

HS1 Data Assurance Review (2015/16)

Office of Rail and Road

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EXECUTIVE SUMMARY

The Office of Rail and Road (ORR) appointed DNV GL to carry out a detailed review of the data and data processes involved in producing key operational performance and asset management data for High Speed 1 (HS1) Ltd. The review was carried out for the data and results for the reporting year 2015/16.

The present document is DNV GL's report of that data review, the aim of which was to assess the quality, accuracy and reliability of the quarterly data. This was done by performing:

- A high-level review of the performance measures – including a confidence grading and a rating of the progress made relative to the 2014 recommendations;
- A high-level review of Asset Management measures – including a confidence grading and providing assurance that the high level of quality has been maintained and is continually improving;
- A review of the asset register – providing assurance that the high level of quality is maintained and is continually improving.

The Key Performance Indicators (KPIs) to be used for assessing the performance of HS1 Ltd are laid out in the High Speed 1 Monitoring Handbook [1]. Four KPIs are mandated for operational performance and five for Asset Management.

As part of the data review, each KPI is given a confidence rating, reflecting the result of the review of the data underlying that KPI as well as the processes used to transform that data into the KPI value. The confidence rating takes the form of a letter and a number. The letter represents the reliability of the KPI value, with A being the highest rating, and D the lowest. The number represents the accuracy of the KPI value, with 1* being the most accurate to 6, the least accurate.

Performance KPIs

The confidence ratings for the Performance KPIs are as follows:

Key Performance Indicators for Performance	2015/16 rating
Total number of trains timetabled	A1*
Total number of trains delayed	B4
Number of trains delayed by an incident wholly or mainly attributable to HS1	A1*
Number of trains delayed by an unidentifiable incident	A1*

All KPIs exhibited the highest confidence ratings, in common with the ratings awarded in previous years with the exception of the KPI "Total Number of Trains Delayed".

A shortcoming in the processing of the "Total number of trains delayed" KPI was identified and is reflected in the narrative description, the grading for that KPI and the recommendations. This shortcoming resulted in a 14% over-estimate of the KPI, meaning that the number of trains delayed was recorded at a level higher than it actually was.

The production of all the other KPIs was found to be of high quality with well documented and robust procedures in place. The calculation process for the KPI for the total number of trains delayed takes a

completely different path from the others and therefore the shortcoming in that one KPI calculation does not affect the others.

Asset Management KPIs

The confidence ratings for the Asset Management KPIs are as follows:

Key Performance Indicator for Asset Management	2015/16 rating
Overall Fault Levels	A1*
Plan attainment	A1*
Track quality-induced TSRs	A1*
Broken Rails	A1*
Service-affecting defective rails	A1*

All the asset management KPIs exhibited the highest confidence ratings, in common with the ratings awarded in previous years.

Review of the Asset Register

By interview, consultation and the review of policy documents and data spot-checks, DNV GL assessed the asset register structure, implementation and supporting processes. DNV GL found the asset register to be well-specified, well-implemented and the processes governing the data contained in the register to be appropriate and robust. There is sufficient evidence to determine that the asset data is subject to continual improvement and that progress has been made relative to the issues arising from the 2014 review.

Recommendations

DNV GL also reviewed the progress made relative to the recommendations made in the [2014 data review](#) and has found that progress to be satisfactory.

Three new recommendations have been made. All three recommendations relate to the robustness of the computation of the performance KPIs. They are outlined in the table below.

Number	Recommendation	Data Owner
2016.R1	Correct the logic used in the Performance Floor workbook to count the total number of trains delayed.	HS1
2016.R2	Add to the Performance Floor workbook an additional cross-check to make timetable counts independent of the service code groups input table.	HS1
2016.R3	Add to the Performance Floor workbook an additional cross-check to detect whether the list of delay-causing incidents is correctly time-ordered.	HS1

1 INTRODUCTION

1.1 Background

The Office of Rail and Road (ORR) has responsibility for both the independent economic and safety regulation of railways in Great Britain (GB) as set out in the Railways Act 1993, The Railways and Transport Safety Act 2003 and the Railways Act 2005. ORR became the regulator of High Speed 1 (HS1) Ltd in October 2009 under a concession that sets out performance and asset management obligations. The HS1 concession states that ORR has the right to audit the data and information supplied on operational performance and asset management, including any monitoring procedures completed by HS1 Ltd.

The last review was carried out in 2014. It is important for ORR to conduct a follow up review for data assurance purposes and monitor progress since the last review. To this end, ORR appointed DNV GL to perform this task in May-June 2016, using the quarterly and annual reports for the 2015/16 year.

1.2 Objective

The aims of the data assurance review are to carry out:

1. A high-level assessment of the following quarterly operational performance data:
 - A. Total number of trains timetabled – this includes progress against the 2014 recommendation which was to review the methodology for extracting 'Trains run' data using train service codes
 - B. Total number of trains delayed
 - C. Number of trains delayed by an incident wholly or mainly attributable to HS1
 - D. Number of trains delayed by an unidentifiable incident
2. A high-level assessment of the following quarterly asset management data:
 - A. Plan attainment (backlog)
 - B. Overall fault levels
 - C. Track quality-induced speed restrictions
 - D. Broken rails
 - E. Service-affecting defective rails
3. A review of the asset register - to provide assurance that the high level of quality is maintained and is continually improving.

The overall outcome of this review is an assessment of all the key performance indicators (operational performance and asset management) and an identification of what progress has been made since the 2014 review, together with a set of recommendations for further improvements.

In particular, progress against two specific recommendations arising from the 2014 review has been assessed, namely:

- To review the methodology for extracting 'Trains run' data using train service codes
- To review the procedures for allocating a 'prime' cause for trains cancelled for more than one primary reason/cause code, and determine how these are reported.

2 METHODOLOGY

This section outlines DNV GL's methodology for producing the required project outputs.

Inception meeting

Before detailed audit work began, a kick-off meeting was held between DNV GL and ORR to clarify the running of the contract itself and to arrange specific target dates for various project milestones and arrange introductions to the most suitable contacts at HS1 and NR.

Data Exchange

DNV GL arranged the creation of a secure data exchange facility to facilitate transferring the necessary data between NR (High Speed) to DNV GL. DNV GL then invited NR (HS) to upload the data to that facility which was password protected.

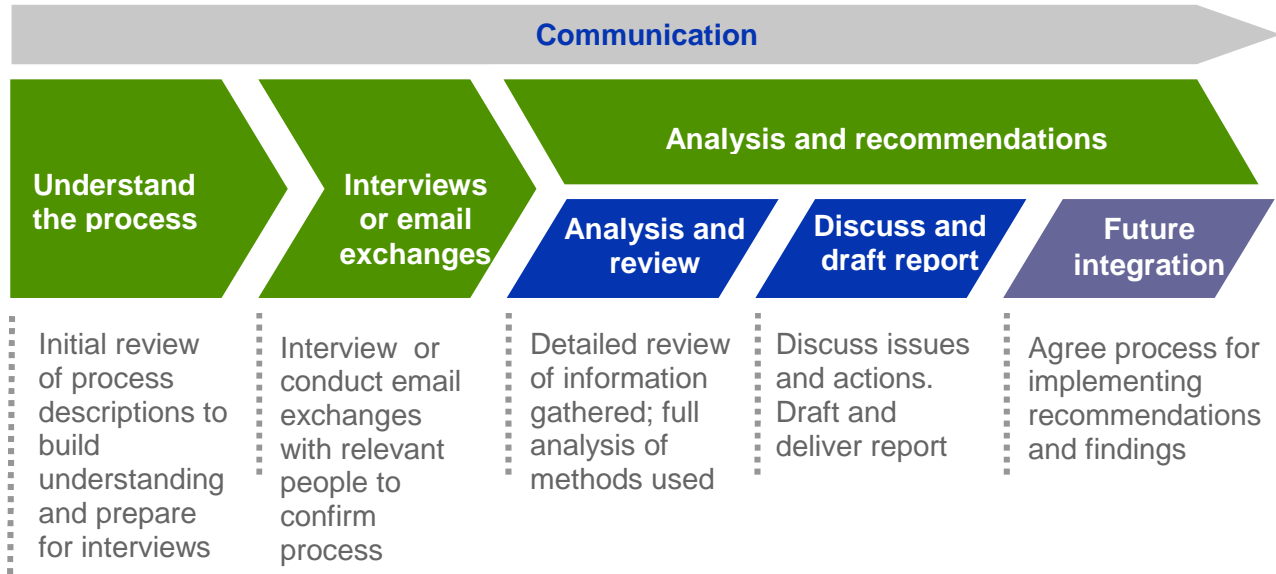
The data in question consisted of the following:

- Quarterly and annual data manipulation spreadsheets for performance data. These contained the necessary data pre-imported.
- Manipulation spreadsheets for asset management data.
- Query definitions used to specify the input data requirements for these systems and extract them from the relevant databases.
- Documents relating to the processes and procedures by which HS1 captures, calculates and records the performance and asset management data. These took the form of a detailed set of instructions for the analyst preparing the quarterly or annual reports.
- Manipulation tools: databases, spreadsheets or code used to manipulate the raw data to produce the performance indices.
- Documents relating to the 2014 data assurance review and any evidence supporting progress towards its recommendations.

The Review Process

The high-level part of the methodology is the audit process illustrated in Figure 1. This high-level process was supplemented by correspondence between DNV GL and ORR or NR (HS) in order to resolve questions and gain clarification at multiple points in the process as well as by meetings held between DNV GL and those parties.

Figure 1: High level phases of work in the present data review



Having exchanged the necessary data the review became essentially the following three stages.

- Stage 1: Planning and Preparation
- Stage 2: Analysis, review and assessment
- Stage 3: Reporting and Recommendations

Each stage is described in more detail below. With only minor variation where necessary, this process applied for

- Operational performance data, and
- Asset management data and documents.

Stage 1: Planning and Preparation

Stage 1 Description	Understanding the process and interviews.
Activities	<p>DNV GL examined both the HS1 monitoring handbook and the data transferred after the project start in detail in order to understand the process involved in producing the desired performance indices.</p> <p>A full day’s interview was held with NR(HS) staff to aid understanding of the processes. One NR representative was responsible for the Performance Floor process and another for the Asset Management processes. The interviewees were confirmed as suitable and accepted by ORR.</p> <p>Before the interviews, DNV GL prepared a list of questions for the interviewees where examination of the documents did not yield clear answers.</p>
Outcomes	Following this stage, DNV GL was able to begin the review in detail having been well informed regarding the process, as implemented by HS1, for producing the KPIs.

Stage 2: Analysis, Review and Assessment

Stage 2 Description	Detailed analysis of the methods used by HS1, review of the processes and DNV GL's assessment of the process as a whole, resulting in a confidence grading for the output data.
Activities	<p>Activities for this stage included the following.</p> <ul style="list-style-type: none"> ▪ A desktop review of the processes used to acquire and present the raw data for the ultimate production of the KPIs. ▪ A review of the data itself, checking for internal consistency and completeness. ▪ A detailed review of the calculation methods used to transform the raw data into performance measures. This included: <ul style="list-style-type: none"> ○ Forensic examination of spreadsheet formulae. That is, the results of the calculation process were traced back, through the formula links to verify that the calculation process implements the process as intended. ○ "Mirroring" processing of data: building a parallel process (usually spreadsheet) to independently reproduce the performance measure from the raw data. ○ Inspection of program source code. ○ Spot-checking individual calculations on a random basis. ▪ Making a reliability assessment of the key results as presented by HS1 in the form of a confidence grading for each output. ▪ Review of the documentation describing how this process is implemented. ▪ An assessment of progress made in the implementation of the recommendations of the 2014 data assurance report.
Outcomes	This stage was the core of the data assurance exercise and its outcomes directly informed this report.

Stage 3: Reporting and Recommendations

Stage 3 Description	Reporting on the data assurance review and producing recommendations for future improvements.
Activities and outcome	Following the review and analysis process, DNV GL collected any additional evidence by email correspondence and prepared the present report.

3 REVIEW OF PERFORMANCE MEASURES

3.1 Performance Measures and Outcomes

The four performance measures on which HS1 is monitored are shown in Table 1 together with the outcome of the present review for each measure.

Table 1: Performance Measures and associated review outcomes

Measure	Confidence Grading
1. Number of trains scheduled	A1*
2. Number of trains delayed - all trains delayed by more than 4mins 59 seconds	B4
3. Trains delayed by incidents wholly or partially attributable to HS1	A1*
4. Trains delayed by incidents with unidentifiable attribution	A1*

These results and the means by which they are derived are explained further in the sections that follow. The confidence grading scheme is explained in Section 5.1.

The data that is used to calculate the values for the four measures is collated in an MS Excel workbook known as the "Performance Floor Workbook" (PF Workbook) which also includes the calculations to evaluate the four performance measures.

3.2 Measure 1: Number of trains scheduled

3.2.1 Preparation of the input data

3.2.1.1 Method

The data required for calculating the number of trains scheduled is taken from the weekly train counts that are prepared for commercial purposes. DNV GL examined the process that the analyst must go through to prepare and import the relevant data, both in the case of Train Operating Companies and Freight Operating Companies.

3.2.1.2 Findings

As a result of this review, DNV GL finds that:

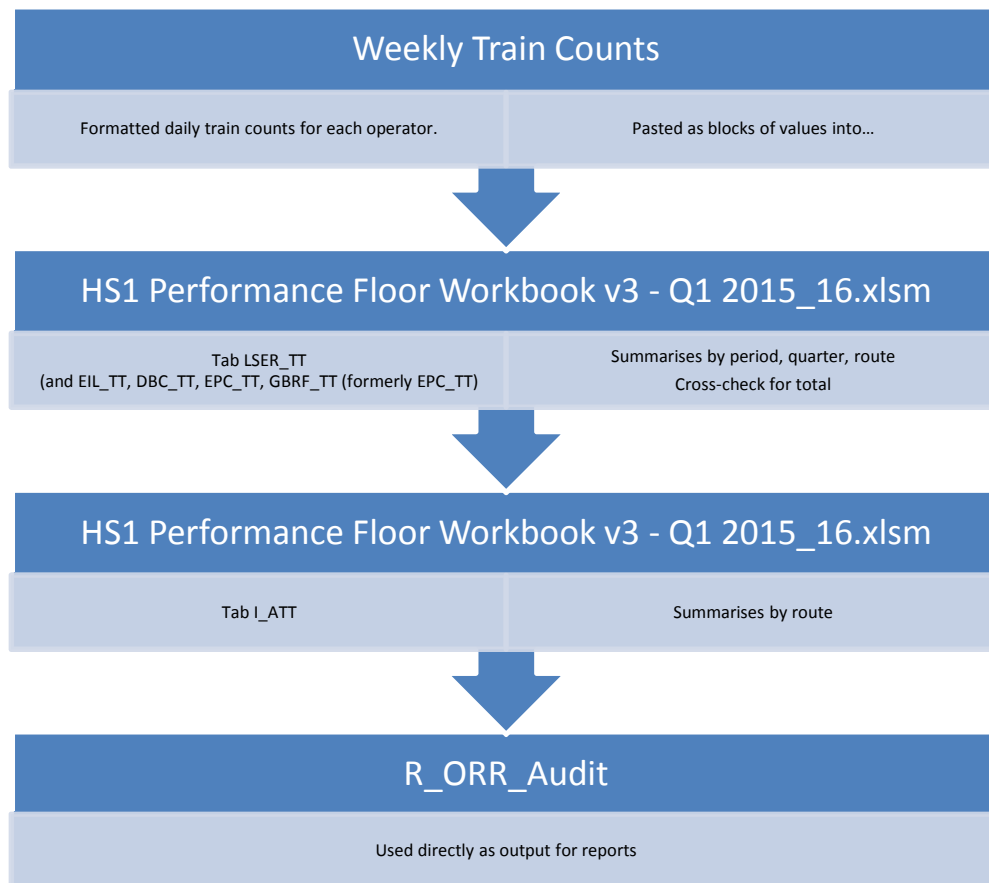
- The processes accomplish what they set out to do – i.e. produce appropriate data for the Performance Floor workbook to operate upon.
- The processes are manual, which is appropriate for this type of process that is non-repetitive within the reporting cycle.
- The manual nature of the processes allows for variation in the precise workbook names for the originating data files and in the network location of those files. The scope for human intervention at this stage lends robustness to the process. There is appropriate cross-checking at a later stage in the overall process (in the Performance Floor workbook) for the manually input elements.
- The process is well described in the "Report Methodology" document [2].

3.2.2 Producing the KPIs from the input data

3.2.2.1 Method

The method for calculating the overall number of trains scheduled from the imported raw data proceeds as shown in the Figure 2. The spreadsheet name is the example for Quarter 1 but the process is identical for the other quarters and for the annual results.

Figure 2: Process flow for number of trains scheduled.



DNV GL has inspected every stage of this calculation by examination of the formulae in the Performance Floor workbook.

3.2.2.2 Findings

DNV GL finds that this method is in agreement with first principles, well-designed and robust.

During the inspection of the calculation flow, DNV GL identified a potential vulnerability in the process. The calculation method relies on a number of additional inputs such as:

- definitions of Quarters and Periods
- service type names and cross-reference to route (shown in Figure 3)

The potential vulnerability lies in the table, part of which is shown in Figure 3. An inconsistency in the precise form of the service type names can affect the summation of the trains in the timetable. This arises because it is the summary columns in the timetable sheets that are used for the summation, by cross-referencing with the entries in the table shown in Figure 3.

For example, an invisible trailing space or the use of an em dash instead of an en dash (a common “auto-correct” substitution in Microsoft Office software) will result in an error.

Figure 3: Additional input table in Performance Floor workbook

Total	Service
Ash	PEAKSt P - Ashford W Jn Total
Ash	OFF PEAKSt P - Ashford W Jn Total
Ash	PEAKAshford W Jn - St P Total
Ash	OFF PEAKAshford W Jn - St P Total
Ash	SPI - AD PK
Ash	SPI - AD OP

The mitigations against this potential vulnerability are that this table is a constant feature in the Performance Floor workbooks and is edited only when changes are made to the routes employed. Therefore the failure of the workbook to “match” a new or modified entry should be clear to a vigilant analyst at the time of editing once the workbook is calculated.

In addition to the main calculation stream described above, there is an alternative calculation route in the workbook from the input data to the result. This alternative stream is used for cross-checking purposes and shows an error if a discrepancy is detected. This represents a degree of internal checking, which is positive, but it shares the same vulnerability with the main calculation because it also uses the input table shown above. Further remarks are made and a possible alternative cross-checking procedure is shown in Appendix A.

A recommendation (**2016.R2**) is made that an additional cross-checking routine for the total number of trains for each operator be added to the spreadsheet that is independent of route summary table shown above.

3.2.3 Parallel calculation for number of timetabled trains

3.2.3.1 Method

DNV GL performed a parallel calculation of the number of timetabled trains in the reporting period, using Quarter 1 as an example. The starting point for this calculation was the data that was imported into the Performance floor workbook as raw data and the calculation proceeded from first principles using only built-in MS Excel functions. The spreadsheet containing these parallel calculations is supplied as an additional deliverable with the present report.

3.2.3.2 Findings

The result of this activity was that a perfect match to the results in the Performance Floor workbook was obtained. It is important to note that the calculation of these results did not use the additional input table used in the main and cross-check calculation in the Performance Floor workbook (Figure 3).

The Performance Floor workbook also splits the LSER services into two routes, namely the route via North Kent (NKL) and that via Ashford (ASH). The distinction between these two routes depends on the additional input table shown in Figure 3 (i.e. this information is not present in the data imported into the PF workbook). This calculation was therefore performed by DNV GL, using that table, from first principles, again using the Quarter 1 results as an example. Again, the result of this investigation was that a perfect match between the parallel calculation and Performance Floor workbook was found. This calculation is presented in more detail in Appendix A.

3.3 Measure 2: Trains Delayed

3.3.1 Preparation of the input data

3.3.1.1 Method

The data that is used for the calculation of the number of trains subject to a delay is extracted from Business Objects by running two queries from within the Business Objects application which is accessed through a web browser. One query is for delays and the other for cancellations. These queries are pre-defined standard queries within Business Objects.

The queries are run and saved in a specified format. Past result sets from earlier executions of the queries are also accessible in the Business Objects interface, which is a good resource for cross-checking.

The data is pasted (as values) into the destination areas in the Performance Floor workbook.

The imported data is then sorted by date/time and any train with a departure time before 01:59 on any date has its date changed to the preceding day in line with the contract. A cross-check with the weekly train count workbook is part of the analyst's procedure.

DNV GL had sight of the relevant Business Objects queries and witnessed the process of extracting that data.

3.3.1.2 Findings

The only vulnerable part of the process is the manual entry of the reporting dates for the reporting quarter (or year) in question when running the queries and the manual modification of certain dates.

This degree of manual intervention is regarded as appropriate for a procedure of this nature and there is:

- suitable cross-checking of the dates performed in the Performance Floor spreadsheet into which this data is later imported, and
- suitable cross-checking of the recognition of the timetabled trains against the weekly train counts.

These cross-checks are regarded as sufficient to make these possible vulnerabilities well-mitigated.

3.3.2 Producing the KPIs from the input data

3.3.2.1 Method

Once the data is imported into the Performance Floor workbook, the calculation of the KPIs takes place.

The principle is that a reported delay should count as a delay if and only if:

- the delay exceeds 4'59" (this filtering takes place in Business Objects), AND
- the delay occurs to a train service that is part of the timetable (including spot bid additional services), AND
- the delay is not a planned delay.

This processing for the latter two points takes place in the Performance Floor model in worksheet "I_<Operator/Route identifier>_Delays".

The imported timetable for the relevant operator is searched by headcode for instances of services that experienced the delay and the date on which it occurred. If such an instance occurs, the delay should be counted in the final statistics.

3.3.2.2 Findings

The coding of this last logical step noted in section 3.3.2.1 in the PF workbook makes the unsafe assumption that headcodes are unique within each day for each operator. Unfortunately this is not the case as domestic services (i.e. LSER services) that start and terminate at St Pancras, which are regarded as two separate services because they leave and enter the HS1 area at distinct points, share a headcode. (Such services are known as “rounder” services.)

The consequence for the results is that every delay that occurs to a rounder service is reflected in the final total number of delays twice. If a delay is reported for both the outbound and inbound parts of the rounder service, the number of delays is counted as 4. DNV GL makes a recommendation (**2016.R1**) corresponding to this issue and a further observation (**2016.O5**) regarding future quality protection.

In terms of the KPI results, the total number of delays (regardless of attribution) is quite severely overestimated in the case of the LSER operator (see Table 2).

In terms of the robustness of the process, this is a vulnerability that applies to all the delay data in the model, and it is only a result of the fact that (date, headcode) combinations are indeed unique for the other operators (Eurostar and the freight operators) that greater inaccuracy does not follow.

All other aspects of the production of this KPI have been examined by DNV GL, including the filtering of the results for planned cancellations/delays, and found to be both appropriate and robust.

3.3.3 Parallel calculation for delays (all attributions)

3.3.3.1 Method

DNV GL performed a parallel calculation of the number of delays to timetabled trains in the reporting period, using Quarter 1 as an example.


3.3.3.2 Findings

The results were as shown in Table 2, below. The label “Double counting present” refers to the multiple counting predicted in section 3.3.2.2 above.

Table 2: Parallel calculation verification of number of delayed trains by operator type

	Domestic via NKL	Domestic via ASH	International	Freight	All
PF Workbook result	597	849	995	28	2469
Parallel calculation result	479	656	995	28	2158
Verification result	Double counting present	Double counting present	Agreement	Agreement	Double counting present

The parallel calculation results reflect the prediction from the validation exercise that the number of delayed timetabled services would be over-estimated by the PF workbook in the case of the domestic operator. In particular, the number of delays is over-estimated by c.25% for the domestic operator and c.14% overall.



More detail on the parallel calculation of this statistic appears in Appendix A and the spreadsheet used for this purpose is supplied together with the present report.

3.4 Measures 3 and 4: Trains delayed by incidents attributable to HS1 or unidentifiable

3.4.1 Method Validation

3.4.1.1 Method

The method for calculating these two measures proceeds from the list of incidents imported from Business Objects. Line items that represent duplicates or that affect trains that are not timetabled services are filtered out as are instances of “change of origin”. The remaining line items are categorised according to whether the incidents in question are Excludable, Unidentifiable and attribution status (agreed or disputed). The “attribution agreed” items are assigned the agreed to responsible party.

An additional condition to the logic was added following the 2013/14 review that deals with the case of incidents with multiple causative incidents.

3.4.1.2 Findings

DNV GL has examined the logic and the way that it is implemented in the Performance Floor workbook and finds that it correctly implements the process intended. The process is considered robust and well implemented. The calculation path that leads to this KPI is independent of the path that leads to the KPI “Total number of trains delayed”, so the over-estimation identified in the method used for the latter KPI does not affect the outcome in the present case.

The only potential vulnerability in the process is that the logic for checking whether the incidents are duplicates relies on the items in the list being in time order. The written process for importing this data specifies a step to sort the data and it is anticipated that the analyst will implement this step reliably. However, it is recommended (**2016.R3**) that an additional cross-check is built into the model to detect whether the time ordering is correct.

3.4.2 Parallel calculation for delays attributable to HS1 and unidentifiable

3.4.2.1 Method

DNV GL performed a parallel calculation of the number of incidents that result in delays to trains that are wholly or partly attributable to HS1, using Quarter 1 as an example. Specifically, the calculation was performed for the LSER trains that follow the North Kent route.

3.4.2.2 Findings

The result of this investigation was that a perfect match between the Performance Floor workbook and the parallel calculation was observed. The match was observed both for delays attributable to HS1 and for the unidentifiable group of delays. More detail on this calculation is presented in Appendix A.

Although this parallel calculation was carried out for just one of the operator/route combinations, this is regarded as sufficient evidence of the validity of the Performance Floor model for the other operators or routes.

3.5 Recommendations for Performance Measures

The review of the data and methods has given rise to three recommendations, as described in Table 3.

Table 3: Recommendations arising from the present data review

Number	Recommendation	Data Owner
2016.R1	Correct the logic used in the Performance Floor workbook to count the total number of trains delayed.	HS1
2016.R2	Add to the Performance Floor workbook an additional cross-check to make timetable counts independent of the service code groups input table.	HS1
2016.R3	Add to the Performance Floor workbook an additional cross-check to detect whether the list of delay-causing incidents is correctly time-ordered.	HS1

4 REVIEW OF ASSET MANAGEMENT

4.1 Asset Management Measures and Outcomes

The quality of Asset Management data is monitored according to measures defined in the HS1 Monitoring Handbook[1]. Five specific Key Performance Indicators are specified:

1. Overall fault levels
2. Plan attainment (backlog)
3. Track quality-induced speed restrictions
4. Broken rails
5. Service-affecting defective rails

DNV GL reviewed the extracted data and processes that generate these KPIs and has awarded a confidence grading of A1* to all of them. Note that this grading assessment applies to the extracted data and subsequent processes, not to the raw data. The rationale for these gradings is provided in sections 4.2 to 4.4 below.

In addition, DNV GL reviewed the asset register, especially with respect to data specifications, change management processes and the methodologies used to generate the data necessary for KPI reporting to ensure that these are appropriate and being effectively implemented (see section 4.5).

4.2 Overall Fault Levels

4.2.1 Asset Management Service KPIs

4.2.1.1 Method

The following is reported for Asset Management Service KPIs and is based on faults that have resulted in a service delay (severity 1) or which had the potential to result in a service delay (severity 2).


Figure 4: Reporting of Asset Management Service KPIs

Overall Fault Levels	Average Faults Per Period (Target to improve on 2011/12 levels)	2011/12 result	Average per period	
Signalling		19	12.31	Met
Communications		3	1.15	Met
M&E		12	4.46	Met
OCS		3	0.31	Met
Civils		0.1	0	Met
Track		0.2	0	Met

DNV GL inspected the "scripts" (the instructions used to extract the raw data), the manipulation of that data (via spreadsheets), the allocation of faults to severity levels and the management processes governing these activities.

4.2.1.2 Findings

The scripts (i.e. the query code) used to extract the data from the database are considered to be fit for purpose. In particular, they correctly include the required filters for dates and severity class.



From the raw data extract, pivot tables are used to count the number of severity 1 and 2 faults. These are divided by the number of periods in the assessment range to give an average faults per period. The pivot tables were checked for accuracy in terms of selection criteria and data ranges and no errors were identified. Further, an independent check was made by summing each severity 1 and 2 fault recorded in the data set and comparing that with the results returned by the pivot tables; an exact match was found in each case.

DNV GL noted however that the analyst is required to manually select certain pivot table parameters (such as the time period to be covered), with the potential for error. There were no apparent checks built into the data analysis spreadsheets to alert the analyst to potential errors, except for an overall count of faults. The onus is therefore on the review and checking process to identify potential errors (for example from selecting the incorrect time period, severity categories etc.).

This potential for error is mitigated by the fact that the process is relatively simple and therefore this potential vulnerability is noted in this review only as an Observation (**2016.01**).

The review and checking process mentioned above was assessed through interview and a detailed inspection of the queries and processing spreadsheets used.

In summary a detailed review of process from data extraction through to presentation in the Asset Management Annual Statement has been performed. No errors were found in the processes investigated and thus the statement that the targets have been met is supported by the results of this review.

4.2.2 Asset Management Corrective Work Orders

4.2.2.1 Method

In addition to the Service KPIs, DNV GL checked the Corrective Work Orders (CWOs) and the “scripts”, the manipulation of that data (via spreadsheets) and the management processes governing these activities.

4.2.2.2 Findings

DNV GL inspected the scripts used to extract the data from the database and considers them to be fit for purpose.

From the raw data extract, pivot tables are used to count the number of events corresponding to each norm description (e.g. “*PTS-INSPECT AND REPAIR*”) and a top ten extracted for presentation. The pivot tables were checked for accuracy in terms of selection criteria and data ranges and no errors were identified. Further, an independent check was made by summing event (characterised by its norm description) and comparing that with the results returned by the pivot tables; an exact match was found in each case.

The same findings apply as described in section 4.2.1.2 concerning the need for manual selection and limited checks in the data analysis spreadsheets. Therefore it is observed (**2016.02**) that the possibility of building some internal checks into the process might be considered.

The review and checking process mentioned above was assessed through interview and a detailed inspection of the queries and processing spreadsheets used.

In summary a detailed review of process from CWO data extraction through to presentation in the Asset Management Annual Statement has been performed. No errors were found in the processes investigated and the data reported therein is supported by the results of this review.

Possible additional improvements include:

1. The top ten Corrective Work Order (CWO) activities represent different percentages of the totals in each category. For example those reported under signalling equate to c.68% of the total events in this category, whilst the top ten reported under communications equate to c.80%. An additional column in each table to represent the percentage each norm description contributes may improve understanding. This has resulted in an Observation (**2016.03**).
2. It is noted that the reporting of communications in the report version provided for this review included the norm description "SIG-INSPECT AND REPAIR" twice. This has resulted in an Observation (**2016.04**).

4.3 Plan Attainment

4.3.1 Method

The process for assessing plan attainment proceeded in a manner similar to that for corrective work orders.

4.3.2 Findings

DNV GL inspected the scripts used to extract the data from the database and considers them to be fit for purpose. Furthermore, DNV GL examined the structuring of the resultant data and the pivot tables used to classify the resulting data and considers both to be fit for purpose and unlikely to result in error.

4.4 Track quality-induced speed restrictions/ Broken rails/ Service-affecting defective rails

These measures are all zero in the present reporting period. DNV GL has reviewed the script used for extracting this information however and discussed its processing with NR (HS) staff. It is considered that there is no reason to doubt the validity of the results and that the processes used are robust. DNV GL examined the history of the execution of the queries and found that the appropriate queries had been run at the appropriate times during the reporting cycle, increasing confidence that the measures will be given non-null values should these events occur.

In addition, DNV GL has examined the data structures used to hold the resulting data (in the event of non-null data being produced) and has verified that the structure, together with the pivot table processing, is highly likely to produce a robust result.

4.5 Review of Asset Register

DNV GL undertook interviews with NR (HS) personnel to gain familiarity with the asset register, its specifications and the processes that govern the maintenance of its data. In particular, DNV GL examined the specification of that data, and the processes governing changes to that data. DNV GL reviewed various policy and procedure documents relating to the maintenance and quality of the asset register data and data specification.

4.5.1 Data Specifications

4.5.1.1 Method

DNV GL reviewed the NR (HS) documents relating to data specification, quality and maintenance within the asset register, namely the Asset Knowledge Standard [4], the Data Dictionary [5] and the Asset Decision Support Tool [6]. Important input was also gathered from the operating policies for data maintenance and work management [7,8].

4.5.1.2 Findings

DNV GL found that the data within the asset register is well-specified, in a way that matches the concept of a “single source of truth” recommended in an earlier data review. There are clear and comprehensive definitions available and a firm correspondence with former paper-based methods is maintained through the use of a “flattened copy” of asset records that can be stored separately from the main asset database. The electronic data set is used as the primary source of record (“single source of truth”) and is used for all subsequent data extractions and calculations. The paper record is a useful resource for studies that span the period over which the electronic data source was introduced.

In addition, DNV GL had sight of randomly-selected individual data records and confirmed that the fields are populated in a way that is consistent with the principles described in the policy and definition documents.

4.5.2 Change Management Processes

4.5.2.1 Method

DNV GL’s assessment of the change management processes for the asset register was based primarily on the data maintenance and work management operating policies [7,8] and an interview with NR (HS) personnel on this subject.

4.5.2.2 Findings

The documents describe processes to:

- Create a new asset
- Remove or renew an asset
- Fit or de-fit assets for repairable assets
- Make standing data changes
- Install new assets for project works contractors.

The processes for each of these activities are well-described in a series of flowcharts and it has been established through interview that these process flows are in active use. DNV GL has reviewed these processes and found that they are well-defined, fit for purpose and robust. The fields that record whether an asset remains in use are not used in the data-extraction queries reviewed in the sections above, meaning that past failures of an asset are still (correctly) counted in failure statistics.


Significant progress has been made towards encoding these processes into an electronic data maintenance system for use in the field and this system, although still under development and used only for certain asset classes, is fully-compliant with the processes described. DNV GL therefore considers that the asset register and its associated procedures and systems are subject to continual improvement.

It would be an appropriate activity for a future review to examine examples of actual changes that have been recorded in the asset register to verify that the procedures examined here are being used in practice.

4.5.3 Data Coverage and Data Verification processes

4.5.3.1 Method

NR (HS) demonstrated to DNV GL that systems are in place to allow for continuous improvement of the quality of data in the asset register. For example a GIS mapping tool is in use to compare data from the asset register with mapping data to allow visual verification of an individual asset and its location. This



tool also allows for the addition of any missing assets discovered in this way. The improvement of data quality and completeness is also addressed as part of the development of “electronic quality plan forms” which are subject to a verification process to eliminate discrepancies.

4.5.3.2 Findings

DNV GL considers that the processes in place to improve data coverage and quality in the asset register are effective and robust.

4.5.4 Process for the production of AMAS KPIs

4.5.4.1 Method

Data from eAMS is downloaded daily to a local database at NR (High Speed) known as the Asset Reporting Tool (ART). This daily update contains a comprehensive set of data that is useful for multiple functions at NR (HS).

DNV GL has inspected the queries that are used for this purpose and discussed the process with NR personnel.

4.5.4.2 Findings

DNV GL considers that the process is fit for purpose and robust. The remainder of the process, which consists of processing the data to produce the KPIs, is reviewed in Sections 4.2 to 4.4.

4.6 Recommendations and Observations for Asset Management

The 2014 data review stated that improvements in the quality of asset data “*should be seen as work in progress as part of a continuous improvement process*”. Based on the improvements noted in change management processes concerning the electronic encoding of these processes (section 4.5.2.2) and the improvements in data coverage and verification, noted in section 4.5.3.1, DNV GL finds that there is evidence of a continuous improvement process. In a future review it would be good practice to verify that examples of actual changes recorded in the asset register have followed the change management procedures described in section 4.5.2.

No recommendations regarding asset management arise from the present review, but four observations are made as shown in Table 4.

Table 4: Observations arising from the present data review

Number	Observation	Data Owner
2016.01	In the process of producing the reports for overall fault levels for the asset management KPIs, the analyst is required to manually select certain pivot table parameters (such as the time period to be covered) with the potential for error. The data owner might consider whether it is possible to extend the spreadsheet to include some cross-checks to alert the analyst to potential errors.	HS1
2016.02	In the process of producing the reports for Corrective Work Orders (CWOs) for the asset management KPIs, the analyst is required to manually select certain pivot table parameters (such as the time period to be covered) with the potential for error. The data owner might consider whether it is possible to extend the spreadsheet to include some cross-checks to alert the analyst to potential errors.	HS1
2016.03	The top ten Corrective Work Order (CWO) activities represent different percentages of the totals in each category. For example those reported under signalling equate to c.68% of the total events in this category, whilst the top ten reported under communications equate to c.80%. An additional column in each table to represent the percentage each norm description contributes may improve understanding.	HS1
2016.04	It is noted that the reporting of communications in the report version provided for this review included the norm description "SIG-INSPECT AND REPAIR" twice.	HS1

5 CONFIDENCE RATINGS

5.1 The Confidence Grading System

The confidence grading system used in this review is consistent with the criteria used by the Independent Reporter to assess Network Rail in Control Period 5 (CP5). It provides a combined assessment of reliability and accuracy, with the letter being the reliability rating and the number the accuracy rating. The rating system is summarised in the tables below.

Table 5: System reliability grading system

System reliability band	Description
A	Sound textual records, procedures, investigations or analysis properly documented and recognised as the best method of assessment.
B	As A but with minor shortcomings. Examples include old assessment, some missing documentation, some reliance on unconfirmed reports, some use of extrapolation.
C	Extrapolation from limited sample for which Grade A or B data is available.
D	Unconfirmed verbal reports, cursory inspections or analysis.

Notes:

1. System reliability is a measure of the overall reliability, quality, robustness and integrity of the system that produces the data.
2. Some examples of the potential shortcomings include old assessment, missing documentation, insufficient internal verification and undocumented reliance on third-party data.

Table 6: Accuracy grading system

Accuracy band	Description
1*	Data used to calculate the measure is accurate to within 0.1%
1	Data used to calculate the measure is accurate to within 1%
2	Data used to calculate the measure is accurate to within 5%
3	Data used to calculate the measure is accurate to within 10%
4	Data used to calculate the measure is accurate to within 25%
5	Data used to calculate the measure is accurate to within 50%
6	Data used to calculate the measure is inaccurate by more than 50%
X	Data accuracy cannot be measured

5.2 Confidence Grading Results for Performance KPIs

Based on the review presented in Section 3, the following Confidence Grading results have been assigned.

Table 7: Confidence grading results for operational performance

Key Performance Indicator	2015/16 rating	2013/14 rating	2011 rating
Total number of trains timetabled	A1*	A1*	A1
Total number of trains delayed	B4	A1*	A1
Number of trains delayed by an incident wholly or mainly attributable to HS1	A1*	A1*	A1
Number of trains delayed by an unidentifiable incident	A1*	A1*	A1

The KPI “total number of trains delayed” is over-estimated as the performance floor workbook makes the unsafe assumption that headcodes are unique within each day for each operator. This is described in more detail in Section 3.3.2.

As this error is a small part of an otherwise robust process, and because of the ease with which it could be corrected to bring the rating up to “A”, DNV GL has interpreted the reliability grading to be “B”.

The result for total number of trains delayed is affected for the domestic operator only, resulting in an overall error of about 14%, which results in a “4” in the accuracy part of the grading scheme.

5.3 Confidence Grading Results for Asset Management KPIs

Based on the review presented in Section 4, the following Confidence Grading results have been assigned.

Table 8: Confidence grading results for operational performance

Key Performance Indicator	2015/16 rating	2013/14 rating	2011 rating
Overall Fault Levels	A1*	A1*	A1
Plan attainment	A1*	A1*	A1
Track quality-induced TSRs	A1*	A1*	A1
Broken Rails	A1*	A1*	A1
Service-affecting defective rails	A1*	A1*	A1

Note that this grading assessment applies to the extracted data and subsequent processes, not to the raw data.

6 PROGRESS RELATIVE TO 2014 REVIEW RECOMMENDATIONS

There were two recommendations made in the 2014 data review, as shown in Table 9.

Table 9: Recommendations from the 2014 data review

Number	Recommendation	Data Owner	Date Due
2013.P.01	Review the methodology for extracting "Trains Run" data using trains service codes to mitigate the risk of error (missed trains) when train service codes are changed within the train planning system	HS1	July 2014
2013.P.02	Review the procedures for allocating a "prime" cause for trains cancelled for more than one primary reason/cause code, and determine how to report on these. Incorporate the revised methodology into the HS1 Performance Floor Report methodology	HS1	July 2014

2013.P.01.

The data owner has reviewed this methodology. This was established during the course of DNV GL's interview with NR (HS) and is reflected in the process documentation. The documentation explains that the relevant queries in Business Objects would be amended in the event of train service code changes and an additional internal validation step has been inserted into the performance floor workbook to highlight significant changes in the number of trains observed relative to the previous performance report. Significant changes are required to be investigated by the analyst and there is a prompt for this investigation.

2013.P.02

The data owner has reviewed these procedures and made the required adjustments. This is visible in the Performance Floor Workbook, but no special arrangements are made for the reporting of such occurrences.

7 RECOMMENDATIONS AND OBSERVATIONS

The present data review has resulted in three new recommendations.

Table 10: Recommendations arising from the present data review

Number	Recommendation	Data Owner
2016.R1	Correct the logic used in the Performance Floor workbook to count the total number of trains delayed.	HS1
2016.R2	Add to the Performance Floor workbook an additional cross-check to make timetable counts independent of the service code groups input table.	HS1
2016.R3	Add to the Performance Floor workbook an additional cross-check to detect whether the list of delay-causing incidents is correctly time-ordered.	HS1

As a result of the review five observations were also made for consideration by the data owners.

Table 11: Observations arising from the present data review

Number	Observation	Data Owner
2016.O1	In the process of producing the reports for overall fault levels for the asset management KPIs, the analyst is required to manually select certain pivot table parameters (such as the time period to be covered) with the potential for error. The data owner might consider whether it is possible to extend the spreadsheet to include some cross-checks to alert the analyst to potential errors.	HS1
2016.O2	In the process of producing the reports for Corrective Work Orders (CWOs) for the asset management KPIs, the analyst is required to manually select certain pivot table parameters (such as the time period to be covered) with the potential for error. The data owner might consider whether it is possible to extend the spreadsheet to include some cross-checks to alert the analyst to potential errors.	HS1

Number	Observation	Data Owner
2016.03	The top ten Corrective Work Order (CWO) activities represent different percentages of the totals in each category. For example those reported under signalling equate to c.68% of the total events in this category, whilst the top ten reported under communications equate to c.80%. An additional column in each table to represent the percentage each norm description contributes may improve understanding.	HS1
2016.04	It is noted that the reporting of communications in the report version provided for this review included the norm description "SIG-INSPECT AND REPAIR" twice.	HS1
2016.05	Consider a further check of the Performance Floor workbook to identify whether there are further implied assumptions concerning timetabling that, if the timetabling arrangements are changed, might lead to future errors similar to the error affecting "rounder" services.	HS1



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3. HS2 Data Assurance Review, REP/232046/00, Ove Arup & Partners Ltd., June 2014.
4. Asset Knowledge Standard, C-10-IM-39-2004, Network Rail High Speed, Draft C, Revision date 28/07/2014
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APPENDIX A ENHANCED DETAIL ON CALCULATION METHODS AND PARALLEL CALCULATIONS

Calculations leading to Performance KPIs

Total number of trains timetabled in Q1 2015/16

DNV GL performed a parallel calculation of the number of timetabled trains in the reporting period, using Quarter 1 as an example. The starting point for this calculation was the data that was imported into the Performance floor workbook as raw data and the calculation proceeded from first principles using only built-in MS Excel functions. The spreadsheet containing these parallel calculations is supplied as an additional deliverable with the present report.

This section describes how that parallel calculation was performed.

There are dual calculation streams in the workbook for this data, which represents a degree of internal checking. The imported data is a mixture of individual train codes and summary columns and both calculation streams rely on a second input table that specifies the column header names for the summary columns. This reliance of both calculation streams on the same manually entered input table represents a vulnerability in the cross-checking process and a recommendation is made in the main body of this report corresponding to this issue.

In the parallel calculation worksheet, the figure for the number of trains timetabled was reproduced from the raw imported timetable in two ways.

First, noting that if all the data is summarised in the timetable summary columns correctly, the sum of the whole imported block should be exactly twice the number of timetabled trains. This was verified in the parallel calculation worksheet by adding the entire block of data that represents the timetable and dividing by two.

Secondly, it is noted that the headcodes for individual trains in the imported timetable are exactly four characters long. Using this as a selection criterion for the columns, the raw data can be used to reproduce the same result independently of the assumption that the summary columns are correct. This was done and the result was verified once again. This calculation was done for all four operating companies using the HS1 line, as shown in the following table.

	LSE	EIL	DB Schenke	Europorte Channel
PF Workbook result	13458	4915	112	106
Parallel calculation result	13458	4915	112	106
Verification result	Verified	Verified	Verified	Verified

The parallel calculation workbook was also used to reproduce the split between the two routes in use for the domestic services, namely the route via North Kent (NKL) and that via Ashford (ASH). This

investigation resulted in the following table, providing further evidence that the calculation method of the Performance Floor workbook is sound.

Route	Workbook result	Parallel Calc. result
NKE	6476	Match
ASH	6982	Match

Number of delayed trains

The example used for numerical purposes is once again Quarter 1 of 2015/6, for the LSER operator, this time focussing on route NKL.

The top level result for KPI[2], quoted in the PF workbook sheet ORR_Report, is 597.

This figure is derived from this formula: =SUM(I_DomNKL_Delays!\$W\$4:\$W\$3243). The number reported is the sum of the entries in column W of sheet I_DomNKL_Delays.

Except for blank rows (which return no result), the formulae in column W are as follows (using row 4 as an example)

$$W6 = 1 - V6$$

V6 = 1 - T6, except in the case of planned delays, which are excepted.

Therefore:

$$W6 = 1 - (1 - T6) = T6$$

In other words, that which is reported as KPI[2] is the sum of the entries in column T (apart from the omission of planned delays).

The formulae in column T count the number of trains in the relevant timetable (in this case sheet LSER_TT) that match the headcode and the date. This is relevant because delays to trains that are not timetabled are not to be counted. However, instead of enquiring whether there are trains that match the (headcode, date) duplet, the formula counts the number of such trains in the timetable.

To see how this arises, consider that a simplified form of the existing column T equation, having removed all exception-traps, is:

$$T6 = \text{SUMIF}(\text{INDIRECT}(Y6), F6, \text{INDIRECT}(Z6))$$

Replacing the indirect references with their targets, this is:

$$T6 = \text{SUMIF}(\text{"LSER TT"!12:12}, F6, \text{"LSER TT"!13:13}).$$

F6 contains the headcode ("1F24" in this case).

This formula sums the entries on the timetable sheet in row 13 for which the headcode matches "1F24". (Row 13 is the appropriate row for the date in question, and the headcodes are stored in row 12 of the timetable sheet.)

(The actual formula used in column T on this sheet in the PF workbook differs slightly. It is extremely complex – it is the subject of another remark in this Appendix – but it is mathematically identical.)

The result of this formula is 2, because there are two trains timetabled to run on the date in question with that headcode. Therefore, the single delay report (in row 6 of the _Delays worksheet) is counted as 2 in the total number of delays, KPI[2].

The re-use of a headcode in a single day arises in the case of a "rounder" service (i.e. one that leaves and enters the HS1 area at distinct points). If both legs of this journey are delayed, it appears as two delay reports in the I_DomNKL_Delays sheet and counts 4 towards the total number of delays.

Both these cases are erroneous.

As a sensitivity test, DNV GL inserted the value of 76 into a single cell on the timetable sheet that corresponds to headcode 1L24 on the relevant date (instead of 1). It was verified that this was carried through to an inflated result in columns T and W on the _Delays sheet, and therefore to the final KPI[2] result.

	Base Case					Sensitivity Test				
	WTT	WTT	WTT	WTT	WTT	WTT	WTT	WTT	WTT	WTT
Detail of LSER timetable sheet	1F35	1F37	1L24	1Z24	1F39	1F35	1F37	1L24	1Z24	1F39
	1	0	1		1	1	0	76		1
	1	0	1		1	1	0	1		1
Detail of I_DomNKL_Delays sheet	T	U	V	W	X	T	U	V	W	X
	597					672				
	in ATT					in ATT				
	ATT?	Main Incident is a Planned Delay?	Remove from Reports?	Include in Reports? (1st Table) 1="Yes"		ATT?	Main Incident is a Planned Delay?	Remove from Reports?	Include in Reports? (1st Table) 1="Yes"	
72	1	0	0	1		1	0	0	1	
95	2	0	-1	2		2	0	-1	2	
01	2	0	-1	2		77	0	-76	77	
58	1	0	0	1		1	0	0	1	

The value of 77 arises because there were previously two "1L24" trains that day in the timetable as two separate entries of 1. The analyst increased one of the 1s to 76 and left the other at 1. 76 + 1 = 77.

This error can be corrected very easily by adjusting the formulae in column V and W of the _Delays sheets.

Number of trains delayed by incidents wholly or partly attributable to HS1, or unattributable

Here, the parallel calculation for this statistic is described. The starting point for this calculation was the data that was imported into the Performance Floor workbook as raw data and the calculation proceeded from first principles using only built-in MS Excel functions.

The numerical example provided here is once again for the domestic operator (LSER) for Quarter 1, on the NKL route.

For this set of data, there are 365 incident reports in the dataset and the allocations according to the parallel calculation are as shown in the following table.

Row Labels	PF Workbook	Parallel Calculation	Verification result
High Speed	27	27	Verified
Other operators or disputed	75	75	Verified
<Not in timetable or duplicates>	75	75	Verified
Planned Cancellation	169	169	Verified
Excludable	15	15	Verified
Unidentifiable	4	4	Verified
Grand Total	365	365	Verified

This parallel calculation provides the validation required for incidents wholly or partly attributable to HS1 and for the unidentifiable group.

Although this parallel calculation was carried out for just one of the operator/route combinations, this is regarded as sufficient evidence of the validity of the Performance Floor model for the other operators or routes.

Remarks on technical aspects of the Performance Floor worksheet

Note 1

On sheet I_DomNKL_Delays, in column T, there is a very complicated array formula. Much of it is designed to trap errors, but the core of the function is

`{=SUM(IF(INDIRECT(Y4)=F4,INDIRECT(Z4),0))}` (using the example from row 4)

Unpacking the indirect references this becomes:

`{=SUM(IF('LSER TT'!12:12=F4, 'LSER TT'!13:13,0))}`

Because this is an array formula, it sums all the entries in row 13 for which the train code (in row 12) matches the train code sought (stored in cell F4). This is slow in evaluation and complicated. The formula can be simplified to:

`=SUMIF(INDIRECT(Y4),F4,INDIRECT(Z4))`

(Note that this is a conventional formula, not an array formula. The evaluation of array formulae in Excel is slow and the internal algorithms of SUMIF (for instance) are much faster.)

This formula is repeated on sheets I_DomAsh_Delays and I_Intl_Delays.

Replacing the formulae in this manner in these three places speeds up the evaluation of the workbook about 20-fold.

Note 2

On sheet I_DomNKL_Incidents, in column AW, there is a complicated array formula. Much of it is designed to trap errors, but the core of the function is

`{=IF(AV4>1,MAX((Z$4:Z4=X4&AQ4)*OFFSET(O$4:O4,0,AV4-1)),MAX((Z$4:Z4=X4&AQ4)*O$4:O4))}`
(using the example from row 4).

When the If clause is true, i.e. when $AV4 > 1$, the function is

`{=MAX((Z$4:Z4=X4&AQ4)*OFFSET(O$4:O4,0,AV4-1))}`

However, even when $AV4=1$, this "true" clause works for the entire formula, because `OFFSET(O$4:O4,0,0)` is identical to `O$4:O4`, which is the form of the equation in the "false" clause. Thus, the true and false clauses are identical and the IF() statement is unnecessary.

Thus, the core part of the formula can be simplified to:

`{=MAX((Z$4:Z4=X4&AQ4)*OFFSET(O$4:O4,0,AV4-1))}` (an array formula)


Note 3

On sheet I_Freight_Delays, in column T, is the following formula (example picked from row 4)

`=OFFSET(INDIRECT("'"&N4&"!A1"),R4-1,S4-1)`

(Again, this is the core of the formula, ignoring the nested IF statements that trap degenerate cases.)

This formula constructs the address of cell A1 on another sheet, determined by N4, and picks a value offset from that cell using the row and column numbers in columns R and S.



An easier, but mathematically identical, version of this formula is

=INDIRECT(ADDRESS(R4,S4,,,N4)).

This avoids the awkward notation in hard-coding the single quote marks and sheet name to construct the cell address as well as the need to convert from the absolute row and column numbers to offset from a fixed cell. This improves readability and reduces the scope for error in future updates.

Note 4

On sheet LSER_TT, in M397:P436, there is a complicated array formula. The core of the function is

{=SUM(IF(\$J\$12:\$ZW\$12=\$C397,IF(\$G\$13:\$G\$378=M\$396,\$J\$13:\$ZW\$378,0),0))}
(using the example from row 397)

This formula represents a sophisticated double SUMIF – it sums the entries in J13:ZW378 using two filtering criteria. (This is a task normally accomplished by a pivot table.)

This calculation is only used in one place, namely as a cross-check for the total number of scheduled trains in the reporting period and for the operator in question. The split into explicit quarters is not used (only the total is used). Therefore, this task is much more easily computed using the methods documented in the parallel calculation worksheet and in this Appendix for the total number of timetabled services.



About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.