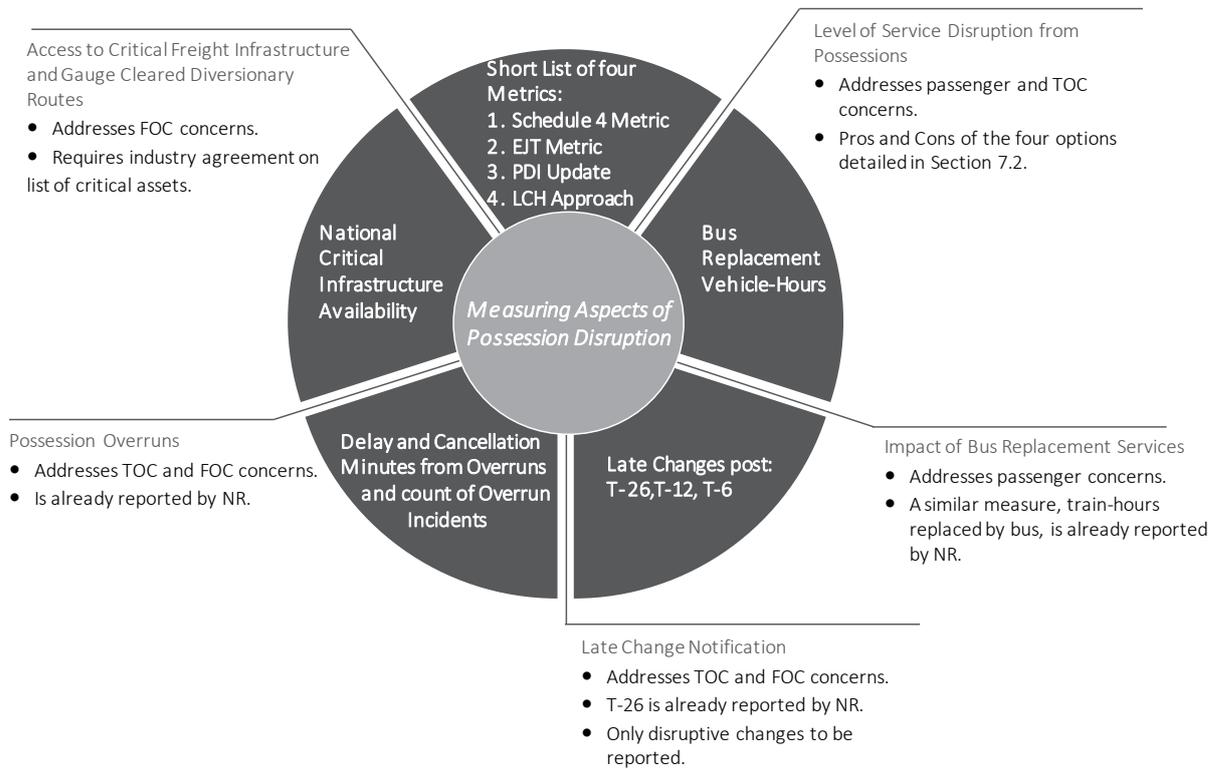


Figure 8: Suite of measures emerging from Sift Workshop.

7 Possession disruption metrics

We have considered in detail a Short List of four possession disruption metrics. These metrics are:

1. A Schedule 4 Measure;
2. An Excess Planned Journey Time Measure;
3. An Update to PDI;
4. A 'Dutch' Lost Customer Hour Approach.

Options 1-3, and possibly option 4, would make use of the existing Schedule 4 systems and infrastructure. For this reason, before going into further detail on the Short List of possession disruption metrics, we will give a detailed view of how Schedule 4 payments are calculated.

This analysis emerged primarily from the Challenge & Consensus Workshop, held on 22/3/18.

7.1 Detail of Schedule 4 Payment Schedules

Schedule 4 payments are calculated in accordance with Schedule 4 of the Track Access Agreements. The major components, which are summed together to reach the total payment, are the **Delay and Cancellation Payment**, the **Additional Payment for Train-Bus-Train Pattern**, and **Reimbursement of Operating Costs**. In this section an overview of these major components is given.

Delay and Cancellation Payment

$$\text{Delay and Cancellation Payment} = \sum ((\text{WACM} + \text{NREJT}) \times \text{BF} \times \text{NRPR} \times \text{NF})$$

Schedule 4 delay and cancellation payments are based on the Weighted Average Cancellation Minutes (WACM), the Network Rail caused Extended Journey Time (NREJT), a Busyness Factor (BF), the negotiated Network Rail Payment Rate (NRPR), and the Notification Factor (NF).

$$\text{Weighted Average of Cancellation Minutes: WACM} = (\text{CM} - \text{NRPP}) \times \sum \frac{(\text{MPW} \times \text{CS})}{\text{SS}}$$

With the following definitions for the component expressions:

CM is the Cancellation Minutes for a Service Group;

NRPP is the Network Rail Performance Points specified in Schedule 8;

\sum is the sum all Monitoring Points in the Service Group;

MPW is the Monitoring Point Weighting specified in Schedule 8;

SS is the number of stops at the Monitoring Point in the Corresponding Day Timetable;

CS is the number of stops at the Monitoring Point that are cancelled due to Network Rail restricting use.

$$\text{Network Rail caused Extended Journey Time: NREJT} = \text{EJT} \times \left(1 - \frac{\sum (\text{MPW} \times \text{CS})}{\text{SS}} \right)$$

With the following definitions for the component expressions:

MPW, SS, and CS are as described above for WACM;



EJT is the Extended Journey Time as a result of Network Rail restricting use. The calculation of the Extended Journey Time includes a cap to the attributable extension for each Service Group, and is otherwise calculated as the average scheduled journey time for the Service Group multiplied by a factor representing the percentage decrease in average speed in the New Working Timetable versus the Corresponding Day Timetable as shown below.

$$\text{Extended Journey Time: } EJT = AJT \times \left(\frac{(u - v)}{v} \right)$$

Where u is the average speed of trains in the Service Group in the Corresponding Day Timetable and v is the average speed of trains in the Service Group in the New Working Timetable.

BF is the Busyness Factor. It gives a greater weighting to Cancellation and Delay Minutes incurred on days of the year when the network is more heavily used. That is, it will typically weight disruption on weekdays more heavily than disruption on weekends.

$$\text{Busyness Factor: } BF = \frac{\sum(MPW \times SS)}{AS}$$

With the following definitions for the component expressions:

MPW and SS are as described above for WACM;

AS is the average number of stops at the Monitoring Point per day in the Bi-annual Timetable.

The Busyness Factor is therefore:

- larger for days in the year that are busier than average in terms of number of trains calling,
- smaller for days of the year that are less busy than average in terms of the number of trains calling.

$$\text{Network Rail payment Rate: } NRPR = \text{Payment rate specified in Schedule 8}$$

The payment rates are determined to reflect the revenue impact of disruption to the TOC.

$$\text{Notification Factor: } NF = \begin{cases} x & \text{if notification by } T - 26 \\ y & \text{if notification by } T - 22 \\ z & \text{if notification after } T - 22 \end{cases}$$

Where $x < y < z$, and x , y , and z are contractually agreed for each Service Group. The Notification Factor is sometimes referred to as the Notification Discount Factor, and reported separately as an indicator of how far in advance Network Rail plans and communicates its possession requirements.

The Notification Factor is smaller for disruptions where TOCs are notified by T-26, which is six months prior to the day the disruptive possession occurs.

Additional Payment for Train-Bus-Train Pattern

In the case of Train-Bus-Train Pattern on account of Network Rail restricting use of the network, additional payments are made according to the following rules.

$$\text{Additional Network Rail Payment: } ANPR = \frac{TTS_{SG}}{TTR_{SG}} \times (CM - NRPP) \times DV \times NRPR \times BF \times NF$$

With the following definitions for the component expressions:

TTS_{SG} is the number of trains in the Service Group terminating at a Monitoring Point other than those that would have terminated there in the Corresponding Day Timetable;

TTR_{SG} is the total number of trains in the Service Group scheduled to run in the Corresponding Day Timetable;

DV takes a value of 0.125; and

CM, NRPP, NRPR, and BF have the definitions outlined above.

This additional payment compensates the TOC for loss of revenue due to the additional traveller disbenefit caused by a mode switch from rail to bus and the associated interchange.

Reimbursement of Operating Costs

Lastly, the TOC will have changed operating costs due to restrictions on the Network, which Network Rail is obliged to reimburse.

$$\text{Cost compensation} = \sum (\text{RRBC} + \text{TMC})$$

With the following definitions for the component expressions:

RRBC is the Rail Replacement Bus Cost, determined by a payment rate and replacement bus mileage run.

TMC is the Train Mileage Cost, determined by the change in train-miles operated by the TOC due to restrictions on the network and a payment rate. If fewer train-miles are run relative to the Corresponding Day Timetable, Network Rail's overall payment to the TOC would decrease to reflect the cost saving of the TOC. If more bus-miles and/or train-miles are run, the TOC receives a greater payment.

In summary, the Schedule 4 payment mechanism holds several data components, potentially useful for developing a possession disruption metric, that are already calculated for other purposes.

7.2 Short List of Possession Disruption Metrics

In this section we introduce the four shortlisted metrics for possession disruption indicators. They are presented in increasing order of cost and effort to implement.

7.2.1 Schedule 4 metric

The Schedule 4 metric would report the total Network Rail Schedule 4 payment made in each period.

1 S4 Measure

Definition:	Level of Schedule 4 payments
Unit:	£ GBP
Timeframe:	Periodic
Route-level to national level aggregation:	Sum of payments for each route

Schedule 4 payments are calculated via a complex system of equations as described in Section 7.1. The payments from NR to operators mitigates the loss of present and future revenue, the cost of running replacement buses, the change in train operating costs relative to the non-disrupted timetable, and costs relating to cancelled / late amended possessions. The payments are discounted if early notification is given.



As a focused measure of the level of possession disruption occurring on the Network, Schedule 4 is too complex. It is not possible, for example, to understand if a fall in Schedule 4 payments is due to earlier notification causing the Notification Discount Factor to increase, or better planning and cooperation with TOCs causing excess journey time and cancellation minutes to fall.

As an already accepted industry measure, this metric would be easy to implement. It is already calculated and put to commercial use each period within the industry. This makes it the shortlisted metric with the lowest implementation cost.

The complex calculation method has been negotiated between TOCs, NR and government over many years. It captures the majority of conceivable impacts of possession disruption on the operator. However, as noted in Section 4.4, holding the operators financially neutral to changes in the level of possession disruption is not the same as balancing the level of possession disruption against the costs to the passenger or the wider economy. Furthermore, operators may respond to possession disruption by running services that maximise the Schedule 4 payments that they receive, which is not necessarily the optimum service for passengers. This highlights the shared responsibility of operators and NR to work together to provide the least disrupted service while maintenance, renewals and enhancements are delivered.

Schedule 4 payments are calculated in nominal GBP, and as such are affected by the rate of inflation. Payment rates are renegotiated at least once per Control Period. Both of these factors hinder trend analysis.

Lastly, a further drawback of publishing Schedule 4 payments is that some inputs, in particular payment rates, are commercially sensitive and confidential. They therefore may make a poor candidate for reporting to the public as they may be perceived as a 'fine' or damages caused by NR to rail users or the wider economy, instead of a practical commercial necessity.

Strengths	Weaknesses
<ul style="list-style-type: none"> ▪ Already an accepted industry measure. ▪ A potential path of least resistance. ▪ If TOC revenue is a good proxy for passenger experience, it is a sophisticated measure that captures many elements of lost revenue. 	<ul style="list-style-type: none"> ▪ As an existing metric, it fails to sufficiently incentivise good possession planning as reported by operators. ▪ It does not effectively incentivise balancing works cost against the wider economic costs of possession disruption. ▪ As a nominal GBP measure it is not independent of inflation. ▪ Payment rates are reset periodically, hindering trend analysis. ▪ Quoting the impact of Network Availability as a monetary quantity could be perceived as 'fining' Network Rail for taking necessary possessions in their day-to-day operations.

7.2.2 An Extended Journey Time metric

The Extended Journey Time (EJT) metric is a cut-down version of the Schedule 4 measure. It captures the increase in journey time and Cancellation Minutes in the Plan of Day compared to the Corresponding Day Timetable. This metric was developed out of Option 4: Comparison of Corresponding Day Timetable against Plan of Day from the optioneering and sift process.

2 Excess Planned Journey Time Definition

Definition:	Relative / absolute increase in the Corresponding Day Timetable total journey time
Unit:	Relative / absolute increase in journey time over CDTT total journey time
Timeframe:	Periodic / weekly
Route-level to national level aggregation:	Dependant on Service Group Weighting (SGW)

The EJT metric represents an effort to ‘strip down’ the Schedule 4 payment mechanisms to create a simple, comprehensible and focused measure of the level of possession disruption occurring on the network.

It is derived from the existing Schedule 4 mechanisms. We believe implementation will be possible at a lower cost than rebuilding NARS, given that the component expressions are already computed for the purpose of calculating Schedule 4 payments.

$$\text{Absolute Extended Journey Time Metric} = ((\text{WACM} + \text{NREJT}) \times \text{SGW})$$

$$\text{Relative Extended Journey Time Metric} = \sum \left(\frac{(\text{WACM} + \text{NREJT})}{\text{AJT}} \times \text{SGW} \right)$$

With the following definitions for the component expressions:

WACM and NREJT are the Weighted Average Cancellation Minutes and the Network Rail Extended Journey Time Schedule 4 components described in Section 7.1 above;

AJT is the average scheduled running time (Average Journey Time) for a Service Group in the Corresponding Day Timetable as described in Section 7.1 above;

SGW is a Service Group Weighting which could be one of the following:

- Number of trains in the Service Group;
- Proportion of total train-hours in the Service Group;
- Proportion of total passenger-hours in the Service Group;
- Typical passenger loadings.

Σ is the sum across all Service Groups.

Note that the Absolute Extended Journey Time (A-EJT) metric is the same as the Schedule Delay and Cancellation Payment presented in Section 7.1 above, with:

- the Busyness Factor and Notification Discount Factor removed,
- the Network Rail Payment Rate replaced with a (non-pecuniary) Service Group Weighting.

The Relative Extended Journey Time (R-EJT) Metric is as A-EJT, but normalised by the Average Journey Time for each Service Group.

To aggregate across days in a reporting period, a mean average should be calculated for R-EJT, while for A-EJT an average can be taken to express the mean absolute impact per day, or a sum to express the total delay across the reporting period.

Service Groups can vary drastically by number of trains, train-km run, train-hours scheduled, number of passengers, or fares taken. It is therefore necessary to weight each service group with a Service Group Weighting in order to aggregate across Service Groups in a meaningful way. A Service Group Weighting that yields a meaningful and understandable expression of delay on the Network. Train-focused expressions have less demanding data requirements, while passenger-focused expressions better measure the experience of the ultimate user.

Determining the most suitable choice for CP6 would depend upon data and resource availability for reporting.

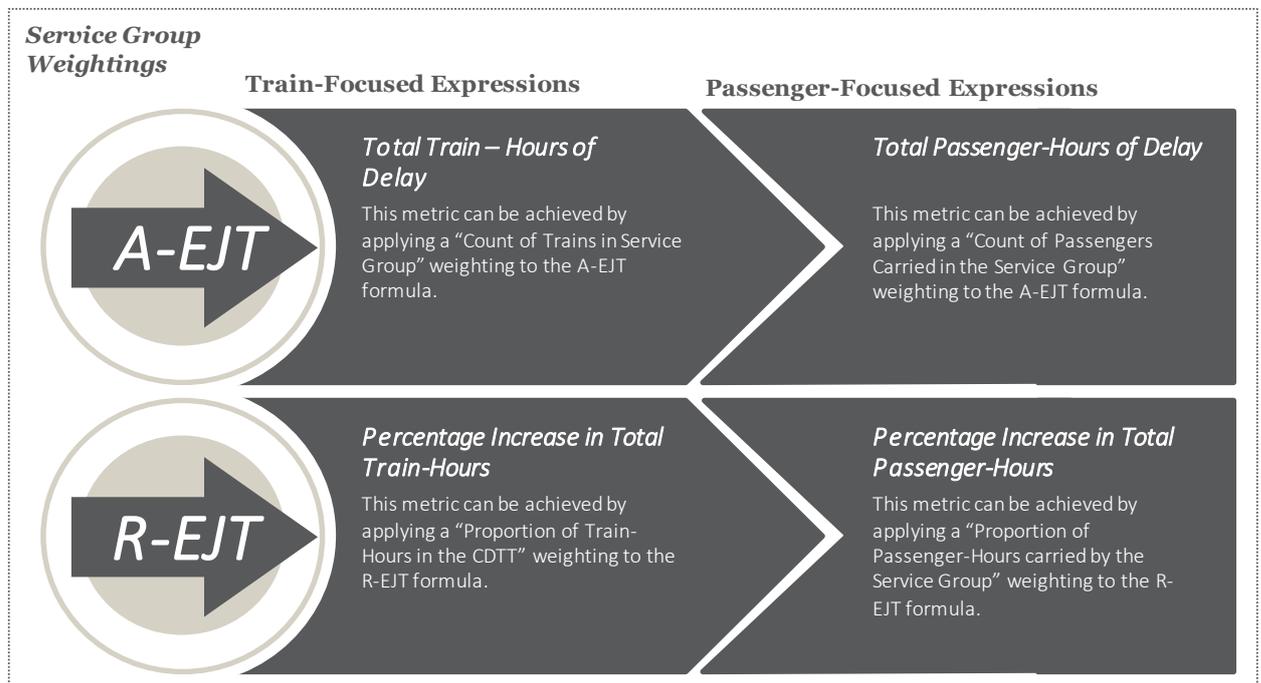


Figure 9: Service Group Weightings for the proposed EJT metrics.

By drawing on established components of Schedule 4, this option captures the planned - but not unplanned - disruption across the network.

While A-EJT and R-EJT will capture any extension in journey time to a scheduled service due to replacement bus service, it would not explicitly capture the additional disbenefit due to interchange from train to bus (interchange penalty), or the passenger preference for travelling on trains over travelling on bus. Furthermore, the metric does not vary in response to early or late notification or capture the impact of possession overruns. This can be seen as an advantage or a disadvantage: an EJT metric has a clear place in a suite of measures, each focused on a single aspect of possession disruption. Alternatively, the Schedule 4 measure rolls several different aspects into a single measure.

Strengths	Weaknesses
<ul style="list-style-type: none"> ▪ Should capture all planned, but no unplanned, disruption on the network. ▪ Relative increase in journey time / cancellation minutes can be used to benchmark disruption levels across routes. ▪ Absolute increase in journey time / cancellation minutes can be used to track total disruption over time. 	<ul style="list-style-type: none"> ▪ Does not capture negative experience of bus replacement. ▪ Does not capture early notification. ▪ Does not capture overruns. ▪ The passenger-focused service group weightings have cost and resource requirements, and would need remodelling if there is a significant change in passenger demand or service offering.

7.2.3 A revisited PDI metric

This metric is an enhancement to PDI, fixing the implementation issues and allowing Route-level reporting. The calculation methodology would be tweaked to allow the expression of passenger-delay minutes per km.

3 PDI v2 Definition

Definition:	An updated PDI, expressed in delay-minutes and disaggregated to Route level
Unit:	Delay minutes per train-km
Timeframe:	Periodic
Route-level to national level aggregation:	Mean average, weighted by scheduled train-km in each Route

$$EPJwVT = \frac{\sum_{SG} \left[\sum_d \{ (NREJT_{SG,d} + WACM_{SG,d}) \cdot BF_{SG,d} \cdot PASS_{SG,d} \cdot ToDW \} \right]}{\sum_{SG} PT_{SG}}$$

The equation reflects an estimate of the additional journey time for passengers, divided by scheduled train kilometres. The inputs are:

- Extended journey time (**NREJT**) for the service group (**SG**), by day (**D**). This is a component of Schedule 4.
- Weighted average of cancellation minutes (**WACM**) for service group, by day. This is a component of Schedule 4.
- Busyness factor (**BF**) measuring the frequency of services, for service group, by day. This is a component of Schedule 4.
- Average passenger train kilometres scheduled by service group (**PT**).
- **PASS** is the daily average number of passenger journeys per day for the relevant service group. This weighting is in NARS, but may require updating.
- Time of Day Weighting (**ToDW**) is a pre-determined fraction representing the percentage of passenger journeys for the relevant Service Group during the time of day (average values for each hour of the day) and day of week. This weighting is in NARS, but may require updating.

Strengths	Weaknesses
<ul style="list-style-type: none"> ▪ It may be possible to make use of the existing NARS work ▪ Is sophisticated enough to capture the customer experience well given current data sources 	<ul style="list-style-type: none"> ▪ Possibly would retain 'toxic' connotations of PDI ▪ May not be independent of service group changes ▪ Does not reflect that passengers do not (dis)value all delay minutes equally ▪ Would need a re-branding exercise ▪ Stakeholders have strongly hinted that the money to rebuild NARS is not available

7.2.4 A Lost Customer Hours metric

This metric would involve modelling a 'reasonable pre-estimate' of the delay and cancellation minutes / hours for any piece of infrastructure that may be taken as a possession, for all times of day and year. The modelling could conceivably go to a very detailed level; for example, on London's tube network, TfL has assigned estimates of lost customer walk time within stations for non-availability of escalators. However, a workable system could be envisaged where the most frequently taken possessions were modelled in a first phase, with additional updates to the system being implemented over time.

4 'Dutch' Lost Customer Hour Approach Definition

Definition:	Track modelled disruption due to unavailability of all relevant network assets
Unit:	Lost Customer Hours
Timeframe:	Periodic / weekly
Route-level to national level aggregation:	Sum of Lost Customer Hours for each Route

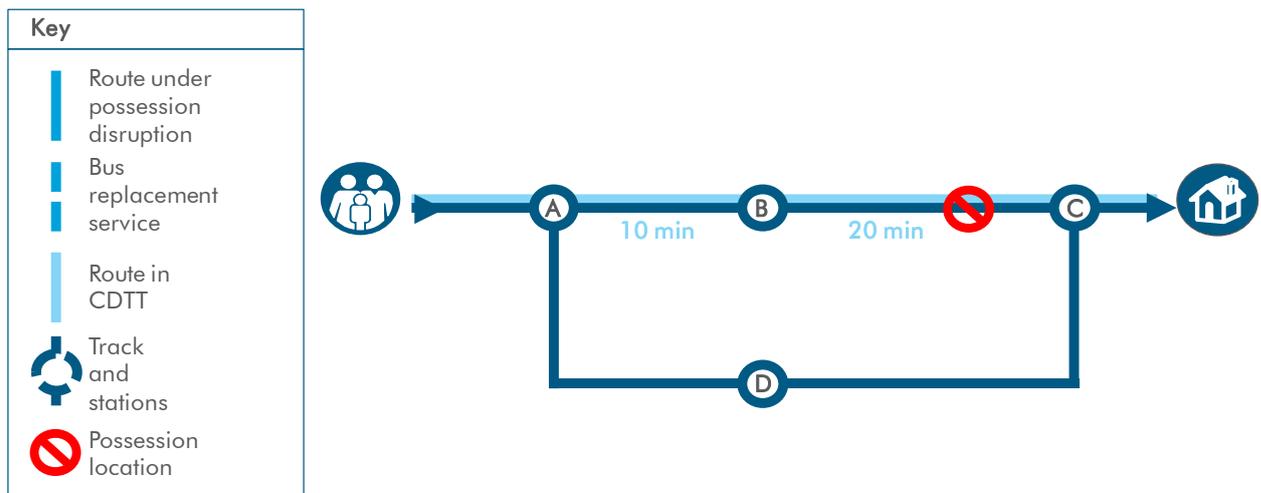
An appealing aspect of this metric is that the database of reasonable pre-estimates of disruption for any possession can be accessed by engineers, works planners and train planners, allowing for coordinated and informed decisions to be made across NR and the wider industry regarding the impact of possessions. This has helped drive to a transformation of culture within TfL, moving from an engineering-focused to a customer-focused outlook from inception in the mid 1990's to today.

This forward-looking approach can be used by NR to hold third parties to account when e.g. developers or utility companies require possessions. Understanding of the impact of the third party schemes is a first step to negotiating compensation or possession patterns with less impact on services.

Strengths	Weaknesses
<ul style="list-style-type: none"> ▪ Proven international record. ▪ Proven ability to change organisational focus as in LUL. ▪ Effectively captures customer experience by acknowledging the various values for different types of customer (dis)benefit. ▪ GJT for all OD pairs on the national network is already calculated. 	<ul style="list-style-type: none"> ▪ Requires expenditure and time on modelling work to set up. ▪ Would require work to adjust methodology to specifics of National Rail network, and account for greater heterogeneity. ▪ Attribution of LCH to Routes may be non-trivial. ▪ Passenger impact of potential bus replacement services would need modelling work to understand. ▪ Data requirements may be spread across industry organisations. ▪ LENNON data not as granular as Oyster taps.

7.3 Analysis of possession disruption metrics for major possession disruption types

In order to give a more detailed understanding of how the shortlisted possession disruption metrics perform under different types of network disruption. We have identified six major types of possession disruption, which are described in the following diagram and table (see key below).



Disruption Type	Description
Type 1: Bus diversion with extended journey time	Train scheduled to service A-B-C. Bus replacement operates between B-C, increasing journey time by 10 minutes.
Type 2: Rail diversion with missed station	Train scheduled to service A-B-C. Train is re-routed via D, skipping stop at B. There is no extension of journey time from A to C.
Type 3: Rail diversion with interchange	Train scheduled to service A-B-C. Train is re-routed to D, skipping stop at B. Passengers change to connecting service to C onward. There is no extension of journey time from A to C.
Type 4: Rail diversion with extended journey time	Train scheduled to service A-B-C. Train is re-routed via D, skipping stop at B. There is a 10 min extension of journey time from A to C.
Type 5: Customer chooses not to travel	Train scheduled to service A-B-C. Train is re-routed via D, skipping stop at B. There is a 20 min extension of journey time from A to C. Many passengers are deterred from travelling.
Type 6: Customer unable to travel	Train scheduled to service A-B-C. Train terminates at B, and no feasible alternative arrangements for B-C are provided (This is relatively uncommon on the UK railways).

7.3.1 Summary of results

The results of the analysis of the six disruption types are summarised in the following table. The full analysis of each disruption type can be found in Appendix D.

Metric	Type 1: Bus diversion with extended journey time	Type 2: Rail diversion with missed station	Type 3: Rail diversion with interchange	Type 4: Rail diversion with extended journey time	Type 5: Customer chooses not to travel	Type 6: Customer unable to travel
1. Schedule 4	Yes	Yes	Partial	Yes	No	No
2. EJT Metric	Partial	Yes	Partial	Yes	No	No
3. PDI v2	Partial	Yes	Partial	Yes	No	No

4. LCH Approach	Yes	Yes	Yes	Yes	Yes	Yes
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The LCH approach can be configured to capture any disruption type, but its implementation is costly to achieve such a level of detail. It is possible that a phased introduction would not capture all disruption types in an initial version.

Schedule 4 has complex caveats to capture the impact of bus transfer, but has drawbacks as a regulatory measure due to reliance on bilaterally negotiated commercially sensitive payment rates.

The EJT Metric and PDI have a similar performance, as they both draw on the same elements of Schedule 4: NREJT and WACM. However, the EJT Metric is significantly less costly if it can be computed without a refresh of the Network Availability Reporting System (NARS) on which it relies.

8 Recommendations and Next Steps

Based on the analysis in this report, our recommendation for a measure of the level of possession disruption on the railway network is to develop the EJT metric, by carrying out a cost-benefit evaluation of reporting A-EJT and R-EJT. Ideally a passenger-focused Service Group Weighting should be used, but we expect that the train-focused alternative will have lower implementation costs.

In the longer term, the industry should consider the feasibility of moving to a Lost Customer Hours approach.

In aggregate, the regulatory stance for Network Rail's delivery of Network Availability in CP6 should reflect the following.

- Network Availability should be monitored both publicly above and beyond the Schedule 4 mechanism, which is not alone sufficient to balance possession disruption against the impact on passengers or the wider economy.
- Possession disruption has several aspects that impact different stakeholders. These should be monitored separately with a suite of measures, to better understand the full picture of Network Availability. The suite of measures should comprise:
 - *The A-EJT and R-EJT metric*: if feasible, a passenger-focused approach should be adopted, using the passenger-focused service group weightings presented in Figure 9. Alternatively, the train-focused metrics could be used, which have less demanding data requirements.
 - *Delay and Cancellation Minutes due to Possession Overrun metric*: NR should continue to report this existing metric.
 - *A Bus Vehicle-Hours metric*: Train-hours replaced with bus service are already reported. If possible, the more passenger-focused Bus Vehicle-Hours should be reported.
 - *Disruptive Late Changes post T-26, T-12 and T-6*: Late changes post T-26 are already reported by NR. Changes post T-12 and T-6 should be reported as these very late changes are disruptive to operators and ultimate users.
 - *Critical Freight Infrastructure*: If industry can agree on a list of critical infrastructure for freight, the count and average duration of incidents of non-availability should be reported.



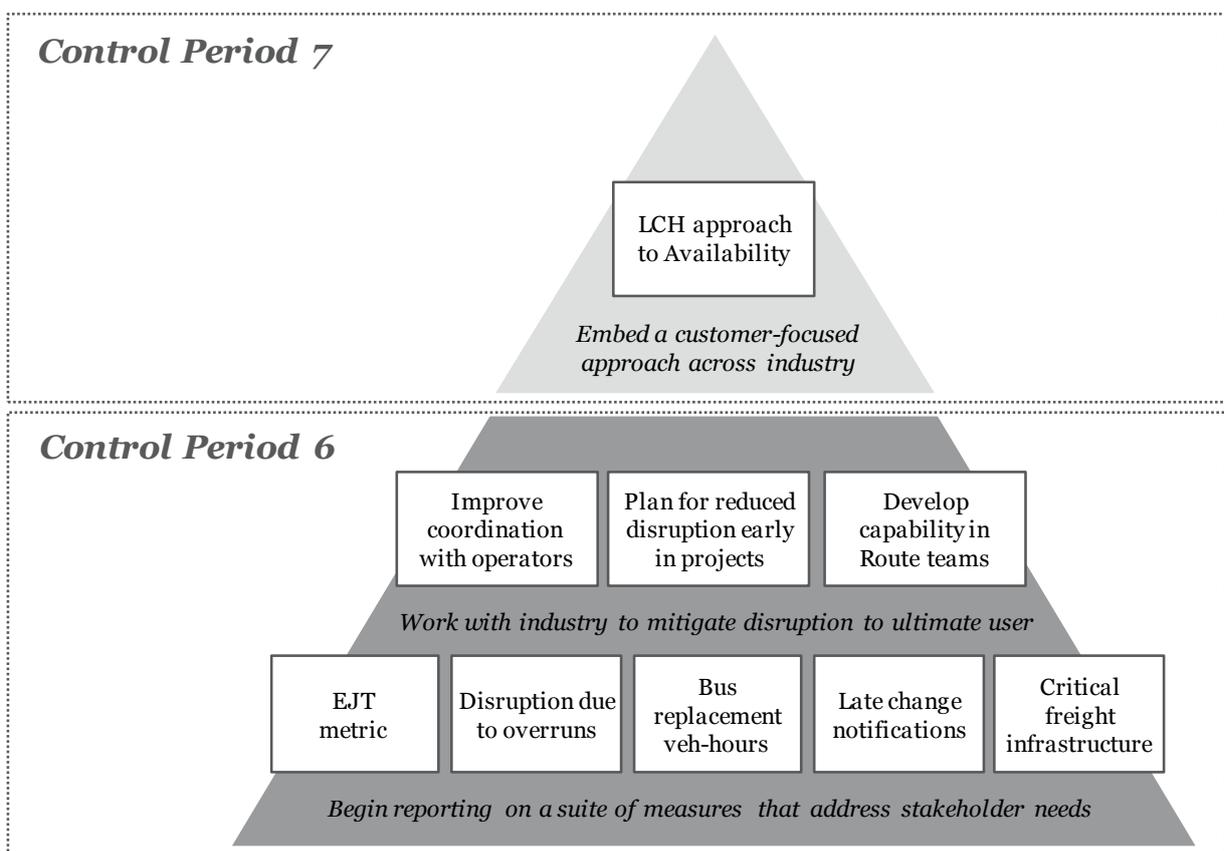
These metrics can all be reported at a Route level, to facilitate performance benchmarking in addition to trend analysis.

- The level of possession disruption will vary depending on the output requirements of NR. Major enhancements may, for example, cause huge disruption but deliver yet greater benefits. The suite of measures should therefore be used to generate informed discussion on the topic of Network Availability, with the understanding that disruption from possessions may sometimes increase with good reason.
- The response of operators to possession plans can impact the disruption experienced by the end user. The metrics could therefore be considered to be jointly owned by the infrastructure owner and operators.
- In the long term towards CP7 and beyond, consideration should be given to moving towards a 'Dutch' Lost Customer Hours approach to delivering Network Availability, used as a tool to help shift industry culture towards a focus on the ultimate customer.

The DfT has responded to the draft version of this report with a statement which we present in Appendix E.

To follow on from this work, the natural next steps are to:

- Carry out a wider industry consultation on the value of the proposed measures.
- Undertake a more detailed analysis of the practicalities of implementing the measures, including costing and identifying barriers to implementation.



Appendix A Further details on weaknesses of Schedule 4 as a measure of Network Availability

To further illustrate why Schedule 4 is not ideal as a single metric of disruption, consider the following conceptualisations of the disruption minimisation problem. Starting with a view of what the overall objective of the railway should be. The aim of the railway manager (including operational, regulation, and government functions) is surely to make rail travel as easy as possible for all passengers and freight. For passenger operations, we can write the railway manager's objective mathematically (see Harris et al, 2016, p22) as minimising the sum of generalised disruption cost over each origin i and destination j for each passenger type p , where each origin-destination and passenger type group is a group of n_{ijp} passengers.²

There are at least three potential economic weighting factors r_{ijp} , g_{ijp} , or e_{ijp} that can be applied to each origin-destination passenger type group. Let r_{ijp} be the operator revenue impact of disruption, g_{ijp} the generalised cost to the passengers, and e_{ijp} the overall loss of economic activity.

Schedule 4 holds operators revenue-neutral to changes in the level of network disruption. NR must compensate them for the lost fare revenue; NR is therefore incentivised to act to minimise the sum of disruption impact in terms of revenue loss.

$$\min R = \min \sum_{i=1}^I \sum_{j=1}^J \sum_{p=1}^P n_{ijp} * r_{ijp}$$

Conceivably, an alternative set of weightings g_{ijp} could be used, to represent the total passenger and operator loss in terms of generalised cost from network disruption. This would be equal to the loss of revenue to the operator plus the loss of surplus to the passenger. The various extra inconveniences experienced by the passenger would be included here, the greatest of which would be loss of time. Given the proportion of time and revenue benefits typically calculated for railways improvement schemes, we would expect the lost time element to be at least as large as the revenue element.

$$\min G = \min \sum_{i=1}^I \sum_{j=1}^J \sum_{p=1}^P n_{ijp} * g_{ijp}$$

Lastly, we might instead weight disruption by the impact on the wider economy. In practice this might be done using economic multipliers. This would be equal to the loss of revenue to the operator plus the loss of surplus to the consumer, plus the indirect loss to business and the wider economy due to potential journeys not being made (including impacts on health, the environment etc. as well as other economic activity per se).

$$\min E = \min \sum_{i=1}^I \sum_{j=1}^J \sum_{p=1}^P n_{ijp} * e_{ijp}$$

A recent example of this was the £100million quoted for the economic loss to Devon and Cornwall after the collapse of the sea-wall and the railway at Dawlish in 2015 where, for instance, tourism expenditure was reduced as holidaymakers could not access the region by train. However, more recent attention to wider economic (and agglomeration) benefits suggests that these figures may be significant in a wider range of situations than previously considered.

² Harris, N G, Haugland, H, Olsson, N & Veiseth, M (2016) "An Introduction to Railway Operations Planning", A & N Harris, London



To balance the benefits of possession disruption against the costs to the wider economy, NR should balance possession planning against the total economic cost of disruption E . It is clear from the definitions above that $r_{ijp} \leq g_{ijp} \leq e_{ijp}$, implying $R \leq G \leq E$. Therefore, although Schedule 4 is a necessary mechanism for insuring operators against changes in the level of network disruption, it is not sufficient to incentivise the optimal level of possession taking from the perspective of the economy as a whole.

Appendix B Sift Scoring Criteria

This is the sift scoring criteria used to assess the long list of approaches discussed in Section 6.

		Scoring category					
		Economic Impact Tool	Management Regulatory Tool	Perverse Incentives	Ease of use	Alignment to broader asset management strategy	
Score	Very Good	Takes into account the economic impact on operators, passengers, and the wider economy	Can be applied all the following: benchmark performance, analyse time trends, and hold third parties to account	Can be used to hold NR to account at a route level, including providing insight on specific incidents	Not likely to negatively impact on any other output.	The metric is likely to be intuitive to front-line staff and the public, and can be computed near to real time	The method is complementary to other regulated outputs
	Good	Takes into account the economic impact on operators and passengers	Can be applied to two of the following: benchmark performance, analyse time trends, hold third parties to account	Can be used to hold NR to account for performance in managing possessions, including providing insight on specific incidents	There is a limited chance of unintended consequences	The metric is either likely to be intuitive to front-line staff, or it can be computed in near to real time	The method is complementary to other regulated outputs, but there is some overlap
	Poor	Takes into account the economic impact on operators	Can be applied to one of the following: benchmark performance, analyse time trends, hold third parties to account	Can be used to hold NR to account for performance in managing possessions, not including providing insight on specific incidents	There is a large chance of unintended consequences	The metric is not particularly intuitive, and takes over a week to compute	The method does not add any incentives above S4 or other
	Very Poor	Does not reflect the economic impact of possessions	Can be applied to none of the following: benchmark performance, analyse time trends, hold third parties to account	Cannot realistically be used to hold NR to account for performance in managing possessions	The method incentives behaviour that is inconsistent with good practice	The metric is difficult to understand and takes over a week to compute	The method distorts S4 or other incentives

Appendix C A-EJT and R-EJT example calculation

In this section we work through some examples of calculating the A-EJT and R-EJT metrics using the train-focused and passenger-focused approach.

Setting

Consider a disrupted day on a network with three service groups, and the details given below.

Service Group	Count of Trains	Average Journey Time (hours)	Scheduled train-hours	Typical passengers / train	Total scheduled passenger-hours	Total passengers	WACM + NREJT (hours)
HT01	12	0.50	6.0	90	540.0	1,080.00	-
HT02	10	1.00	10.0	75	750.0	750.00	0.33
HT03	8	0.67	5.3	100	533.3	800.00	-
Totals	30	-	21.3	265	1,823.3	2,630.00	

We will walk through an example where possession disruption has caused NREJT + WACM for Service Group HT02 of 20 minutes. This represents an average delay or cancellation minutes per train in the HT02 Service Group of 20 minutes.

Train-focused approach

If data on passenger loadings is not readily available, a train-focused approach should be used. The suggested Service Group Weighting for a train-focused approach is the Count of Trains in Service Group for A-EJT and the Proportion of Train-Hours for R-EJT.

Calculating Service Group Weightings

Service Group	HT01	HT02	HT03
Count of Trains in SG	12	10	8
Train-Hours in SG	6.00	10.00	5.33
Total Train-Hours	21.33	21.33	21.33
Proportion of Train-Hours	0.28	0.47	0.25

A-EJT

$A-EJT: \text{SUM} ((NREJT + WACM) * SGW)$

Service Group	HT01	HT02	HT03
Count of Trains in SG	12	10	8
NREJT + WACM	0.00	0.33	0.00
$(NREJT + WACM) * SGW$	0.00	3.30	0.00

A-EJT	3.30 train-hours
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This is the total train-hours of delay on the network.

R-EJT

$R-EJT: \text{SUM} (((NREJT + WACM) / AJT) * SGW)$

Service Group	HT01	HT02	HT03
Proportion of Train-Hours	0.28	0.47	0.25
NREJT + WACM	0.00	0.33	0.00
AJT	0.50	1.00	0.67
$((NREJT + WACM) / AJT)$	0.00	0.33	0.00
$((NREJT + WACM) / AJT) * SGW$	0.00	0.15	0.00

R-EJT	0.15 percent
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This is the percentage increase in total train-hours due to possessions.

Passenger-focused approach

If data on passenger loadings is readily available, a passenger-focused approach can be used. The suggested Service Group Weighting for a train-focused approach is the Count of Passengers Carried in Service Group for A-EJT and the Proportion of Passenger-Hours Carried for R-EJT.

Service Group Weightings

Service Group	HT01	HT02	HT03
Count of Passengers Carried	1080	750	800
Passenger-Hours in SG	540.00	750.00	533.33
Total Passenger-Hours	1,823.3	1,823.3	1,823.3
Proportion of Passenger-H	0.30	0.41	0.29

A-EJT

$A-EJT: \text{SUM} ((NREJT + WACM) * SGW)$

Service Group	HT01	HT02	HT03
Count of Passengers Carried	1080	750	800
NREJT + WACM	0.00	0.33	0.00
$(NREJT + WACM) * SGW$	0	247.5	0

A-EJT	247.5 passenger-hours
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This is the total passenger-hours of delay on the network.

R-EJT

$R-EJT: \text{SUM} (((NREJT + WACM) / AJT) * SGW)$

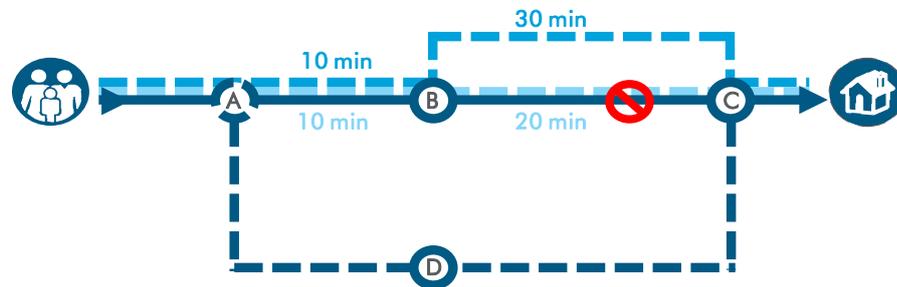
Service Group	HT01	HT02	HT03
Proportion of Passenger-H	0.30	0.41	0.29
NREJT + WACM	0.00	0.33	0.00
AJT	0.50	1.00	0.67
$((NREJT + WACM) / AJT)$	0.00	0.33	0.00
$((NREJT + WACM) / AJT)$	-	0.14	-

R-EJT	0.14 percent
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This is the percentage increase in total passenger-hours due to possessions.

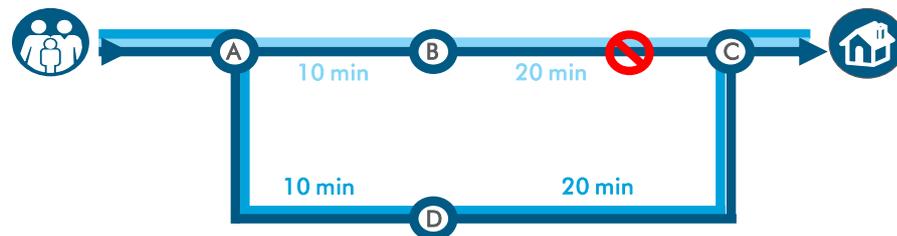
Appendix D Full Analysis of Types of Possession Disruption

1. Bus diversion with extended journey time



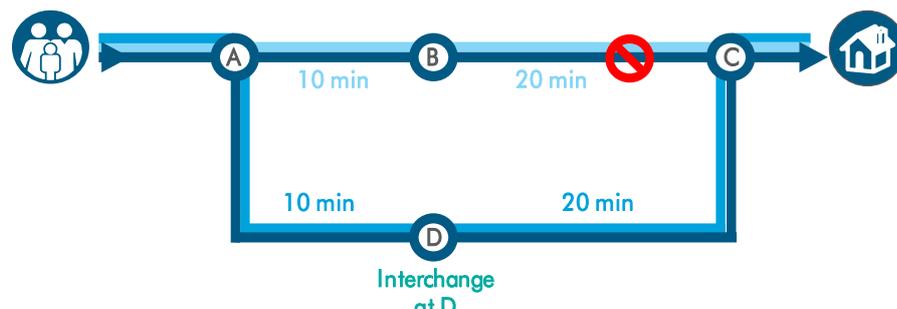
Option	Impact Captured	Note
1. Schedule 4	Yes	EJT, interchange / bus penalty captured (Train-Bus-Train Pattern)
2. EJT Metric	Partial	Excess journey time captured, but not interchange / bus penalty
3. PDI v2	Partial	Excess journey time captured, but not interchange / bus penalty
4. LCH Approach	Yes	All impacts could be modelled

2. Rail diversion with missed station



Option	Impact Captured	Note
1. Schedule 4	Yes	Cancellation at B captured via Cancellation Minutes
2. EJT Metric	Yes	Cancellation at B captured via Cancellation Minutes
3. PDI v2	Yes	Cancellation at B captured via Cancellation Minutes
4. LCH Approach	Yes	All impacts could be modelled

3. Rail diversion with interchange



Article I. Option	Article II. Impact Captured	Article III.	Note
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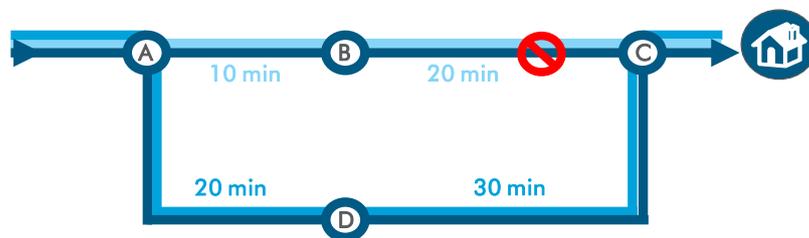
1. Schedule 4	Partial	Cancellation at B captured, but not interchange penalty at D
2. EJT Metric	Partial	Cancellation at B captured, but not interchange penalty at D
3. PDI v2	Partial	Cancellation at B captured, but not interchange penalty at D
4. LCH Approach	Yes	All impacts could be modelled

4. Rail diversion with extended journey time



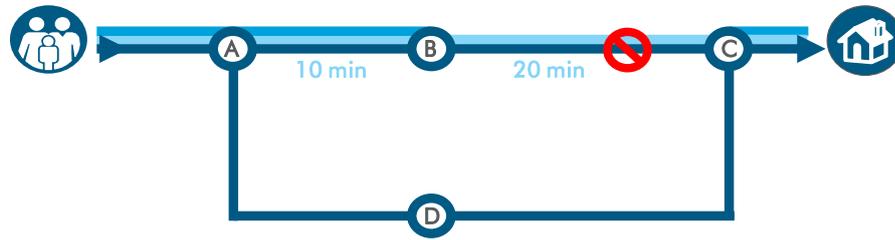
Option	Impact Captured	Note
1. Schedule 4	Yes	Cancellation at B and extended journey time to C captured
2. EJT Metric	Yes	Cancellation at B and extended journey time to C captured
3. PDI v2	Yes	Cancellation at B and extended journey time to C captured
4. LCH Approach	Yes	All impacts could be modelled

5. Customer chooses not to travel



Option	Impact Captured	Note
1. Schedule 4	No	Does not capture non-linear threshold for non-travel
2. EJT Metric	No	Does not capture non-linear threshold for non-travel
3. PDI v2	No	Does not capture non-linear threshold for non-travel
4. LCH Approach	Yes	GJT elasticity thresholds could be modelled

6. Customer unable to travel



Option	Impact Captured	Note
1. Schedule 4	No	No allowance for non-provision of alternative route
2. EJT Metric	No	No allowance for non-provision of alternative route
3. PDI v2	No	No allowance for non-provision of alternative route
4. LCH Approach	Yes	Penalties for non-provision of alternative routes could be included

Appendix E Response from DfT

“DfT agrees that measuring the disruption caused by possessions could be valuable, and that measures could support discussions between Network Rail and operators on how well the impact on both passengers and freight is managed - so long as measures were not focused on to the exclusion of other factors in possession planning and management.

Disruption is inevitable, and Network Rail and operators should work together to plan the best overall strategy for efficiently delivering necessary work, and within that strategy consider and manage the impact on users. This could include reviewing opportunities to undertake works for part of the traffic day when rail usage is light.

For passengers, ideally a measure of extended journey time would be passenger-based rather than train-based, given the variation in service utilisation. Disruption to freight users will also be important to consider, including the need to make diversionary routes available. In the longer-term, we agree that developing a ‘lost customer hours’ measure could be helpful, and could support thinking about the impact on users from all disruption (planned or unplanned).

There are several issues relevant to how possessions impact on users which will have to be considered alongside the measures suggested. For example, the quality and timeliness of communications, the practical ability of alternative routes to absorb displaced passengers, the quality of replacement services (e.g. bus comfort and facilities), and whether users choose not to use replacement services at all.

We also want to avoid the creation of perverse incentives in disruption measures. For example, we would not want minimising ‘bus vehicle hours’ to incentivise making replacement buses less frequent. And we would not want to incentivise shorter possessions in circumstances where longer, well-managed and publicised possessions are the best overall strategy.

Ultimately we want well planned possessions, with good activity levels during them, with users supported by good publicity and appropriate levels of alternative services. We would like to see a regulatory approach which takes account of the various responsibilities of Network Rail and train operators in delivering those objectives, and how effectively they work together in doing so, and which is supported by but not driven by individual metrics.”

Amendment Record

Issue	Description	Distribution	Date
1.0	First Draft Issue	Sneha Patel (ORR), Matt Durbin (ORR)	27/04/18
2.0	Final Issue	Sneha Patel (ORR), Matt Durbin (ORR)	25/05/18

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