Office of Rail Regulation, Network Rail

Independent Reporter (Part A)

Network Availability Reporting System (NARS) Suitability Assessment Report

Mandate AO/009

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Executive Summary

Arup was appointed by the Office of Rail Regulation (ORR) and Network Rail on the 7th April 2011, in its capacity as their Independent Reporter (Part A), to conduct a technical review of Network Rail's Network Availability Reporting System (NARS). This report presents our findings in relation to Mandate AO/009: Network Availability Reporting System (NARS) Suitability Assessment.

In order to measure network availability, two indexed measures, Possession Disruption Index – Passenger (PDI-P) and Possession Disruption Index – Freight (PDI-F), were developed and applied by Network Rail and ORR, together with a range of supporting measures. The 2008 Periodic Review established targets of a reduction in disruption from engineering possessions to passengers of 37%, and no overall increase in disruption to freight.

The calculation of PDI-P and PDI-F has been performed using interim systems developed by Steer Davies Gleave (SDG) and adapted by Network Rail and ORR, comprising a complex set of databases and spreadsheets, and importing data from the Schedule 4 Compensation System (S4CS) and the Possession Planning System (PPS). Both data sources are used in PDI-P, while only PPS is used for the calculation of PDI-F.

The interim system was reviewed by the Part A Independent Reporter in the course of Mandates AO/002 and AO/004, and it was noted that plans were in place to move PDI calculation and reporting to an improved, integrated system. This has now been implemented, in the form of the Network Availability Reporting System (NARS), which is currently being operated in parallel with the interim system.

The specific requirements of this review are as below:

i. ORR wishes to be satisfied that NARS is capable of accurately measuring, reporting and forecasting availability against PR08 targets;

ii. ORR wishes to be assured that NARS provides a sound basis for comparison of options at a disaggregated level, such as new patterns of possessions on a particular route and the effects of possible network enhancements (such as bi-directional signalling or additional station platforms); and

iii. ORR needs to be reassured that use of the interim reporting system can be discontinued whilst still maintaining regulatory, user, stakeholder and public confidence in published reports.

To carry out the assessment, we initially met with Network Rail and ORR's Data Champions for Network Availability, to ensure that we fully understood the Mandate objectives and requirements, and to discuss and agree the TOCs, FOCs, improvement schemes and possession patterns to be reviewed, as specified in the mandate requirements, and to make the arrangements to conduct the assessment in Network Rail's offices.

A detailed review of NARS was then conducted at Network Rail's offices, in accordance with the specific requirements set out above. The results from the interim system were provided by Network Rail.

PDI-P and PDI-F for Actuals (Historic Data)

One of the objectives of the audit was to review the computational accuracy of NARS for the calculation of actual PDI-P and PDI-F values from historic data. This was tested by comparing NARS outputs with those from the interim model for a time series from 2007/08 to 2010/11. As a further test, outputs from the two models were also compared against manual calculations for 2010/11 period 13.

It was agreed with Network Rail and ORR that the tests should be carried out for a range of TOCs by service type: one long-distance, inter-city operator (CrossCountry, who are particularly prone to the effects of possessions, because they operate over such a large proportion of the network), one regional operator (Northern, which operates short trains with low occupancy levels), and one commuter operator (NXEA, who, again, have been heavily affected by possession activities). It was similarly agreed that we should look at two FOCs, Freightliner Intermodal (large) and First GBRf (small).

The tests showed that the two models produced similar results until 2009/10 when they markedly diverge. Network Rail have explained that this difference was due to faulty S4CS data from 2009/10 which NARS correctly rejected but the interim model accepted, and also due to NARS using a new and improved source of train mileage data. NARS was also shown to produce results very close to manual calculation checks conducted. It was therefore concluded that NARS produces reliable results for PDI-P and PDI-F based on 'actual' historic data.

PDI-P and PDI-F Forecast

Selections of hypothetical scenarios were tested in NARS in order to compare the forecast PDI-P and PDI-F values.

We tested two prospective schemes for improved Network Availability, and compared two alternative possession patterns for the maintenance and renewal of two distinct routes, in order to verify that the respective benefits and impacts can be determined satisfactorily. A few additional tests were conducted to assess the efficiency of NARS as a suitable possession disruption indicator tool.

These tests showed that NARS can be used to compare the impacts of different possessions strategies on network availability as measured by PDI-P and PDI-F. Some limitations were identified which would be worth investigating further.

Result

In summary it was concluded that NARS is capable of accurately computing the 'actual' PDI-P and PDI-F values, and can be used to forecast the impact of future scenarios. It is therefore recommended that the interim model can be phased out in favour of NARS for PDI computations.

Some recommendations for considering possible enhancements have been made. Also some user improvements to the software have been suggested for possible inclusion in future versions.

1 Introduction

In its capacity as Independent Reporter (Part A), Arup was appointed by the Office of Rail Regulation (ORR) and Network Rail on the 7th April 2011 to conduct a technical review of Network Rail's Network Availability Reporting System (NARS). This report presents the findings of the audit.

2 Background

In order to measure network availability, two indexed measures, Possession Disruption Index – Passenger (PDI-P) and Possession Disruption Index – Freight (PDI-F), were developed and applied by Network Rail and ORR, together with a range of supporting measures. The 2008 Periodic Review established targets of a reduction in disruption from engineering possessions to passengers of 37%, and no overall increase in disruption to freight.

The calculation of PDI-P and PDI-F has been performed using interim systems developed by Steer Davies Gleave (SDG) and adapted by Network Rail and ORR, comprising a complex set of databases and spreadsheets, and importing data from the Schedule 4 Compensation System (S4CS) and the Possession Planning System (PPS). Both data sources are used in PDI-P, while only PPS is used for the calculation of PDI-F.

There are known discrepancies between the 'geographies' used in Network Rail's timetabling and engineering systems, and a significant degree of manual intervention is required in the processes used in the interim systems.

The systems in use were reviewed by the Part A Independent Reporter in the course of Mandates AO/002 and AO/004, and it was noted that plans were in place to move PDI calculation and reporting to an improved, integrated system. This has now been implemented, in the form of the Network Availability Reporting System (NARS), which is currently being operated in parallel with the interim system.

Network Rail's initial experience with NARS indicates that it does not always exactly replicate the outputs of the interim systems. This may reflect the known limitations of the interim systems, but it is important that NARS is capable of being applied retrospectively to the original base year (2007-08) for Network Availability calculations, in order to provide assurance to ORR and the passenger and freight train operators that the required outputs are being delivered by Network Rail.

3 Objectives

There are three specific requirements of the review:

i. ORR wishes to be satisfied that NARS is capable of accurately measuring, reporting and forecasting availability against PR08 targets;

ii. ORR wishes to be assured that NARS provides a sound basis for comparison of options at a disaggregated level, such as new patterns of

possessions on a particular route and the effects of possible network enhancements (such as bi-directional signalling or additional station platforms); and

iii. ORR needs to be reassured that use of the interim reporting system can be discontinued whilst still maintaining regulatory, user, stakeholder and public confidence in published reports.

4 Scope of Assessment

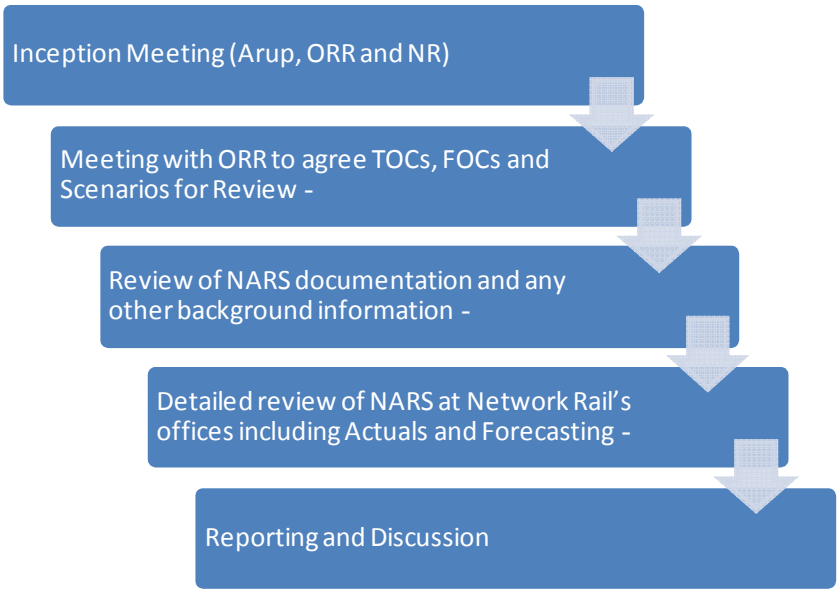
The scope of the review was to assess the suitability of NARS using the following scenarios:

- Compare outputs from NARS against the interim system from 2007-08 to date, in order to provide assurance that the results are similar, or, in the case of any discrepancies, that the results produced by NARS are more reliable and that there are sound reasons for this. The outputs cover the national regulated outputs, and also those for a sample of three passenger Train Operating Companies (TOCs) for PDI-P and two Freight Operating Companies (FOCs) for PDI-F.
- Compare two prospective schemes for improved Network Availability with 'no change' baselines, to demonstrate that the system can forecast the proportionate benefit of the proposed interventions.
- Compare two alternative possession patterns for the maintenance and renewal of two distinct routes, to demonstrate that the system can quantify (in proportionate terms) their respective impacts.

5 Methodology

The methodology used in this review is summarised in **Figure 1**.

Figure 1: NARS Audit Methodology



To carry out the assessment, we initially met with Network Rail and ORR's Data Champions for Network Availability, to ensure that we fully understood the Mandate objectives and requirements, and to discuss and agree the TOCs, FOCs, improvement schemes and possession patterns to be reviewed, as specified in the mandate requirements, and to make the arrangements to conduct the assessment in Network Rail's offices.

We requested system and user documentation for NARS, to enable us to gain some familiarity with the system prior to the start of the 'hands on' review.

A detailed review of NARS was then conducted at Network Rail's offices, in accordance with the specific requirements set out above. The results from the interim system were provided by Network Rail.

Manual calculations were carried out to establish the correct index values for PDI-P and PDI-F and compared these with values obtained from NARS. Auditing the input data itself was out of scope. However, we have checked that the input values in NARS such as Service Group weightings, time of day weighting, etc. have been correctly entered and used.

We also used NARS to compare two prospective schemes for improved Network Availability, and to compare two alternative possession patterns for the maintenance and renewal of two distinct routes, in order to verify that the respective benefits and impacts can be determined satisfactorily. A few additional tests were conducted as described in detail in **Section 8.2** to assess the efficiency of NARS as a suitable possession disruption indicator tool.

6 Acknowledgments

Before we report our findings from the review process, in the following sections, we would like to offer our sincere thanks to Temidayo Amusu and Paul Hebditch at Network Rail for their dedicated support and co-operation throughout the audit process.

7 Review of Network Rail's Assessment of NARS vs. Interim Model

In the inception meeting held on 9th May 2011 at Network Rail's offices in Milton Keynes, Network Rail presented the National PDI-P and PDI-F graphs, and those for a sample of TOCs, comparing the output from NARS to the output from the interim model. These are shown in **Figure 2** to **Figure 5**.

Figure 2: NARS vs. Interim Model Comparison for PDI-P (National)

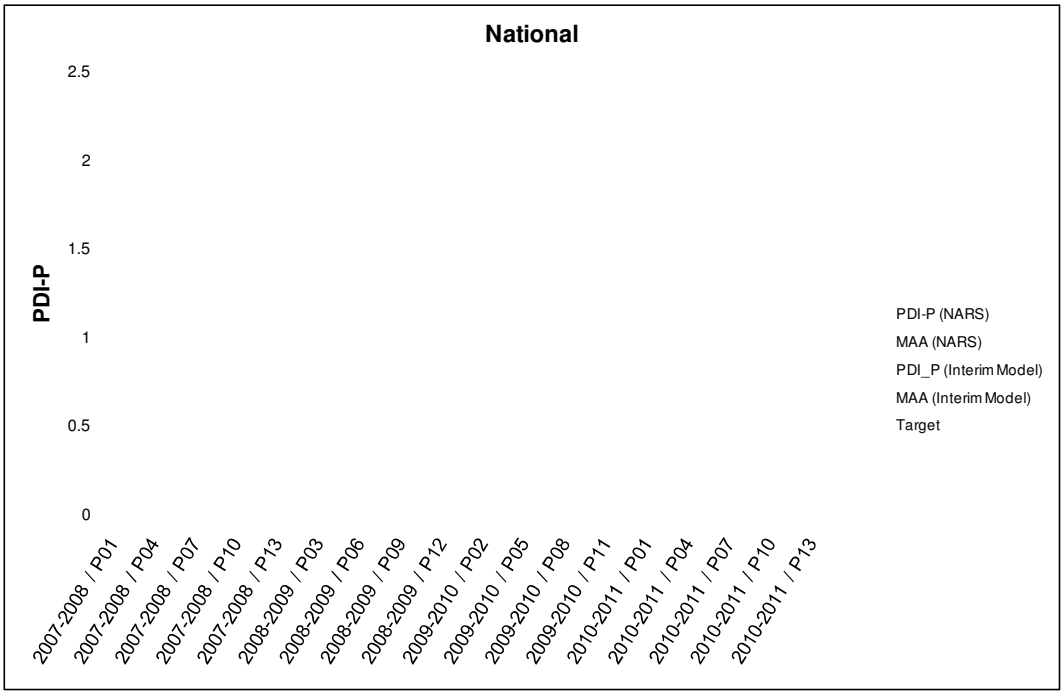


Figure 3: NARS vs. Interim Model Comparison for PDI-P (Northern Rail)

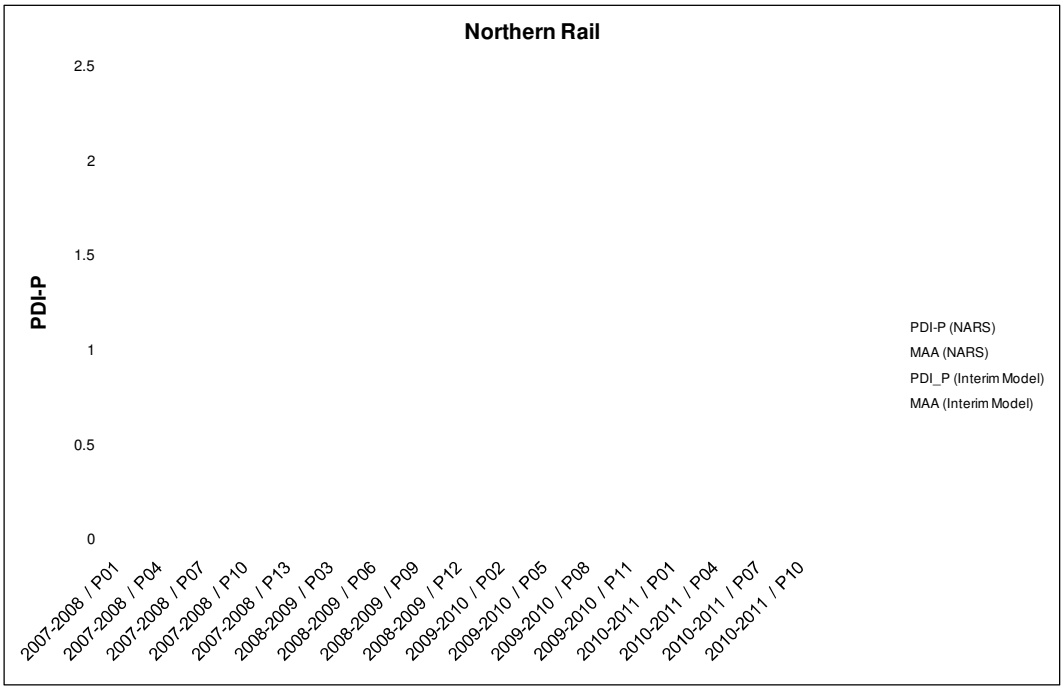
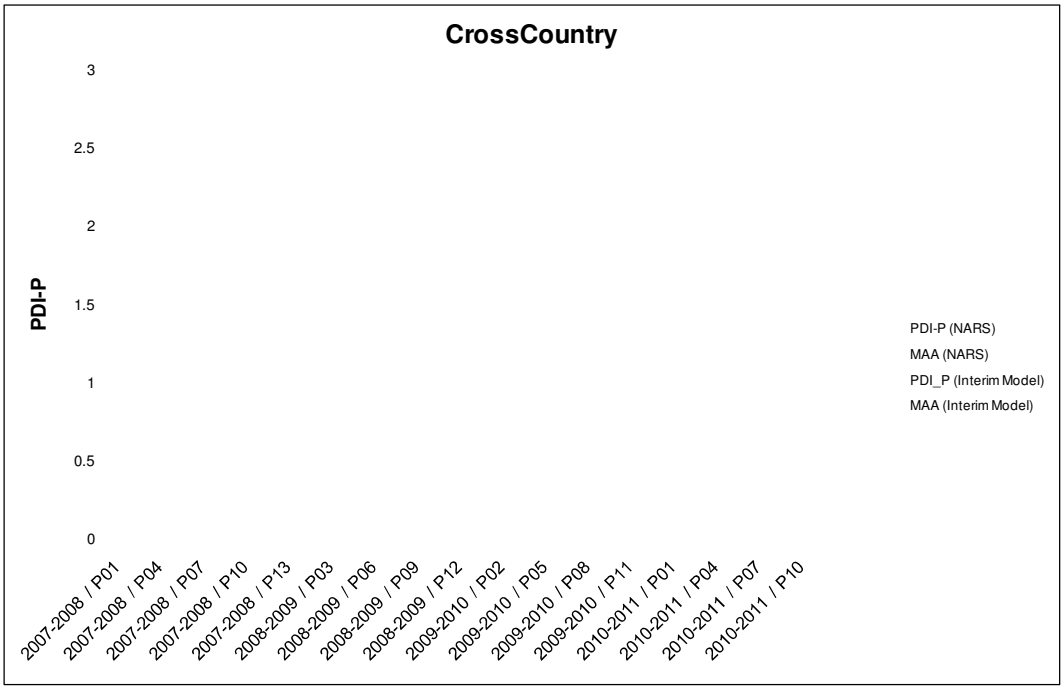


Figure 4: NARS vs. Interim Model Comparison for PDI-P (CrossCountry)



It was observed that, overall; the results from NARS are comparable with the results from the SDG interim model until the year 2008/09. From 2009/10, the graphs showed some significant differences.

This difference in the PDI-P values between the two models was explained by Network Rail as follows:

1. *The train miles mileages used to calculate the PDI-P at a service group differ as they are from different sources as shown in* **Table 1**.*The interim model uses train mileage data from Paladin whilst the data for NARS is from TABS which is the agreed single source of all train mileage data.*

2. *The PDI-P Index values used in the calculation of the PDI-P are different for both models. The PDI-P index in NARS was calculated from validated historic records whilst the interim model was calculated using all the data in the historic files – errors included.*

Table 1: Difference in Train km and PDI-P Index values in NARS and the Interim Model

Train Operating Company	Service Group	Interim Model - Paladin Train km	NARS - TABS Train km	Interim Model PDI-P Index SG0708	NARS PDI-P Index SG0708
National Express East Anglia	EB03	457,978	445,983	0.000199	0.00016
	EB04	353,586	325,937	0.000272	0.00021
Northern Rail	ED09	243,558	246,663	0.000032	0.00002
	ED10	434,213	400,622	0.000082	0.00005
CrossCountry	EH01	1,701,583	1,661,500	0.000022	0.00002
	EH02	530,305	263,990	0.000087	0.00011

In addition to the above discrepancies between the two models, we understand that S4CS data is manually compiled and as a result is susceptible to human errors. Network Rail have informed us that there was a change in the individual compiling the S4CS data which may have compromised the quality of the data received by Network Rail.

Also, in contrast to the interim model, NARS has the capability to check the integrity of the S4CS data and reject any faulty data, which has contributed to the variations between the two sets of model outputs.

To summarise, the factors leading to difference between the two models from 2009/10 are listed below:

i. The interim model uses train mileage data from Paladin whilst the data for NARS is from TABS;

ii. The PDI-P index in NARS was calculated from validated historic records whilst the interim model was calculated using all the data in the historic files – errors included; and

iii. A number of rows of erroneous S4CS data rejected by NARS but accepted by the Interim model.

Figure 5: NARS vs. Interim Model Comparison for PDI-F (National)

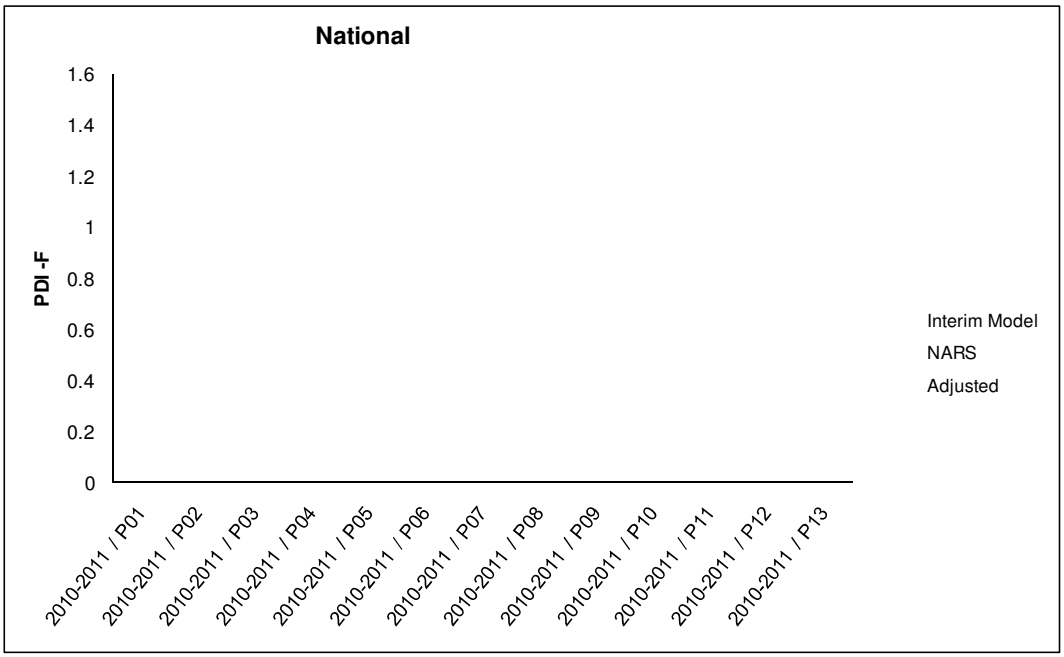


Figure 5 shows a comparison between the PDI-F values from NARS and the interim model. It was observed that the PDI-F values produced by NARS were significantly different from the values in the interim model.

Network Rail have explained that the PDI-F Possession Planning System (PPS) forecasting tool does not include a mechanism to cleanse the duplicate possession records that exist in the PPS system. Network Rail have discovered that the difference between the actual PDI-F produced by NARS and the forecast produced for the same time period was consistent at 1.404 and have therefore adjusted the PDI-F values to obtain the series for the adjusted values in **Figure 5**,

which is observed to have a reasonable fit with the values from the interim model. Network Rail are aware of this issue and are proposing to include the rectification as part of the future NARS enhancements.

8 NARS Review

NARS comprises three key components:

1. **Actuals** – computes the PDI values using historic S4CS data.
2. **Forecasting** – performs possession scenario-based forecasts of PDI values for future years.
3. **Reporting** – the PDI-P and PDI-F reports for actuals (historic possession data) can be viewed readily via Network Rail's Business Objects reporting tool. However, the results from scenarios for forecasting PDIs have to be scheduled to run overnight and viewed the following day.

NARS and Business Objects are two separate tools introduced by Network Rail. Whilst NARS is used to input possession information and to calculate PDI-P and PDI-F values, the PDI reports need to be scheduled separately and extracted using Business Objects. It should be noted that there is dependency on two different applications supported by different IT teams.

8.1 Actuals

One of the objectives of the audit was to review the computational accuracy of NARS for the historic data.

Manual calculations were carried out using a sample of TOCs and FOCs to establish the correct PDI-P and PDI-F values and these were compared with the output from NARS.

It was agreed with Network Rail and ORR that we should include a range of TOCs by service type: one long-distance, inter-city operator (CrossCountry, who are particularly prone to the effects of possessions, because they operate over such a large proportion of the network), one regional operator (Northern, which operates short trains with low occupancy levels), and one commuter operator (NXEA, who, again, have been heavily affected by possession activities).

It was similarly agreed that we should look at one large and one small FOC, and ORR suggested Freightliner Intermodal (large) and First GBRf (small).

8.1.1 PDI-P

The formula used in NARS to calculate PDI-P is as shown below:

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

The model uses various look-up functions and other calculations to compute the PDI-P values.

The first part of the measure is obtained from the outputs of S4CS where:

- **$NREJT_{SG,d}$** is the average extended Journey Time per train as a result of a possession in respect of the relevant Service Group(s) calculated daily;
- **$WACM_{SG,d}$** is the weighted average of cancellation minutes per train for the relevant Service Group calculated daily; and
- **$BF_{SG,d}$** is the busyness factor applicable to the relevant day and Service Group(s).

The second part of the measure represents a weighting to reflect the number of passenger journeys affected for the relevant Service Group(s). It is understood that the following data were imported directly into NARS from the SDG interim model.

- **$PASS_{SG,d}$** is the average number of passenger journeys per day for the relevant Service Group(s).
- **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 (three average values: for weekdays, Saturdays and Sundays) affected by the corresponding possession.

The aggregated daily values are multiplied by the weighted value of time for the relevant Service Group(s).

- **VoT_{SG}** is the value of time for the relevant Service Group(s), reflecting the ratios of business, commuter and leisure traffic and associated values of time for each passenger group (as defined in the DfT WebTAG appraisal guidelines).

One of the observations made during the review process was that the PDI-P calculation in NARS does not reflect independently all the elements of the above equation, in that some of the input data are 'pre-combined' in the data imported directly from the interim model.

Network Rail have explained that they understand the **$PASS_{SG,d}$** and **VoT_{SG}** were integrated into a single value for each TOC in the interim model and the resulting values from the interim model were imported directly into NARS and used in the calculation of PDI-P. However, there is the facility to update the weightings in NARS in a pre-combined form if new versions of the data become available.

Figure 6 summarises the input, computation and output steps used in NARS and Business Objects to obtain PDI-P values.

Figure 6: Steps for calculating PDI-P in NARS

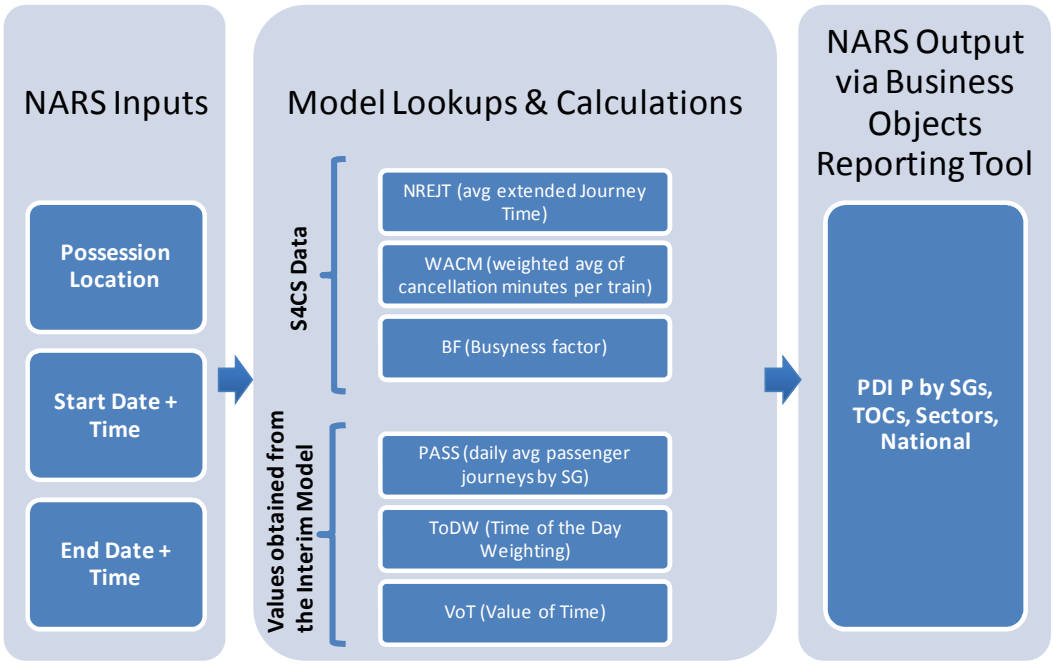


Table 2 and **Table 3** give a comparison of the manually calculated PDI-P values for a sample of TOCs and Service Groups with the values obtained from NARS and from the interim model for Period13 for the year 2010/11. The actual and percentage differences are highlighted in the tables.

The underlying calculations are complex and quite lengthy, so in the time available the checks were conducted for a sample of two Service Groups for each of the three TOCs, and for two FOCs. The manually calculated PDI values are used as a baseline for comparison with the NARS and Interim model values.

The PDI-P outputs from the interim model were provided by Network Rail.

From **Table 2** and **Table 3**, it is observed that the results from the interim model were significantly different from the NARS values and the calculated values. Network Rail have explained that the difference in the graphs from year 2009/10 was due to faulty S4CS data for that period (the erroneous data were rejected by NARS) and also due to system changes for train mileage information.

Despite the complexity of the PDI-P calculations in NARS, the parallel manual calculations produced results that compared well with the NARS outputs as shown in **Table 2** and **Table 3**. It was observed that the difference was within half a percent of the calculated values. It is understood that the small discrepancy in the PDI-P values is due to rounding of the decimal places during the calculation process in NARS.

However, as PDI is an extremely small value, it is recommended that the decimal truncation process in NARS is revisited and calibrated in order to obtain consistent results, even if this is at the expense of increased system memory requirements.

In summary, it is concluded that NARS produces reliable results for PDI – P for 'Actuals' when compared with the manual calculations and is considered as an appropriate tool to replicate and, through reduced potential for human error and increased reliability, improve upon the calculations of the interim model.

Table 2: PDI-P comparison for a sample of Service Groups for Period 13 - 2010/11.

TOC	Service Group	PDI-P		
		Calculated	NARS	Interim Model
National Express East Anglia	EB03	0.097256	0.097057	0.153067
			-0.000199	0.055811
			0.20%	57.38%
	EB04	0.216130	0.217103	0.324028
			0.000972	0.107898
			0.45%	49.92%
Northern Rail	ED09	0.537516	0.536976	0.364012
			-0.000540	-0.173504
			0.10%	32.28%
	ED10	0.114318	0.113777	0.059782
			-0.000541	-0.054536
			0.47%	47.71%
CrossCountry	EH01	0.000011	0.000011	0.000011
			0.000000	0.000000
			0.19%	2.07%
	EH02	0.000004	0.000004	0.000003
			0.000000	-0.000001
			0.30%	30.93%

Table 3: PDI-P comparison for TOCs for Period 13 - 2010/11

TOC	PDI-P		
	Calculated	NARS	Interim Model
National Express East Anglia	0.096536	0.096792	0.14515
		0.000256	0.048614
		0.26%	50.36%
CrossCountry	0.000006	0.000006	0.000004
		0.000000	-0.000002
		0.08%	34.25%

8.1.2 PDI-F

The formula used in NARS to calculate PDI-F is as below:

$$TwF = 1 - \left[\frac{\sum_{FTR} \left\{ \sum_{d} \left(TU_{ELR,d} \bullet FTW_{ELR,d} \right) \right\}}{\sum_{ELR} \left\{ \sum_{d} \left(TT_{ELR,d} \bullet FTW_{ELR,d} \right) \right\}} \right]$$

Where:

- TwF is the track-km availability weighted by freight traffic level
- $TU_{ELR,d}$ is the track-km hours unavailable due to possessions for the relevant ELR on the relevant day;
- $TT_{ELR,d}$ is the total track-km hours for the relevant ELR for the relevant day;
- $FTW_{ELR,d}$ is freight traffic weighting, calculated as:

$$FTW_{ELR,d} = \frac{DwFT_{ELR,d}}{\sum_{ELR} \sum_{d} DwFT_{ELR,d}}$$

Where:

- $DwFT_{ELR}$ is the average freight train movements per day attributed to a relevant ELR. The value is then weighted by the proportion of freight trains operated for the relevant day of the week for that ELR (such that the sum of the weightings for the seven days Sunday to Saturday would equal 1).

The values for $FTW_{ELR,d}$ in NARS are obtained from the interim model. This data will presumably need to be updated at some point. As we understand, the process to update the FOC weighting values is unclear and not documented although Network Rail are considering to review the values with ORR on an annual basis.

Table 4 gives a comparison of the manually calculated PDI-F values with those obtained from NARS and the interim model for Period13 for the year 2010/11 for the two FOCs identified above. The actual and percentage differences are highlighted in the table below.

Table 4: PDI-F comparison for FOCs for Period 13 - 2010/11

FOC	PDI-F		
	Calculated	NARS	Interim Model
GB Railfreight	0.944383	0.944383	0.949458
		-0.000000	0.005075
		0.000000%	0.537346%
Freightliner Inter Modal	0.753084	0.753084	0.772586
		0.000000	0.019501
		0.000000%	2.589524%

It was observed that the values from NARS are similar to the calculated values. However, the results from the interim model differ by a small, but proportionately quite large, amount from the calculated values and NARS. Network Rail have explained that the discrepancy is because the PDI-F 07/08 index again differs between NARS and the interim model, as shown in **Table 5**.

Table 5: PDI-F index 2007/08

PDI-F 07/08	GB Railfreight	Freightliner
Interim model	0.14349	0.12945
NARS	0.14425	0.12751

In summary, it is concluded that NARS produces reliable results for PDI – F for 'Actuals' when compared with the manual calculations and is considered as an appropriate tool to replicate the calculations of the interim model.

8.2 Forecasting

Selections of hypothetical scenarios were tested in NARS in order to compare the forecast PDI-P and PDI-F values.

8.2.1 Conventional versus Accelerated Possession Patterns

Alternative possession patterns were tested for the maintenance and points renewal to demonstrate that the system can quantify (in proportionate terms) the impact. Conventional versus accelerated (pre fabrication of points) possession patterns were tested at Huntingdon North, south of Peterborough on the East Coast Main Line.

Conventional versus high output ballast cleaning possession scenarios were tested at Prestbury, between Macclesfield and Cheadle Hulme, south of Manchester.

The PDI-P and PDI-F results shown in **Table 6** and **Table 7** respectively, show that the accelerated possessions are less disruptive to freight and passenger

services than the conventional methods, thus quantifying the benefits of using accelerated methods.

Table 6: PDI-P Forecasts - Conventional vs. accelerated possessions

Scenario	Possession Location	Huntingdon North			Prestbury ballast cleaning
1	**Conventional approach**	1 x 55-hour possession (23:00 Friday – 06:00 Monday) A	4 x 12-hour possessions (23:00 Saturday – 11:00 Sunday) in run-up B	A + B	8 x 16-hour possessions (23:00 Saturday – 15:00 Sunday)
PDI-P Forecast		0.00364	0.00005	**0.00369**	**0.00008**
2	**Accelerated possessions**	1 x 12-hour (23:00 Saturday – 11:00 Sunday) A	3 x 8-hour possessions (00:00 – 08:00 Sunday) in run-up B	A + B	8 x 8-hour possessions (00:00 – 08:00 Sunday – non-disruptive – high output)
PDI-P Forecast		0.00001	0.00000	**0.00001**	**0.00000**
Difference				**0.00368**	**0.00008**

Table 7: PDI-F Forecasts - Conventional vs. accelerated possessions

Scenario	Possession Location	Huntingdon North			Prestbury ballast cleaning
1	**Conventional approach**	1 x 55-hour possession (23:00 Friday – 06:00 Monday) A	4 x 12-hour possessions (23:00 Saturday – 11:00 Sunday) in run-up B	A + B	8 x 16-hour possessions (23:00 Saturday – 15:00 Sunday)
PDI-F Forecast		0.00215	0.00120	**0.00336**	**0.00005**
2	**Accelerated possessions**	1 x 12-hour (23:00 Saturday – 11:00 Sunday) A	3 x 8-hour possessions (00:00 – 08:00 Sunday) in run-up B	A + B	8 x 8-hour possessions (00:00 – 08:00 Sunday – non-disruptive – high output)
PDI-F Forecast		0.00030	0.00056	**0.00086**	**0.00000**
Difference				**0.00249**	**0.00004**

8.2.2 Identical Possessions at Different Locations

Identical possession patterns were tested at Huntingdon North and Woolmer Green crossover to quantify the change in PDI values resulting from change in location of the possessions.

The results in **Table 8** and **Table 9** show that a total line blockage at Woolmer Green as having a higher disruptive impact than one at Huntingdon. However, in reality a blockage at Huntingdon would require all services to be substituted by buses as there is no alternative route. On the other hand a blockage at Woolmer Green would mean that East Coast, FCC and open access services could be diverted via the Hertford Loop (albeit with some thinning). From a passenger perspective then the Woolmer Green possession is likely to be less disruptive, although, it shall be noted that Woolmer Green will additionally impact Cambridge services.

The higher PDI-P values for Woolmer Green show that NARS assesses that the extra disruption caused by affecting the additional Cambridge services outweighs the benefit of having a diversionary route. For freight, each ELR (Engineer's Line Reference) route section has a weighting to reflect its suitability for single line working or easy diversion which feeds through into PDI-F. In this case, both Huntingdon and Woolmer Green are in the same ELR and so have similar PDI-F values.

Table 8: PDI-P Forecasts – Identical possessions at different locations

Scenarios		**1**	**2**	**Difference**
Possession Location		**Huntingdon North**	**Woolmer Green crossover**	
Conventional approach	1 x 55-hour possession (23:00 Friday – 06:00 Monday) A	0.00364	0.00698	0.00333
	4 x 12-hour possessions (23:00 Saturday – 11:00 Sunday) in run-up B	0.00005	0.00011	0.00006
	A + B	0.00369	0.00709	0.00339
Accelerated possessions	1 x 12-hour possession (23:00 Saturday – 11:00 Sunday) A	0.00001	0.00003	0.00001
	3 x 8-hour possessions (00:00 – 08:00 Sunday) in run-up B	0.00000	0.00000	0.00000
	A + B	0.00001	0.00003	0.00002

Table 9: PDI-F Forecasts – Identical possessions at different locations

Scenario		1	2	Difference
Possession Location		**Huntingdon North**	**Woolmer Green crossover**	
Conventional approach	1 x 55-hour possession (23:00 Friday – 06:00 Monday) A	0.00215	0.00250	0.00035
	4 x 12-hour possessions (23:00 Saturday – 11:00 Sunday) in run-up B	0.00120	0.00156	0.00036
	A + B	0.00336	0.00407	0.00071
Accelerated possessions	1 x 12-hour possession (23:00 Saturday – 11:00 Sunday) A	0.00030	0.00039	0.00009
	3 x 8-hour possessions (00:00 – 08:00 Sunday) in run-up B	0.00056	0.00074	0.00018
	A + B	0.00086	0.00113	0.00027

8.2.3 Weekends vs. equivalent weeknight possessions

Weekend and midweek night possessions were tested at Sawbridgeworth, on the West Anglia Main Line south of Stansted Airport, and at Cheltenham Spa, as shown in **Table 10** and **Table 11**.

In both the cases the PDI-P values for shorter midweek possession are lower than those for the longer weekend possessions, which means that midweek night possession are less disruptive to passengers than the weekend possessions. However, in contrast to the PDI-P results, the PDI-F results in **Table 11** show that, shorter midweek possessions are more disruptive for freight that the longer weekend possessions, reflecting the fact that significant freight movements occur during weeknights.

Table 10: PDI-P Forecasts – possessions on weekends vs. midweek nights

Scenarios	Possessions	Sawbridgeworth	Cheltenham Spa
1	12 **weekends** of 12-hour possessions (23:00 Saturday – 11:00 Sunday)	**0.00018**	**0.00003**
2	8 weeks of 6-hour possessions on 5 **midweek nights** (Monday – Friday, 23:00 – 05:00)	**0.00001**	**0.00000**
Difference		**0.00016**	**0.00002**

Table 11: PDI-F Forecasts – possessions on weekends vs. midweek nights

Scenarios	Possessions	Sawbridgeworth	Cheltenham Spa
1	12 **weekends** of 12-hour possessions (23:00 Saturday – 11:00 Sunday)	**0.00023**	**0.00173**
2	8 weeks of 6-hour possessions on 5 **midweek nights** (Monday – Friday, 23:00 – 05:00)	**0.00166**	**0.01240**
Difference		**0.00143**	**0.01068**

8.2.4 Identical possessions at the same location in different years

Identical possession patterns were tested at Woolmer Green crossover over two different years to assess if there is any change in the PDI values resulting from change in forecast year.

Our tests suggested that the forecast PDI-P values are the same for the future years tested which is as expected. The results are shown in **Table 12**.

Table 12: PDI-P Forecasts – identical possessions in different forecast years

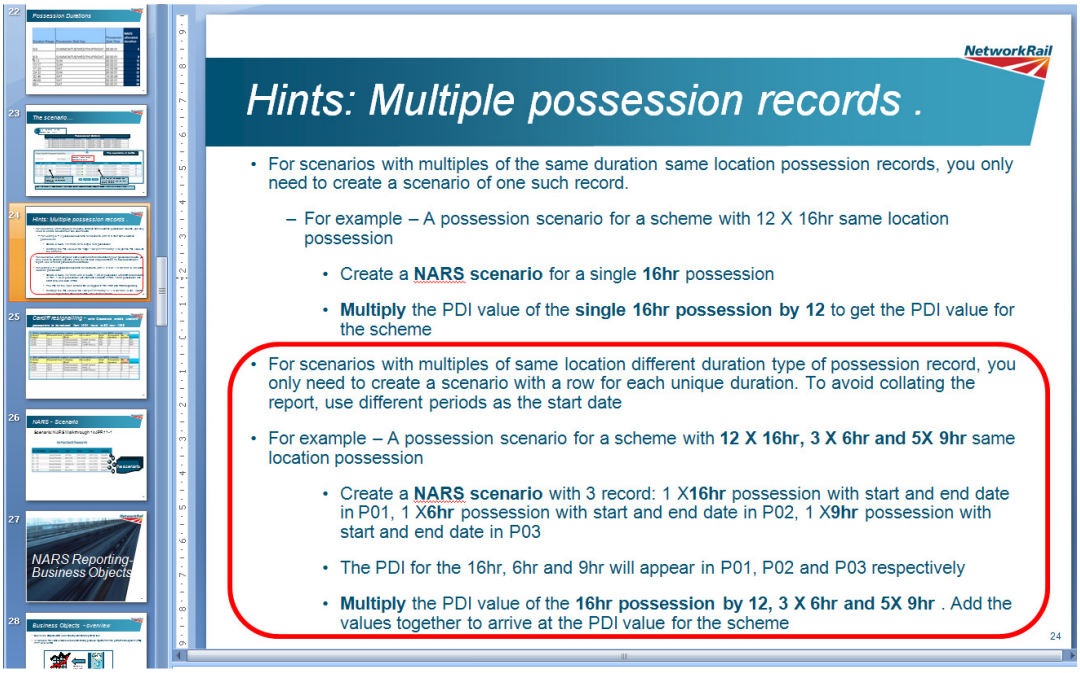
Possession Location	Duration	May 2012	May 2013
Woolmer Green crossover between Welwyn North and Knebworth	1 x 12-hour (23:00 Saturday – 11:00 Sunday)	**0.000028**	**0.000028**

8.2.5 PDIs for multiple possessions

To calculate the PDI-P and PDI-F values of multiple possessions on a single route section, the NARS walkthrough guide prepared by Network Rail suggested calculating the PDI for one scenario and multiplying it by the total number of possessions.

The NARS walkthrough guide also sets out a step-by-step procedure to test the effects on network availability resulting from different possession patterns. The guide suggests that, '*For scenarios with multiples of same location different duration type of possession record, you only need to create a scenario with a row for each unique duration. To avoid collating the report, use different periods as the start date*' as shown in **Figure 7**. This methodology was based on the assumption that the PDI calculations only take into account the time of the day and the day of the week and are not sensitive to the period in which they are tested.

Figure 7: Extract from NARS Walkthrough Guide



In order to verify the above assumption, we tested identical possession scenarios over two different periods as shown in **Table 13**. The results showed different PDI-P and PDI-F values for identical possessions tested in different periods. It was established that the difference in network availability index for different periods was due to the difference in train miles for each period.

Network Rail have advised that train miles do not normally vary in a major way from one period to the next. Each period's train mileage is calculated as the average of the last two years of historic data. In this case, however, the May figure for CrossCountry service group EH02 was about double the figure for July, presumably because of franchise re-mapping or a major timetable change.

This raises an interesting point in that CrossCountry services do not operate at Woolmer Green. They are included because NARS includes all service groups that use the affected ELR. It would be worth considering further if this approach

is appropriate for forecasting PDI-P and PDI-F values, such that in this example the inclusion of CrossCountry services does not unduly influence the PDI-P forecast.

Table 13: Identical Possessions over two Different Periods

Possession Location		Saturday (Start of Possession)	Sunday (End of Possession)	PDI-P
Woolmer Green Crossover	**May**	12/05/2012 23:00	13/05/2012 11:00	**0.000028**
	July	21/07/2012 23:00	22/07/2012 11:00	**0.000123**

The above test ascertained that the PDI values are sensitive to the period in which they are tested. Therefore it is recommended that, to obtain a like for like comparison of the proposed possession patterns, they should be tested as independent scenarios but within the same period. It is suggested that the NARS walkthrough guide is updated accordingly.

Following our review, Network Rail have advised that they have already implemented this update.

8.3 Reporting

All the reporting in NARS is done through Business Objects. Following the creation of scenarios in NARS, the PDI reports are not generated automatically. The user needs to create and schedule the reports to view the result in Business Objects, a reporting tool used by Network Rail. The two applications used by Network Rail and the steps followed to obtain PDI values are summarised in **Figure 8**.

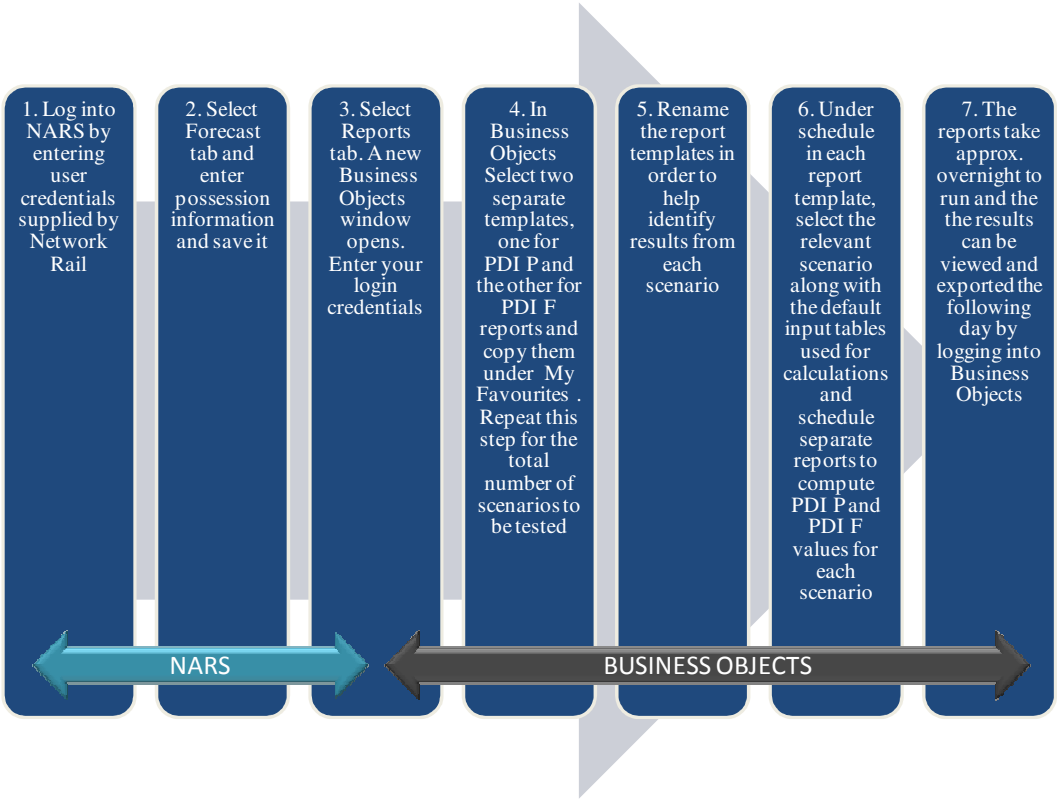
A standard template is available within Business Objects for reporting purposes which ensures consistency among users. However, there is a sequence of steps to be followed to schedule a PDI report in Business Objects.

Whilst the interim model produced results instantaneously, the reports in NARS (Business Objects application) are scheduled to run overnight and the reports are produced the following day. Consequently, the whole process takes at least a couple of days.

It is understood that the Business Objects tool is used by many other applications within Network Rail for reporting purposes, which is likely to result in delays in generating the PDI reports.

Ideally the process of scheduling the PDI reports within Business Objects (Steps 4 to 7 in Business Objects) should be streamlined to a maximum of one or two steps and also the possibility of generating instantaneous reports from NARS is investigated. Although NARS is capable of performing the necessary calculations with minimum or virtually no manual intervention, the possibility of making the application more automated and user friendly should also be explored.

Figure 8: Steps to calculate PDI-P and PDI-F using NARS and Business Objects



9 Observations

9.1 Key Observations

Below is a summary of the key observations made during the review process:

1. NARS is a central automated system to be used by Network Rail staff requiring Network Availability outputs, with integrated input parameters such as S4CS data, TOC and FOC weightings, Train km etc. It therefore provides consistent results among users.

2. NARS has an inbuilt data validation and error checking process which considerably adds to its reliability in comparison with the interim model.

3. NARS and Business Objects are two separate tools introduced by Network Rail, and whilst NARS is used to input possession information, the PDI-P and PDI-F reports need to be scheduled separately and extracted using Business Objects. Therefore there is dependency on two different applications supported by different IT teams.

4. Whilst the interim model produced results instantaneously, the reports in NARS (Business Objects application) are scheduled to run overnight and the reports are produced the following day. Consequently, the whole process takes at least a couple of days.

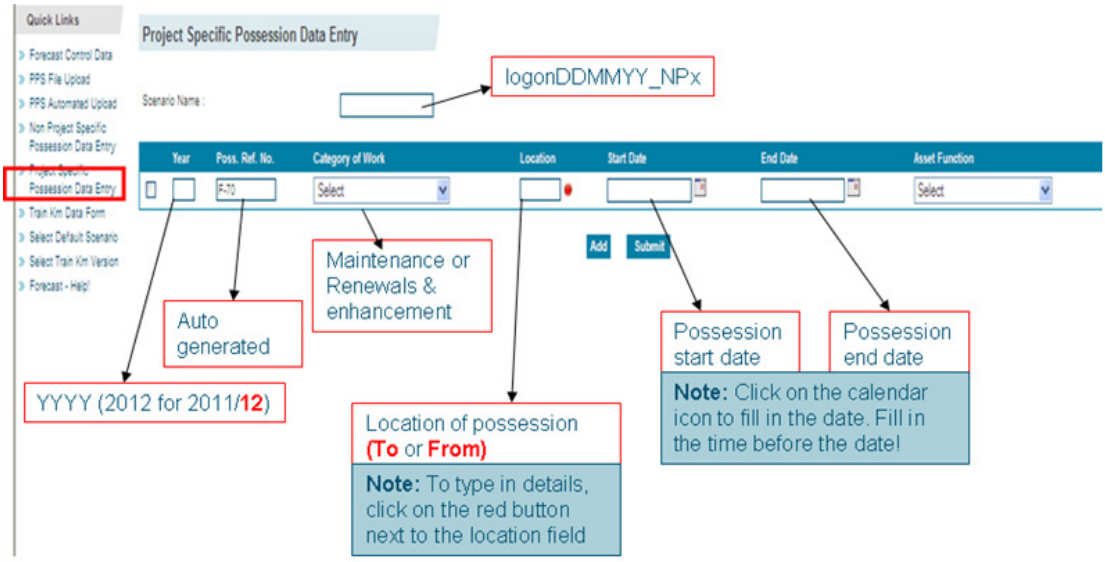
5. A standard template is available within Business Objects for reporting purposes which ensures consistency among users.
6. NARS uses interim SDG model computation methodology and inputs such as Service Group weightings, VoT and ToDW.
7. S4CS and Train km data source are input by Network Rail centrally.
8. The NARS Admin guide, produced by Tata Consultancy Services (the NARS software developers), sets out the methodology used to input data into NARS. However, we have not come across documentation that provides details of the calculation methodology for parameters such as VoT, SG weightings, ToDW etc. Network Rail understand that the $\mathbf{PASS}_{SG,d}$ and $\mathbf{VoT}_{SG}$ elements were pre-combined into a single value for each TOC in the interim model. Consequently, the resulting values from the interim model were imported directly into NARS and used in the calculation of PDI-P. The process for updating these values (especially the average passenger journey weightings) in future is currently unclear.
9. The NARS user guide sets out a methodology to calculate the PDI-P improvement of a possession scheme that enables Single Line Working (SLW). Because NARS assumes current working methods during possessions, an external MS Excel template is used to calculate the improved PDI-P resulting from SLW. A revised timetable analysis needs to be carried out externally to obtain a proportion of trains that will be able to run during the possession period. This proportion is then applied to the PDI-P value obtained from NARS to calculate the likely benefit of SLW. This method, though, does not take into account any changes to journey times. A more accurate – albeit long term - solution would be for the planner to develop an engineering timetable (at least in outline, for example for a standard hour) and to input this into NARS for calculating PDI-P.
10. One of our tests suggested that the PDI values are sensitive to the period they are tested in. Therefore it is recommended that, to obtain a like for like comparison of the proposed possession patterns, they should be tested as independent scenarios but within the same period. Network Rail have updated the NARS user guide to include this methodology.
11. During the process of the audit, the NARS application and Business Objects experienced random crashes leading to delay in obtaining the results from the scenarios. Network Rail have recognised this as a problem and are investigating how the stability of the application can be improved to avoid such occurrences in the future.

9.2 Some suggested improvements

In addition to the above, we have made some observations in relation to the scenario input screen of NARS and suggest some improvements. The input screen of NARS is shown in .

- As the possessions are planned based on the day of the week, it would be particularly useful to see the day of the week information on the input screen along with the possession start and end dates to help verify the possession input data. (For example: 12-May-2012, Saturday as opposed to only 12-May-2012 shown in the current version of NARS.) This feature eliminates the need to validate the possession planning dates using a supplementary calendar.
- In the current version of NARS, users need to click on the red button located under the 'Location' field in NARS and manually type in the location name to be able to enter the possession location information. It would be useful if this process is streamlined and an automated list is included which narrows down to a choice of locations as the users start typing in the initial few letters of the location name. This is a common feature used by most applications in the present day and age. Also a geographical mapping of locations would be ideal to identify the locations of possessions precisely.
- Location, Start Date and End Date are the only three required fields that are used for the purposes of calculation of PDI-P and PDI-F. The remaining fields can be filled in for information only. It would be useful to add in a feature to distinguish the compulsory data entry fields from the rest.

Figure 9: NARS Forecast Scenario Input Screen



10 Summary and Conclusions

The results are summarised in relation to the objectives of this study:

i. *ORR wishes to be satisfied that NARS is capable of accurately measuring, reporting and forecasting availability against PR08 targets;*

Conclusion:

The tests carried out in NARS confirm that it is capable of accurately measuring the actual network availability from recorded possessions, and can be used to forecast PDI-P and PDI-F values.

ii. *ORR wishes to be assured that NARS provides a sound basis for comparison of options at a disaggregated level, such as new patterns of possessions on a particular route and the effects of possible network enhancements (such as bi-directional signalling or additional station platforms);*

Conclusion:

The results of the future scenario tests show that NARS can distinguish between different possession patterns of duration and day of week through the calculation of PDI-P and PDI-F values. This is analogous with the methodology used in the interim model.

However, this methodology assumes the same working methods as used historically in terms of the use of diversionary routes and single line working. To measure the impact of introducing additional single line working or diversionary route improvements, Network Rail has produced a separate add-on process for factoring the PDI-P values calculated by NARS. It would, however, be worth considering improving this methodology in the long term to, for example, take into account increased journey times.

One of our forecast scenario tests highlighted how services not directly impacted by a possession (CrossCountry at Woolmer Green) can influence the PDI-P value. This might be a one-off case (due to franchise re-mapping) but it would be worth carrying out further tests to check that the forecasting methodology is sound.

iii. *ORR needs to be reassured that use of the interim reporting system can be discontinued whilst still maintaining regulatory, user, stakeholder and public confidence in published reports.*

Conclusion:

It was observed that NARS is capable of accurately replicating (and improving upon) the computation of PDI-P and PDI-F parameters for actuals (historic data) as produced by the interim model until 2008/09, and of doing so with minimal manual intervention. The PDI-P results produced by NARS vary from the interim model from 2009/10 onwards and it is concluded that NARS produces reliable results for 'Actuals' when compared with the manual calculations and is considered as an appropriate tool to replicate and, through reduced potential for human error and increased reliability, improve upon the calculations of the interim model.

11 Recommendations

In order to improve the functionality and suitability of NARS as an advanced network availability application, the following is recommended:

Number	Recommendation	Section in Report	Data Champion	Due Date
2011NARS.01	Network Rail / ORR to confirm the current methodology of updating the values of weightings used in the PDI calculations.	8.1	Network Rail / ORR	Dec 2011
2011NARS.02	Carry out further tests on the forecasting methodology to check that it is sound and produce a proposal for any necessary improvements.	8.1	Network Rail	Dec 2011
2011NARS.03	Produce a long term proposal for consideration by Network Rail and ORR for improving the methodology for assessing diversionary routes and SLW.	8.1	Network Rail	Dec 2011
2011NARS.04	The tests carried out in NARS during the audit process confirm that NARS is capable of accurately replicating the PDI-P and PDI-F values as calculated by the interim model. Therefore, it is recommended that the interim model can be phased out in favour of NARS for PDI computations.	10	Network Rail	July 2011

The following improvements are suggested for Network Rail to consider in any future enhancements to NARS:

1. Consider improving the computational accuracy and reduce the discrepancy resulting from rounding in the PDI-P calculations within NARS.
2. Consider establishing an automatic link between NARS and the Business Objects reporting tool such that the task of scheduling the reports is streamlined and the forecast scenarios be scheduled to run in real-time.
3. Consider showing the day of the week information on the input screen along with the possession start and end dates, to help verify the possession input data.

4. It is recommended that the PDI reports include a field showing the name and description of the scenario tested in order to help identify the corresponding results. This would be particularly useful while testing multiple scenarios.
5. Introduce additional functionality to model partial route blockage and the availability of alternative routes.

References

1. Network Availability Reporting System (NARS) –User Guide v1.0, Network Rail
2. Network Availability Reporting System (NARS) –Walkthrough Guide v1.7, Network Rail
3. Network Availability Reporting System (NARS) - Admin user supplementary guide v1.0, Network Rail
4. NARS Design Specification Document - 0.7.1, Network Rail
5. Network Availability KPI - Final Summary Report, November 2007, Steer Davies Gleave