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Audit and Quality Assurance Services for TRACS Type Surveys (TTS) Automated Road Condition Survey Vehicles throughout England

Final Report

Version: 1.0

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Prepared for:Project Record:	**Audit and QA services for TTS Automated Road Condition Survey Vehicles throughout England**
Client:	**Department for Transport, Traffic Management Division (Edward Bunting)**

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Executive summary

Project Reference: **Audit and QA services for TTS Automated Road Condition Survey Vehicles throughout England**

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For the Financial Year 2004/05 the Department for Transport identified TTS as the only acceptable survey method that English Local Highway Authorities may use to calculate the Best Value Performance Indicator BV96.

In order to generate BV96 the TTS data is required to have been provided by an "accredited" TTS machine that complies with the requirements of the TTS Advice Note and Specification Version 1.0.

To provide local authorities, and DfT, with confidence that the TTS data is consistent and suitable for both national performance monitoring, and to support local maintenance operations, a quality assurance procedure was developed and fully incorporated into the TTS specification. The specification defined quality assurance requirements including accreditation tests for all survey vehicles, checks on vehicle operation through a procedure of weekly and daily tests carried out by the contractor, and external audits in the form of repeat surveys undertaken both by the contractor (Contractor's Repeat Surveys) and an independent auditor (Auditor's Repeat Surveys).

The Department appointed TRL as independent Auditor, to provide the quality assurance services defined in the TTS specification. TRL achieved this by carrying out the above quality audits and through the provision of independent advice and consultancy services to both survey contractors and local authorities in relation to accredited TTS surveys carried out on the English Principal Road Network for the financial year 2004/05.

This report presents the summary results of the quality audits carried out on TTS survey vehicles in 2004/05, and also summarises the advice and consultancy provided to local authorities.

The advice provided by TRL has encompassed all areas of the TTS survey, from general guidance to the procedures required in the commissioning and undertaking of the TTS survey, through to the resolution of issues concerning the quality of the data delivered by the TTS contractor and the loading of the data into UKPMS databases. Through the identification of key areas of commonalty in the questions raised by local authorities, the provision of this advice culminated in the delivery of a Frequently Asked Questions (FAQ) document for publication on the UKPMS website. It is recommended that this FAQ document be maintained and updated as the TTS survey progresses in future survey years.

The audits carried out on the TTS survey data commenced with initial discussion with the survey contractors to clarify the quality procedures that would be applied through the survey year. It was decided that the survey contractors would be provided with a list of sites for which contractors repeat surveys should be carried out during the survey year. The data collected by the contractors over these sites was delivered to the auditor for assessment. The sites for Auditor's repeat surveys were chosen by selecting a geographic spread of sites from the Contractors progress reports and the contractors were asked to provide their data for those sites within two weeks of the Auditor's survey being carried out. All repeat survey datasets were checked to ascertain if they were comparable within the tolerances set out in the TTS specification.

In the repeat surveys it was found that the TTS survey vehicles generally met the required levels of performance, or performed within the levels that may be expected. In particular it was found that the

measurement of the profile parameters (texture depth, longitudinal profile variance and rutting) was both highly repeatable and reproducible. However, some processing errors were identified in the data from the contractors that lead to incorrect data or incorrect file formats. Further issues identified in the repeat surveys were associated with the accuracy of locational referencing and the measurement of cracking.

Locational referencing relies heavily on the fact that the road network has been defined correctly, as fitting of survey data to an inaccurate network will decrease the accuracy of the measurements. Therefore it was found that where the contractor had been provided with a poor network definition there was increased likelihood of the delivery of poor data. The accuracy of location referencing (OSGR coordinates) was also affected by the operator’s recording of the section start points and the accuracy of the location measurement system itself.

It was found that the performance in the measurement of cracking can vary significantly. Variation in the level of agreement was seen both when comparing repeat runs made by the same vehicle and when comparing with repeat runs carried out using the reference device. This variation in performance is not desirable, but is consistent with the level of performance that might be expected from these systems.

In addition to the repeat surveys, further checks were carried out through examination of the contractors’ records of daily and weekly checks and examination of delivered data. Although the general level of performance was satisfactory it was found that survey data often contained: duplicate section labels with different section lengths; parameters reported at chainages that exceeded the section length; negative chainages and examples of excessive stretching of data.

It is concluded that the TTS survey of 2004/05 was carried out to a generally high level of quality and accuracy. However, a number of issues have been identified through the auditing process that should be considered for future surveys. These include:

- The resolution of issues with location referencing, including the provision of sound network definitions by local authorities and common definitions for locating section change points.
- Improved quality assurance through, the introduction of a requirement for driver accreditation, more controls on the data delivered (in particular the HMDIF file), and better distributions of repeat surveys.
- Improved accuracy by better control of data fitting, and the application of accepted parameter ranges
- Improvements to the measurement of cracking.

1 Introduction

For the Financial Year 2004/05 the Department for Transport identified TTS as the only acceptable survey method that English Authorities may use to calculate the Best Value Performance Indicator BV96 on the Principal Road Network.

TTS surveys are carried out using traffic-speed devices that measure the geographical position of the vehicle, the longitudinal, transverse and texture profile of the pavement, the road geometry, and the intensity of cracking present on the surface of the pavement. This cracking, longitudinal profile, transverse profile, and texture profile data is processed using UKPMS compliant systems to generate BV96.

In order to generate BV96 the TTS data is required to have been provided by an "accredited" TTS machine that complies with the requirements of the TTS Advice Note and Specification Version 1.0 (hereafter referred to as the TTS specification), and has successfully undergone the acceptance testing described in the TTS Specification. Two TTS survey machines gained accreditation in the spring/summer of 2004, the WDM RAV2 (accredited March 2004) and Jacobs Babtie TTS vehicle (accredited May 2004). A further two vehicles undertook accreditation testing later in the year operated by WDM and DCL. However, although the WDM RAV3 achieved accreditation, this system was not used in the 2004/05 TTS survey. The vehicle operated by DCL was still undergoing the accreditation process at the end of the 2004/05 survey year.

To provide local authorities, and DfT, with confidence that the TTS data is consistent and suitable for both national performance monitoring, and to support local maintenance operations, a quality assurance procedure was developed and fully incorporated into the TTS specification. This procedure would be supervised by an independent Quality Auditor, who would also provide advice and guidance to survey contractors and Local Authorities regarding the TTS survey.

TRL was appointed by the Department as independent Auditor for the 2004/05 TTS survey. This report presents the summary results of the audits of the TTS survey contractors carried out during the 2004/05 survey. The report also summarises the advice that has been provided by TRL during the survey year, and considers the key issues that have arisen during the Audit carried in the 2004/05 survey year.

2 Provision of Advice to English local highway authorities

The TTS specification defines the role of the Auditor as a body appointed by the Employer to undertake auditing of the TTS survey carried out by the survey Contractor. As TTS surveys are contracted by individual Local Authorities, the Employer is defined as the Local Authority. Therefore, although TRL had been appointed as Auditor, it was necessary for each Local Authority to recognise TRL in this role, so that TRL could carry out audits over the whole network. Therefore TRL issued an invitation to all 149 local highway authorities in the UK for TRL to provide Quality Assurance (QA) for their TTS surveys. The QA would be at no cost to the local authority, the funding being provided by DfT.

TRL received 106 replies requesting QA services. It was found that one TTS contractor had tendered a number of their contracts using two payment rates to their clients, to cover surveys with and without QA (a streamlined system). Two local authorities subsequently requested that TRL not perform QA on their behalf. The remaining 41 authorities either failed to reply or were undecided. A list of the LA's who did appoint TRL as Auditor is provided in Appendix A.

To enable efficient communication, and to minimise travel costs (if necessary), TRL appointed two points of contact for the local authorities, one for the North of England and one for the South. These contacts maintained records of advice provided so that the frequency and source of problems could be ascertained.

2.1 Advice to Local Authorities during procurement

During the initial stages of the survey procurement, TRL answered a number of queries on the nature of the TTS surveys and the Quality Assurance procedure. Typical questions (and responses) included:

- How is the QA financed? - *Centrally by DfT.*
- How is the QA performed? – *As defined in the TTS Specification.*
- How are TRL's QA services invoked? - *By request.*
- What is required from the LA with regard to QA? – *Granting of the Auditor permission to see the collected data.*
- Can QA be carried out, after the survey has taken place? - *Yes.*
- What is the 'Streamlined' QA system? –*A system where QA surveys and QA checks are not required.*
- We have employed a Contractor, are they accredited? – Y*es if they have a certificate*
- Will site visits be made? - *Only if necessary.*
- Does the QA check the Contractor or the LA? - *Contractor.*
- How long will it take to complete the QA? - *A continual process throughout the year.*
- If we change TTS contractor next year will this cause consistency problems? - *No.*
- Could you audit our 2003 data? - *The audit covers 2004/05 data only.*
- What is TTS, where can I find out more? - *Directed to relevant documentation.*
- Is night time working acceptable? - *Yes.*

TRL provided advice and guidance to these local authorities via email and telephone. Much of the advice given was to clarify and provide interpretation of the TTS Specification.

2.2 Advice to Local Authorities at meetings

Members of the TRL TTS project team attended the Roads Board SCANNER workshops and IAG meetings to meet local authority representatives, answer questions and discuss concerns. Key issues raised at these meetings included:

- Little confidence in the TTS data (notably cracking), poor condition being reported on newly laid road surfaces.
- Confusion over how the QA would be applied. Local authorities expected repeat surveys and detailed checks of records to be made for each and every authority.
- Data fitting. How should it be done?
- The presence of road features such as traffic calming measures could lead to very high values of longitudinal profile.
- Local Authorities would like to see the results of the Quality Assurance process.
- The vast quantity of data was very time consuming to load into UKPMS.
- The cost of surveys in general was high, given the additional need to perform DVI surveys for footways.
- Will the surveys be completed on time?

Where possible these queries were addressed at the meetings. In cases where there was no immediate solution, the issue was noted for further discussion with the relevant parties.

2.3 Advice to Local Authorities upon delivery of data

As the TTS survey progressed, local authorities began to receive TTS data. A number of queries regarding the loading and interpretation of the data were received, and advice provided as discussed below. Key issues raised were:

- Poor performance of cracking measurement. The reporting of cracks on newly resurfaced roads surprised many local authorities.
- Mistakes in the delivered files. These included negative chainages, defects reported at chainages greater than the section length and omissions from the data.
- The large quantity of data, which was very time consuming to load.
- The reporting of very high values for some parameters. Often this prevented the data from loading due to checks in UKPMS. There was (and is) no clear guidance as to what should be done with such high values.
- Fitting of data to the network. Data sometimes was reported as the wrong Lane or was stretched by a large amount to fit the network.
- Confusion over the use of texture in the calculation of the BVPI.
- Questions over the exclusion of roundabouts from TTS surveys.
- Many issues concerned with the compatibility of HMDIF files with UKPMS accredited systems. Although the systems were accredited it appeared that the data itself would not always load into UKPMS as a result of differences associated with formatting.

2.4 Key advice provided to local authorities

TRL provided advice throughout the period of the survey in the form of responses to the questions and concerns raised above. The following subsections summarise the key areas of advice. Outstanding issues for which further attention is recommended are discussed in Section 7.

2.4.1 Very high values of parameters

TRL's advice regarding very high values of parameters was that any exceeding 9999 should be reduced to 9999. For some parameters, such as profile variance, the high values may not be incorrect, but such high values themselves do not provide any real indication as to the nature of any defect that may be present. The fact that the figure is well above the highest BVPI threshold is sufficient.

2.4.2 Night working

For the 2004/05 survey year we considered night time working as acceptable practice. The equipment used does not rely on ambient light to function, although night working does mean that added value options such as forward facing video cannot be provided. The profile and crack measurement systems both have their own light sources. However, issues may arise associated with the difficulty of operating the survey vehicle in poor visibility and the possible increased risk of accident. Furthermore, TRL felt that night working would increase the risk of poor data arising from damp surfaces that could not be identified at night. Both Contractors indicated that they were only performing night surveys in well lit urban areas, for those very reasons. Two of the Contractors Repeat surveys were performed during the night with no apparent degradation in data quality.

2.4.3 Quality and Compatibility of Delivered Data

On the 1st February 2005, TRL produced a Frequently Asked Questions (FAQ) document (included in Appendix B). It was published on the UKPMS website and announced by email to LA's. As many of the questions that arose during the survey year were associated with loading of the data, and not collection, the aim of this was also to stimulate further discussion on data loading issues. The document addressed eight of the most common problems encountered whilst loading TTS data into UKPMS:

- Incorrectly marked sections (for example, CR1 sections on Dual Carriageways, slip roads or one-way sections).
- Duplicate sections (more than one set of data for a particular section).
- Missing data, roads missing.
- Variable resolution in delivered values (the number of decimal places varies).
- Sub-sections length expected to be 10m, but are not.
- End chainage less than start chainage.
- Negative chainages.
- Blank lines in HMDIF's.

The contents of the document were approved by all accredited survey contractors. It is recommended that the document be maintained and updated in future survey years by the QA Auditor.

3 Advice and Guidance provided to Contractors

For the survey year 2004/05, two survey contractors applied for and gained TTS accreditation. WDM Ltd gained accreditation for their RAV2 vehicle from 16/04/04. Jacobs Babtie gained accreditation to perform surveys from 19/05/04 and to deliver data from 04/08/04.

3.1 Contractors Meetings

At the beginning of the QA contract (17th June 2004) a meeting was held, attended by the survey contractors, DfT, the TTS Auditor and the TTS project manager, to discuss the arrangements for QA, Audit and accreditation of TTS machines. It was important to agree on a uniform 'interpretation' of the TTS specification, to ensure that everyone understood the requirements of the proposed contract, and the expectations of them. The following points relating to TTS QA were discussed and agreed upon:

- The approximate number and length of repeat surveys. – *Five of each type for each contractor. Contractors repeat surveys to be each approximately 10km long, Auditor's Repeat surveys to be sections selected from complete routes.*
- Timescales and practical arrangements for delivering/collecting repeat survey data. – *Suitable contacts were established and arrangements were made to collect progress information and QA documentation on a regular basis, from each contractor. Three weeks being the maximum delay.*
- Importance of keeping records of driver, operator and data processor. – *A substitute for operator accreditation. Any issues can be traced back to their source.*
- Differences between daily and weekly checks, and site selection. – *The Weekly checks were to be slightly longer and to use improved location referencing if preferred.*
- Method of auditing daily and weekly check sites. - *The Auditor would be able to request data and/or reports from the daily or weekly checks at any time.*

- The consequences and risks of failing QA checks. *Flexibility of the QA was required since the vehicles are still in a development phase. It was agreed that the Auditor would work with the survey contractor to ensure an acceptable solution was achieved in the event of any issues arising. The contractors understand that any surveys performed whilst there were still outstanding issues would be performed at their own risk. In extreme cases reaccredidation may be required.*
- The frequency of progress reports and how they should be delivered. - *The lengths and dates of the completed surveys were compiled to track survey progress and enable an estimation of the survey completion date. Although all TTS contractors assured us that their programmed surveys would be completed on time, the collection of this data allowed an independent assessment to be made.*

A further meeting was held approximately midway through the survey year (4th November 2004) to discuss any issues at the "mid point" of the survey. Issues that arose included:

- The Survey
  - Progress of surveys. – discussion of how contractors would achieve coverage. – *Data collected by the Auditor showed it unlikely that the surveys would be completed on-time, at the current rate. The contractors were confident that their targets would be met, having increased the rate of survey by utilising double shifts and surveying 7 days a week.*
  - Progress in delivering data. - *The Auditor had no indication of the amount of data collected that had been delivered and accepted. A summary from each contractor was requested.*
  - Machine Identifiers. –*ambiguity in the reporting of identifiers was resolved, which was important so that correct identification of the source of data for auditing purposes could be ensured. Until this time all survey contractors were using the same machine identifier 'TTS01'.*
- Location Referencing
  - Fitting of data to the network. – *The implications for data trending of rubber-banded data, were discussed. The contractors described how they were informing Local Authorities of any discrepancies between network definition length and survey length.*
  - Incorrect Network Definitions from the Local Authority. – *Both contractors highlighted the sometimes poor network definitions received from Local Authorities. For example, lack of nodes and/or section descriptions. This increases the time required to plan and perform surveys.*
- QA
  - Contractors Daily and weekly checks. – *There had been occasional failures, but these were not considered to be indicative of a problem, provided that there was adequate justification.*
  - Auditors QA – *Repeat surveys. – The stretching being performed by contractors made it difficult to meet the requirements for location referencing.*
  - Primary Check Sites – *the provision of advice on the procedures for primary checks, see section 6.2.*
- Proposals for the 05/06 survey year
  - After experience in 04/05 what is the level of QA that is required in the future? *Alternative options for vehicle accreditation were discussed with a view to decreasing the time and cost to contractors.*

- Operator accreditation. – *This was discussed as a requirement for the following year's survey. See section 7.2.2*

3.2 Key advice provided to contractors

In addition to advice and guidance provided at meetings with the contractors, TRL also provided ongoing guidance to survey Contractors where necessary during the survey year on the implementation of the QA procedures. The following subsections summarise a number of the key areas that were addressed. However, there were a number of issues that arose that require further attention, as discussed in Section 7.

3.2.1 Approval of the cracking daily check procedure.

Section 6.5 of the TTS Specification stated that the Daily and Weekly checks of the crack identification system would be performed to a procedure set in place by the contractor. This is due to the difficulty of applying checks based on statistical differences to cracking measurements recorded over the relatively short lengths used for Daily and Weekly check sites. Shortly after gaining accreditation, each contractor submitted a procedure to the Auditor. The Auditor approved the procedures as suitable for checking the operation of the crack identification system.

3.2.2 Approval of the Daily and Weekly check methodology

On receiving the first sample of daily and weekly check records from contractors in July, some minor corrections and improvements were requested by the Auditor. (See paragraph 6.2). Subsequent samples of checks were satisfactory.

3.2.3 Approval of primary sites for Contractors Checks

This is discussed in Section 6.2

4 Advice and Guidance provided to TTS Project Management

4.1 Progress Reports

Using the data provided by Contractors, periodic (approximately monthly) reports of Contractor's progress were delivered to the TTS Project Manager for dissemination to interested parties (the Implementation Advisory Group, Project Management Group, UK Roads Board, DfT, concerned Local Authorities, etc). The data enabled the Project Manager to assess the progress of the contractors against plan. The progress reports also aided estimating future survey vehicle requirements.

Figure 1 shows the cumulative daily survey totals reported to the Auditor by the Contractors. Initially the total length in Lane km of Principal Road Network in the 149 Local Authorities was estimated to be around 54839 km, as shown by the red 'Target' line, which also shows how the survey might be expected to progress in an ideal situation. In reality, the Principal Road Network was divided up between three survey contractors. Only two of those survey contractors successfully accredited survey vehicles and then only managed to begin surveying part way into the survey year (the end of May). The 'Total Contracted' target line takes into account these two facts, the estimated total figure of 47280km representing the total length which these contractors were requested to survey by 128 Local Authorities.

The targets were estimated from the figures given by Local Authorities for their total length of principal road network. As the survey year progressed it became apparent that the figures given were not always accurate. Hence the Contractors actually surveyed slightly more than was expected (1299km more, a total of 48579km).

As can been seen from Figure 1 the contractors began well but started to fall behind in July 04, partially due to poor weather and partially due to other factors (such as other work and equipment breakdowns). Improvements were made throughout the year with the survey teams adopting double shifts and utilising night surveys to accelerate the rate of progress. The last TTS survey for the year 2004/05 was completed on 31st March 2005.

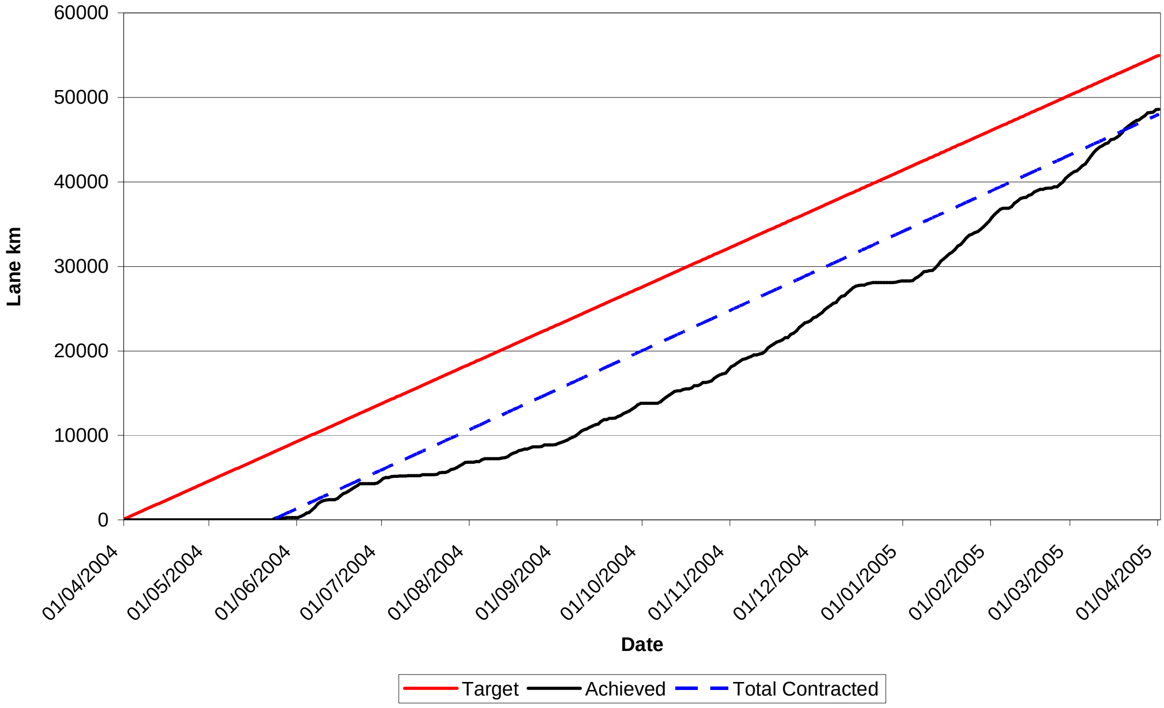


Figure 1: Cumulative daily totals for all Contractors with expected targets.

Determining future survey capacity is not straightforward. Figure 2 shows the weekly survey totals achieved by the two accredited contractors and how they varied throughout the year. The average survey rate was affected by many factors that will vary greatly from year to year. For example both contractors undertook other non TTS work during the duration of the TTS survey year. The progress reports delivered to the auditor did not include this other work. Other factors that affect the survey rate include inclement weather, LA's requesting repeat surveys, and equipment breakdowns. As both contractors changed their approach during the year to include night surveys it is difficult to estimate how many lane kilometres they would be able, or be prepared, to survey in future.

For the 45 weeks that the contractors were accredited during the 2004/05 survey year, the mean weekly total per contractor was 540km with a standard deviation of 410km. The highest single weekly total for any contractor was 1820km during February. Figure 3 shows the frequency distribution of both contractor's weekly survey totals in bands of 200km. The figure of 9% achieving 0km per week is to be expected due to machine repairs, holidays and extreme bad weather. The most frequent weekly totals being in the 400 – 600 km band at 22%.

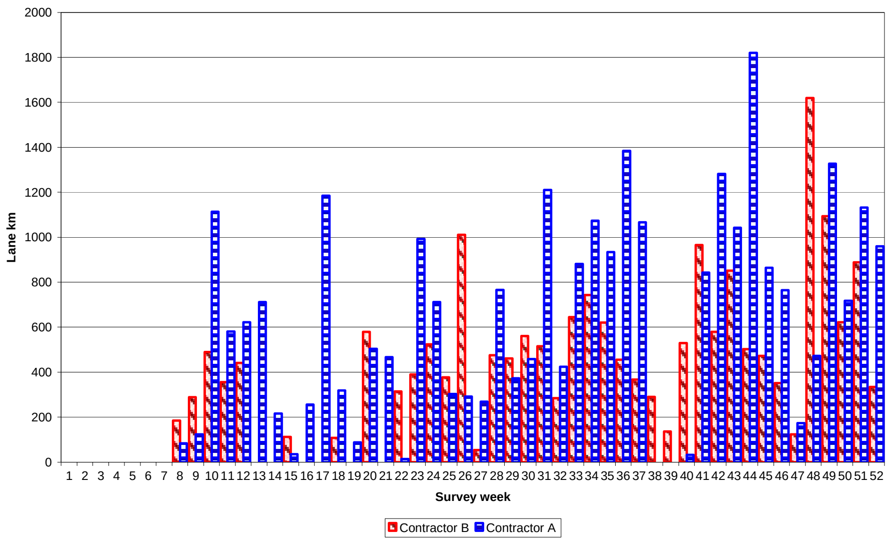


Figure 2: Weekly survey totals from the two accredited contractors.

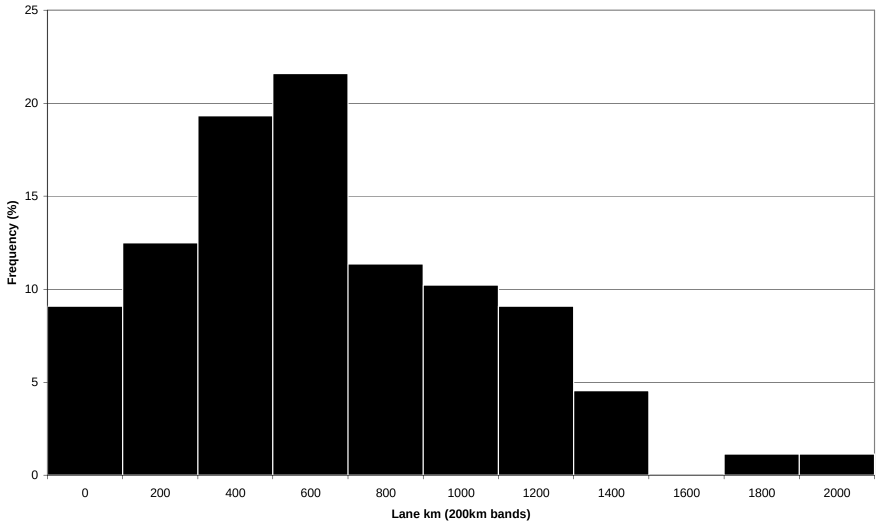


Figure 3: Frequency distribution of weekly survey totals from all contractors.

4.2 Identification of ongoing concerns

Throughout the survey year TRL identified several issues that, although not strictly associated with the application of the QA procedures, affected the data quality. It was recommended that resolution of these issues would lead to a more accurate and consistent survey, and improve data interpretation. These included:

- To consider stricter controls on the different location referencing methods used by LA's and contractors
- To encourage LA's to resolve network definitions to improve the survey quality and the fitting of the survey data
- Consideration of the thresholds used in the assessment of the survey data, in particular the current assessment of 10m data against condition thresholds established for 100m data.
- The establishment of methods to apply quality control checks to delivered data
- Investing in improvements to the performance of the measurement of cracking

5 Advice and Guidance provided to Other Parties

As Auditors TRL were also approached by other parties for advice and guidance in the resolution of issues arising during the survey year. Any issues raised by other involved parties (such as UKPMS developers) were addressed or directed to the most appropriate channel to achieve a successful resolution. In some cases local authority issues were referred to TRL via a third party.

An issue of note was associated with the compatibility of delivered HMDIF data with different UKPMS systems. TRL were contacted by CBC regarding a data loading dispute between a local authority and a contractor. The HMDIF supplied by the contractor would not load into the LA's UKPMS system. The contractor maintained that the file was in accordance with UKPMS Technical Note 3 (http://www.ukpms.com/owner_forum/shared_files/TN3_v8.pdf), which is the requirement of the TTS Specification. The contractor also indicated that TRL had approved their method of delivering data during the acceptance trials, and therefore there was little else they were prepared to do. However the local authority maintained that if the data would not load into a UKPMS accredited system then it could not be deemed to be an acceptable HMDIF file. TRL discussed the issues with the relevant parties with the following findings:

- UKPMS Technical Note 3 is open to interpretation, it is not clearly defined how the data should be delivered.
- The Developer of the UKPMS system in question provided a technical explanation of why the system expected the data in the form that it does.
- The UKPMS Support Contractor backed up the UKPMS developer's reasoning for the expected file structure and confirmed that a sample of the problem data would not be expected to load into a UKPMS system.
- At least two other local authorities were struggling with the same issue.
- The same problem had occurred previously with the same contractor and another UKPMS system and had been solved by the contractor. i.e. they were aware that the problem may occur.

TRL informed the contractor that having seen the evidence, in the Auditor's opinion the supplied HMDIF did not meet the requirements of the TTS Specification, and the Local Authority received a corrected version of the data. As a result of such issues the UKPMS Support Contractor intends to update Technical Note 3.

6 Quality assurance surveys

As it is impractical to carry out detailed QA tests of data collected within every local highway authority, the Quality Assurance for the 2004/05 TTS survey was carried out on the basis of assessing each TTS contractor.

The TTS Specification details a procedure of daily and weekly checks that the Contractors are required to perform to demonstrate that their vehicles have not deviated from the standards achieved during the acceptance tests. The Auditor collects a sample of these internal check records as part of the QA process (section 6.2).

In addition, there are a number of repeat surveys requested and performed by the Contractor and Auditor to ensure that the Contractor's QA process is working correctly.

There are two types of repeat survey performed for TTS Quality Assurance, Contractors and Auditors Repeat surveys**.**

Contractor's Repeat Surveys are intended to show the repeatability of the contractor's equipment during a survey. The Auditor informs the Contractor in advance of selected areas of selected sites to be repeated. The Contractor is then required to perform a second survey of that area and deliver the data to the Auditor for comparison. The first run undertaken on the sites was used as the reference data and the second survey was compared to the reference to evaluate the differences between the two survey runs.

Auditor's Repeat Surveys are intended to show the reproducibility of the contractor's equipment against a reference (the Auditor). The Contractors are asked by the Auditor to provide route files for selected sites. The Auditor then surveys the sites in the same manner as the Contractor using an independent survey vehicle. During the survey year 20004/05 the independent survey vehicle used was HARRIS (Highways Agency Road Research Information System). The data collected during the Auditors repeat survey is compared with the Contractors data to evaluate the differences between the two survey runs. It should be noted that for the reference data for the cracking, an auditor's repeat survey was provided through manual analysis of the images of the road surface collected by the HARRIS survey vehicle during the reference survey.

For both the contractor's and the auditor's repeat surveys the TTS survey data was tested for accuracy on all of the survey parameters that are collected under a normal TTS survey. For each survey parameter the differences between the values recorded by the reference and the TTS survey were analysed to see if they fell within the tolerances given in the TTS specification. The machine was then deemed to have passed or failed the test for each survey parameter on each test site. Full details of the assessment procedures are stated in the TTS specification.

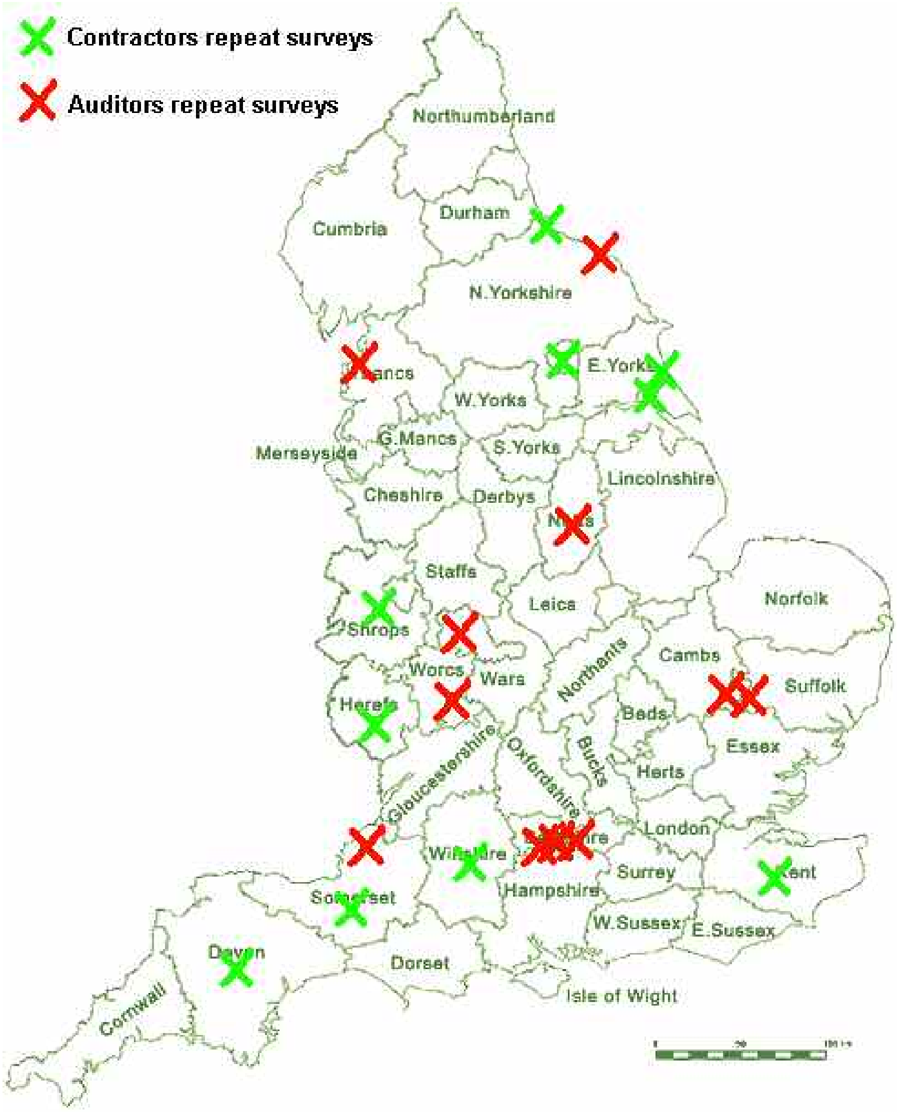
For confidentiality the following paragraphs refer to the accredited contractors as Contractors A and B. The data presented are merely examples to illustrate any points being presented.

6.1 Repeat surveys.

The sites for **Contractor's** repeat surveys were selected by obtaining a list of the authorities that were to be surveyed by each contractor and then selecting 10 repeat survey sites for each contractor within these local authority areas. Sites were chosen on the basis that they would include a variety of challenging road features. Each TTS contractor was provided with the list and asked to select five sites. The Contractors were asked to note the five sites in their survey schedule so that repeat surveys could be carried out during the normal process of the TTS survey. This prevented any additional travelling time being expended to return to a location to repeat a survey. The Contractors were asked to provide the processed data for the two separate survey runs to TRL within three weeks of the survey date. The two datasets were then checked to ascertain if they were comparable within the tolerances set out in the TTS specification. This report contains the results from four contractor's repeat surveys from each contractor. Only four contractor's repeat surveys had been completed (and the data delivered to the auditor) at the end of the 2004/05 survey year.

The sites for **Auditor's** repeat surveys were chosen by selecting a geographic spread of sites from the Contractors progress reports. Sites were chosen on the basis that they would include a variety of challenging road features. The Contractors are asked to provide exactly what is given to their survey teams to perform the surveys, route files, maps, etc. The sites were then surveyed using an independent survey vehicle to provide "reference data" for comparison. Once the Auditor's survey was completed the contractors are asked to provide their data for those sites within two weeks. The two datasets were then checked to ascertain if they were comparable within the tolerances set out in the TTS specification.

A total of 10 Contractor's Repeat surveys and 11 Auditor's Repeat surveys were requested, spread around the UK (Map 1). It was possible to collect and analyse data for 14 of those repeat surveys, within the survey year.



Map 1: The repeat survey sites that were requested

Contractor's Repeat Survey	Local Highway Authority	Auditor's Repeat survey	Local Highway Authority
A365	Wiltshire	A1198	Cambridgeshire
A384	Devon	A33	Reading
A396	Somerset	A44	Worcestershire
A1033	Hull	A1108	Suffolk
A299	Kent	A4	Berkshire
A174	North Yorkshire	A614	Nottinghamshire
A4169	Shropshire		
A417	Hereford		

Table 1: The Contractor and Auditor repeat survey sites surveyed and analysed**.**

6.1.1 Contractor's Repeat Surveys

The data provided by the contractors from the repeat surveys were processed to obtain the area of cracking, average profile variance, average rutting, average texture depth and average geometry (gradient, crossfall, curvature) over 50m reporting lengths. The OSGR data was assessed over 5m reporting intervals. Following alignment of the repeat surveys on the basis of the reported section starts, the differences between the measurements obtained in the repeat runs were assessed against the requirements of the TTS specification.

The results of the assessments are presented in Table 2 and Table 3 for contractors A and B respectively for all the survey parameters except cracking. The results of the assessment of the cracking intensities are reported in Table 4 for both of the TTS contractors. Note that the second 'Target' column in each of these tables (**Table 2**, **Table 3** & **Table 4**) shows the requirements defined in the TTS specification. As can be seen from Table 2 and Table 3, the TTS survey machines generally meet the tolerances required for contractor's repeat surveys for most parameters. However, there were some failures, highlighted in red.

It can be seen from Table 2 that Contractor A did not meet the requirements for the location of the section start points (OSGR co-ordinates) on any of the sites. However, there was not a large error. An overall analysis of the section start points showed that Contractor A achieved 65% of the section start points within 6.03m, against the 5m requirement. This had an inevitable effect on the measurement of location referencing (OSGR co-ordinates of points within the survey). This TTS vehicle achieved 65% of horizontal errors within 7.6m, just outside the requirements. Hence the inconsistency in the recording of the location of the section start points has resulted in poor measurement of location, because the error in the location of the start point is effectively added to the error in the measurement of OSGR co-ordinate along the length of the survey. This was not observed in the repeat surveys carried out by Contractor B.

Parameter	Target	Range	Contractor A - Repeat Surveys, Measured Performance				
			Site 1	Site 2	Site 3	Site 4	Average
Section Lengths	65% Horizontal errors	±0.5 0r 0.1%	100	100	100	100	100
OSGR – Section Start Point	65% Horizontal errors	±5m	50	56	50	30	47
OSGR – Locational Reference	65% Horizontal errors	±7m	58	67	40	79	61
Gradient	65% Differences	±1.5 or 10%	100	99	100	100	99
Crossfall	65% Differences	±1.5 or 10%	100	96	100	99	97
Curvature	65% Differences	±50m or 25%	100	100	100	100	100
3m Variance	65% Fractional Errors	±0.6	90	94	96	94	95
10m Variance	65% Fractional Errors	±0.7	97	98	100	93	98
30m Variance	65% Fractional Errors	±0.9	98	98	100	89	97
Nearside Rut Depth	65% Differences	±3mm	88	87	95	88	89
Offside Rut Depth	65% Differences	±3mm	100	100	98	97	99
Texture-SMTD	65% Differences	±0.25	97	97	98	94	97

Table 2: Results table for Contractor A's repeat surveys.

Parameter	Target	Range	Contractor B - Repeat Surveys, Measured Performance				
			Site 1	Site 2	Site 3	Site 4	Average
Section Lengths	65% Horizontal errors	±0.5 0r 0.1%	92	82	100	100	93
OSGR – Section Start Point	65% Horizontal errors	±5m	100	100	100	100	100
OSGR – Locational Reference	65% Horizontal errors	±7m	97	100	98	100	98
Gradient	65% Differences	±1.5 or 10%	99	99	100	100	99
Crossfall	65% Differences	±1.5 or 10%	99	98	100	100	98
Curvature	65% Differences	±50m or 25%	100	100	100	100	100
3m Variance	65% Fractional Errors	±0.6	94	94	99	97	95
10m Variance	65% Fractional Errors	±0.7	92	94	100	99	92
30m Variance	65% Fractional Errors	±0.9	91	95	98	100	90
Nearside Rut Depth	65% Differences	±3mm	94	97	95	91	96
Offside Rut Depth	65% Differences	±3mm	91	97	95	95	95
Texture-SMTD	65% Differences	±0.25	100	98	99	98	99

Table 3: Results table for Contractor B’s repeat surveys.

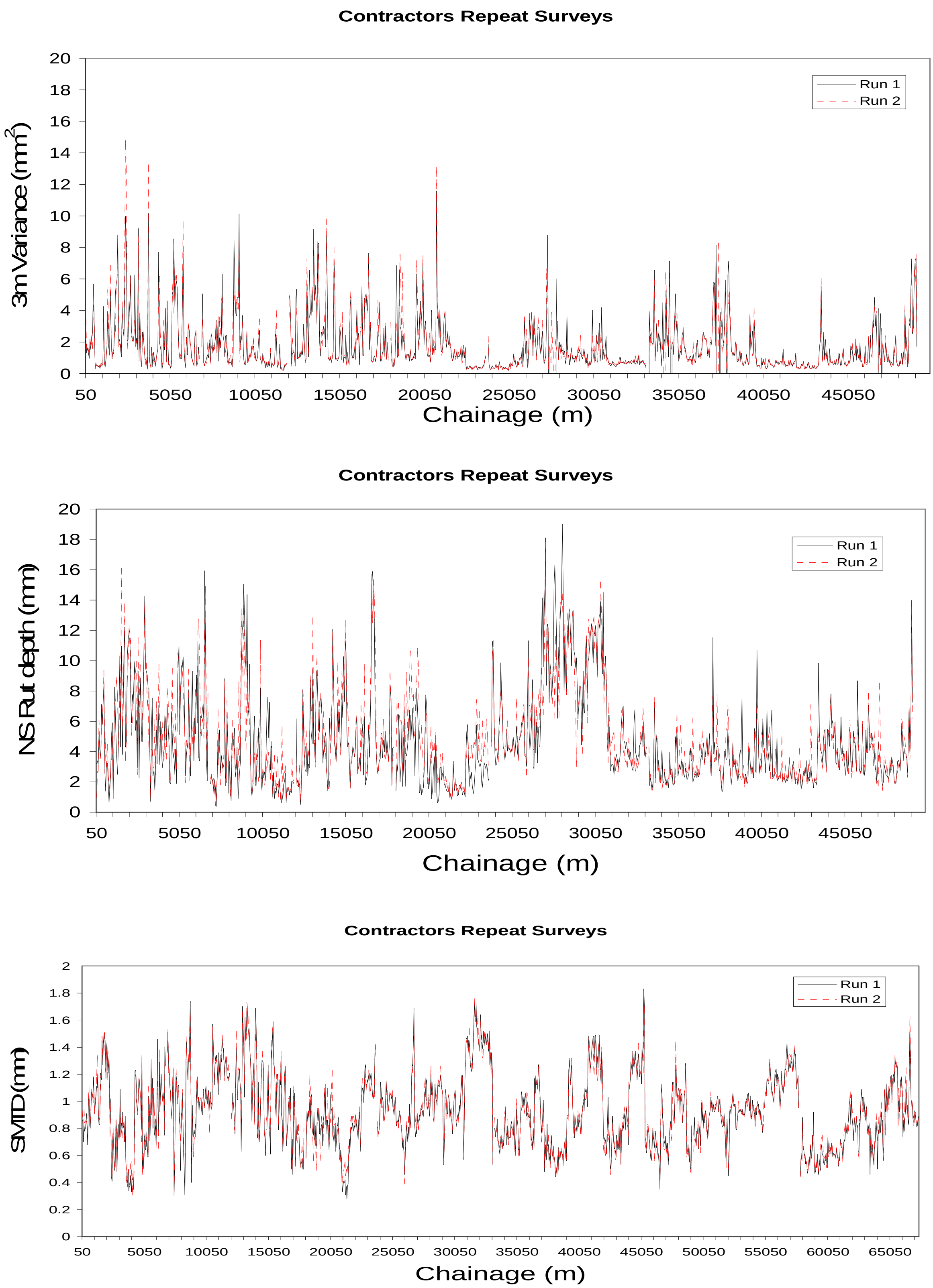


Figure 4: 3m longitudinal profile variance, nearside rut depths and texture measurements for all of the contractors repeat surveys analysed.

The remainder of Table 2 and Table 3 show high levels of repeatability in the measurements made by each Contractor's system. This may be further demonstrated by examination of the graphs in Figure 4, which show the typical agreement seen between the two separate runs for the 3m Variance, Nearside Rutting and SMTD for all of the contractor's repeat survey sites analysed.

The results of the assessment of the measurement of crack intensities are reported in Table 4. The assessment of the measurement of cracking is carried out at two predefined levels of crack intensity: low level of cracking (defined as <0.2%) and high level of cracking (defined as >1.74%). The results were calculated by assessing each 50m subsection of the survey runs and identifying which of these subsections were classified as having low (or high) levels of cracking. The first survey run was defined as the "reference". Each 50m subsection where the reference reported low (or high) cracking was compared to the cracking level that was reported for the same subsection in the repeat survey run. If both runs report high (or low) cracking then that 50m subsection is added to the total number of subsections where there was agreement. The percentage of agreement between the subsections of the two survey runs that contained low (or high) levels of cracking was then calculated on the basis of the total that both reported high (or low) levels of cracking compared with the total number of high (or low) cracked 50m subsections in the reference. This analysis was then repeated but this time using the second (repeat) survey run as the reference data.

		Contractor A							
	Target	Run 1 Reference	Run 2 Reference	Run 1 Reference	Run 2 Reference	Run 1 Reference	Run 2 Reference	Run 1 Reference	Run 2 Reference
Low Cracking Levels	70%	88	87	98	97	95	95	78	88
High Cracking Levels	70%	0	NA	NA	NA	NA	NA	50	33
		Contractor B							
	Target	Run 1 Reference	Run 2 Reference	Run 1 Reference	Run 2 Reference	Run 1 Reference	Run 2 Reference	Run 1 Reference	Run 2 Reference
Low Cracking Levels	70%	80	83	43	53	80	77	69	49
High Cracking Levels	70%	0	0	55	33	0	NA	0	0

Table 4: Results table for cracking for the Contractor's repeat surveys

As can be seen from Table 4, Contractor A's measurements of cracking met the requirements for areas that contained low levels of cracking. The performance was less satisfactory where the level of cracking was high. Contractor B failed to meet the requirements for low level cracking on one site and also on a further where run 2 was used as the reference. Again the performance was poor when assessed in terms of high levels of cracking. However it is noted that, for the sites assessed there was often only a very small number of subsections available for the analysis of high level cracking. Indeed, on several of Contractor A's sites there were no lengths having high levels of cracking. When combined with the lower level of detail that is typically found in the measurement of cracking with the TTS devices, the low number of lengths with high levels of cracking will cause the percentage of agreement to be artificially low. Therefore this assessment of the repeatability of the measurement of cracking was expanded to the examination of the trends in the crack data, and the examination of the crack maps. The graph in Figure 5 shows the levels of cracking recorded in all of the contractor's repeat surveys.

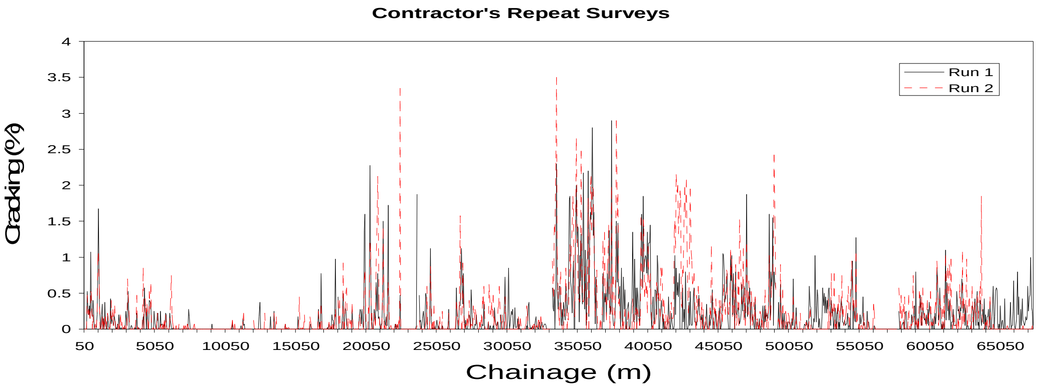


Figure 5: Cracking values reported over all the Contractor's repeat surveys.

It can be seen in Figure 5 that there is often close agreement between the two survey runs, with the general shape and trends of the two lines being fairly well matched. However, there is also disagreement, for example where one run reports the presence of cracking and the other does not (e.g. at 65000m. The crack maps from a number of these areas of disagreement were examined. It was found that, at times, the TTS survey machines were showing good repeatability by identifying cracks in the road surface at the same location in both of the survey runs. Figure 6 shows a diagram of two crack maps obtained from a Contractor's repeat survey where there was good agreement between the two survey runs (the blue lines denote the edges of the crack survey and the grey squares are where cracks have been detected, Note that these show data recorded by the same vehicle on the same site, but in repeat survey runs). There is a slight longitudinal offset between the two survey runs but this is within the limits expected. However, it was also found that there were locations where areas of cracking were reported in the first survey, but not the second survey. This low level of repeatability was significant in places, as shown in Figure 7. It can be seen that, for the section displayed, there were no cracks reported in Run 1 but for the repeat survey (Run 2) there was a large area of cracking recorded.

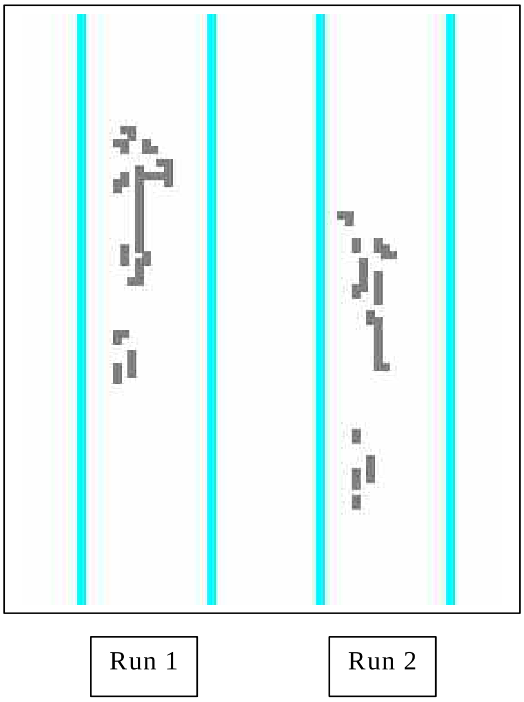


Figure 6: Sample crack maps from a Contractor's repeat survey with good correlation between survey runs.

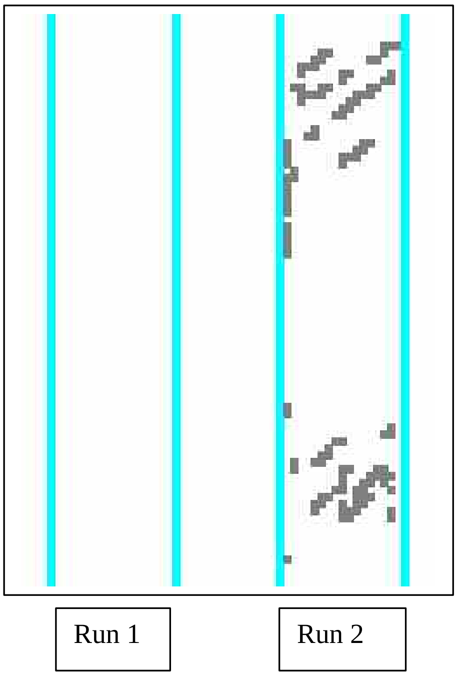


Figure 7: Sample crack map from a Contractor's repeat survey with poor correlation between survey runs

6.1.2 Auditors Repeat Surveys

The Auditor's repeat surveys compared the data collected by each contractor on selected sites with that collected by TRL using the HARRIS survey vehicle, as described in Section 6.1. As this process was comparing different systems it was, inevitably, found that there were more complications in the comparison process than encountered in the contractor's repeat survey.

The problems were often associated with location referencing and data labelling. For example, Contractor A provided data (Contractor A Site 3) in which the data was reported in a backwards direction inside the file. Comparison of the contractor's data with the reference was only possible after inverting the contractor's data, and the analysis of the OSGR data and the cracking data was considered invalid on this site, due to alignment problems caused by the inverted data. Further, the data delivered by Contractor B on Contractor B Site 3 was offset from the reference data by 50m, and required alignment before analysis. Inevitably, the contractor failed the requirements for the measurement of OSGR co-ordinates on this site.

Data labelling problems were identified in some of the data sets provided. For example occasionally the data file from a single survey conducted in a single direction contained sections labelled as both "CL1" and "CR1" (i.e. both directions). There are a number of possible reasons why this may have occurred. The section data may have been reported incorrectly by the contractor, or the network definition supplied to the contractor by the Authority could have been incorrect. Or this could arise from a disagreement in the labelling of dual carriageway sections (all dual carriageway sections should have a label of "CL1" regardless if the survey is carried in a "CR1" direction). It is of note that this problem only arose for contractor A, as Contractor B reported all sections with a unique identifier, and these were always labelled as "CL1". It is recommended that this approach be adopted by both contractors.

The problems observed with data delivery confirmed the existence of processing errors that had also been reported by Local Authorities. These could be overcome through the use of more rigorous quality assurance checks in the contractor's data processing procedures. Furthermore, the observed data delivery issues could also suggest that the contractors are delivering datasets specially prepared for the audits. This approach is not recommended as it does not apply the tests to the TTS data as delivered to the client.

As for the contractor's repeat survey the data provided by the contractors from Auditor's repeat surveys were processed to obtain the area of cracking, average profile variance, average rutting, average texture depth and average geometry (gradient, crossfall, curvature) over 50m reporting lengths. As for the Contractor's repeat surveys, the OSGR data was assessed over 5m intervals. The HARRIS data was similarly processed. Following alignment of the data on the basis of the reported section starts, the differences between the measurements were assessed against the requirements of the TTS specification.

The results from the Auditor's repeat surveys are shown in Table 5 and Table 6. It can be seen that, generally, the TTS survey vehicles met the requirements for the Auditor's repeat surveys. Nevertheless, both contractors failed to meet the requirements for the reporting of survey section lengths and section start points. Both contractors also failed to meet the requirements for cracking intensity. However, it can be seen from Table 5 that, for the measurement of section length, Contractor A failed to meet the requirements by quite a large margin whilst Contractor B failed by a lesser extent. It was found that the differences between the section lengths recorded by the Auditor and Contractor A covered a very large range (0-112m) when compared to the differences obtained between the section lengths measured by the Auditor and Contractor B (0-18m).

As a result of the differences between the contractors and reference measurements of position the reference section start points and section lengths obtained in the Auditor's survey were checked, and confirmed, using the forward facing video taken during the survey. The large differences between the lengths reported in the Auditor's survey and Contractor A's survey are therefore likely to have arisen from two sources. Firstly, it can be seen that the OSGRs of the section start points have failed to meet the accuracy requirements. This implies that the recording of the locations of the section starts has been poor, which will then affect the recorded section length. However, although the reporting of the OSGR of the section start points was poor, it was not so poor that the reported section lengths would have the errors obtained in the assessment. Therefore it is felt there is a second source of error that results in the large difference between the Auditor’s and Contractor’s measurement. This is the process of “fitting” (stretching or compressing) the data to match the survey section lengths provided by the Local Authority. Here Contractor A has “rubber banded” the data to match the lengths provided by the Local Authority. It is apparent that these did not match the lengths recorded in the Auditor’s survey, and this process has resulted in differences in the section lengths. It was apparent that Contractor B had not “fitted” the data, in the same way and therefore reports lengths in closer agreement to the reference survey. Hence, although Contractor B has just failed to meet the requirements for section lengths, it records 65% of the section start within 5.5m which is deemed to be a satisfactory performance. The quality of the network information supplied to the contractor by the Local Authority could also have an effect on the accuracy measurements obtained. Poor quality network information could cause the contractor to mis-report the section start points and thus the accuracy of this test would be affected. It is believed that many of the locational referencing problems encountered in the QA process are related to the accuracy of the network provided by the Authority. It is therefore important that these networks are accurate and up to date if both the TTS survey and the QA process are to work effectively.

As can be seen from Table 5 and Table 6 the contractors generally met the requirements for the measurement of the profile parameters of rutting, texture and longitudinal profile variance. Figure 8 demonstrates the agreement between the two surveys via typical examples of the reference data and contractor’s measurements of variance, rutting and texture depth. There were, however, a few notable failures, which have been investigated. The failure of Contractor A to meet the requirements for 30m variance on site 2 was due to the presence of many roundabouts on this site. The contractor has reported very high variance values on the approach and exit of the roundabouts. This may be because of the sudden changes in road geometry encountered at roundabouts and the subsequent recovery period for the vehicle.

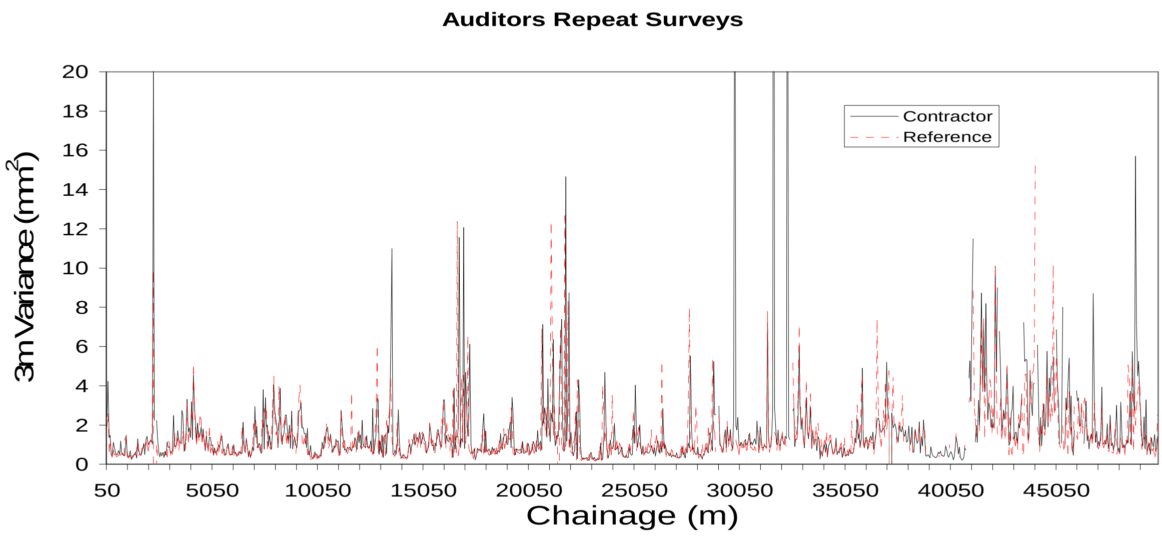
Parameter	Target	Range	Auditor's Repeat Surveys for Contractor A, Measured Performance (%)			
			Site 1	Site 2	Site 3	Average
Section Lengths	65% Horizontal errors	±0.5 0r 0.1%	12	0	0	4
OSGR – Section Start Point	65% Horizontal errors	±5m	35	25	NA	30
OSGR – Locational Reference	65% Horizontal errors	±7m	80	71	NA	75
Gradient	65% Differences	±1.5 or 10%	76	85	84	82
Crossfall	65% Differences	±1.5 or 10%	83	76	84	81
Curvature	65% Differences	±50m or 25%	100	100	100	100
3m Variance	65% Fractional Errors	±0.6	70	68	73	70
10m Variance	65% Fractional Errors	±0.7	71	65	65	67
30m Variance	65% Fractional Errors	±0.9	70	53	78	67
Nearside Rut Depth	65% Differences	±3mm	84	87	85	85
Offside Rut Depth	65% Differences	±3mm	90	91	84	88
Texture-SMTD	65% Differences	±0.25	81	70	82	78
Cracking Intensity	Low Levels of Cracking	70%	84	71	NA	78
Cracking Intensity	High Levels of Cracking	70%	6	50	NA	28

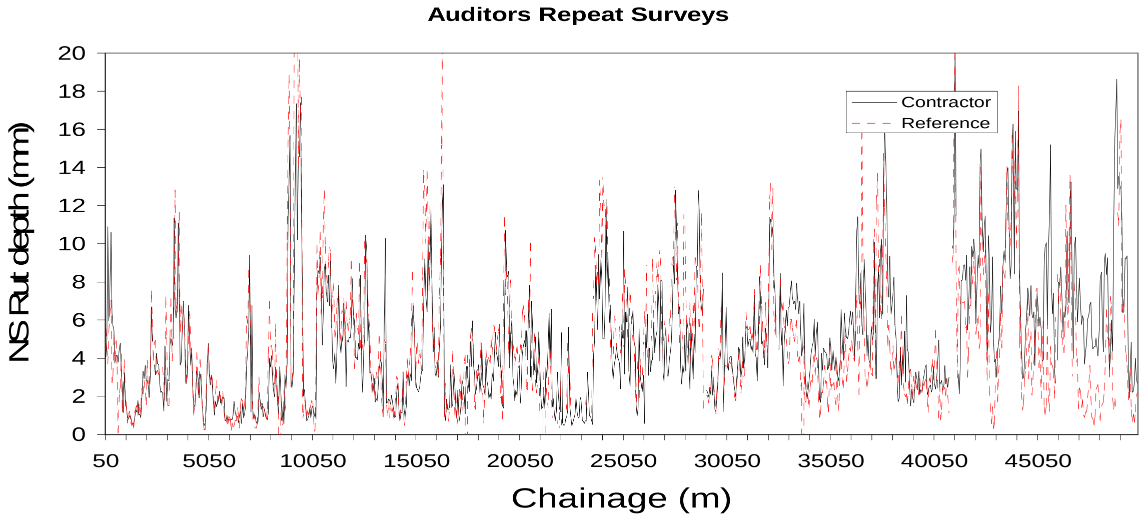
Table 5: Results table for the Auditors repeat surveys for Contractor A.

Parameter	Target	Range	Auditor's Repeat Surveys for Contractor B, Measured Performance (%)			
			Site 1	Site 2	Site 3	Average
Section Lengths	65% Horizontal errors	±0.5 0r 0.1%	63	47	100	70
OSGR – Section Start Point	65% Horizontal errors	±5m	88	59	0	49
OSGR – Locational Reference	65% Horizontal errors	±7m	84	81	23	63
Gradient	65% Differences	±1.5 or 10%	98	97	93	96
Crossfall	65% Differences	±1.5 or 10%	81	95	95	90
Curvature	65% Differences	±50m or 25%	100	100	100	100
3m Variance	65% Fractional Errors	±0.6	95	75	95	96
10m Variance	65% Fractional Errors	±0.7	95	83	93	90
30m Variance	65% Fractional Errors	±0.9	83	81	88	84
Nearside Rut Depth	65% Differences	±3mm	83	61	94	79
Offside Rut Depth	65% Differences	±3mm	91	83	93	89
Texture-SMTD	65% Differences	±0.25	97	89	96	94
Cracking Intensity	Low Levels of Cracking	70%	62	50	100	70
Cracking Intensity	High Levels of Cracking	70%	NA	4	100	52

Table 6: Results table for the Auditors repeat surveys for Contractor B

The failure of Contractor B to meet the nearside rut depth requirement on site 2 is thought to be down to differing driving lines taken by the two survey vehicles. It may have been caused by Contractor driving too far to the nearside of the carriageway, and thus recording too much of the kerb, or white line (which has not been filtered out effectively) in the rut depth measurement. It is not possible to check this theory because the TTS data only contains rut depth depths, whereas the transverse profile data would be required for this analysis. However, the contractor did record 65% of the readings within 3.2mm of the reference data on this site, and this performance is deemed to be satisfactory.





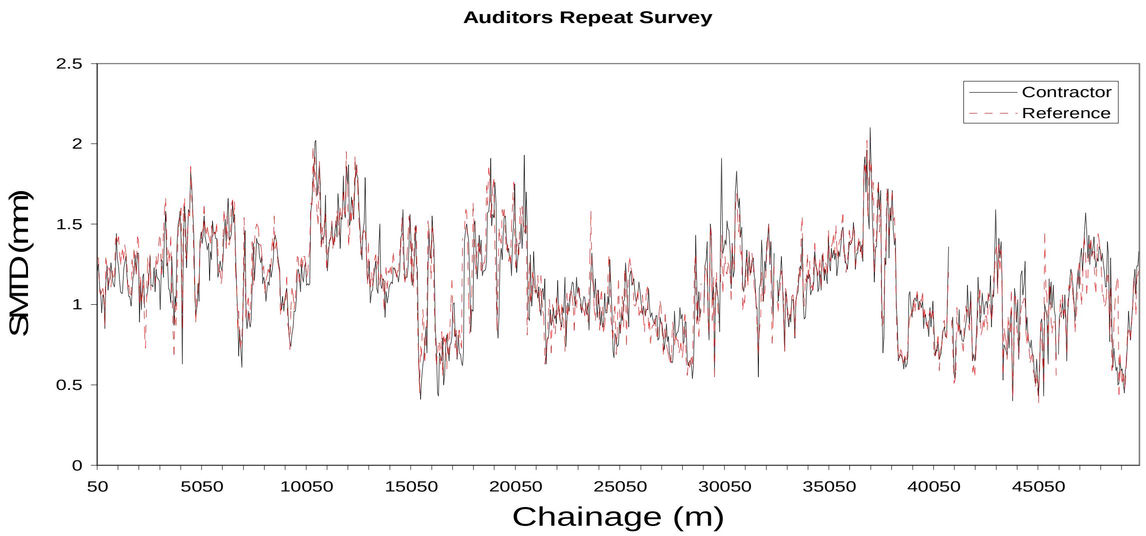


Figure 8: 3m longitudinal profile variance, nearside rut depths and texture measurements for the Auditors repeat surveys.

The assessment of cracking was undertaken in a similar way to that described above for the assessment of the repeat surveys. However, for the Auditor's survey the reference was obtained from the HARRIS measurements. Here an assessor manually identifies the cracks present in the images recorded during the HARRIS survey. From Table 5 it can be seen that Contractor A generally met the requirements for subsections having low level cracking intensity, but failed to meet them for the subsections having high crack intensities. From Table 6 it can be seen that Contractor B narrowly failed to meet the requirements for the subsections having low level cracking intensity and failed to meet the requirements for high level cracking.

As for the contractor's repeat survey, the nature of the assessment of the crack measurement can be affected by the distribution of cracking. Because the frequency of highly cracked subsections would be expected to be lower than the frequency of lowly cracked subsections, and because the comparison has been carried out over a reasonably short total length, we obtain a low total number of highly cracked subsections. This affects the assessment and the statistics can hide the level of performance achieved. A more subjective assessment can be made by assessing the general agreement between the Contractor's and Auditor's data. Figure 9 compares the cracking reported by the contractors with the reference. As can be seen there is less of a correlation between the two cracking data sets than seen for the other (profile) parameters. In order to ascertain the reasons why the two surveys show differing amounts of cracking, the crack maps of the two surveys were analysed.

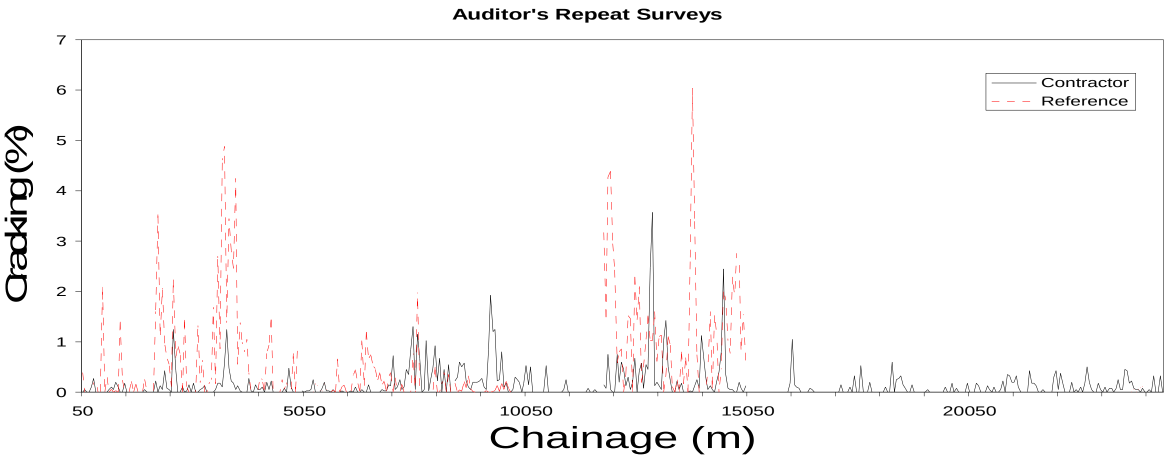


Figure 9: Cracking values reported for all the Auditor's repeat surveys analysed.

Figure 10 and Figure 11 show two examples taken from the crack maps recorded in the Auditor's repeat surveys. As can be seen in Figure 10 the Auditor's survey reported a large amount of cracking in this length, but the Contractor's survey reported no cracking. It is possible that for this length the surface type recognition system in the TTS contractor's software has incorrectly identified the surface type of the road. This would then apply the incorrect sensitivity settings to the crack analysis, leading to the system missing the cracks present. Conversely, in Figure 11 the Auditor's survey shows no cracking present whilst the Contractor's survey shows the presence of longitudinal cracking. This may be because the TTS contractor has falsely reported a longitudinal feature present on the road surface (such as the edge of a white road marking) as cracking. Both Contractors were found to have many instances of mis-matched areas of cracking when comparing the TTS surveys with the reference survey.

It is therefore apparent that the contractors did not demonstrate strong agreement with the reference data in the measurement of cracking in the Auditor's repeat surveys. However, the behaviour observed in these tests is consistent with what may be expected from these systems in their current state of development.

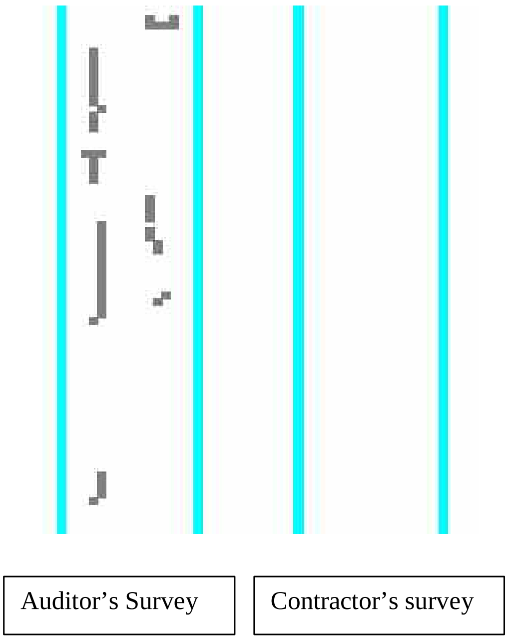


Figure 10: Sample crack maps from an Auditor’s repeat survey showing the TTS survey not recording cracks that are present in the reference survey.

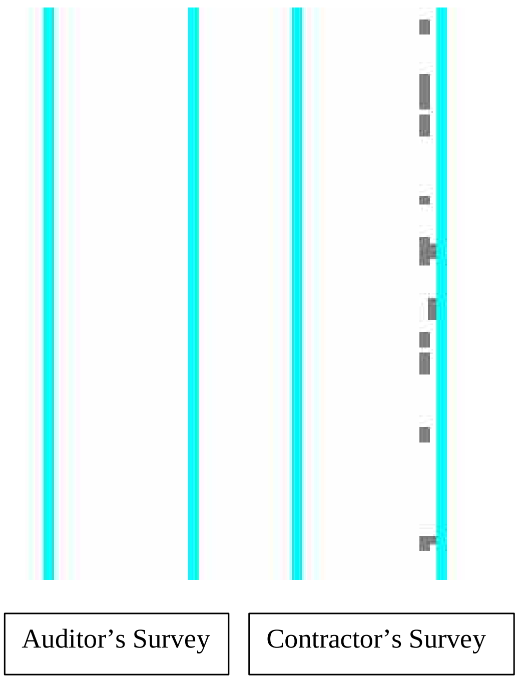


Figure 11: Sample crack maps from an Auditor’s repeat survey showing the TTS survey reporting cracks that are not present in the reference survey.

6.1.3 Summary of Repeat Surveys

For the repeat surveys carried out under the TTS Quality Assurance programme it was found that the TTS survey vehicles have either generally met the required levels of performance, or performed within the levels that may be expected. In particular the measurement of the profile parameters (texture, rutting and variance) has been highly repeatable and reproducible. For the measurement of location and cracking it has not been felt appropriate to penalise either contractor with regard to the quality of their data given the levels of performance that may be expected and the early stage of implementation of traffic-speed surveys on the local road network. However, it is noted that:

- Processing errors were present on receipt of the data from the Contractors. Such errors have also been reported by the LA's.
- The accuracy of locational referencing relies heavily on the fact that the road network has been defined correctly. Any fitting of survey data to an inaccurately defined network will cause the accuracy of these measurements to be lowered. To minimise errors it is necessary for Local Authorities to keep their network definitions as accurate and up to date as possible. However, this also relies on the Contractor's working with the Local Authorities to highlight differences. The easy route of simply stretching to fit should be avoided.
- The accuracy of location referencing (OSGR) is affected by the accuracy with which the operator records the section start points. This can also be dependent on the information provided to the contractor regarding the location of these points.
- The accuracy of location referencing (OSGR) is also affected by the accuracy of the location measurement system, and can be reduced in adverse conditions.
- For the measurement of gradient, crossfall, curvature, longitudinal profile variance, rut depths and surface texture both TTS survey vehicles were performing satisfactorily on the test routes.
- The measurement of cracking can vary. Variation in the level of agreement is seen both when comparing repeat runs made by the same vehicle and when comparing with repeat runs carried out using the reference device. The variation in performance is not desirable, but is consistent with the level of performance that might be expected from these systems.

6.2 Daily and Weekly Checks

Contractors daily and weekly checks are intended to highlight any drift or step changes in the equipment calibration. They are there primarily to reduce contractor's risk by highlighting problems quickly and ensuring they are fixed before continuing to survey.

For a daily check the contractor selects a short length of road (typically ~ 500m) in close proximity to the day's survey. The contractor will survey this length and store the results as the first action of the day. After surveys have been completed for the day the test length will then be resurveyed and the results compared within the tolerances set out in the TTS Specification. This way any sudden step change during the day will be highlighted. Weekly checks are performed in a similar manner, except they capture drift changes over longer periods and use longer site lengths (~1km). The tolerances used for the weekly checks are tighter, since it is expected that the Contractors will use a more accurate means of location referencing for these checks (reflective marker posts, typically).

The contractor selects one or more of the weekly test sites to be a primary weekly test site. The primary weekly test site is surveyed within 2 weeks of the equipment accreditation taking place. The survey data from this primary test site is stored and the site is resurveyed at a maximum of 28 survey day intervals. During the Auditor's meeting with contractors of the 4th November 2004, the contractors noted that the need to return to the primary weekly check site every 28 days lead to a large quantity of 'dead' time travelling to and from the test site. It was therefore agreed that the contractors would be able to set up "second class" primary weekly check sites spread around the country. Provided the second class primary weekly check sites were surveyed immediately after leaving the primary weekly check site and the regime of daily and weekly checks maintained the second class site would perform the same function as the primary site.

All of the test sites chosen were required not to be heavily trafficked to ensure that large changes to the measured parameters would not occur during the survey year.

Spot checks on the daily and weekly checks, were carried out by TRL. The contractors were asked to supply their Daily and Weekly check records for the following periods:

- 26th June 2004 - 2nd July 2004
- 20th September 2004 - 26th September 2004
- 29th November 2004 - 5th December 2004
- 10th January 2005 - 16th January 2005

At the first request (June) both contractors delivered the records within a week of the request. Although the checks performed by the TTS contractors were deemed acceptable, there were some changes that were requested to ensure compliance with the TTS Specification. Two notable absences were:

- The application of the maximum tolerances to ensure that any gross error is picked up immediately and corrected. For example, a loose connection could cause an intermittent fault that would lead to zero values for texture. If the zero values occurred only sporadically, the data may pass the tolerances applied for a Daily checks which only require that 65% of the values are within 0.25mm.
- The outcomes of the procedures for checking the cracking measurement system. Since this check is not part of the statistical analysis of the recorded data it was not automatically included on the spreadsheets delivered to the Auditor.

Through discussions with contractors and collection of the later samples of check data, it was found that machines occasionally failed Daily or Weekly checks. The Auditor worked with the Contractors to ascertain the causes of these failed checks and to ensure that the reasons for continuing surveys were acceptable. Two approaches were used by the contractors.

One contractor was able to process and analyse check data, onboard. If a parameter did not meet the required tolerances the check run would be repeated. The most likely reasons for failing to meet tolerances are due to differing driving line and slight variation in location referencing (entering events either too late or too early). If the parameters still failed to meet the tolerances, the cause would be investigated.

The other contractor did not have the ability to process data onboard. In this case the data would be relayed to the Quality control manager at the vehicle's base, who would process the data and decide if the results were acceptable for continuing the survey. They would then inform the survey crew of their decision. It is noted that not every check gave a clear 'pass'. If the reason for the failure could be adequately explained or was determined to be an isolated incident which would be monitored, then the surveys would continue. An example of a failure might be poor OSGRs due to very poor GPS availability in an urban area.

6.3 Other Checks

6.3.1 Samples of delivered data

In October 2004 TRL obtained a sample of data delivered to Local Authorities for each of the accredited survey Contractors. This was to examine data outside the routine audit to aid in the assessment of typical errors present in delivered HMDIF files. The following observations were made:

- There were duplicate section labels with different section lengths
- There were parameters reported at chainages that exceeded the section length
- There were negative chainages

- There were examples of stretching of data by more than 20% - implying that the contractors measured section length had significantly disagreed with the length provided by the Authority.

The Auditor also consulted two other Local Authorities who were not members of the IAG to determine their views on location referencing. The consultations highlighted that the LA's were not aware of any of the potential issues of incorrect network definitions, the difficulty of surveying without nodes or the many and varied methodologies of placing events (paragraph 7.1.1).

This gave an indication of the problems that were to occur later. The Auditor raised the issues with the Contractors and TTS Project management, and began to research a response which eventually became the TTS FAQ (Appendix B).

6.3.2 IAG concerns

During the IAG meeting of 23rd November 2004, Worcestershire CC gave a presentation highlighting some of the issues that they were encountering whilst loading delivered TTS data into their UKPMS system. These issues were considered representative of those being encountered by a number of Local Authorities. The Auditor contacted Worcestershire CC and undertook an independent survey of two of the sites that had been highlighted in the presentation. The sites demonstrated two extremes of condition, one being a very recently laid surface of Hot Rolled Asphalt and the other being a 5 year old Thin Surfacing with extensive wheel track cracking. Analysis of the data supported the claims of the Authority, that the TTS crack measurements were indeed incorrect. However, the Authority did confirm that there were other locations on their network where there was agreement between the TTS data and their opinions of the sites. This supported the findings from the Auditor's repeat surveys, in that the cracking measurements can be subject to variability.

7 Outstanding issues

This report has summarised the issues that have arisen under the auditing and advice component of the 2004/05 TTS survey. As has been described in the preceding sections, a number of the issues under which advice was sought have been resolved or brought to a point such that they did not prevent the carrying out of the TTS survey or the use of the data. However, there are, inevitably, a number of outstanding issues that have arisen during the year. These may be separated into issues related to the survey itself, issues concerning the quality assurance process and issues associated with the TTS data and its use. These are summarised below with, where appropriate, suggested methods for their resolution. It is recommended these issues be addressed for the 2005/06 survey.

7.1 The TTS Survey

7.1.1 Location referencing

Network definitions

Achieving good data quality starts at the beginning of the process with the Local authority's network definition. If the network definition is wrong, or not clearly defined, the survey will reflect this. Local authorities need to understand that their networks must be carefully and correctly defined. Incorrect section lengths, additional unrecorded sections, poor descriptions, lack of nodes and sections that are digitised in the wrong direction lead to complications for the survey contractor. The contractor is unable at this late stage to correct the root cause of the problem and may have to implement a fix that results in incorrect data being delivered to fit an incorrect network. This ensures that data will load into UKPMS but does not highlight any deficiencies in the network definition. There is the possibility of using the TTS or SCANNER data to correct the network, but if the data has been 'fixed' by the contractor (by, for example, shrinking the data to fit a shorter section length), the inconstancy in section length will not become apparent. This could be considered to be a suitable argument for the shifting of the stretching of the data to UKPMS, with a warning to be issued if the section length differs by more than a set tolerance.

Provision of Nodes

Many local authorities do not use or were not able to supply survey contractors with nodes. Although nodes are not mandatory within UKPMS, the use of them was expected by the TTS Specification, and makes performing surveys and fitting data a much simpler task. This will become more of an issue as surveys move to the lower classes of roads (B's, C's & U's) which are less likely to have nodes.

Methodology for locating sections

Although the TTS Specification included advice to survey contractors on the positioning of section change points during surveys, it became apparent during the year that not all local authorities followed the same practice. If each local authority has its own standard there is a greater likelihood of poor locational referencing and errors in the survey as it is difficult for a survey vehicle operator to learn, remember and apply many different standards. This raises the question of whether a national standard for locating these points should be established. However, if a national standard was devised local authorities may have to redefine their networks.

7.1.2 Surveys of Roundabouts

There are a number of practical reasons why roundabouts are not currently included in any UK traffic speed condition surveys:

- It simplifies the surveys.
- It is a risky procedure for a survey vehicle to survey 'Lane 1' of a roundabout. Drivers generally expect a vehicle in the outer lane to be leaving at the next available junction.
- 'Lane 1' of many roundabouts is often difficult to define, many are wide enough to allow HGVs to take a wide line and yet have no lane markings. Also, defining the 0m point of a roundabout is problematical, since it is unlikely to be the point at which the roundabout was entered.
- The low speed and tight radius brings the equipment to the lower limit of its capability, and much of the data may be flagged as unreliable anyway. Images for cracking are likely to be blurred and longitudinal profile is likely to be inaccurately represented due to the extreme geometry.
- There is some debate of the usefulness of TTS data recorded on a roundabout. Even if you could ensure that the vehicle had followed the correct line and the data was reliable, what is the primary requirement for the condition of a roundabout? Ride quality or skid resistance?

However, the question has been raised as to whether roundabouts should be included in the TTS survey.

7.1.3 Night Surveys

Although there is no technical reason why night surveys would give results any different to daytime surveys, they may affect the overall survey rate if forward facing video is required. It can be speculated that night surveys could lead to a greater possibility of operator error and thus poor data quality. Furthermore, there is greater likelihood of failing to identify poor surface condition (e.g. damp surface) at night.

Two of the Contractor's repeat surveys were performed at night with no discernable loss of data quality. For an example of a Repeat survey performed at night see Site 3 in Table 3. Unfortunately none of the Auditor's Repeat survey sites were surveyed at night by the contractors. This would have given the opportunity to identify any shortcomings in reproducibility when compared to an auditor's survey carried out during the day. Further research assessing night surveys would assist in resolving this question. The necessity of this, of course, depends on the likelihood of contractors employing night time surveys in future.

7.2 The QA process

7.2.1 Distribution of repeat surveys

The Contractor's Repeat surveys were chosen by the contractors from a list provided by TRL. In one case, purely coincidentally, the majority of the repeat surveys occurred within two months of each other at the end of the survey year. To ensure that a even spread of surveys is achieved in future survey years, it is suggested that Contractor's Repeat surveys be chosen not at the beginning of the year, but at pre-defined intervals throughout the year in the same manner that Auditor's Repeat surveys were chosen during the 2004/05 survey year. This would require the contractor to supply the auditor with an accurate and updated survey programme at the pre-defined intervals.

7.2.2 Driver Accreditation

Concerns have been raised over the accreditation of survey drivers and operators. In the current TTS Specification (04/05) they are not required to be accredited. Drivers determine the line which the vehicle takes and operators enter the events that define the beginning and end of test sections. Therefore these personnel do influence the data quality. It is suggested that a basic operator accreditation could be achieved by requiring that contractors demonstrate the use of training on vehicle operation, combined with a procedure that ensures that only a trained operator/driver may operate the vehicle on TTS survey.

7.3 The TTS Data

7.3.1 Cracking

The Quality Assurance tests have highlighted a need for further development work in the measurement of cracking. Primarily such developments should concentrate on improving the underlying variability in the crack measurements – ensuring that we can be confident that where TTS reports cracking there is cracking present, and vice versa.

7.3.2 Quality control of data delivered – including HMDIF compatibility

Through data delivered to TRL for the purposes of auditing, and conversations with Local Authorities, it has become apparent that further work is needed regarding quality control of delivered data. There have been cases were obvious errors have been included in data files delivered both to TRL, and to the Local Authorities. This leads to the data being rejected, and subsequently reprocessed. This delays the delivery and increases expense (to the contractor and Authority). However, it can probably be assumed that eventually the extra costs incurred by the contractor will be passed onto the customer (the Local Authorities). At the commencement of TTS surveys it was determined that quality control of the data could be maximised by using a defined data processing package to deliver the HMDIF files. However, use of this software (the Machine Survey Pre-processor, or MSP) is not compulsory as its use could increase costs to some contractors. It is felt that many of the errors encountered in the survey data would not have been present in MSP outputs, and suggests that either the system become compulsory or much more stringent checks and definitions be put in place for the delivered data.

Situations also arose during the year where delivered HMDIF files would not load into accredited UKPMS systems. Again, use of a controlled pre-processing system, and/or better checks and control of the delivered data would help. However, any single check can only cover a small number of the possible permutations of the data file parameters. Using the knowledge gained during the 04/05 survey year, the HMDIF specification itself could be clarified to ensure that it cannot be misinterpreted.

The final point of responsibility in the resolution of issues associated with incompatibilities between delivered data and UKPMS should also be clarified. Currently where issues arise the Authority passes the problem back to the contractor. As the contractor is paid on delivery they would feel obliged to resolve the problem. This is not necessarily appropriate.

7.3.3 Fitting

The fitting of data to the network for the 04/05 survey year was performed by the contractors. The two contractors used differing methods. For the surveys to be consistent and comparable in future years a uniform method should be agreed upon and implemented by all contractors or UKPMS systems, whichever party is given responsibility for fitting data.

7.3.4 Parameter ranges

There have been a number of questions raised over the definition of acceptable ranges for the measured parameters For the survey year 04/05 TRL suggested that any defects values that exceeded 9999 be reduced to 9999 (Paragraph 2.4.1) by either the contractor or UKPMS system, following the practice used for TRACS. It would be worthwhile considering what ranges for parameters are suitable and providing common values for all contractors.

Acknowledgements

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Appendix A: Local Authorities who requested Quality Assurance services

Local Authority	Region	Approximate Lane km
Barking & Dagenham	London	74.1
Barnet	London	151.5
Barnsley	Yorkshire & Humberside	257.8
Bedfordshire	Eastern	459.0
Bexley	London	149.9
Birmingham	West Midlands	391.6
Blackburn with Darwen	North West	129.0
Blackpool	North West	81.6
Bolton	North West	202.4
Bracknell forest	South East	101.0
Brent	London	97.6
Bromley	London	138.6
Buckinghamshire	South East	750.0
Bury	North West	110.0
Cambridgeshire	Eastern	772.0
Camden	London	55.3
Cheshire	North West	1450.0
City of London	London	16.8
Coventry	West Midlands	73.6
Croydon	London	112.2
Cumbria	North West	1425.0
Darlington	North East	118.0
Derbyshire	East Midlands	1336.0
Devon	South West	1936.0
Doncaster	Yorkshire & Humberside	269.2
Dudley	West Midlands	159.0
Durham	North East	737.0
Ealing	London	71.4
East Riding of Yorkshire	Yorkshire & Humberside	700.0
Enfield	London	124.2

Essex	Eastern	1212.0
Greenwich	London	104.3
Hackney	London	30.4
Halton	North West	90.0
Hammersmith & Fulham	London	54.1
Hampshire	South East	1344.0
Haringey	London	56.1
Harrow	London	89.7
Hartlepool	North East	71.9
Havering	London	69.6
Herefordshire	West Midlands	707.0
Hillingdon	London	132.8
Hounslow	London	78.7
Islington	London	46.9
Kensington & Chelsea	London	33.0
Kent	South East	1600.0
Kingston-upon-Hull	Yorkshire & Humberside	100.0
Kingston-upon-Thames	London	56.6
Lambeth	London	53.3
Lancashire	North West	1300.0
Leeds	Yorkshire & Humberside	476.4
Lewisham	London	41.2
Lincolnshire	East Midlands	2080.0
Liverpool	North West	236.2
Luton	Eastern	53.0
Manchester City	North West	226.6
Merton	London	68.3
Middlesbrough	North East	72.5
Newham	London	97.2
North East Lincs	Yorkshire & Humberside	170.0
North Lincs	Yorkshire & Humberside	320.0
Northumberland	North East	763.0
Nottingham City	East Midlands	108.0

Nottinghamshire	East Midlands	1062.0
Oldham	North West	166.0
Plymouth	South West	56.0
Poole	South West	57.0
Portsmouth	South East	89.6
Reading	South East	143.0
Redbridge	London	88.3
Redcar & Cleveland	North East	178.0
Richmond upon Thames	London	98.0
Rochdale	North West	185.6
Rotherham	Yorkshire & Humberside	189.2
Salford	North West	213.0
Sandwell	West Midlands	152.0
Sefton	North West	112.0
Sheffield	Yorkshire & Humberside	299.0
Shropshire	West Midlands	1000.0
Slough	South East	43.0
Solihull	West Midlands	101.0
Somerset	South West	1273.0
South Gloucs	South West	160.0
Southampton	South East	100.0
Southend on Sea	Eastern	67.0
Southwark	London	55.7
St Helens	North West	130.0
Stockport	North West	160.0
Stockton on Tees	North East	144.0
Surrey	South East	1200.0
Sutton	London	24.4
Tameside	North West	130.0
Telford & Wrekin	West Midlands	68.0
Thurrock	Eastern	126.8
Tower Hamlets	London	26.2
Trafford	North West	112.8
Walsall	West Midlands	138.4
Waltham Forest	London	89.4

Wandsworth	London	42.2
Warrington	North West	236.0
Warwickshire	West Midlands	750.0
Westminster	London	87.5
Wigan	North West	216.0
Wirral	North West	240.0
Wokingham	South East	376.0
Wolverhampton	West Midlands	123.6

Appendix B: TTS FAQ

15th February 2005

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Loading TTS data into UKPMS
Frequently Asked Questions

This document has been compiled by TRL (the TTS Auditor) to provide a general response to a number of the queries we have received from Local Authorities whilst loading TTS data into UKPMS.
The aim is to ensure that any problems or solutions are shared, hopefully reducing the time taken to successfully load TTS data into UKPMS.

Q1 Incorrectly marked sections (CR1 sections on Dual Carriageways, slip roads or One way sections, for example).

TTS surveys are directional, thus all delivered HMDIF files should contain only CL1 sections (unless a Lane 2 survey has been requested). Check that the network definition is correct, then refer to your data supplier if they do not. The process of fitting the survey data to the network is then carried out by UKPMS.

Q2 Duplicate sections (more than one set of data for a particular section).

There may be occasions that the survey vehicle will cover the same section of road twice. The data with the latest survey date should be used. You can remove the duplicate data using a text editor. This can be done by your data supplier.

Q3 Missing data, roads missing.

Data is not supplied for roundabouts. Check that the section is not a roundabout. There should be a data coverage report supplied with your data. This should list all lengths for which data is missing and why (roadworks, parked cars, not suitable for TTS survey, unable to locate).

Q4 Variable resolution in delivered values (the number of decimal places varies).

This should not occur. Contact your data provider.

Q5 Sections expected to be 10m, but are not.

This can occur for a number of reasons. For example, where a section is not a round 10m length (556m for example) the last length in that section may be reported as a remainder (6m in this case). This will then be followed by a length to make up the full 10m (i.e. 4m) at the beginning of the next section (14m, 24m etc. thereafter). However, all UKPMS databases should be able to cater for sections that are not 10m in length. Contact your UKPMS developer for further details.

Q6 End chainage less than start chainage.

This should not occur. Contact your data provider.

Q7 Negative chainages.

This should not occur. Contact your data provider.

Q8 Blank lines in HMDIF's.

This should not occur. Contact your data provider.

If you have any additions or particular solutions you think should be included, please contact either myself or Stacy Smith, the Northern England TTS Auditor.

Craig Thomas
Southern England TTS Auditor