Published Project Report
PPR388

Creating the future of transport

SCANNER accredited surveys on local roads in England – accreditation, QA and audit testing – annual report 2007-08

P Werro, I Robinson and A Wright

Transport Research Laboratory

PUBLISHED PROJECT REPORT PPR388

SCANNER Accredited Surveys on Local Roads in England - Accreditation, QA and Audit Testing - Annual Report 2007-08

by P Werro, I Robinson and A Wright (TRL)

Prepared for: Project Record:	**SCANNER Accredited Surveys on Local Roads in England - Accreditation, QA and Audit Testing**
Client:	**Department for Transport, Regional and Local Transport Strategic Finance Division** **(Edward Bunting)**

This Published Report has been prepared for Department for Transport.

The views expressed are those of the author(s) and not necessarily those of Department for Transport.

	Name	Date Approved
Project Manager	A Wright	20/01/2009
Technical Referee	John Pynn	22/01/2009

When purchased in hard copy, this publication is printed on paper that is FSC (Forest Stewardship Council) registered and TCF (Totally Chlorine Free) registered.

Contents

Executive summary

To provide local highway authorities, and the Department for Transport, with confidence that SCANNER data are consistent and suitable for national road performance monitoring and to support local maintenance operations, a quality assurance procedure was developed and incorporated into the SCANNER specification. The specification defines accreditation tests and quality assurance requirements for all survey vehicles (including checks on machine operation, repeat surveys by the survey contractor and external audits in the form of repeat surveys undertaken both by an independent auditor).

The Department for Transport has appointed TRL as independent Auditor, to provide the quality assurance services defined in the SCANNER specification. TRL has carried out accreditation testing, quality audits, and provided independent advice and consultancy services to survey contractors, local highway authorities and the Department for Transport in relation to accredited SCANNER surveys carried out on the English local road network.

In addition to the SCANNER survey of the English local road network, further surveys are carried out on the Scottish local road network under a single survey contract and the Welsh Principal Road Network under a further contract. The work carried out in Scotland and Wales is fundamentally similar to SCANNER and has a similar requirement for Quality Assurance testing. TRL was requested to apply the SCANNER Quality Assurance procedures to the Scottish surveys and Welsh surveys in 2007/08.

This report summarises the results of the accreditation testing and quality audits carried out by TRL in England, Scotland and Wales in 2007/08, and also summarises the advice and consultancy provided during the year.

It is reported that the performance of the survey vehicles at the SCANNER accreditation generally met (or came close to) the SCANNER specification requirements. Although there are some differences between the systems, these should not be taken as an indication of generally poor data, as the differences are often small and the systems have been assessed against a demanding specification. However, to meet the highest levels of accuracy, it is desirable that ongoing improvements be implemented. Survey contractors have been issued with Improvement Action Plans (IAP) for this purpose.

For the survey year 2007/08 the SCANNER specification was revised to require all survey vehicles to measure a number of new SCANNER survey parameters. All survey contractors made significant efforts to upgrade their equipment and processing software to accommodate these changes. This process took a lot longer than anticipated. Because the survey contractors spent a lot of time and effort implementing the new SCANNER measurements for this survey year (2007/08), they did not have enough time to work on the issues reported in the previous (2006/07) IAPs. Therefore many of the issues seen in the 2006/07 IAPs have been carried forward to the 2007/08 IAP.

The advice provided by TRL can encompass all areas of the SCANNER survey, from general guidance on the procedures required in the commissioning and undertaking of the SCANNER survey, through to the resolution of issues concerning the quality of the data delivered by the survey contractor. In the 2007/08 survey year advice has been provided to a number of stakeholders, including the Department for Transport, local highway authorities and the SCANNER survey contractors. Many of the issues arising under the advice component of the work, have been resolved or brought to a point such that they do not significantly affect the carrying out of SCANNER surveys or the use of the data.

The quality audits undertaken by TRL (as repeat surveys) have found that the survey machines 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 the observed behaviour has shown a need for improvement but it has not been felt appropriate to penalise the survey contractors.

Although many issues have been resolved, the work carried out during 2007/08 has identified a number that would benefit further investigation. These may be separated into issues related to the survey itself, issues concerning the quality assurance process, and issues associated with the SCANNER data and its use. These outstanding issues are summarised and recommendations given regarding the work required to resolve these.

1 Introduction

The introduction of traffic-speed surveys on the local road network was stimulated by concerns over the robustness and consistency of the visual survey data provided to the Department for Transport (DfT) for the purpose of national road condition monitoring through the National Road Maintenance Condition Survey (NRMCS). The rapid developments in machine-based survey technology, and the successful application of these survey methods on the motorway and trunk road network under the Highways Agency's TRAffic-speed Condition Survey (TRACS) contract, led the DfT to conclude that visual surveys could be replaced by automated condition surveys for the purposes of national performance monitoring of carriageways.

For the financial Year 2004/05 the Department for Transport identified TRACS Type Survey (TTS) as the only survey method that English local highway authorities were permitted use to calculate the Best Value Performance Indicator (BVPI) on the Principal Road Network. From April 2005 the DfT extended the survey to other classified roads. For this extended survey the TTS specification was revised and the survey renamed as Surface Condition Assessment of the National Network of Roads (SCANNER). The specification for SCANNER, including the acceptance and QA procedures, was developed from those previously developed for the TRACS and TTS surveys.

SCANNER surveys are carried out using traffic-speed devices that measure the shape, texture and surface condition of the pavement. The SCANNER data are processed using UKPMS accredited systems to generate the Best Value Performance Indicators (BVPIs)for road condition BV223 (condition of principal roads) and BV224(a) (condition of other classified roads)[1]. In order to generate these BVPIs, the SCANNER data must be provided by an accredited SCANNER machine that complies with the requirements of the SCANNER Surveys for Local Roads Specification (Halcrow, 2007), hereafter referred to as the SCANNER specification. All SCANNER survey machines are therefore required to undertake accreditation testing as described in the SCANNER Specification. These tests are supervised by an independent Auditor appointed by the Department for Transport.

To provide local highway authorities, and the DfT, with confidence that the SCANNER data is consistent and suitable for both national performance monitoring, and to support local maintenance operations, a quality assurance procedure was developed and included within the SCANNER specification. As with the accreditation process, this procedure is also supervised by the independent Auditor, who also provides advice and guidance to survey contractors and local highway authorities regarding the SCANNER survey.

TRL was originally appointed by the DfT as independent Auditor for the SCANNER surveys in England. As the project has progressed the role of the Auditor has been further extended, and for the 2007/08 survey year it includes the audit of both the Scottish and Welsh road condition survey. In addition to auditing; TRL provides advice to both local and national governments.

This report presents the summary results of the accreditation testing and audits of the SCANNER survey contractors carried out during the 2007/08 survey. The report also summarises the advice and guidance that has been provided by TRL, and considers the key issues that have arisen during the Audit of the survey year.

[1]Note that April 2008 saw the introduction of National Indicators (NIs), which are obtained using a fundamentally similar method to BVPIs. However, the content of this report refers to SCANNER surveys carried out before April 2008.

2 Accreditation

2.1 The process

Since the commencement of the SCANNER survey, surveys have been carried out using traffic-speed devices that measure the geographical position of the machine, the longitudinal profile in the nearside wheelpath, the transverse profile, the texture profile in the nearside wheelpath, the road geometry, and the intensity of cracking on the surface of the pavement. The SCANNER accreditation tests check that the SCANNER survey vehicle is able to measure each of these properties to the level of accuracy defined in the SCANNER specification. The tests also check the accuracy of the devices in measuring the SCANNER derived parameters (e.g. longitudinal profile variance, which is derived from the measurement of longitudinal profile and rutting which is derived from the measurement of transverse profile).

A full SCANNER accreditation test comprises three sets of tests, undertaken on the Primary Test sites, the Network Routes and the Crack and Rut sites. The Primary sites are a number of test sites located on the TRL test track or on the road network close to TRL. The tests on these sites examine the performance of the machines in the measurement of individual survey parameters (e.g. there is a site to test the measurement of geometry). The Network routes are located on the UK road network in the south of England. The tests on these sites examine the performance in the simultaneous measurement of all the survey parameters. The Network Routes also test the ability of the survey crew to follow a defined survey route, and consider the accuracy and compatibility of the processed data. The Crack and Rut sites are located on the UK road network in the south of England and are to used to examine more extensively the performance of the system in measuring cracking and rutting.

A SCANNER re-accreditation test comprises two sets of tests, undertaken on the Primary Test sites and two of the Network Routes referred to as the SCANNER road routes. The re-accreditation tests consist of similar tests to those applied for the full accreditation, but at a reduced level of intensity. In particular, no dedicated crack and rut sites are surveyed during the re-accreditation tests as these parameters are assessed on the Network Routes.

A more detailed description of the accreditation process is provided in the SCANNER Specification - Halcrow Ltd (2007).

2.2 Revisions for 2007/08

The 2007/08 survey year saw the introduction of some additional measurements and derived parameters (these are discussed in more detail in Appendix A and the SCANNER specification, Halcrow 2007) but the main changes were as follows:

- Longitudinal profile
    - The removal of 30m variance.
    - Measurement of Longitudinal profile in the offside wheelpath.
    - Introduction of enhanced variance (in both wheelpaths).
    - Introduction of the bump measure (in both wheelpaths).
- Transverse profile
    - Introduction of cleaned rut depths (in both wheelpaths).
    - Introduction of transverse profile unevenness.

    - Introduction of edge deterioration measures of edge roughness measures, edge stepping and transverse variance.
- Texture profile
    - The introduction of MPD in the nearside wheelpath.
    - The introduction of RMST measure in a minimum of three measurement lines (nearside wheelpath, offside wheelpath and middle lane).
    - The introduction of an RMST variance measure in three measurement lines (nearside wheelpath, offside wheelpath and mid wheelpath).
    - The introduction of the 5th and 95th percentile RMST values.
- Cracking
    - Introduction of the derived parameters of transverse cracking and surface deterioration.

To provide efficient testing of the accuracy of survey vehicles in measuring the new parameters, performance levels are required in the SCANNER specification for a subset of these parameters:

- Offside longitudinal profile variance
- Cleaned rut depths (both nearside and offside wheelpaths)
- Nearside MPD
- RMST
- Transverse unevenness (absolute deviation)
- Edge roughness

However, because of the lack of experience in the measurement of transverse unevenness and edge roughness, the current SCANNER specification does not define specific numerical performance levels for these parameters. Instead it is intended that the performance levels obtained (by all vehicles) at the 2007/08 accreditation tests be used to derive performance requirements, which will be included in the 2008/09 tests.

This year also saw the end of the centrally supported (and accredited) SCANNER data processing software. This meant that all the survey contractors were responsible for developing and maintaining their own data processing software.

2.3 2007/08 Testing

In the 2006/07 survey year there were seven survey vehicles holding SCANNER accreditation certificates, and these were submitted for re-accreditation in 2007/08. Because of the additional measurements and derived parameters it was necessary to make appropriate enhancements to the SCANNER accreditation process to accommodate testing of the new measurements and the calculation of the new parameters. Therefore all machines were required to complete either full accreditation (for new or highly modified vehicles) or re-accreditation (for vehicles where only minor changes had been made since the 2006/07 tests) testing. Ultimately, it was necessary for only one survey vehicle to undertake full accreditation testing, with the remaining six machines undertaking “extended” re-accreditation tests which included a component of full accreditation for the measurements and parameters that were additional to those included in the previous year’s test programme.

Because of the complications involved with testing the new parameters the 2007/8 accreditation testing took much longer to carry out than was originally expected. Therefore it was decided to allow the SCANNER survey contractors to undertake surveys once the collection of the raw survey data was proved to be satisfactory, even though they had not yet accurately calculated the new derived SCANNER parameters. The adjustments required to achieve this were in the processing software and hence these changes could be introduced at any time after the survey had been carried out and before the data was processed and delivered.

Seven SCANNER survey machines successfully gained accreditation for the survey year 2007-08:

- WDM RAV4 (accredited from February 2007)
- WDM RAV1 (accredited from May 2007)
- WDM RAV2 (accredited from May 2007)
- DCL ARAN01 (accredited from July 2007)
- WDM RAV3 (accredited from July 2007)
- Jacobs RST26 (accredited from August 2007)
- DCL ARAN02 (accredited from December 2007)

Note that because accreditation certificates are valid for 12 months from the date of accreditation, some of the machines accredited during 2007/08 had valid accreditation certificates continuing from 2006/07 accreditation testing, but were unable to deliver the new SCANNER parameters until they had undertaken their scheduled 2007/8 re-accreditation tests.

The main issues raised in the 2007/08 accreditation were:

- Poor distance measurement under some circumstances.
- Offsets in OSGR data.
- Gradient not fully meeting the requirements of the specification.
- Radius of curvature not fully meeting the requirements of the specification.
- Profile measurement (variance) performance slightly below required standard. In particular the observation of differences between GM and HRM measurement systems
- Rut depth measurement being too dependent on driving line and poor filtering of kerb features
- Offsets in the texture data.
- Poor reproducibility and repeatability of cracking measurements.

A detailed summary of the issues occurring with the accreditation up to October 2007 was delivered to the SCANNER project manager and survey contractors. An undated report covering all accreditation carried out in 2007/08 is presented in Appendix A.

The SCANNER specification defines the performance requirements for the measurement of each survey parameter. Occasionally the survey contractors are not able to satisfy these requirements in full. Where it is determined that this would not have a significant effect on the survey an accreditation certificate is issued together with an Improvement Action Plan (IAP). Each survey vehicle was issued with an IAP in the 2007/8 accreditation tests, which specified the particular areas identified for improvement, and timescales for the delivery of the improvements.

It is noted that all survey contractors were required to make significant efforts to upgrade their equipment and processing software to accommodate the delivery of the new SCANNER parameters. This process took a lot longer than anticipated and therefore survey contractors may not have had as much time as they would have liked to work on the issues reported in the previous (2006/07) IAPs. Therefore many of the issues seen in the 2006/07 accreditation (and hence included in the 2006/07 IAPs) also appeared in the 2007/08 tests, and so have been carried forward in the 2007/08 IAP.

3 Provision of advice to local highway authorities

3.1 Advice to local highway authorities during procurement of SCANNER surveys

In 2007/08, as in 2006/07, the majority of enquires received from local highway authorities were in connection with the accreditation of the survey contractors. The local highway authorities wished to award a contract to an accredited survey contractor for their surveys and needed information on their accreditation status, before awarding the contract. Often the survey contractor was in the best position to determine exactly how close to accreditation they were, being are more aware of the progress they have made in any developments required (e.g. in the measurement equipment and processing software) to achieve accreditation. However, only TRL was able to provide the latest information on when survey machines have been accredited.

3.2 Advice provided to local highway authorities on SCANNER

The following subsections summarise two technical investigations carried out by TRL.

3.2.1 SCANNER survey not reporting poor ride quality

A local highway authority had approached the SCANNER implementation consultant (Halcrow) about a length of the A31 where they had received complaints about poor ride quality. The authority's SCANNER 2005/06 survey data did not show excessively poor ride quality as the complaints implied and hence there were questions about its accuracy. The SCANNER implementation consultant carried out an initial investigation and asked TRL to investigate the case in more detail.

The SCANNER data available from this site (2005/06 survey) was examined and it was confirmed that the data did not show as poor ride quality as the complaints had implied. TRL carried out independent surveys of this site to enable a better understanding of this issue. The work included carrying out a survey using the HARRIS1 survey vehicle, further "user perception" surveys, and detailed investigation of the user and SCANNER data, including the application of other analysis methods such as Power Spectral Density, the bump measure and 3D profile. The results of this investigation were collated for the Department in a separate unpublished TRL report – Benbow and Wright (2008). A summary of the conclusions are as follows:

- The 2005 SCANNER data did not report significantly poor ride quality. However, the 2007 SCANNER survey of the site did report the condition of this road to be in a poor condition, which suggested deteriation of the site had occurred.
- The measurements reported in the 2007 SCANNER data were confirmed by the independent HARRIS1 survey.
- The independent user survey also reported that the site has lengths of poor ride quality.
- Other assessments of the profile data have shown that the poor ride quality does not arise from a "repeating feature". The ride is being affected by random longitudinal roughness giving rise to local roughness and bumps.
- The presence of changes in profile across the road may also be contributing to the perceived roughness (rocking of the vehicle).
- If the local authority's road network is considered as a whole, the carriageway in question has significantly poorer 3m variance than an average A class road.

3.2.2 Misreporting of deep rut depth measurements

One local highway authority contacted TRL to ask for advice on the reporting of rut depth measurements on a particular site. This site contained particularly deep rut depths which were not being identified in the SCANNER survey data and hence there was concern over the accuracy of the rut depths delivered to this client.

TRL contacted the survey contractor and investigated the survey data. It was found that there was an issue with the survey contractor's rut depth algorithm. Any rut depth algorithm will have a number of different steps that are used to calculate the rut depth. One of the first stages of most algorithms is to try and identify whether any of the profile lasers at the edge of the carriageway are correctly measuring the height of the pavement surface and not recording another carriageway edge feature (e.g. kerb or raised white line). If these other features are not correctly removed from the transverse profile before calculating the rut depths then the reported values can be (falsely) increased.

One of the ways of attempting to identify if the lasers are recording the height of another feature is to look at the difference in profile height recorded between two adjacent lasers in each transverse profile. If this difference exceeds a pre-determined limit then the information from the offending laser (or even the complete transverse profile) can be classed as "invalid" and excluded from the calculations for rut depths.

For this particular case it was found that the survey contractor's "adjacent laser step height threshold" was set too low for this particular site. The data set was re-calculated using an increased step height limit for the rut depth calculation and the deep rut depths were then correctly reported.

It should be noted that the majority of rut depths reported by this survey contractor were unaffected. Investigations revealed that it was only an issue for isolated cases where the ruts were very steep sided (and deep). On this particular site the rutting had been slowly increasing and had finally reached a depth sufficient to trigger the step height limit in the survey contractor's algorithm.

Nevertheless, the survey contractor was asked to consider revisions to their rut algorithm for the next survey year (2008/09).

4 Advice and guidance provided to survey contractors

4.1 Specification updates

During the accreditation process (specifically with the assessment of the new SCANNER parameters) it was found that the SCANNER specification required further clarification in regards to the explanation of the new parameter calculations. TRL therefore issued two specification updates to all survey contractors to resolve ambiguities with the specification.

4.2 Survey contractor's meetings

Meetings between the Auditor and the survey contractors provided the opportunity to discuss ongoing issues. Two meetings were held at TRL, attended by the SCANNER implementation manager and all of the survey contractors (17th May 2007 and 25th October 2007), the purpose of these being to discuss issues of general concern. The following key issues were discussed:

- Implementation of the new SCANNER parameters - The survey contractors and the Auditor had spent considerable time and effort making changes to their survey equipment and processing software to incorporate these parameters. Unfortunately these took much longer to implement (by both the auditor and the survey contractors) than originally anticipated.
- The expected changes to the BVPI calculations using the SCANNER RCI revised "weighting sets".
- Data consistency - The results of the study undertaken by TRL into the consistency of SCANNER data – see section 5.3.
- OSGR data fitting – The survey contractors stated that their Client's road networks were often poorly defined, and the proposed introduction of OSGR fitting had therefore been met with a mixed response. Clients often did not have their networks defined this way and were not planning to redefine their networks in terms of geographical referencing.
- Timeliness of Accreditation and QA data delivery to Auditor - This year saw changes to the requirements for data delivery from accreditation tests. Strict deadlines had been defined for the delivery of data to the Auditor. This brought an end to the previously practice of "surveying at risk" (survey contractor's collecting survey data for long periods without obtaining accreditation). Now, the awarding of accreditation certificates was systematically linked to prompt data delivery. The timeliness of delivery of the QA data to the Auditor has also generally improved this year, this may have been in some part to the more efficient system introduced by the Auditor.

A number of private meetings were held with individual survey contractors to discuss specific issues concerned with the accreditation process, as and when required.

4.3 Daily checks of measurement equipment

Some survey contractors were finding it difficult to meet the daily check requirements (see Section 7.1) and stated they were even hindering survey progress. The SCANNER specification stated that, for a daily check, the survey contractor must survey the same length of road both first thing in the morning and last thing at night. The survey data from these two surveys (over the same length of road, on the same day) could be compared against the performance requirements outlined in the SCANNER specification. This test would provide a QA check for the measurement device on that particular day.

Some survey contractors were finding it difficult to complete a rerun of the length of road surveyed in the morning. This could be due to inclement weather or the fact that survey plans meant that the vehicle was travelling away from the chosen location and hence a lot of unproductive miles would have to be travelled to successfully complete the test.

A change to the daily check procedures was agreed by all parties (Auditors, SCANNER management and survey contractors) that would allow more flexibility to the survey contractors without reducing the quantity of the QA checks. It was agreed that the minimum requirement would be for a single QA survey run to be completed each day. This QA run would then have to be compared to a previous (or following) day’s survey on the same site. Thus a QA check on each day’s survey is still maintained, but with only half the number of test runs.

5 Advice and guidance provided to SCANNER project management

Throughout the survey year regular progress meetings were held with the SCANNER implementation manager at approximately monthly intervals, to review any issues that had arisen, and to discuss their resolution. In addition, regular survey progress reports (section 5.1) were provided for the SCANNER implementation project manager for reporting to other interested parties (the SCANNER Implementation Advisory Group, the SCANNER Project Management Group, the UK Roads Board, the Department for Transport, concerned local highway authorities, etc).

TRL maintained a contact list for each of the 149 English local highway authorities (and also the Scottish and Welsh local highway authorities) and provided a route for direct communication from the SCANNER implementation project to individual local highway authorities.

TRL also undertook a number of special investigations of the SCANNER data, as discussed below in sections 5.3 and 5.4.

5.1 Progress reporting

The survey contractors supplied weekly progress reports on the amount of SCANNER surveys completed. This was collated in an overall progress chart and delivered (monthly) to the SCANNER implementation project manager. This data enabled the SCANNER project manager to assess the overall progress of the survey contractors against plan.

Figure 1 shows the cumulative daily survey totals for England reported to the Auditor (TRL) by the survey contractors. Initially, the total length (in lane km) of the network to be surveyed in the 149 local highway authorities was estimated to be around 94224 km. This is shown by the red 'Target' line, which also shows how the survey might be expected to progress in an ideal situation. For the SCANNER survey year 2007/08 the total length surveyed in England reported to the auditor was 91209 km, this meant that 97% of the expected survey was completed.

The target figure was estimated from the figures given by local highway authorities for the total length of the classified road network and the DfT requirements for network survey coverage. As contracts were awarded to survey contractors and routes prepared the estimate was improved. As for previous years, it was apparent that many local highway authorities requested additional surveys, above the minimum requirement.

It can be seen from Figure 1 that the progress was always running behind the predicted survey rate (red line). Note that, because of the extra work involved getting the survey devices ready to measure the new SCANNER parameters, not all vehicles were ready to start surveying at the commencement of the survey year. This meant that by the time all machines were accredited to carry out surveys, the overall progress was significantly behind schedule. Considerable efforts were made by all survey contractors to improve this situation. Between September and early December it appeared that the survey contractors were catching up and would be able to complete their contracted surveys within the normal survey year. Unfortunately during late December and January 2008 very poor weather hindered progress. One survey contractor also experienced serious mechanical breakdowns with their vehicle, and hence this machine was out of action for approximately two months.

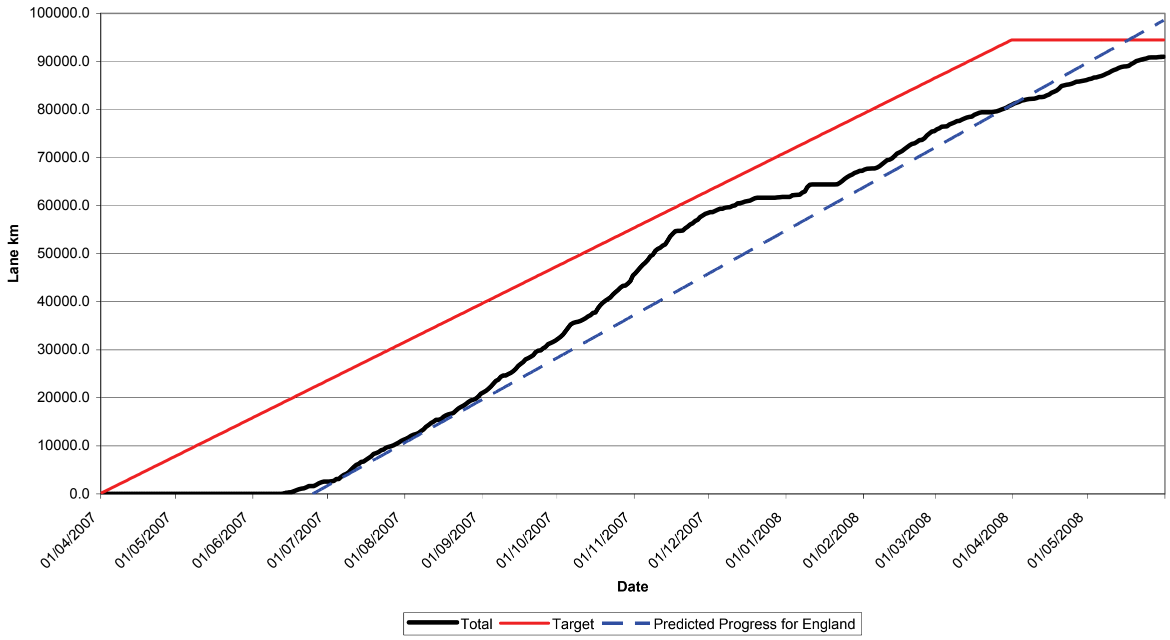


Figure 1: Cumulative daily totals for all survey contractors, with expected target 2007/08 for England.

At the start of February 2008 it became clear that the survey was not going to be completed before 31st March. The SCANNER implementation project manager discussed the situation with the DfT and the Audit Commission. It was agreed that a two month extension would be granted to allow the surveys to be completed. This meant that the 2007/08 SCANNER survey year was extended until 31st May 2008. One survey contractor (WDM) managed to complete their SCANNER surveys before the 31st March deadline but the other two survey contractors both required the extension to complete their surveys. To avoid any confusion it was agreed (for the survey contractors making use of the extended deadline) that all 2007/08 surveys would be completed before any 2008/09 surveys were commenced. Table 1 shows the start and end dates for the 2007/08 survey year for all the survey contractors.

Table 1: Survey year dates for each survey contractor

Survey Company	Official Start date of 2007/08 surveys	Finish date for 2007/08 surveys	Start date of 2008/09 surveys
Jacobs	1st April 2007	31st May 2008	11th June 2008
WDM	1st April 2007	30th March 2008	5th April 2008
Yotta DCL	1st April 2007	26th May 2008	9th June 2008

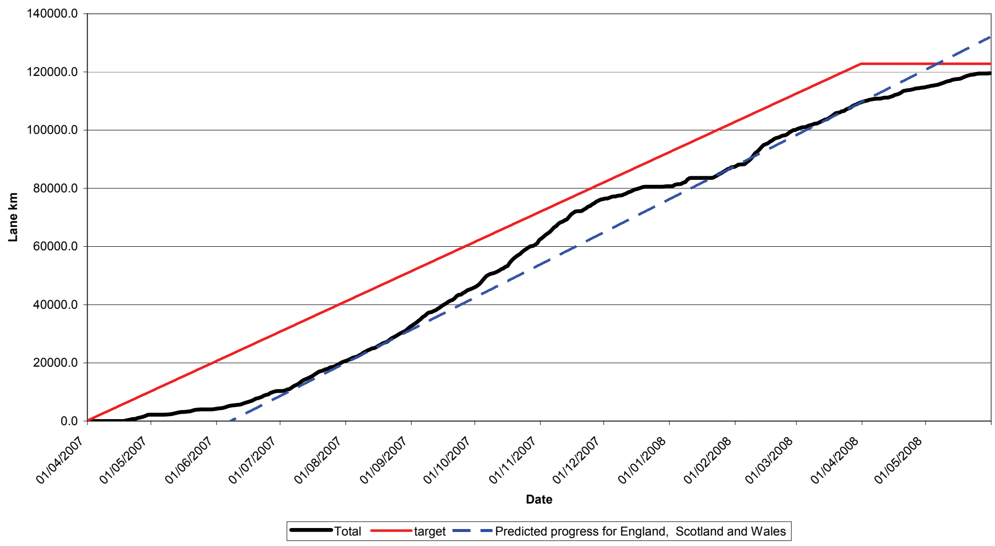


Figure 2: Cumulative daily totals for all the survey contractors with expected target 2007/08 for England, Scotland and Wales.

Figure 2 shows the cumulative daily survey totals for England, Scotland and Wales. The total length (in lane km) of the network to be surveyed in the 32 Scottish local highway authorities was estimated to be 18861 km and the total length (in lane km) of the network to be surveyed in the 22 local highway authorities for Wales was estimated to be 9380 km. Adding these to the English total (94224 km) gives an overall total of 122465 km, as shown by the red 'Target' line in Figure 2.

5.2 Survey progress

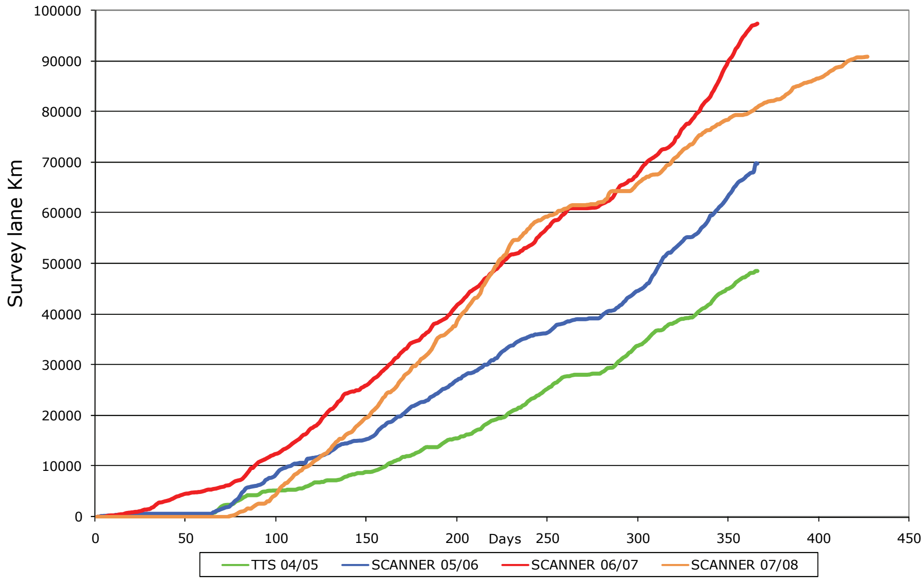
The average rate of survey progress is affected by many factors, which are likely to vary from year to year. For example, there is often a delay at the beginning of the survey year whilst survey vehicles are maintained and re-accredited, which reduces the time available for surveying. Other factors include inclement weather, local highway authorities requesting additional surveys, night work, equipment breakdowns, the number of survey vehicles operating and the class of roads being surveyed. Table 1 shows the average survey rates achieved in each of the of the four survey years in England. These values are calculated from the actual survey figures provided by the survey contractors.

Table 2: Vehicle capacity by year

Survey year	Total survey length (lane km)	Number of accredited vehicles	Average survey length per vehicle (lane km)	Average daily survey length per vehicle (lane km)
TTS 2004/05	48579	2	24290	67
SCANNER 2005/06	69718	4	17430	48
SCANNER 2006/07	97513	7	13930	38
SCANNER 2007/08	90989	7	12998	36*

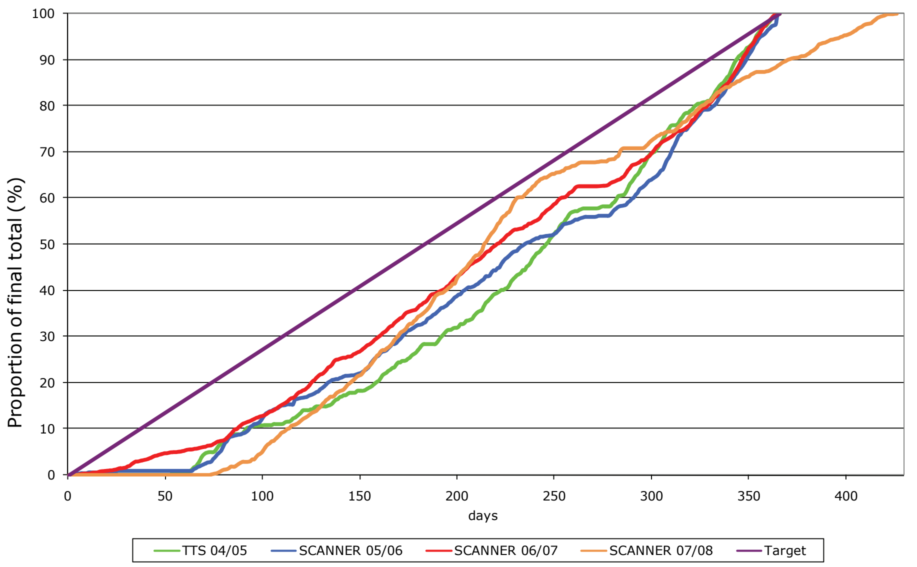
Note:* This figure has been calculated using a 365 day survey year even though some vehicles required a two month extension to the survey year to complete the work.

From Table 2 it can be seen that the survey rate per vehicle has been dropping year by year. The most likely reasons for this in the earlier years are the increase in the number of accredited survey vehicles and the inclusion of lower class (B & C) roads (which have a lower productivity rate). The overall length of the road network surveyed has generally increased since 2004 (see also Figure 3 and Figure 4). A survey peak of 97513km was reached in 2006/07 where the survey contractors reported that many local authorities requested more surveys to be completed than was mandatory. The survey requirements have also changed through the years and the proportion of B and C class roads surveyed has increased (see Figure 5).



Note: The 2007/08 survey year was extended by two months to allow completion of surveys.

Figure 3: Survey progress in England during the four years of TTS/SCANNER surveys.



Note: The 2007/08 survey year was extended by two months to allow completion of surveys.

Figure 4: Normalised survey rates during the four years of TTS/SCANNER surveys.

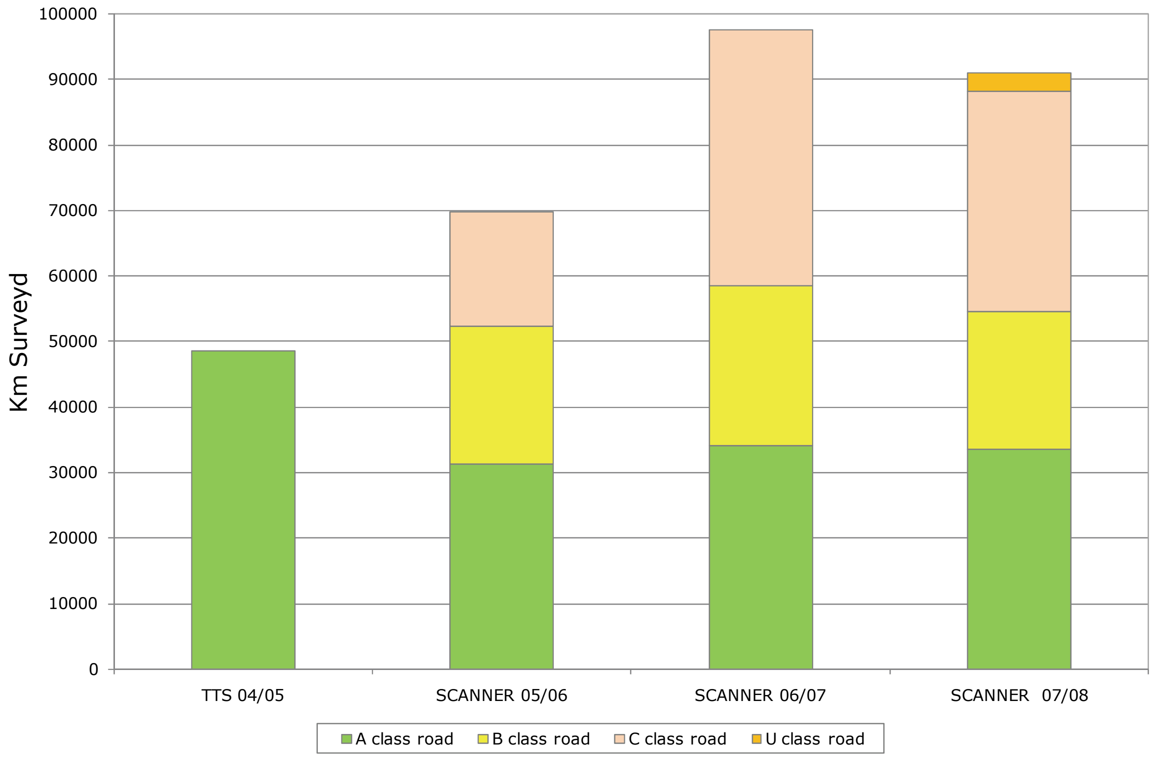


Figure 5: Proportion of overall survey length by road classification for England.

5.3 Consistency

Even though there is more confidence in the consistency of the SCANNER surveys (when compared to visual surveys), there is a need to understand the consistency of the automated survey, in order to make reliable quantitative comparisons between the condition of roads in different parts of the country. Therefore, TRL was requested to undertake an investigation of the consistency of results produced from accredited SCANNER survey machines, the ultimate aim being the derivation of confidence limits for the SCANNER data.

A separate report on this work was produced for the Department – Benbow and Wright, 2008. A summary of the conclusions follows:

- The report used the consistency calculation developed by Chris Britton Consultancy to produce results for both the SCANNER parameters, the RCI and the BVPI. The method has been applied to the data from the SCANNER road route surveys used during the accreditation testing of SCANNER vehicles to obtain an estimate of the likely error in the BVPIs obtained from a surveyed network.
- This typically gives a range of ±1.5%. However, this range reflects the behaviour expected when the road network, used to obtain the consistency measures is in good condition.
- It has been found that using poorer test networks to obtain the consistency measures predicts that the likely range of error in the BVPI will be larger, at approximately ±4%.
- It would therefore seem appropriate to suggest tolerances for the accuracy of the BVPI of between ±1.5% and ±4% for networks with BVPIs ranging from good to poor.

5.4 Assessment of RMST data

The 2007/08 survey saw the introduction of a new measure of surface texture (RMST) and the parameter RMST variance (which is derived from the RMST values provided by survey contractors). Although the minimum requirement for the measurement of RMST is to measure this parameter over three measurement lines (nearside, middle and offside), one survey contractor developed their equipment so that this minimum requirement was greatly exceeded – providing a measure over 20 measurement lines distributed across the lane width. TRL therefore undertook an investigation to determine whether the data delivered by these two approaches produced consistent RMST values. The work also investigated the levels of RMST and texture variability that may be expected on typical local roads so that advice could be developed for the use of this data.

A separate draft report on this work was produced for the Department – Benbow et al., 2008. A summary of the conclusions follows:

- In general, the RMST measurements made using texture lasers are higher than those measured with profile lasers. On average, this difference is 0.1mm, for any road class. Thus, the two measurement systems cannot be considered to be equivalent for RMST and should be dealt with separately during SCANNER accreditation and network assessment. However, they report very similar levels of variability and can be considered equivalent for this parameter.
- Also, RMST measurements made using multiple profile lasers, per transverse position, have been shown to be slightly lower than those measured with only one laser. On average, this difference is -0.03mm for A or B class roads, and -0.01mm for other road classes. Similarly, the variability measured by multiple lasers, per transverse position, is lower, with an average difference of -0.03 for all road types (-0.04 for A roads, -0.02 for B roads and -0.01 for other road classes). Thus, using multiple lasers per transverse measurement line cannot be considered to be equivalent to measuring RMST or Variability with only one, and should be dealt with separately during SCANNER Accreditation and network assessment.

6 Advice and guidance given to other parties

As auditors TRL can be 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 (e.g. survey contractor, DfT) to achieve a successful resolution.

7 Quality Assurance

As it is impractical to carry out detailed QA tests of data collected within every local highway authority, the Quality Assurance for the 2007/08 SCANNER survey was carried out on the basis of assessing each survey contractor.

The SCANNER specification prescribes a procedure of daily and weekly checks that the survey contractors are required to perform to demonstrate that their machines have not deteriorated from the levels of performance achieved during the acceptance tests. TRL collected a sample of these internal check records as part of the QA process (Section 7.1).

In addition to the daily and weekly checks, repeat surveys are carried out by, either the survey contractor or the Auditor, to ensure that the surveys are repeatable and reproducible. There are two types of repeat survey - Contractor’s and Auditor’s Repeat Surveys.

Contractor’s Repeat Surveys (CRS) are intended to show the repeatability of the survey contractor’s equipment during a survey. The Auditor informs the survey contractor in advance of selected areas or selected sites to be repeated. The survey 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 is used as the “reference” and the second survey compared to the reference to evaluate the differences between the two survey runs.

Auditor’s Repeat Surveys (ARS) are intended to show the reproducibility of the survey contractor’s equipment against a reference (the Auditor). The survey 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 survey contractor using an independent survey machine. During the 2007/08 survey year the independent survey machine used was HARRIS1 (Highways Agency Road Research Information System). The data collected during the ARS is compared with the survey contractor’s data to evaluate the differences between the two survey runs. It should be noted that for the reference data for the cracking on ARS was provided by manual analysis of the images of the road surface collected by the HARRIS1 survey machine during the reference survey, rather than by automatic analysis.

For both the CRS and the ARS the SCANNER survey data were tested for accuracy on all of the survey parameters that are collected under a normal SCANNER survey. For each survey parameter the differences between the values recorded by the reference and the SCANNER survey were analysed to see if they fell within the tolerances given in the SCANNER specification. The equipment was deemed to have passed or failed the test for each survey parameter on each test site. Full details of the assessment procedures are given in the SCANNER specification.

A QA status report was sent to each survey contractor at approximately monthly intervals. The report contained a summary of how many CRS and ARS had been requested, delivered and processed. It also highlighted any areas where data delivery (or processing) was behind schedule. Summary performance reports of all repeat surveys analysed during that period were also supplied.

For confidentiality, the following paragraphs refer to the accredited survey contractors as “SCANNER vehicles”. The data presented are merely examples to illustrate any points being presented, rather than intended as criticism of any individual survey contractor’s performance.

7.1 Daily, weekly and monthly checks

Survey Contractor's daily, weekly and monthly checks are intended to rapidly highlight any drift or step changes in the equipment calibration. They are there primarily to reduce the risk of collecting erroneous data by highlighting problems quickly and ensuring they can be fixed before continuing to survey.

For a daily check the survey contractor selects a short length of road (typically ~ 500m) in close proximity to the day's survey. The survey 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, either that evening, or the next morning and the results compared within the tolerances set out in the SCANNER specification. Using this approach any sudden step change in the performance during the day will be highlighted. Weekly and monthly checks are performed in a similar manner, except they capture changes over longer periods and use longer site lengths (~1km). The tolerances used for the weekly and monthly checks are tighter, since it is expected that the survey contractors will use a more accurate means of location referencing for these checks (typically using reflective marker posts positioned at either end of the survey length).

The test sites chosen were required to be lightly trafficked to ensure that large changes in the measured parameters would not occur during the survey year.

Three different approaches were used by the survey contractors to process the check data.

1. The checks were performed onboard before deciding whether to continue surveying
2. The checks were performed remotely but on the same day
3. The checks were performed remotely some days after the survey, but with a simplified version of the checks performed onboard to minimise the risks

Where it was not possible to perform the checks onboard, the survey contractors understood and accepted the possibility of having to resurvey where it might later have been found that there was a problem with the survey equipment.

Spot checks were carried out by the auditor on the daily, weekly and monthly checks. For the 07/08 SCANNER survey year a total of 16 daily, 9 weekly and 10 monthly checks were requested from the survey contractors. No problems were identified with the checks on the results received.

7.2 Repeat surveys

The sites for CRS were selected by the survey contractors according to a set of criteria dictated by the Auditor. Approximately once a month the Auditor would contact each of the survey contractors and request that a repeat survey be performed within a set time period (usually within the following week) and would sometimes define the road classification (A/B/C) or environment type (Urban/Rural). This prevented any additional travelling time being expended to return to a location to repeat a survey. The survey 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 SCANNER specification.

The sites for ARS were chosen by selecting a geographic spread of sites from the survey contractors' progress report. Sites were chosen on the basis that they would hopefully include a variety of challenging road features. The survey contractors were 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 machine (HARRIS1) to provide "reference data" for comparison. Once the ARS was completed the survey contractors were 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 SCANNER specification.

Some survey contractors were quicker than others in delivering QA data. TRL often had to send out reminders to deliver the QA data for analysis. To ensure an efficient QA process it is vital to have prompt delivery (and analysis) of the data concerned. TRL processed the repeat survey data received and reported the results to each survey contractor at approximately monthly intervals.

A total of 47 CRS and 16 ARS were analysed in England, Scotland and Wales (see Table 3, Table 4 and Figure 6).

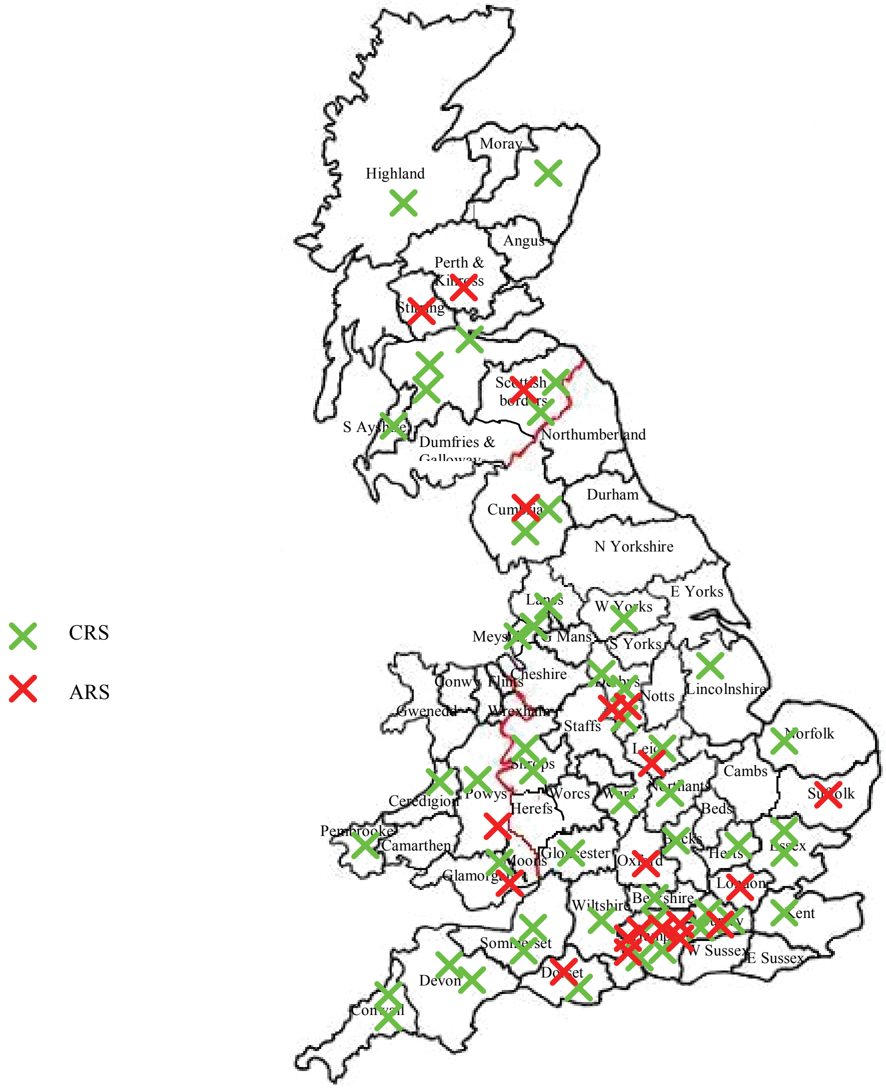


Figure 6: Repeat survey sites requested during 2007/08.

Table 3: Contractor's repeat survey sites

Site	Road ID	Local highway authority	Site	Road ID	Local highway authority
1	B6277	Cumbria	25	B6364	Scottish Borders
2	A134	Essex	26	C30	Devon
3	C90097	Essex	27	A752	North Lincolnshire
4	A628	West Yorkshire	28	A70	Lanarkshire
5	B1038	Hertfordshire	29	A920	Aberdeen
6	B2127	Surrey	30	A803	Falkirk
7	A323	Surrey	31	A926	Perthshire
8	A247	Surrey	32	A70	East Ayrshire
9	A0374	Cornwall	33	A483	Pontnewnydd
10	C6113	Leicestershire	34	A140	Suffolk
11	A422	Northamptonshire	35	B1222	Kent
12	B1160	Norfolk	36	C1018	Cheshire
13	A454	Shropshire	37	C9	Buckinghamshire
14	C3143	Gloucester	38	A514	Derbyshire
15	B4396	Shropshire	39	B3046	Hampshire
16	B4453	Warwickshire	40	B2177	Hampshire
17	C0274	Cornwall	41	A31/A337	Hampshire
18	B3092	Wiltshire	42	A4	Slough
19	C45	Devon	43	B5178	Liverpool
20	A836	Highlands	44	A41	Wirral
21	B3170	Somerset	45	B1380	Middlesbrough
22	A726	Scotland	46	A6	Derbyshire
23	C133	Dorset	47	C188	Newcastle
24	A707	Scottish Borders			

Table 4: Auditor's repeat survey sites

Site	Road ID	Local highway authority	Site	Road ID	Local highway authority
1	A40	TFL	9	A3057[2]	Hampshire
2	B6263	Cumbria	10	A27[2]	Hampshire
3	B4030	Oxfordshire	11	A334	Hampshire
4	B582	Leicestershire	12	B6401	Scottish Borders
5	A1120	Suffolk	13	A91	Stirling
6	B1380	Middlesbrough	14	A726	Lanarkshire
7	A3057[1]	Hampshire	15	B4046	Wales
8	A27[1]	Hampshire	16	B3130	Somerset

[1] These surveys were undertaken by one SCANNER device
[2] These surveys were conducted by another SCANNER device

7.2.1 Contractors Repeat Surveys (CRS)

Generally very good agreement was seen between the two data sets received for the CRS. This can be seen in Figure 7, which demonstrates the generally high level of repeatability seen for three of the SCANNER survey parameters. It can be seen that there are some small localised differences between the two survey runs but this is within the expected range of variability. The performance figures for all 47 CRS undertaken are listed in Appendix B. There were some occasions where the survey devices did not fully meet the requirements for the survey parameters. These are highlighted in red in the performance tables and are discussed below:

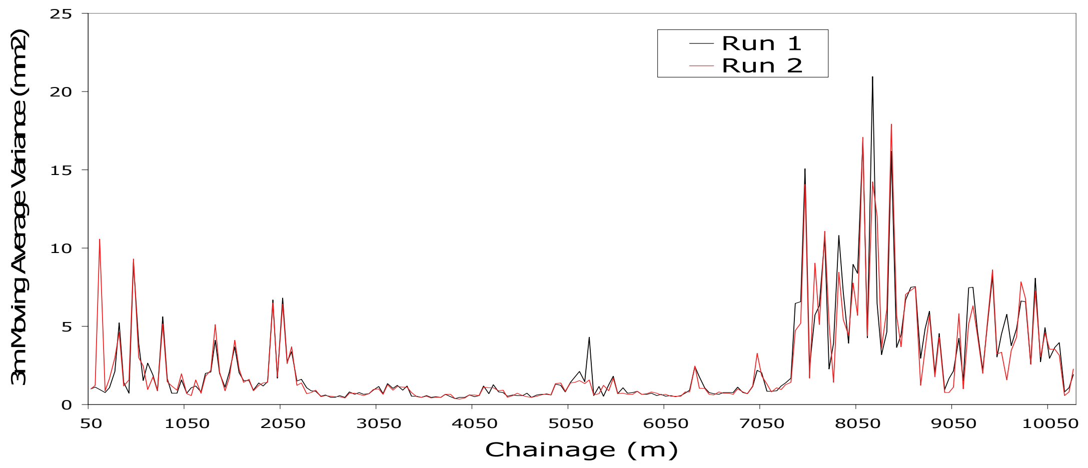
- OSGR co-ordinates
- Radius of Curvature
- Cleaned rut depths
- MPD
- Cracking

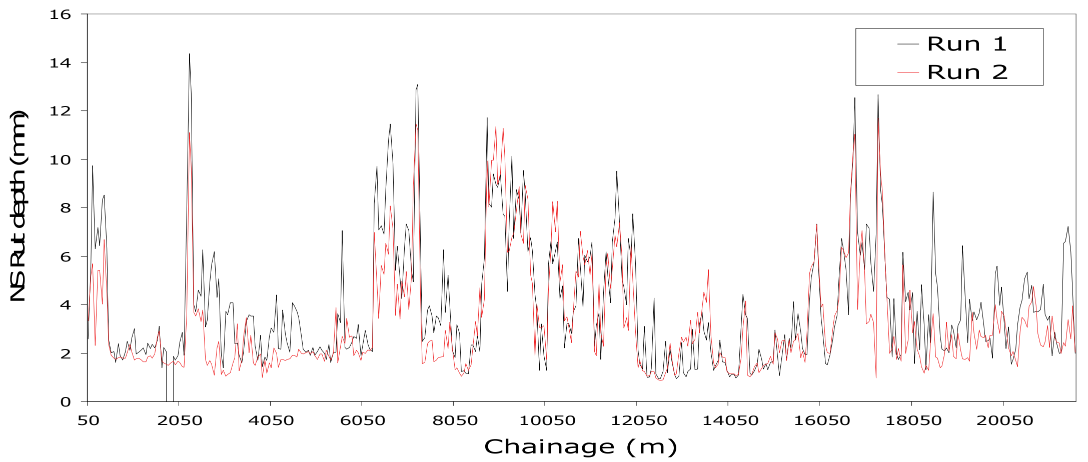
OSGR Co-ordinates

Large differences were sometimes seen between the OSGR co-ordinates provided by the two surveys. These differences can be caused by either poor measurements, poor data processing or by poor alignment of the survey data. There were some cases where it was apparent (e.g. single OSGR co-ordinates that were a long way from the rest of the survey) that the measurement device was in error. For other cases it was apparent that poor alignment of the survey data had occurred. The details of these differences were forwarded to the survey contractors concerned and they were asked to improve their measurement systems to deal with circumstances such as these.

Radius of Curvature

The repeatability requirements were often not met for the measurement of Radius of Curvature. It is recognised that the SCANNER specification requirements for the measurement of radius of curvature is challenging. This is because of the rapidly changing nature of this measure and the fact that as the radius gets smaller the absolute accuracy requirement is harder to achieve. It is also noted that the surveys which failed to meet the requirements for radius of curvature generally had a more of a curved nature. Therefore the original TRACS requirements (65% within $\pm 0.0015 m^{-1}$) for the measurement of curvature (1/ radius of curvature) were applied as a further test. These requirements were typically met. It is recommended that switching to the assessment of curvature should be considered for future surveys.





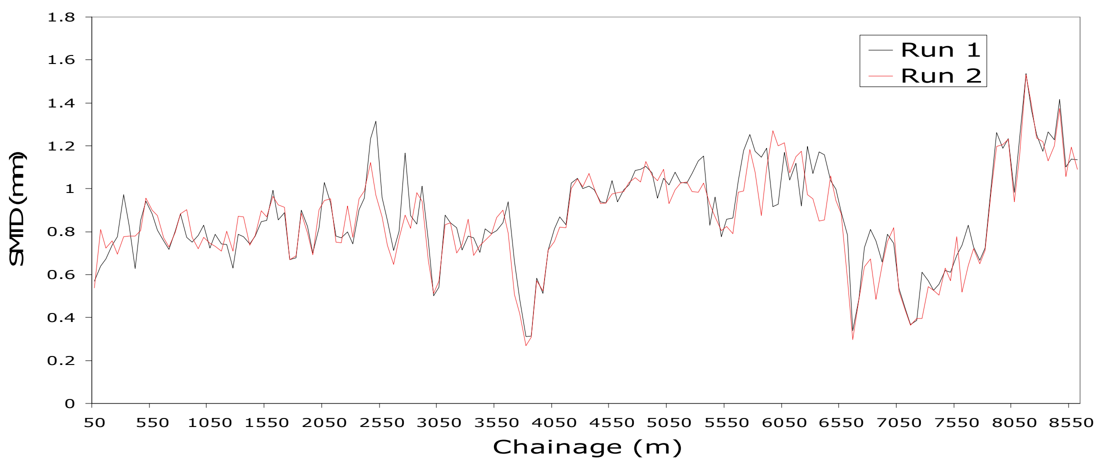


Figure 7: Sample CRS data (one from each survey contractor) to demonstrate high levels of repeatability - 3m longitudinal profile variance (top), nearside rut depths (middle) and SMTD texture measurements (bottom).

Cleaned Rut depths

One survey contractor was found to occasionally report very high values (>40mm) for the offside cleaned rut depth measurements. These high values were generally being reported in both of the CRS runs (even though the standard rut depths at the corresponding locations did not report a high level of rutting), indicating that there was something in the transverse profile that triggered these values. There was also one case from this survey contractor where the cleaned rut depth was reported as "-1" when the minimum value allowed to be reported is zero. The survey contractor concerned was provided with the data and requested to ensure their equipment and software was behaving correctly in these circumstances.

MPD Texture measurement

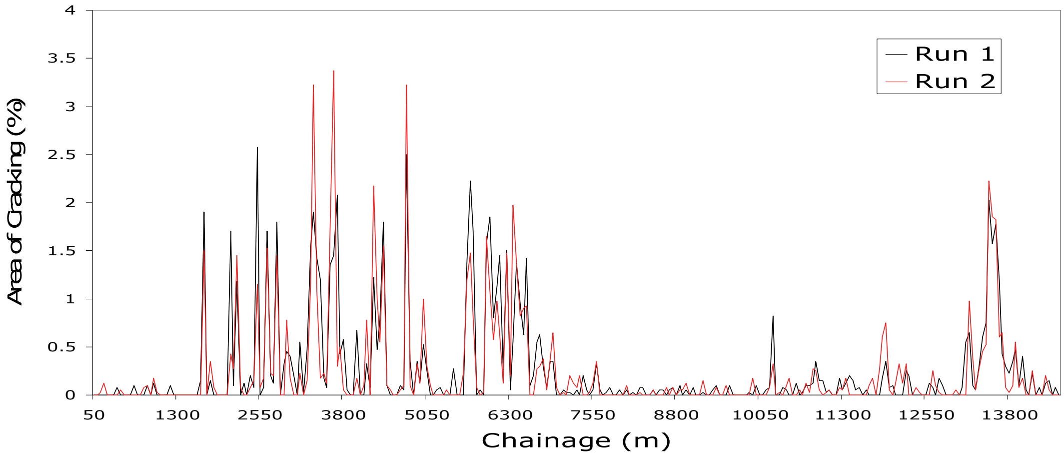
It was found that two of the survey contractors were incorrectly reporting the MPD texture values. One survey contractor was reporting values that were an order of magnitude too large and the other was reporting large amounts of invalid data. These were reported back to the survey contractors concerned who have since implemented solutions to these problems.

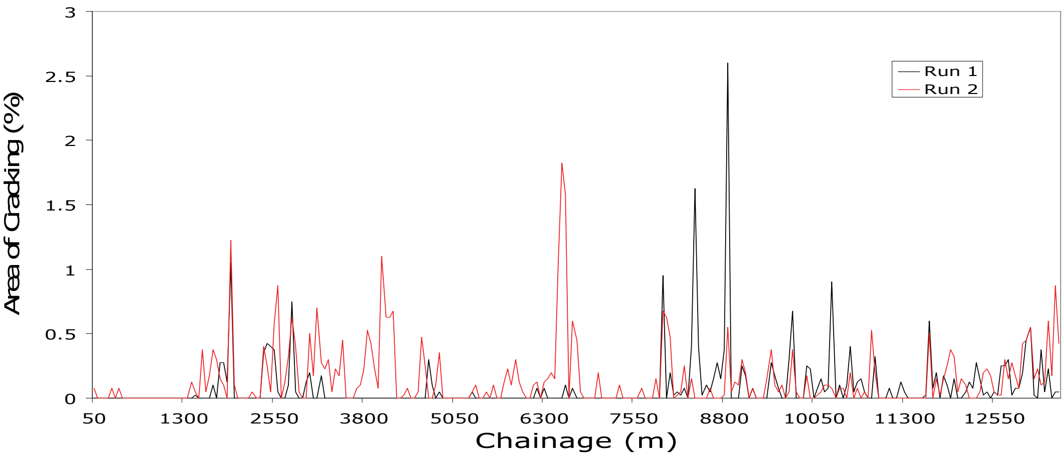
Cracking

The assessment of cracking is carried out at two levels of crack intensity: low levels of cracking (defined as <75th percentile of the whole data set) and high levels of cracking (defined as >88th percentile of the whole data set - further details of how the cracking is assessed can be found in Volume 4 of the SCANNER specification). 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 agreement was then calculated on the basis of the total of subsections that both reported high (or low) levels of cracking compared with the total number of high (or low) subsections in the reference.

From previous experience it is known that the measurement of cracking is less repeatable than the other SCANNER parameters. Previous survey years have shown that this measurement is more susceptible to changes in the environmental conditions and to the vehicle driving line. The survey Contractor's Repeat Surveys from the 2007/08 survey year have shown a similar behaviour. For all survey contractors it was found that the measurement of cracking generally met (or was close to) the requirements for lengths that contained low levels of cracking. The performance was less satisfactory for the measurement of high levels of cracking, where poor repeatability was often seen. It should be noted that there were often only small amounts of high level cracking reported on these sites. This has often meant there was a small data set on which to carry out the assessment and this may give misleading performance figures; for example if there are only two areas of high level cracking reported in the reference survey (run1), and only one of these agrees with run 2, a performance level of 50% is obtained (which is classified as a failure to meet the requirements)

Figure 8 shows three example cracking graphs from the survey contractor repeat surveys. These exhibit typical levels of repeatability seen with the measurement of cracking. Site A (top graph) shows good repeatability at both low and high levels of cracking. Site B and Site C, (middle and bottom graphs) show both good and poor repeatability at various points during the surveys (poorer agreement is often associated with at least one run reporting a higher level of cracking). It should be noted that all three sites met the repeatability requirements for low level cracking whilst only site A met the requirements at the high level.





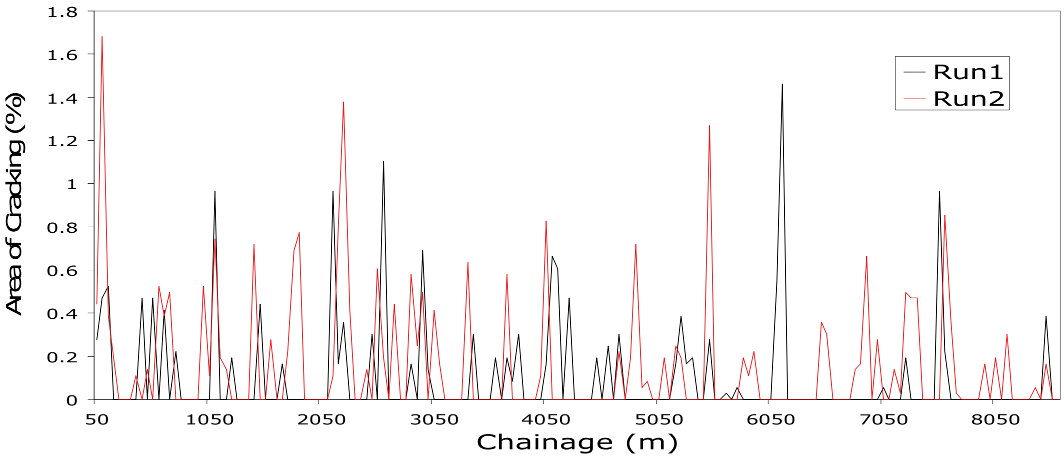


Figure 8: Examples of cracking data from 3 survey contractors repeat surveys; Site A (top), site B (middle) and site C (bottom).

The crack maps from a number of the CRS sites were also examined. It was found that the SCANNER survey machines often showed good repeatability, by identifying cracks in the road surface at the same location in both of the survey runs. The left hand side of Figure 9 shows two crack maps obtained from a CRS where there was good agreement between the two survey runs (the blue lines denote the transverse limits of the crack survey and the grey squares are where cracks have been detected). Note that these figures show data recorded by the same machine on the same site, but in repeat survey runs. There is a slight longitudinal offset between the two survey runs due to the locational referencing, but this is within acceptable limits. However, it was also found that there were locations where there were differences between the crack maps reported from the two survey runs. This low level of repeatability was significant in some places, as shown in the right hand side of Figure 9. Here it can be seen that there a large area of cracking was reported in the initial survey, but the repeat survey reported no cracking.

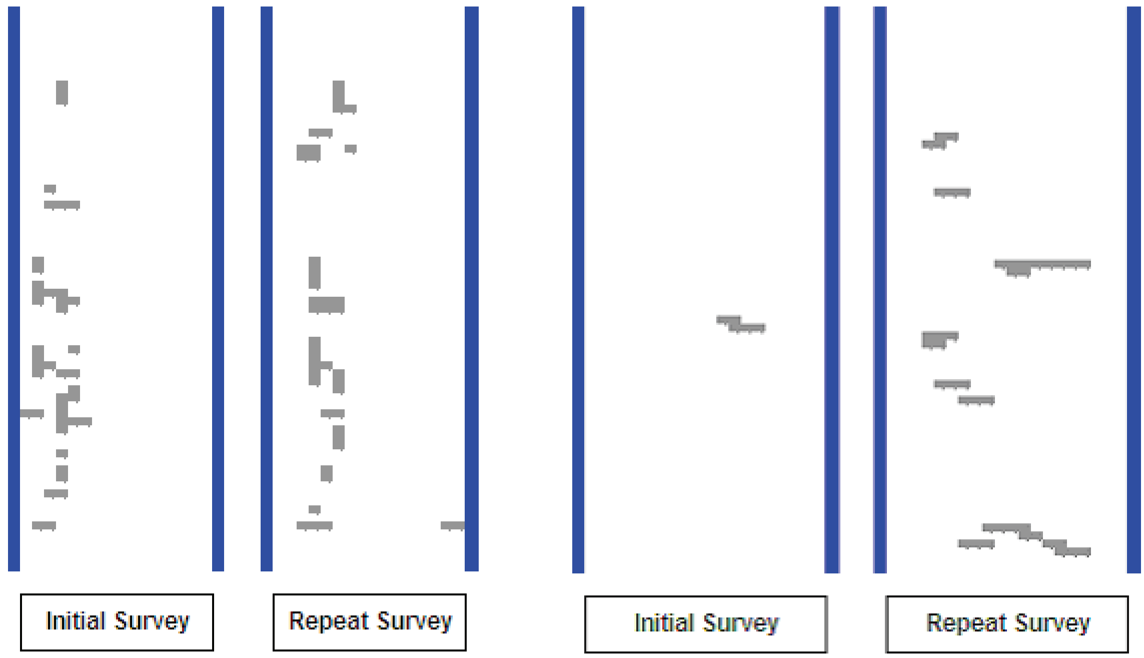


Figure 9: Example of good (left hand side) and poor agreement seen in CRS crack maps

New SCANNER Parameters

Not all of the new SCANNER parameters introduced for the 2007/08 survey have performance requirements defined in the specification. However, for the parameters for which requirements have been specified generally good agreement was seen between the survey runs and the performance met (or came close to) the requirements. Figure 10 shows sample data (one from each survey contractor) which demonstrates this high level of repeatability. In addition, visual assessment of the data was carried out and the following observations noted:

- The measurement of longitudinal profile variance in the offside wheel path was good and generally met the performance requirements.
- The bump measure was not always repeatable (it was found that the survey contractors were calculating the parameter correctly but it is thought that this parameter is very sensitive to the driving line taken by the survey device).

- The measurement of cleaned rutting showed that there was generally good agreement between the repeat SCANNER surveys which usually met (or came close to) the performance requirements. The CRS showed that the statistical repeatability of cleaned rutting is generally slightly higher than that achieved with the normal rut depth calculation. Due to the nature of the calculations it should be expected that the cleaned rut depths will be reported as slightly lower values than the normal rut depths. This is due to the "cleaning" process which removes part of the transverse profile thought to be over the road edge (and contains relatively high features in the profile). The removal of this higher edge part of the profile means that the rut depth algorithm then calculates the rut depths from the remaining profile. In certain circumstances it has been noted that the opposite behaviour occurs and the cleaned rut depths will be reported as higher values. This is thought to be because the original profile sometimes contains two depressions or "ruts" on the nearside of the road. The original rut depth algorithm selects the nearest rut to the road edge (which may be the shallowest) and reports the depth of this. The cleaning algorithm may remove (some or all of) the smaller rut and then measures the depth of the (deeper) second depression.
- Performance requirements have yet to be specified for the measurement of transverse unevenness and edge roughness. These will be determined from the performance of the SCANNER devices during the 2007/08 accreditation tests and verified using the 2007/08 QA data. These requirements will be introduced for future survey years.
- For the measurement of nearside MPD the devices were found to be repeatable and generally met the requirements for the CRS.
- The assessment of the three lines of RMST texture data showed that the devices were also repeatable and generally met the requirements.
- The assessment of the three lines of RMST variance, RMS percentiles (5^{th} and 95^{th}) and the RMS variance (all parameters without specified performance requirements) showed the two surveys to be generally repeatable. There were some occasional localised differences seen between the survey runs which have so far been unexplained.
- The measurements of transverse cracking and surface deterioration have no specified performance requirements and have not been statistically assessed as part of this QA programme. Visual assessment of the data has shown that these parameters are not very repeatable. Cracking data is known to be susceptible to environmental conditions. It is also thought that these parameters are also very sensitive to the driving line taken by the vehicle and the environmental conditions at the time of the survey.

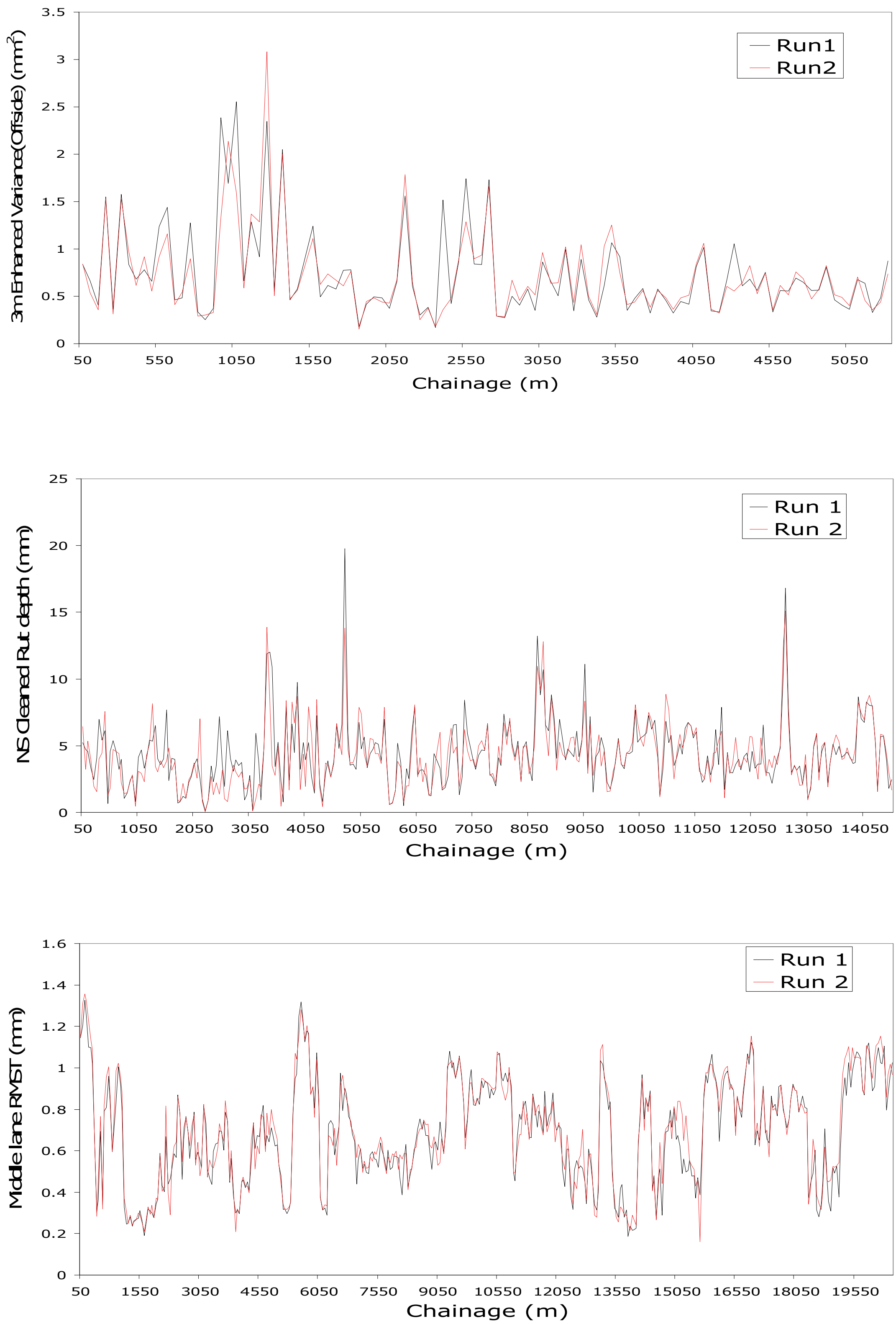


Figure 10: Sample CRS data (one from each survey contractor) to demonstrate high levels of repeatability of the new SCANNER parameters. 3m offside enhanced longitudinal profile variance (top), nearside cleaned rut depths (middle) and middle RMST texture measurements (bottom).

7.2.2 Auditor's Repeat Surveys (ARS)

ARS compare the data collected by each survey contractor on selected sites with that collected by TRL using HARRIS1. As this process compares surveys undertaken by different systems there are inevitably more difficulties encountered in the comparison process than for the CRS.

In the 2007/08 survey year poor network definitions (which are used to identify section start and end points) continued to be a problem when carrying out ARS. The network definitions are supplied by the local highway authorities to the survey contractor, and these are forwarded to the Auditor to assist in planning the ARS. The auditor has to ensure that all data is aligned correctly between the two surveys before comparing the data. The poor network definitions supplied often result in differences between the alignment of the two data sets and in the worst cases the data from these unmatched sections was removed from the assessment. These alignment problems were often associated with location referencing and data labelling.

Data labelling problems were also identified in some of the datasets. For example, occasionally the data from a single survey carried out in a single direction contained sections labelled as both "CL1" and "CR1" (i.e. both directions). Strictly, all data should be provided with the direction "CL1", and it is of note that this problem only arose for one survey contractor. The other two survey contractors reported all sections with a unique identifier, and these were always labelled as "CL1".

In the same way as the CRS, the data provided by the survey contractors for the ARS 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, and the OSGR data was generated at 5m intervals. The HARRIS1 (reference) 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 SCANNER specification.

The performance statistics obtained from the 16 ARS conducted in 2007/08 are listed in Appendix C. In general, good agreement was seen between the SCANNER survey data and the reference and hence the SCANNER data generally met the requirements for the ARS. This can be seen in Figure 11, which demonstrates the generally high level of reproducibility between the two surveys via typical examples of the reference data and survey contractor's measurements of 3m variance, nearside rut depths and texture depth (SMTD). It can be seen that there are sometimes localised differences between the two surveys and this type of behaviour is typical of that normally seen during this process (remembering that the two surveys are conducted by different vehicles and survey crews and undertaken at different times). The performance figures for all 16 ARS undertaken are listed in Appendix C. There were some occasions where the survey devices did not meet the requirements for the ARS. These are highlighted in red in the performance tables and are discussed below:

- Location Referencing and Section Lengths
- OSGR co-ordinates
- Geometry
- Rutting
- Cracking
- New SCANNER Parameters

Location Referencing and Section Lengths

The poor agreement between the Auditor's and survey contractor's section lengths and OSGR data is probably the most notable area of concern. To obtain the Auditor's (reference) data, the positions recorded for the section start points in the Auditor's data were checked using the HARRIS1 forward facing video taken during the Auditor's survey. The locations of the reference section start points were adjusted if necessary so that the section change corresponded, as closely as possible, to the location described by the local highway authority (e.g. "at the junction").

Assuming that we have confidence in the reference data, the differences between the reference location of the section change points and survey contractor's reported location for the section change points are likely to have arisen from poor recording of the locations of the section starts by the survey contractor during the survey. This is probably because these points are recorded manually (using a "push button") in most survey contractor's surveys.

Poor recording of the section change points will also lead to poor recording of the section lengths. However, poor performance in reporting of section length also arises from the process of "fitting" (stretching or compressing) the data to match the section lengths provided by the local highway authority. Here the survey contractor is required to "rubber band" the data to match the lengths provided by the local highway authority. It is apparent that these lengths often do not match the lengths recorded in the Auditor's survey. Therefore the quality of the network information supplied to the survey contractor by the local highway authority affects the accuracy of the measurements obtained. It is believed that many of the location referencing problems encountered in the QA process are related to the accuracy of the network provided by the local highway authority.

It is expected that moving to a road network that is defined using OSGR co-ordinates would improve the performance of the SCANNER measurement devices for locational referencing

Geometry

For the measurement of gradient and crossfall the SCANNER devices usually met the requirements for ARS. However, there were occasionally small biases (<0.5%) seen when comparing the data sets from different measurement devices. This is thought to be down to calibration of the measurement systems. Although the presence of bias is undesirable, the magnitude is believed not to be a major concern. All survey contractors have been reminded to ensure their calibrations are both correct and up to date at all times.

As discussed for the CRS the assessment process of the Radius of Curvature is very challenging and hence the SCANNER devices also often failed to meet the requirements for the ARS. The requirements for the measurement of curvature specified for the TRACS survey were therefore applied, resulting in a generally acceptable performance.

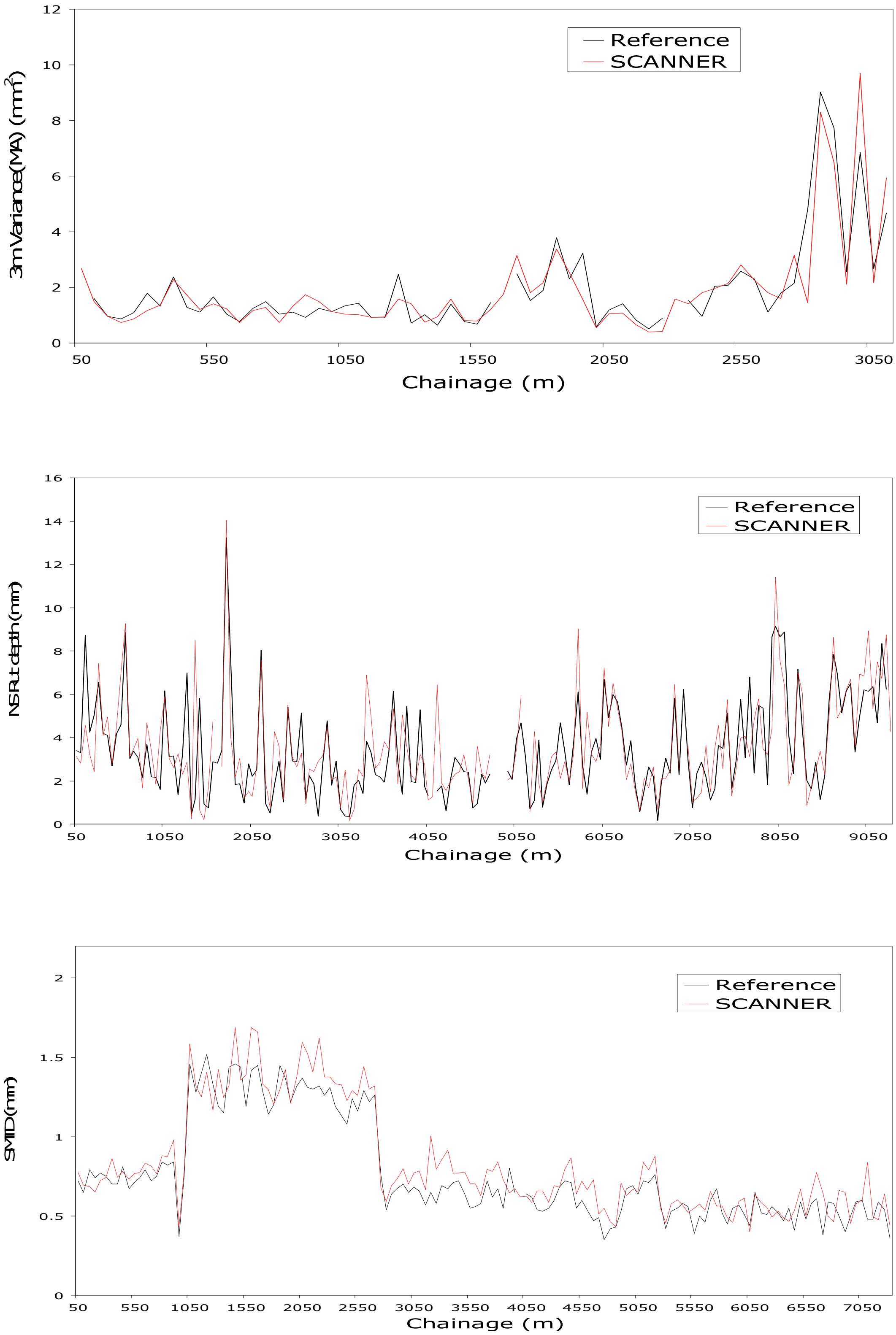


Figure 11: Sample ARS data (one from each survey contractor) to demonstrate the reproducibility of the SCANNER data. 3m longitudinal profile variance (top), nearside rut depths (middle) and SMTD texture measurements (bottom).

Rutting

For the measurement of rutting the SCANNER devices generally met the requirements for ARS. The differences seen between the reference and the SCANNER survey data exhibited slightly different behaviour patterns depending upon which wheelpath was being analysed.

For the nearside wheelpath localised areas of disagreement were generally noted. The SCANNER data could be either higher or lower than the reference data with no obvious pattern. These more random differences (i.e. localised over short lengths) were thought to be caused by differing driving lines being taken in the two separate surveys. These could lead to differences in the identification (and removal) of any kerb (or verge) features in the transverse profiles and hence the calculated rut depths.

For the offside wheelpath measurements good agreement with the reference measurements was often seen, but where differences were seen, these were more likely to be of a consistent nature (i.e. extending over long lengths). In these cases the SCANNER device usually measured a slightly higher rut depth than the reference, showing a small positive bias. The magnitude of this bias varied with the SCANNER devices but was usually within the range 0.5mm-2mm. This also implies that the offside rut depth measurements may vary slightly between SCANNER devices (which have been highlighted in the accreditation tests in previous survey years). The reasons behind these differences have yet to be identified, although there are a number of possible explanations:

- Driving line
- Beam calibration
- Rut depth calculations (algorithm differences)

It is hoped that the introduction of the new “cleaned” rut depth measurement will reduce some of the differences seen between the SCANNER devices.

Cracking

The assessment of cracking was undertaken in a similar way to that described above for the CRS. However, for the ARS the reference data was obtained from manual analysis of the downward facing images provided by HARRIS1.

Figure 12 compares the SCANNER cracking data reported from three separate ARS with the reference. As can be seen there is less agreement between the two cracking data sets than seen for the other (profile) parameters. For sites A and C the two data sets generally follow the same trends, with some localised differences. For site B there are large differences seen between the two data sets. In order to ascertain the reasons why the two surveys showed such differing amounts of cracking, the crack maps of the two surveys were analysed. From the crack maps it was evident that the SCANNER device was often missing the cracking that was being reported in the reference survey. It was also over reporting the amount of cracking present in some areas.

Figure 13 shows two examples where the SCANNER device was over reporting the cracking with “false positives”. The left had side shows the SCANNER device reporting the presence of an edge feature that was not identified in the reference survey. The right hand side shows road markings (identified by the green squares in the reference survey) probably being identified as cracking in the SCANNER survey.

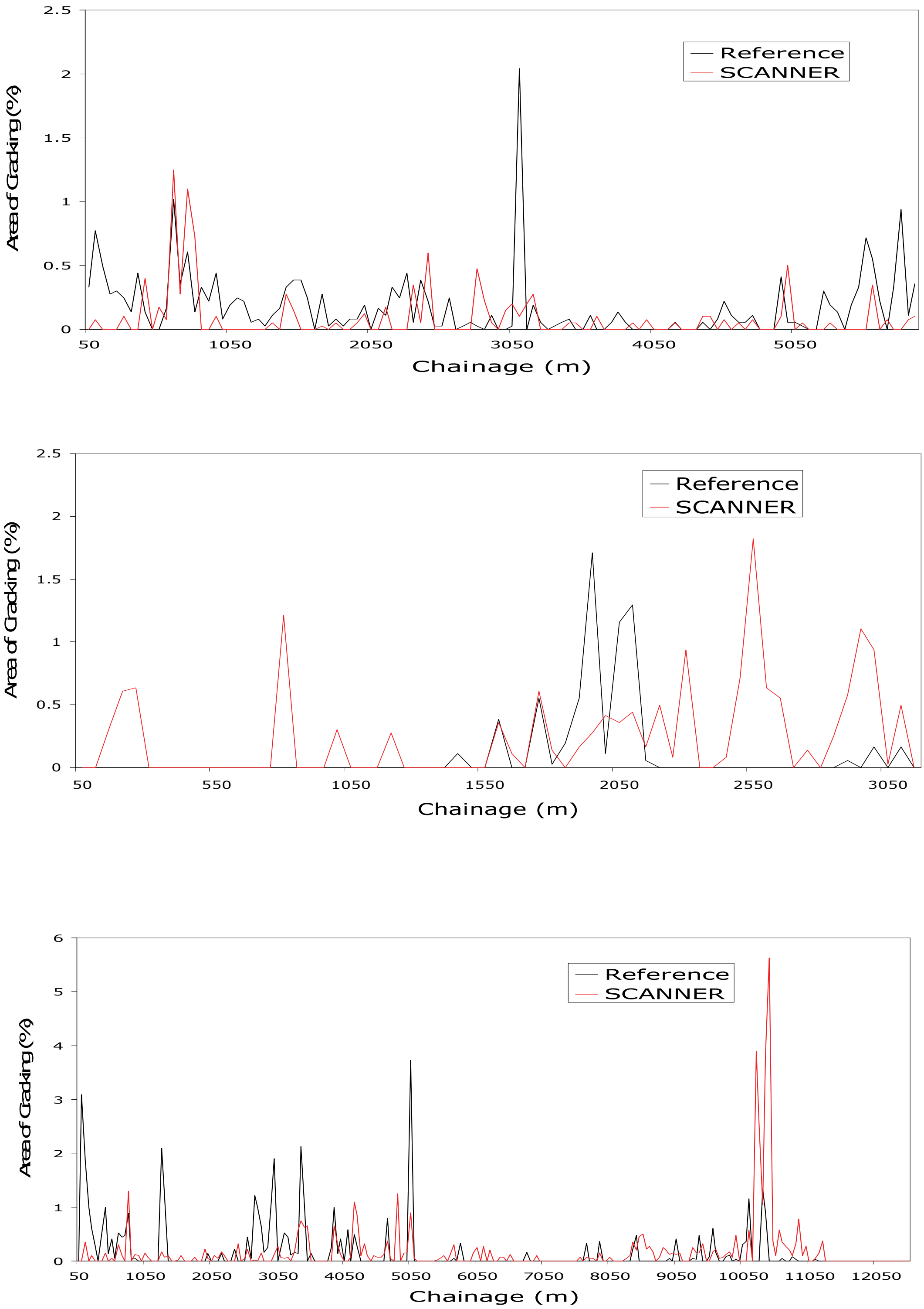


Figure 12: Examples of cracking data from 3 CRS; Site A (top), site B (middle) and site C (bottom).

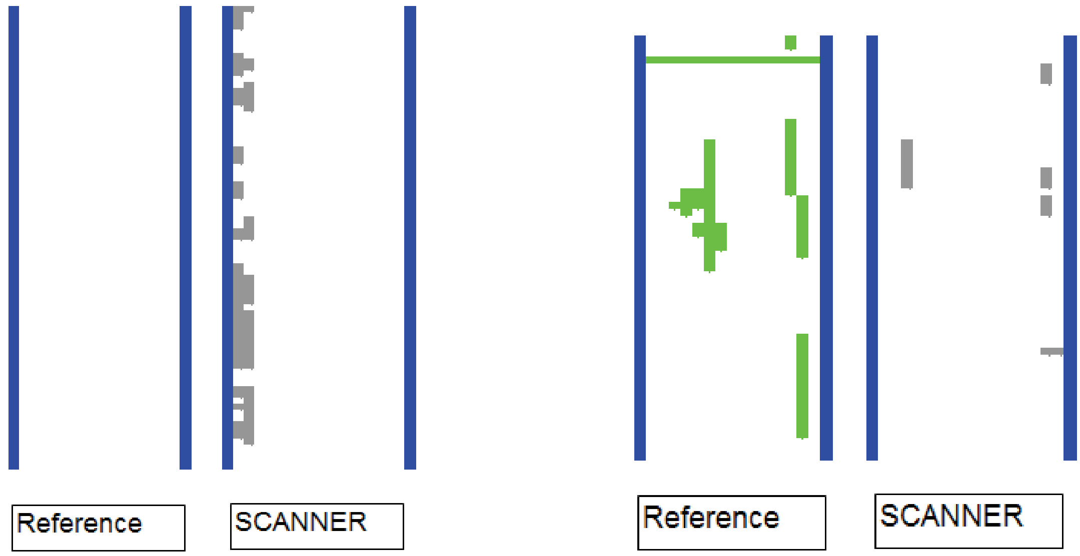


Figure 13: Crack maps extracts from site B

In 2007/08 (due to at least one local highway authority carrying out some repeat surveys with a different SCANNER device) it was possible to compare two different SCANNER survey devices over the same site. A reference survey was also conducted on this site and hence a three-way comparison was possible. Figure 14 shows the levels of cracking reported by the reference survey and the two SCANNER devices. The graph shows that neither of the SCANNER devices identified the high level of cracking present at 300m in the reference survey. However, although the two SCANNER devices do not exactly match each other the agreement between the devices was otherwise reasonable.

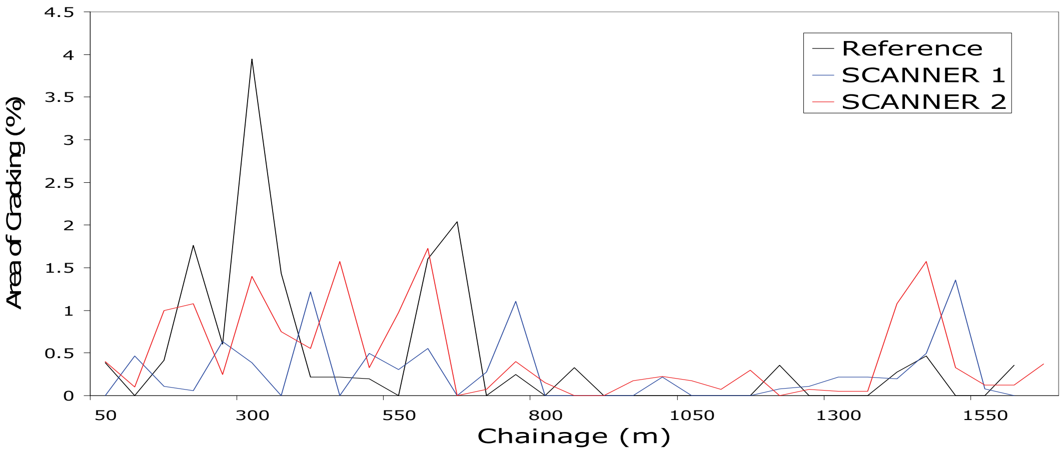


Figure 14: Cracking data from three separate surveys over the same site.

The crack maps from this site were examined, extracts of which are shown in Figure 15. In the left hand side of the figure a cracking feature has been identified in all three surveys (with possibly an extra feature present in the SCANNER 2 survey). Unfortunately for every case found where there was good agreement between the SCANNER device and the reference, we could also identify a length of poor agreement. The right hand side of Figure 15 shows the reference survey reporting two minor transverse cracks to be present. The SCANNER 1 survey identifies no cracking at all, whereas SCANNER 2 reports too much cracking.

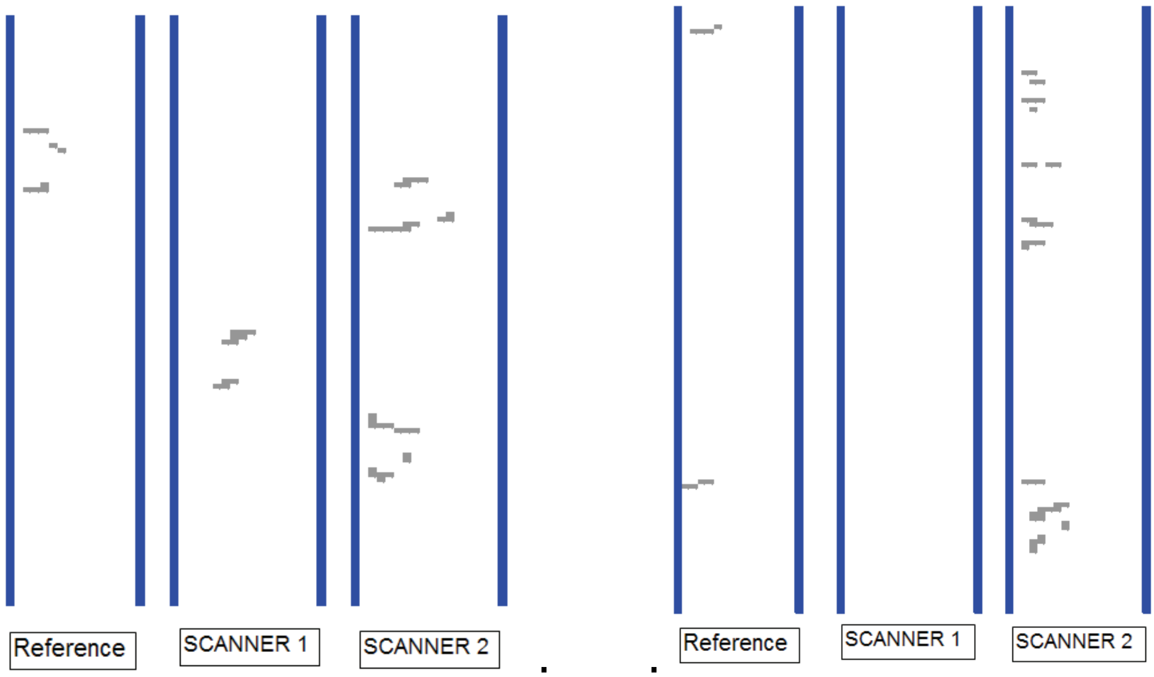


Figure 15: Crack map extracts from the multiple survey site

From the evidence it is therefore apparent that the SCANNER data does not always demonstrate strong agreement with the reference data for the measurement of cracking. There is evidence to suggest that all survey contractors, at various times, both over and under report cracking.

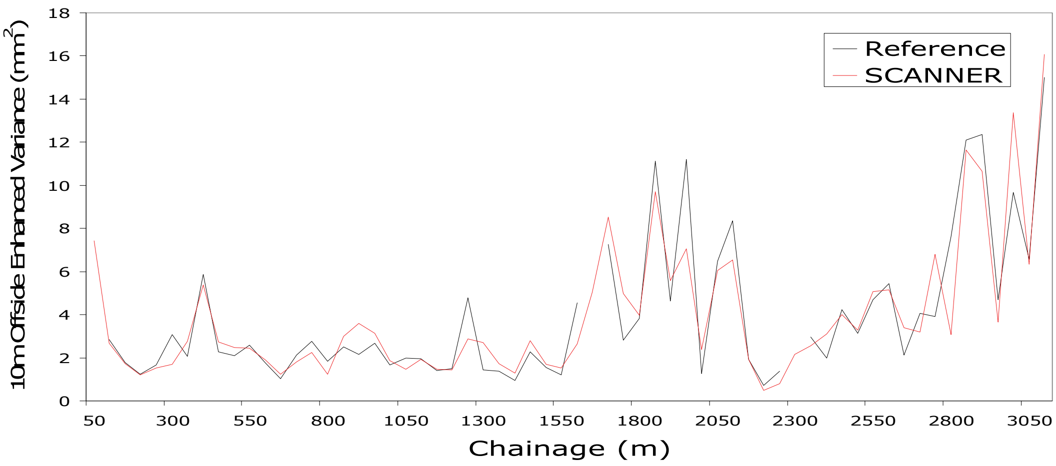
New SCANNER Parameters

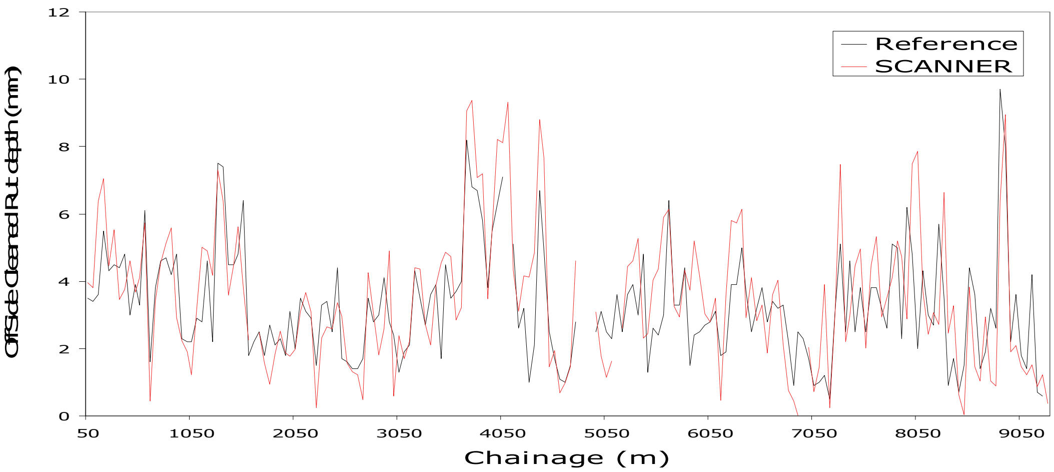
Not all of the new SCANNER parameters have performance requirements defined in the specification. Only the parameters that have specified requirements were statistically assessed for the Auditor's Repeat Surveys. It was found that for these parameters good agreement was generally seen between the survey runs and the performance met (or came close to) the requirements. Figure 16 shows sample data (one from each survey contractor), which demonstrates this high level of reproducibility. Visual assessment of the survey data from the other new SCANNER survey parameters was carried out. The performance of each of these new parameter is discussed below:

- The measurement of longitudinal profile variance in the offside wheelpath was good and generally met the performance requirements.
- The measurement of the bump measure showed that this was not always reproducible.
- The measurement of cleaned rutting showed that there was generally good agreement between the surveys, which usually met (or came close to) the performance requirements. The ARS indicate that the statistical performance is generally slightly higher than that achieved with the normal rut calculation.
- Performance requirements have yet to be specified for the measurement of transverse unevenness and edge roughness. These will be derived from the performance of the SCANNER devices during the 2007/08 accreditation tests and verified using the QA data.
- Two of the survey contractors had difficulty reporting the MPD texture values. It should be noted that the parameter of MPD was not assessed at the 2007/08

accreditation tests because of problems obtaining suitable reference data, which also affected the ability to undertake ARS. However, qualitative visual assessment of the MPD values from the ARS data showed that one survey contractor was reporting values that were an order of magnitude too large and the second survey contractor was reporting large amounts of invalid data. These were reported back to the survey contractors concerned who have since corrected these issues.

- The ARS assessment for the three lines of RMST texture data was being introduced throughout the survey year and hence analysis was not available for all the ARS sites completed. The analysis that was possible showed the two surveys to be generally reproducible. There were occasional localised differences seen, which are so far unexplained and the review of the RMST measurements will be continued in 2008/09.
- The ARS assessment of the three lines of RMST variance, RMS percentiles (5^{th} and 95^{th}) and the RMS variance (all parameters without performance requirements) was being introduced throughout the survey year and hence analysis was not available for all ARS sites completed. The analysis that was possible showed the two surveys to be generally reproducible. There were occasional localised differences seen, which are so far unexplained and the review of the RMST parameters will be continued in 2008/09.
- The measurements of transverse cracking and surface deterioration have no performance requirements and have not been statistically assessed as part of this QA programme. Visual assessment of the data has shown that these parameters are not very reproducible. Cracking data is known to be susceptible to variation between survey runs and devices. It is also thought that these parameters are also very sensitive to the driving line taken by the vehicle and the environmental conditions at the time of the survey.





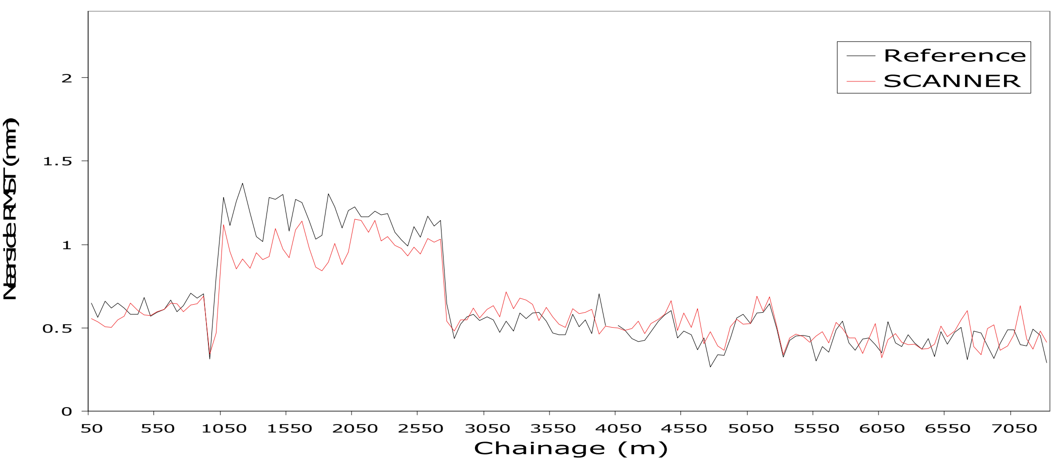


Figure 16: Samples of ARS data (one from each survey contractor) to demonstrate the reproducibility of the new SCANNER parameters. 10m offside enhanced longitudinal profile variance (top), offside cleaned rut depths (middle) and nearside RMST texture measurements (bottom).

7.3 Summary of Repeat surveys

The repeat surveys have found that the survey machines 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 the observed behaviour has shown a need for improvement but it has not been felt appropriate to penalise the survey contractors.

Summary observations include:

- Processing errors were occasionally present on receipt of the data from the survey contractors (fewer occurrences seen this year which suggests there have been improvements in the survey contractor's internal QA processes).
- 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 highway authorities to keep their network definitions as accurate and up to date as possible. However, this also relies on the survey contractors working with the local highway authorities to highlight differences. The easy route of simply stretching data 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 survey contractor about 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 (SMTD) all survey machines were generally performing satisfactorily on the test routes.
- The measurement of the new SCANNER parameter "bump" was not very reproducible
- There were some as yet unexplained differences observed in the measurement of the new SCANNER parameters derived from RMST
- Testing of MPD has not been carried out, but it is expected that this should be comparable with the repeatability of SMTD.
- The cleaned rutting measurement may be more repeatable that standard rutting. However, the algorithm has been shown to sometimes have unpredictable behaviour, leading to significant disagreements with the true level of rutting present.
- The measurement of cracking can vary. Variation in the level of agreement is seen both when comparing repeat runs made by the same machine 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 in the current state of development, and is a subject that requires further improvement.

8 Conclusions and Recommendations

This report has summarised the work carried out by the SCANNER Auditor (TRL) in the 2007/08 survey year. This has included the undertaking of accreditation and quality assurance testing, and the provision of advice to a number of stakeholders, including the Department, local highway authorities and the SCANNER survey contractors.

It is noted that all survey contractors were required to make significant efforts to upgrade their equipment and processing software to accommodate the delivery of the new SCANNER parameters. This process took a lot longer than anticipated and therefore survey contractors may not have had as much time as they would have liked to work on the issues reported in the previous (2006/07) IAPs. Therefore many of the issues seen in the 2006/07 accreditation (and hence included in the 2006/07 IAPs) also appeared in the 2007/08 tests, and so have been carried forward in the 2007/08 IAP.

As described in the preceding sections, many of these issues, including those arising under the advice component of the work, have been resolved or brought to a point such that they do significantly affect the carrying out of SCANNER surveys or the use of the data. However, the work carried out during the 2007/08 year has identified a number of issues that would benefit further investigation. These may be separated into issues related to the survey itself, issues concerning the quality assurance process, and issues associated with the SCANNER data and its use. These are summarised below with, where appropriate, a recommended approach for their resolution.

- **Location referencing**: Achieving good data quality starts at the beginning of the process, with the local highway authority's network definition. Incorrect section lengths, additional unrecorded sections, poor descriptions, lack of nodes and sections that are digitised in opposing directions all affect the quality of survey. The survey contractor will undertake fitting of the SCANNER data to the poorly defined network to ensure that the data will load into UKPMS. This detracts from the value of the data, for identifying lengths for investigation and, in particular, trending. There is a need to review this process, including the methodology for fitting the survey data to the network and defining the network. This could include encouragement of processes that use geographical referencing for section change points, and increased involvement of the local highway authority in the fitting process.
- **Geometry**: The survey machines often fail to meet the requirements for the measurement of radius of curvature (but they do meet the TRACS requirement of curvature). It is recommended that the SCANNER specification be changed to assess the measurement of curvature, rather than radius of curvature.
- **Cracking**: The Quality Assurance tests have highlighted a need for further development work in the measurement of cracking. Primarily, such developments should concentrate on reducing the underlying variability in the crack measurements – ensuring that we can be confident that where SCANNER reports cracking there is cracking, and vice versa.
- **Longitudinal profile**: Notable differences were encountered in the accreditation tests as a result of differences between GM and HRM measurement systems. These were resolved by the application of filters in certain survey vehicles (see Appendix A). It may be appropriate to review filters defined within the specification, to improve consistency across all vehicles.
- **Longitudinal profile**: No concerns have arisen in the measurement of enhanced variance, and this may be a more stable measure than moving average variance. Use of this measure instead of moving average variance should be considered.
- **Longitudinal profile**: There may be concerns over the reproducibility and repeatability of the bump measure. There is a need to consider how this measure should be reported and used by local highway authorities.

- **Transverse profile**: There is evidence to suggest that cleaned rut depths are slightly more reproducible than standard rut depths. However, there have been cases identified where the cleaned rut depths have been reported as significantly higher than the standard rut depths. Further review and comparison of the rutting parameters is recommended, to ascertain whether the cleaned rut depth calculation is more accurate and reliable, or whether further improvements are required, and whether it would be appropriate to switch to cleaned rutting as the primary measure of rutting.
- **Texture profile**: It is recommended that the differences observed between RMST measurements provided by different devices be investigated further, to ensure that this is not a significant problem.

Acknowledgements

The work described in this report was carried out in the Infrastructure Division of the Transport Research Laboratory. The authors are grateful to John Pynn who carried out the technical review and auditing of this report.

References

Halcrow Group (2007), SCANNER Surveys for Local Roads – User guide and Specification Volumes 1-5.

Benbow and A Wright (2008), A31 "Hog's Back" Site Investigation (UPR IE/28/08), Unp*ublished Project Report,* Wokingham, Berkshire: Transport Research Laboratory (TRL).

Benbow and A Wright (2008), Assessment of the Consistency of SCANNER Parameters, RCI and BVPI (PPR 321), P*ublished Project Report,* Wokingham, Berkshire: Transport Research Laboratory (TRL).

Benbow E, Werro P and A Wright (2008), RMST and Texture Variability Measures (UPR/IE/079/07), Unp*ublished Project Report,* Wokingham, Berkshire: Transport Research Laboratory (TRL).

Appendix A SCANNER survey vehicle re-accreditation tests for the 2007/8 survey year

DOCUMENT PREPARED BY	P Werro, Infrastructure Division, TRL
TITLE	SCANNER survey vehicle re-accreditation tests for the 2007/8 survey year - summary
PROJECT	SCANNER Accreditation
PM	A Wright
DATE	5th January 2009
FILE	INF/13E/0225
REQUESTED BY	Andrew Gallagher

1 Introduction

In the 2006/07 survey year seven survey vehicles were awarded SCANNER accreditation. The performance of the measuring systems on these survey vehicles was generally close to or met the requirements of the SCANNER specification.

For the survey year 2007/08 the SCANNER specification was revised to include a requirement to measure a number of additional survey parameters. All survey contractors therefore had to enhance their measurement and/or processing systems to accommodate the new survey parameters. It was also necessary to make enhancements to the SCANNER accreditation process to accommodate testing of the calculation of the new parameters. All machines were required to complete either full accreditation (for new or highly modified vehicles) or re-accreditation (for vehicles where only minor changes had been made since the 2006/7 tests) testing before carrying out SCANNER surveys in the survey year 2007/08.

The SCANNER accreditation tests comprise three sets of tests, undertaken on the Primary Test sites, the Network Routes and the Crack and Rut sites. The Primary sites comprise a number of test sites located on the TRL test track or on the road network close to TRL. The tests on these sites examine the performance of the machines in the measurement of individual survey parameters. The Network routes are located on the road network in the south of England. The tests in these sites examine the performance in the measurement of all the survey parameters (simultaneously). The Network routes also test the ability of the survey crew to follow a defined survey route, and consider the accuracy and compatibility of the processed data. The Crack and Rut sites are located on the UK road network in the south of England and are to used more extensively to examine the performance of the system in measuring cracking and rutting.

The SCANNER re-accreditation tests comprise two sets of tests, undertaken on the Primary Test sites and the SCANNER road routes. The re-accreditation tests consist of similar tests to those applied for the full accreditation, but at a reduced level of intensity. The SCANNER road routes are the same test sites as Network routes 1 & 2 from the full accreditation Network routes. The SCANNER road routes are used for the re-accreditation of the measurement of cracking and rutting. No dedicated crack and rut sites are surveyed during the re-accreditation tests.

For the 2007/8 tests only one survey vehicle undertook full accreditation testing. The remaining six machines undertook re-accreditation testing. However, because of the additional parameters required for the 2007/8 survey all machines undertook a component of full accreditation testing to assess the measurement of any new survey parameters that were not included in the 2006/7 survey. This report summarises the observations made during the accreditation (or re-accreditation) of the seven survey machines in the 2007/08 tests.

As described in the following sections, no machine fully met the requirements of the SCANNER specification. However, it was considered that the shortfall in performance would not severely affect the quality of the SCANNER survey. It was therefore recommended that the machines proceed with the survey, but the operators should consider undertaking improvements, which were formalised in the form of Improvement Action Plans (IAP) for each survey machine. The IAP outlined the areas where it was recommended that the survey contractor improved the performance of the measuring system and also contained a timescale for these improvements to be demonstrated to the auditor.

Three separate survey contractors that own and operate the SCANNER survey vehicles. This report presents a summary of the issues identified in the (re)accreditation tests, without referring to specific survey vehicles. Each survey contractor has been provided with a more detailed report summarising the results obtained for their vehicles.

2 Issues Arising

2.1 Distance Travelled

There were a number of problems identified with the measurement of distance travelled on the TRL test track, which lead to differences between the SCANNER survey vehicles' reported lengths and the reference lengths.

Following discussion with survey contractors, and number of reasons were suggested for these problems:

- The early triggering of the reflective marker posts used to mark the section start points, particularly when turning corners. Upon reprocessing of the data to compensate for this an improved performance was seen on the relevant survey vehicle.
- Incorrect extraction of the survey data – a processing issue.
- Problems on very curved sections - there is one section on the primary test site that is highly curved. This caused problems for some vehicles, which reported section lengths that differed by between 2m and 6m from the reference lengths.
- Distance measurement varying with survey speed (the faster the device surveyed the shorter the distance measured) – which may be associated with "warming up" of the equipment (in particular the tyres).
- Incorrect distance calibration. A distance calibration site is provided at the accreditation tests, and it is recommended that all survey contractors calibrate their systems on this site before commencing the accreditation tests. Incorrectly calibrated distance measurement devices have small but significant consequences for the accuracy of the SCANNER data at a network level. However, SCANNER data is typically stretched or compressed to fit the network. Therefore, assuming all other errors are minimised (i.e. a correctly defined road network and correct recording of section change points), such fitting can help to compensate for calibration errors. Nevertheless, thorough calibration and QA checks of the distance measuring equipment fitted to the SCANNER survey vehicles is considered an essential requirement.

An action was added to the IAP of the lower performing machines to demonstrate a general improvement to the distance measurement systems in next year's accreditation (2008/09).

2.2 OSGR Co-ordinates

The performance of most of the survey machines in the reporting of OSGR co-ordinates on the primary sites met or was very was close to the requirements. A particular improvement in the level of performance was achieved by one survey contractor (when compared to the previous accreditation), who had implemented improvements to their position measurement system (as a requirement of their 2006/07 IAP). As a result of this all of the survey contractor’s now have high quality inertial assisted GPS systems fitted to their survey vehicles, and it is anticipated that these should generally meet the specification requirements for OSGR co-ordinates.

However, for at least two survey vehicles the OSGR co-ordinates on the primary test site (TRL test track) were longitudinally offset from the reference data. These offsets were often small (2-3m) but one offset of up to 11-12m was observed. The survey contractors operating these vehicles were asked to investigate the reasons for these offsets occurring, and to eliminate them.

The measurement of altitude from one survey vehicle was seen to be less accurate than with other devices. An improvement to this level of performance was requested in the IAP.

2.3 Geometry

Gradient

The performance in measuring gradient for all survey machines was generally satisfactory although for one survey machine the “shape” of the data on the site level tests does not follow the reference as well as the others. On the network level tests the machines generally showed a satisfactory performance, but there was some evidence of small bias (~0.5%) between some survey vehicles and/or the reference data. Survey contractors were asked to ensure that the systems are correctly calibrated at all times.

Crossfall

The performance in measuring crossfall was generally satisfactory. The statistical requirements were generally met on both of the SCANNER accreditation road routes.

Radius of Curvature

The performance in measuring radius of curvature did not fully meet the requirements of the specification for all survey vehicles. It was noted that the assessment of radius of curvature is complicated by the rapid changes that occur in this data, and the wide range of measurements. Therefore for these tests we also applied the requirements given in the TRACS contract, which specifies tolerances for the measurement of curvature (=1/radius of curvature), in addition to the radius of curvature. When the measurements were assessed against this requirement (95% of all differences within $0.003m^{-1}$ and $0.0015m^{-1}$ for the primary and secondary sites respectively) most of the SCANNER survey vehicles met the requirements, and hence were deemed to be performing satisfactory.

For one survey vehicle it was noted that some survey runs demonstrated a slightly different behaviour in the middle of the primary test site than was to be expected. This behaviour generally did not affect the performance seen on this site.

One survey vehicle did not meet the requirements for the measurement of radius of curvature (and curvature) on the second SCANNER road route. The second road route is of a much more curved nature than the first road route, and as such is a more demanding test for the equipment, but it is expected that it should be able to meet the requirements for (at least) curvature. Improvements to the measurement of radius (and curvature) were requested for the next year's accreditation (2008/09).

One survey contractor had not truncated the radius of curvature values in the HMDIF file at 2000m as required. This was reported to the survey contractor and subsequently corrected.

2.4 Longitudinal Profile Variance (LPV)

For the 2007/08 SCANNER surveys there have been some changes to the requirements for the measurement of longitudinal profile measurements.

- The measurement of 30m variance is no longer required.
- Measurement is now required in the offside wheelpath.
- Enhanced variance has been included in addition to moving average variance. This is designed to give a more robust measurement of ride quality that better reflect users opinion. The enhanced variance measurements are generally lower in value than moving average variance. In order to have comparable LPV data for the calculation of BVPI's (which require 2 years' survey data), nearside variance is being reported as both moving average and enhanced variance.
- This offside measurement of LPV will be reported as enhanced variance.
- A measurement of bumpiness has been introduced (the bump measure).

On the primary site (TRL test track) the performance of the SCANNER vehicles generally met (or was very close to) the requirements for enhanced variance, but often fell slightly below the requirements for moving average variance. Hence, the performance of the SCANNER vehicles was generally closer to the reference when analysed using the enhanced variance than with the moving average variance. It was also noted that the performance in measuring 3m variance measurement tended to agree with the reference better than at the 10m wavelength. The variance measurements reported by the vehicles in the nearside wheelpath were also closer to the reference values than were observed in the offside wheelpath.

Two survey vehicles were seen to have longitudinal offsets when comparing the LPV data with the reference data on the primary site. One survey vehicle was deemed to have an incorrect distance calibration, and for the other it was felt that the data had been extracted incorrectly. In both cases it merited a request for tighter internal QA controls to be applied by the survey contractors.

For one survey vehicle there was a lower level of performance achieved on the primary test site at higher survey speeds (40, 60 & 80kmh) than at the slower survey speeds (10, 20 & 30kmh). This lower performance was thought to have arisen from differing driving lines being taken at the higher speeds. The survey contractor was reminded of the importance of accuracy and consistency for these tests.

A further survey vehicle also demonstrated a higher level of performance with increased survey speed. However, this was the same device that experienced varying distance measurements with survey speed and it was deduced that these two observations were connected. Therefore it was felt that the IAP requirement for the delivery of improved distance measurement would assist in improving the longitudinal profile measurement.

Most survey vehicles exhibited a small positive bias when comparing their variance measurements to the reference device (the ARRB walking profiler) on the primary site. This bias was more apparent at 3m wavelengths than at 10m wavelengths. The two survey machines that use the HRM method for LPV measurement did not show this bias, and hence demonstrated slightly better agreement with the primary reference. Conversely, the machines that had shown a small bias on the primary site showed better agreement with the reference on road routes, with the HRM devices now showing a small bias. It should be noted that the primary site and the network routes have different reference measurement devices. The reference device on the network routes is the HARRIS1 survey vehicle (which uses a GM measurement method), whereas the ARRB walking profiler (which is an absolute profile measurement system) is used as the reference on the primary site (test track). Following discussion with the Survey contractor operating the HRM systems, it was proposed that the differences between the HRM and GM systems may arise from the use of filters that were being applied to raw profile data to achieve improved agreement with the reference on the primary site. This approach achieved high levels of success on this primary site, but resulted in reduced consistency across the different SCANNER survey vehicles. This highlights a potential issue with the approach taken to the treatment of profile data that requires further investigation.

One benefit of the HRM measurement systems is that they deliver accurate data over the full range of survey speeds. Hence these two vehicles were accredited to deliver LPV at survey speeds down to 5 km/h and were given acceleration/deceleration limits of 3 ms^{-2} for all wavelengths. The remaining (GM) machines were accredited to deliver LPV at survey speeds down to 20 km/h and were given acceleration/deceleration limits appropriate to the range of wavelengths being reported.

It was noted that the effect of deceleration had less effect on the accuracy of the measurement of enhanced variance. Therefore it may be possible (further investigations recommended) that the deceleration limits currently applied to the GM measurement devices could be decreased if enhanced variance replaces moving average variance.

It is noted that LPV is a "key" parameter for the BVPI calculations, and therefore a poorly performing system could significantly effect network level reporting. It is therefore crucial that the performance of the survey machines is not allowed to deteriorate, and the necessary improvements are undertaken, as part of the Improvement Action Plans.

For the 2007/08 SCANNER survey a new survey parameter has been introduced which is calculated from the longitudinal profile data. The new "bump" measure is reported at 10m intervals in the HMDIF files. The survey contractor's calculation of this new measurement (from the raw profile) was checked as part of the accreditation process. It was found that there were differences when comparing the survey contractor's calculation of the bump measure with that of the auditor. Work was undertaken to identify and correct these differences.

2.5 Transverse Profile (Rutting and SCANNER parameters)

All systems rely on the measurement of transverse profile to obtain the rut depths. The transverse profile is processed using a rut depth algorithm to identify and quantify the nearside and offside rut depths. The measurement and processing technique can lead to differences between devices that are not a result of a failure to correctly record the transverse profile, but instead highlight limitations of the rutting algorithm. Hence, for the measurement of nearside rut depths, if a survey vehicle drives too close to the nearside edge of the carriageway this will cause the survey vehicle to measure features present at the edge of the carriageway, which could include the white lines, kerbs and raised banks. The height of these features, if not extracted correctly by the rut algorithm, will be included in the size of rut depth reported. A driving line that is too far from the nearside edge of the carriageway could under-measure the nearside rut depth, but will also lead to the measurement of features present at the offside edge of the carriageway (e.g. cats' eyes, white lines). Added to this is the possibility that slight differences in the calibration of the transverse profile measurement system could affect the underlying measurement.

The assessment of the systems found that, for all survey machines, the performance in measuring rut depths did not fully meet the requirements of the specification. It was felt that this arose from the issues listed above, and the observed differences were not evidence of a significant fault in the measurements of transverse profile. However, one survey vehicle experienced significant problems in matching the reference rut depths to a satisfactory standard. There were also differences seen when comparing this machine to other SCANNER devices. Therefore adjustments to this machine's rut depth measurements were undertaken in order to better match the reference data and the other survey machine's rut depth measurements.

For one survey vehicle problems were observed in the raw transverse profile data. There were some cases where individual transverse profiles showed "erratic" behaviour (e.g. large peaks that were not really present on the pavement). Investigations were carried out by TRL and the survey contractor to reduce the number of these problems until a satisfactory level of performance was obtained. Where the erratic profiles could not be corrected it was agreed that they should be reported as invalid. It is anticipated that the number of these should be such that the coverage requirements are not affected.

The 2007/08 SCANNER survey saw the introduction of new SCANNER transverse profile parameters:

- "cleaned" rut depth
- absolute deviation
- transverse variance
- Edge roughness.

These parameters are calculated after "cleaning" of the transverse profiles has taken place. Cleaning is carried out by identifying the location of the road edge in the transverse profile data and eliminating any part of the transverse profile outside of this edge. The cleaned rut depths are reported in parallel with the normal rut depth measurements in the SCANNER data.

Work was undertaken to ensure that the survey contractor's calculation of the cleaned transverse profile and the derived parameters was correct. Some differences were seen with the cleaned rut depth calculations when comparing the Auditor's and survey contractor's calculations. It was found that the description of how to calculate the road edge (to clean the profile) in the SCANNER specification was unclear. This led to the survey contractors implementing different calculations in their processing software, and hence identifying the road edge in a different place from the auditor. This then affected the calculation of all of the new SCANNER transverse profile parameters. A specification update was issued in order to clarify the road edge calculation. There is currently no statistical requirement for the measurement of the SCANNER transverse profile parameters (absolute deviation, transverse variance and edge roughness). These will be calculated from the analysis of the 2007/08 accreditation tests and introduced for the 2008/09 accreditation tests.

2.6 Surface Texture (SMTD, MPD, RMST and SCANNER parameters)

All survey vehicles met the requirements for the measurement of SMTD. However, although it met the statistical requirements, one survey vehicle provided texture depth values on average 0.1mm lower than the reference values. This did not fail to meet the accreditation requirements because the current version of the specification (2007/08) only contains a requirement for SMTD at the 95% level. To compensate for differences the survey contractor concerned was asked to add 0.1mm to all texture data values before delivery to their clients. However, this is seen as a short term fix. In the long term a demonstration of the correct measurement of surface texture is required, and has again been included in the Improvement Action Plan for this system.

Texture data (SMTD) is also a key parameter for the BVPI calculations and any uncorrected bias could cause a lowering of the texture values, which in turn could have an effect on any calculated BVPI.

This survey year has seen the introduction of the measurement of

- MPD
- Multiple line texture (RMST)

Accreditation of MPD was not completed because of problems confirming the reference data, and therefore accreditation of this parameter was not undertaken for the 2007/08 survey year. It is currently thought that there may be some small differences in how the auditor's reference measurement device (HARRIS) reports the MPD measurements. Investigations are being carried out to resolve this problem.

For the measurement of RMST there are two possible methods currently available;

- Using the "low frequency" transverse profile lasers
- Using the "high frequency" texture lasers

Using the transverse profile lasers to measure RMST means that you can have as many measurement lines for this parameter as the number of transverse profile lasers available (typically 20) and no extra equipment is needed to report these values.

Using the texture profile lasers to measure RMST means that extra texture lasers have to be added to the vehicle in the relevant measurement lines. As well as the extra costs involved, the physical size of the equipment will limit the number of measurement lines available. The specification states that a minimum of three survey lines of RMST data are required. These are the nearside and offside wheelpaths and mid way between the two wheelpaths.

Different RMST measurement methods have both been adopted by the different SCANNER Survey contractors. Two survey contractors (3 survey vehicles in total) have adopted the high-frequency texture laser approach, and one survey contractor has adopted the low frequency transverse profile approach (4 survey vehicles in total). Research has shown that there may be some slight differences between the values of RMST reported by the two different measurement methods. Therefore the reference data was obtained on the test sites using both measurement methods and applied to the accreditation tests as appropriate.

A number of problems were encountered when checking the survey contractor's calculation of RMST and the parameters derived from RMST. TRL worked with the survey contractors to address these issues (in some cases this became a drawn out iterative process). Ultimately the survey contractor's software produced very similar results to the auditor, with occasional small differences. These differences may be due to certain nuances of the individual software packages, e.g. "number rounding", and were not felt to be significant. The issue will be monitored during the QA and 2008/9 accreditation.

2.7 Cracking

Although the above sections highlight some minor differences between the systems, cracking was the survey parameter where the most significant variations in levels were observed. There was evidence of both good and poor reproducibility and repeatability for all survey vehicles on the test sites (e.g. on certain road surfaces). Indeed, on a survey vehicle basis the *repeatability* was generally satisfactory (in that the survey vehicle could generally repeat itself, if not reproduce other survey vehicles or the reference), but some localised differences were observed between the different survey runs.

The amount of cracking reported is known to be susceptible to the level of dampness present on the road surface, and it is possible that localised poor surface condition affected the measurements. It is not yet known if the level of cracking is also susceptible to other environmental issues (e.g. surface temperature). Furthermore, as with rut depths differing driving lines could also be a critical issue.

In the measurement of cracking there will often be differences in the intensity of the cracking reported by the survey vehicle and the reference (obtained by manually analysing the images obtained from HARRIS). These fall into two main categories; over or under reporting of cracking. Over reporting of cracking by the survey vehicle is usually due to the vehicle falsely reporting other surface features as cracking (e.g. fretting, patch edge, drains or covers). This could be improved by better identification (and hence removal) of these features from the crack data. Under reporting the level of cracking is usually due to the survey vehicle either not identifying the cracking at all, or the survey vehicle identifying the cracking and then not delivering the crack data because of a decision made by the vehicle's analysis software to reject the cracking. Work can be undertaken to improve the crack identification software.

The potential for variability between different SCANNER surveys on the same length of road (between survey vehicles and from year to year) could be large. Improvements to the crack identification systems (especially the identification of other road surface features) would help elevate some of these differences, and it was recommended that the survey contractor's concentrate their efforts in this area.

One of the survey contractors has seen some variations in the cracking values reported by its different survey vehicles. This is thought to be an unbalanced lighting issue resulting in less cracking being reported from a section of the image. This means that there are some consistency issues, which will need to be addressed.

Although generally we are still a way off achieving the same level of reproducibility as that achieved for the other survey parameters, progress continues to be made.

This survey year has seen the introduction of:

- Crack map cleaning algorithms
- Transverse cracking
- Surface deterioration features

Tests were undertaken to assess the survey contractor's calculation of these parameters. There were some differences seen with the SCANNER cracking parameters when comparing the survey contractor's survey data with the reference data. During the accreditation process it was found that the description of how to calculate the transverse cracking in the SCANNER specification was unclear. This uncertainty may have led to the survey contractors implementing different calculations in their processing software and reporting a different level of transverse cracking to the auditor. A specification update was issued to clarify the transverse cracking calculation, and all survey contractors are now implementing the algorithms satisfactorily. There is no performance requirement for the measurement of transverse cracking or surface deterioration.

2.8 Data Delivery, Data Processing and Other Issues

The introduction of the new SCANNER survey parameters for the 2007/08 survey year has meant that all parties have had to make some adjustments to their measurement (and processing) systems to accommodate these. These changes were reviewed in two stages:

- Assess the collection of the raw data
- Assess the processing of this data to produce the derived survey parameters

The delivery of the raw data to the Auditor was frequently quicker than seen in previous years. This could, in part, be attributed to the introduction of a new accreditation timetable for the 2007/08 survey year. This new timetable has strict deadlines in which to deliver the data to the Auditor and will not allow vehicles to survey past these dates without achieving accreditation.

For one survey contractor some of the survey parameters in the raw condition data (RCD) file were occasionally offset from the other parameters by a few metres. This highlights a software fault in the RCD file generation that needs resolving.

Another survey contractor delivered data files that contained no data at the start of the slow speed surveys. This was due to the collection lasers being switched off at slow speeds (for safety reasons). This is to be reviewed and procedures implemented to ensure full data collection is possible in future accreditation tests.

The accreditation of the calculation of the new derived parameters by the survey contractors took longer to implement than was originally expected. Therefore it was decided to allow the survey contractors to undertake SCANNER surveys once the collection of the raw survey data was proved to be satisfactory, even though they could not accurately calculate the new derived SCANNER parameters. The adjustments required to achieve this were to be in the processing software and hence these changes could be introduced at any time after the survey had been carried out, but before the data was processed and delivered.

In SCANNER the data processing encompasses a number of areas, specifically this includes, processing of the survey data to generate RCD to the required format and accuracy, and fitting of the data to the network and generation of HMDIF. Two survey contractors followed this approach, using their own versions of the (previous) Machine Survey Pre-processor (MSP) to obtain HMDIF from the RCD. The third survey contractor generally generated fitted HMDIF directly from their survey data, without the routine generation of RCD. However, this survey contractor can deliver RCD when required, at the same time as HMDIF. This is an enhancement from last year, where a separate run would need to be carried out in order to produce an RCD file.

The SCANNER specification defines procedures for data fitting. This includes the ability to fit SCANNER survey data using OSGR co-ordinates. For the accreditation tests the network routes were supplied with OSGR co-ordinates for some of the section start points, exactly for this purpose. One survey contractor has been awarded accreditation for OSGR fitting. It is believed the other two survey contractors are working towards this.

As with last year there were some instances seen of poor "housekeeping". These involved data files containing no data for certain parameters. This demonstrates the need to ensure that QA procedures are enforced (and regularly updated) for data processing systems.

3 Conclusions

The performance of the survey vehicles at the SCANNER accreditation has generally met (or come close to) the SCANNER specification requirements. Although there are some differences between the systems, these should not be taken as an indication of generally poor data, as the differences are often small and the systems have been assessed against a demanding specification. However, to meet the highest levels of accuracy, it is desirable that ongoing improvements be implemented. Survey contractors have been issued with Improvement Action Plans (IAP) for this purpose. The above sections have reported where such improvements have been requested.

For the survey year 2007/08 the SCANNER specification was revised to require all survey vehicles to measure a number of new SCANNER survey parameters. All survey contractors made significant efforts to upgrade their equipment and processing software to accommodate these changes. This process took a lot longer than anticipated. Because the survey contractors spent a lot of time and effort implementing the new SCANNER measurements for this survey year (2007/08), they may not have had as much time as they would have liked to work on the issues reported in the previous (2006/07) IAPs. Therefore many of the issues seen in the 2006/07 IAPs have been carried forward to the 2007/08 IAP.

Appendix B Survey contractor’s Repeat Survey performances

Parameter	Target	Range	Measured Performance (%)															
			Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16
Section Lengths	65% horizontal errors	±5m or 0.1%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Section Start – OSGR co-ordinates	65% horizontal errors	±5m	N/A	33.3	87.5	0.0	33.3	62.5	33.3	50.0	37.5	50.0	100	16.7	50.0	80.0	100	47.4
OSGR co-ordinates	65% horizontal errors	±7m	0.0	47.8	94.6	17.2	51.6	68.8	34.9	55.9	77.9	58.2	99.3	56.3	95.1	86.5	85.0	79.1
Altitude	65% differences	±5m	100	100	99.5	100	100	82.4	100	100	78.0	100	100	100	100	100	100	100
Gradient	65% differences	±1.5% or 10%	90.3	99.5	100	100	95.2	99.4	99.1	100	95.8	99.5	100	100	100	100	100	99.7
Crossfall	65% differences	±1.5% or 10%	87.2	98.5	99.0	100	95.7	95.7	95.3	98.3	97.3	99.5	100	99.3	100	99.0	97.4	98.6
Radius of Curvature	65% differences	±50m or 25%	57.0	65.0	55.7	46.1	31.7	26.8	28.4	27.3	64.4	58.3	84.3	43.2	66.1	30.0	37.0	37.8
LPV- 3m NS moving average	65% fractional errors	±0.6	88.0	89.9	96.5	95.1	85.6	90.2	85.6	90.7	95.8	81.3	98.4	93.7	93.1	91.0	89.4	94.2
LPV- 10m NS moving average	65% fractional errors	±0.7	89.9	95.0	97.5	98.1	89.9	98.2	88.4	95.3	95.2	90.9	98.8	97.8	96.8	97.5	94.9	97.3
LPV- 3m NS Enhanced	65% fractional errors	±0.6	78.7	89.4	97.0	92.7	87.0	90.2	87.0	89.0	89.7	92.5	96.7	95.9	93.1	88.5	91.2	92.4
LPV- 10m NS Enhanced	65% fractional errors	±0.7	86.8	93.5	96.0	96.6	90.4	94.5	87.9	94.2	94.9	78.6	97.5	96.7	96.3	96.5	93.4	96.6
LPV- 3m OS Enhanced	65% fractional errors	±0.6	90.7	85.9	98.5	96.6	82.2	91.5	95.3	88.4	77.0	94.7	98.0	97.8	99.1	98.0	89.7	96.9
LPV- 10m OS Enhanced	65% fractional errors	±0.7	91.9	91.0	99.5	99.0	85.6	93.3	96.7	97.1	74.0	96.3	99.2	94.4	98.2	97.0	94.9	92.4
NS Rut depths	65% differences	±3mm	86.4	95.0	98.5	99.0	86.5	94.5	90.7	95.3	82.5	87.2	90.6	91.1	91.7	91.5	93.8	93.1
OS Rut depths	65% differences	±3mm	98.8	98.5	99.5	97.6	98.1	98.8	96.3	97.1	94.9	98.4	98.4	97.4	98.2	98.0	98.9	99.7
NS Cleaned Rut depths	65% differences	±3mm	91.5	91.5	99.0	99.5	89.4	98.8	95.8	90.7	75.2	92.5	97.5	87.0	98.2	93.5	96.3	96.9
OS Cleaned Rut depths	65% differences	±3mm	98.4	97.0	99.5	99.5	96.2	100	94.9	96.5	92.1	97.3	98.4	98.1	98.6	85.0	97.1	99.7
Texture -SMTD	65% differences	±0.25mm	95.3	97.5	97.5	98.5	98.6	99.4	99.5	98.2	97.0	90.3	99.6	98.9	96.3	89.4	97.8	100
Texture- MPD	65% differences	±0.25mm	85.6	95.5	92.0	95.1	94.2	91.4	98.6	97.7	93.0	79.0	97.9	97.4	90.8	88.4	94.9	96.6
Texture- NS RMST	65% differences	±0.25mm	100	99.0	100	100	100	100	100	99.4	96.4	89.8	100	99.3	100	96.5	100	100
Texture- Mid RMST	65% differences	±0.25mm	99.2	100	100	100	99.0	100	100	99.4	90.3	96.8	100	95.1	100	100	99.6	100
Texture- OS RMST	65% differences	±0.25mm	100	99.5	100	100	100	100	100	100	99.1	100	100	100	100	99.0	100	100
Cracking Intensity- Low level	Agreement	70%	86.8	98.6	93.3	63.7	88.5	86.3	89.7	88.7	96.9	85.4	98.2	79.0	100	90.1	87.4	95.0
Cracking Intensity High Level	Agreement	70%	N/A	25.0	50.0	41.7	52.0	57.9	65.4	33.3	50.0	N/A	50.0	28.1	53.8	59.1	43.8	74.3

Parameter	Target	Range	Measured Performance (%)															
			Site 17	Site 18	Site 19	Site 20	Site 21	Site 22	Site 23	Site 24	Site 25	Site 26	Site 27	Site 28	Site 29	Site 30	Site 31	Site 32
Section Lengths	65% horizontal errors	±5m or 0.1%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Section Start – OSGR co-ordinates	65% horizontal errors	±5m	100	50.0	94.7	69.2	38.5	53.1	66.7	48.4	62.5	75.0	100	32.5	42.9	64.4	81.8	47.4
OSGR co-ordinates	65% horizontal errors	±7m	98.7	61.9	87.7	71.0	66.8	50.3	90.1	87.2	92.9	86.9	100	24.7	55.5	84.0	88.1	54.5
Altitude	65% differences	±5m	100	100	95.5	100	94.7	94.9	100	80.6	100	99.8	100	100	100	100	100	100
Gradient	65% differences	±1.5% or 10%	98.5	98.8	99.7	99.6	100	95.4	99.0	100	99.0	100	100	88.1	100	100	100	97.2
Crossfall	65% differences	±1.5% or 10%	98.0	97.9	97.9	98.9	98.8	93.5	99.0	99.0	100	100	100	87.3	100	100	100	96.4
Radius of Curvature	65% differences	±50m or 25%	53.2	75.6	23.1	51.5	42.0	29.0	25.2	81.3	78.7	60.0	70.2	24.6	39.0	41.7	37.1	60.5
LPV- 3m NS moving average	65% fractional errors	±0.6	94.6	80.2	94.9	80.1	92.6	87.6	92.1	94.2	96.9	98.1	86.8	79.9	93.0	91.2	94.4	95.7
LPV- 10m NS moving average	65% fractional errors	±0.7	99.0	90.1	98.2	90.4	96.9	94.0	99.0	98.1	99.0	99.4	90.7	84.8	97.1	95.3	97.3	96.8
LPV- 3m NS Enhanced	65% fractional errors	±0.6	98.5	89.7	99.4	80.5	94.2	87.6	88.6	98.1	96.9	97.4	92.7	82.0	93.0	94.7	94.9	91.3
LPV- 10m NS Enhanced	65% fractional errors	±0.7	96.1	83.1	96.1	83.8	96.9	92.2	96.5	94.2	96.9	98.7	88.7	82.8	93.4	95.3	94.9	96.4
LPV- 3m OS Enhanced	65% fractional errors	±0.6	98.5	92.6	96.1	94.5	95.7	86.2	94.6	99.0	98.0	96.4	93.4	77.5	97.8	97.7	98.9	94.1
LPV- 10m OS Enhanced	65% fractional errors	±0.7	98.5	95.5	97.6	95.2	96.9	89.4	99.5	95.2	98.0	99.4	96.0	82.8	98.2	97.7	95.5	95.3
NS Rut depths	65% differences	±3mm	93.1	88.8	95.5	94.5	93.0	94.0	97.5	92.3	94.9	93.5	96.0	94.3	93.8	98.2	94.9	93.7
OS Rut depths	65% differences	±3mm	97.0	95.9	98.2	100	99.6	98.2	96.5	100	100	96.1	97.4	96.7	98.2	100	96.1	99.2
NS Cleaned Rut depths	65% differences	±3mm	98.0	96.3	97.6	98.5	98.8	95.9	90.6	100	95.9	98.1	98.7	96.7	95.6	99.4	95.5	95.3
OS Cleaned Rut depths	65% differences	±3mm	90.1	94.6	81.7	99.3	98.8	99.1	70.3	100	100	83.9	96.7	94.7	99.3	99.4	98.9	98.4
Texture -SMTD	65% differences	±0.25mm	100	95.4	98.2	96.3	96.5	92.6	98.5	99.0	98.0	98.1	98.7	92.6	99.6	96.5	98.9	99.6
Texture- MPD	65% differences	±0.25mm	97.5	88.4	95.2	88.9	94.5	89.4	88.1	100	96.9	97.4	96.7	83.5	96.7	94.1	95.5	94.0
Texture- NS RMST	65% differences	±0.25mm	96.5	99.6	97.0	98.5	99.6	98.6	91.0	100	98.0	97.4	99.3	97.9	99.6	99.4	99.4	100
Texture- Mid RMST	65% differences	±0.25mm	100	99.2	100	100	100	100	100	100	100	98.7	100	97.9	100	100	100	99.2
Texture- OS RMST	65% differences	±0.25mm	100	98.3	99.4	99.6	99.6	99.1	97.0	100	100	98.7	98.7	97.9	100	99.4	100	99.6
Cracking Intensity- Low level	Agreement	70%	98.5	95.8	91.2	79.0	88.6	96.1	84.9	N/A	N/A	98.5	91.3	N/A	97.3	93.1	89.8	100
Cracking Intensity High Level	Agreement	70%	N/A	N/A	60.5	50.0	63.0	30.8	61.1	N/A	N/A	100	6.3	N/A	11.8	76.2	65.0	N/A

Parameter	Target	Range	Measured Performance (%)															
			Site 33	Site 34	Site 35	Site 36	Site 37	Site 38	Site 39	Site 40	Site 41	Site 42	Site 43	Site 44	Site 45	Site 46	Site 47	
Section Lengths	65% horizontal errors	±5m or 0.1%	100	100	100	100	100	100	100	100	100	100	87.5	93.8	100	100	100	
Section Start – OSGR co-ordinates	65% horizontal errors	±5m	48.4	36.0	77.8	100	100	98.4	87.5	80.0	66.7	100	87.5	93.8	100	100	100	
OSGR co-ordinates	65% horizontal errors	±7m	56.0	35.3	91.7	100	100	99.7	98.4	97.1	100	100	89.8	100	100	99.9	100	
Altitude	65% differences	±5m	92.9	97.6	100	100	100	100	100	100	100	100	100	100	100	100	100	
Gradient	65% differences	±1.5% or 10%	100	97.9	99.8	100	100	100	100	100	100	100	100	100	100	100	100	
Crossfall	65% differences	±1.5% or 10%	100	95.1	97.1	100	100	99.0	99.8	100	100	100	96.1	100	100	98.8	100	
Radius of Curvature	65% differences	±50m or 25%	62.0	29.8	34.1	72.6	82.6	67.3	69.4	83.7	80.9	70.4	79.2	85.5	75.2	80.8	76.7	
LPV- 3m NS moving average	65% fractional errors	±0.6	99.3	95.3	93.8	93.2	89.1	94.2	95.9	96.5	97.3	91.6	84.8	89.8	100	97.0	97.9	
LPV- 10m NS moving average	65% fractional errors	±0.7	97.5	92.5	95.2	98.3	89.1	97.1	97.8	97.7	98.9	95.8	89.4	98.9	100	98.2	100	
LPV- 3m NS Enhanced	65% fractional errors	±0.6	100	98.1	93.8	90.3	90.2	94.2	96.1	97.7	97.9	88.8	80.5	90.0	96.3	96.4	97.3	
LPV- 10m NS Enhanced	65% fractional errors	±0.7	99.8	95.1	95.6	98.4	90.2	95.1	97.8	94.8	97.9	92.2	87.9	95.7	100	98.2	99.9	
LPV- 3m OS Enhanced	65% fractional errors	±0.6	99.1	97.2	90.0	96.7	96.7	91.3	97.4	97.7	98.9	95.2	93.9	98.9	98.1	97.6	98.6	
LPV- 10m OS Enhanced	65% fractional errors	±0.7	98.4	94.9	94.1	100	96.7	96.1	98.7	97.7	98.9	93.4	93.9	98.9	100	100	97.9	
NS Rut depths	65% differences	±3mm	98.6	91.6	87.3	100	100	99.0	97.8	99.4	98.9	95.3	89.5	94.9	100	93.3	89.6	
OS Rut depths	65% differences	±3mm	98.4	98.4	98.0	100	100	100	99.2	96.5	94.7	98.2	85.5	96.5	100	98.2	99.3	
NS Cleaned Rut depths	65% differences	±3mm	97.7	93.0	90.5	100	100	98.1	94.0	95.9	97.3	98.2	84.0	70.7	98.1	93.9	88.0	
OS Cleaned Rut depths	65% differences	±3mm	99.3	98.4	96.1	100	96.5	100	99.2	95.9	94.1	96.9	84.0	96.4	100	97.0	99.3	
Texture -SMTD	65% differences	±0.25mm	99.8	92.6	96.1	100	95.6	99.0	99.1	95.9	100	100	85.5	98.4	99.1	99.4	100	
Texture- MPD	65% differences	±0.25mm	99.8	95.0	93.8	3.3	87.9	24.5	96.5	93.0	99.5	95.9	75.0	95.5	15.6	96.4	96.6	
Texture- NS RMST	65% differences	±0.25mm	100	97.9	99.3	100	96.7	100	99.1	97.1	99.5	100	100	100	100	100	100	
Texture- Mid RMST	65% differences	±0.25mm	100	96.7	100	100	98.9	100	99.6	98.8	98.9	99.4	100	100	N/A	N/A	100	
Texture- OS RMST	65% differences	±0.25mm	100	96.5	99.3	100	97.8	100	99.3	100	100	100	100	100	N/A	N/A	100	
Cracking Intensity- Low level	Agreement	70%	93.2	N/A	N/A	83.7	92.6	90.8	85.3	90.7	92.1	81.3	74.4	76.7	82.9	85.7	94.2	
Cracking Intensity High Level	Agreement	70%	38.8	N/A	N/A	62.5	54.5	66.7	55.4	66.7	28.3	21.1	40.0	64.7	38.5	47.4	15.4	

Appendix C Auditor's Repeat Survey performances

Parameter	Target	Range	Measured Performance (%)															
			Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16
Section Lengths	65% horizontal errors	±5m or 0.1%	N/A	50.0	80.0	16.6	44.4	37.5	80.0	100	66.7	100	55.0	50.0	8.7	27.3	N/A	8.2
Section Start – OSGR co-ords	65% horizontal errors	±5m	N/A	N/A	66.7	100	33.3	71.4	70.0	100	0	100	5.0	35.7	70.6	66.7	N/A	25.1
OSGR co-ordinates	65% horizontal errors	±7m	76.5	71.1	89.0	93.8	66.1	90.1	93.5	87.0	20.3	76.1	43.2	75.3	90.1	84.0	66.5	80.7
Altitude	65% differences	±5m	N/A	14.8	100	N/A	100	100	N/A	N/A	N/A	29.0	64.0	44.8	70.1	66.9	70.1	94.7
Gradient	65% differences	±1.5% or 10%	97.6	88.7	94.5	88.8	96.6	98.3	94.4	100	91.9	90.3	91.7	80.9	97.9	94.5	91.0	88.8
Crossfall	65% differences	±1.5% or 10%	98.8	80.6	95.9	90.8	95.9	94.9	91.7	93.3	91.9	87.1	100	83.7	96.8	95.6	91.5	86.5
Curvature	65% differences	±50m or 25%	52.2	27.4	15.1	30.6	37.2	55.9	36.1	53.3	35.1	41.9	25.0	20.2	46.6	29.7	32.0	23.6
LPV- 3m NS moving av	65% fractional errors	±0.6	87.4	88.7	84.9	78.6	81.4	93.2	69.4	80	70.3	80.6	91.7	83.7	84.7	76.9	84.5	76.7
LPV- 10m NS moving av	65% fractional errors	±0.7	88.5	96.0	95.9	79.6	93.1	94.9	83.3	80	83.8	74.2	87.5	83.7	91.0	73.6	89.0	85.7
LPV- 3m NS Enhanced	65% fractional errors	±0.6	90.1	69.4	86.3	78.6	81.4	96.6	77.8	93.3	78.4	87.1	83.3	80.9	84.7	67.0	83.5	74.0
LPV- 10m NS Enhanced	65% fractional errors	±0.7	90.9	95.2	91.8	77.6	86.2	94.9	80.6	83.3	81.1	77.4	91.7	84.3	86.8	80.2	88.5	83.0
LPV- 3m OS Enhanced	65% fractional errors	±0.6	91.7	84.7	83.6	86.7	95.2	89.8	80.6	86.7	81.1	90.3	87.5	96.1	88.4	80.2	91.5	82.1
LPV- 10m OS Enhanced	65% fractional errors	±0.7	89.3	87.9	87.7	87.8	94.5	96.6	83.3	96.7	83.8	96.8	91.7	92.7	95.2	87.7	89.0	86.1
NS Rut depths	65% differences	±3mm	91.7	95.1	93.2	91.1	41.4	94.9	80.0	82.8	80.6	86.7	91.7	94.4	93.7	92.3	97.5	86.9
OS Rut depths	65% differences	±3mm	92.5	96.8	97.3	100	80.7	96.6	88.9	86.7	89.2	90.3	95.8	98.3	94.7	94.5	89.0	97.8
NS Cleaned Rut depths	65% differences	±3mm	84.6	80.2	79.5	100	84.8	100	77.8	89.7	78.4	96.8	100	87.1	93.1	95.6	96.4	91.5
OS Cleaned Rut depths	65% differences	±3mm	94.1	95.6	94.5	98.9	96.6	100	88.9	86.2	89.2	83.9	95.8	98.3	94.2	92.3	100	97.8
Texture -SMTD	65% differences	±0.25mm	90.9	98.4	98.3	92.8	97.9	91.5	97.1	100	97.2	100	95.7	97.7	84.0	86.8	95.5	93.2
Texture- RMST*	65% differences	±0.25mm	N/A	N/A	N/A	N/A	95.1	N/A	97.1	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cracking Intensity-Low	Agreement	70%	80.4	83.2	82.5	85.4	N/A	79.1	78.6	78.3	92.9	91.3	88.2	78.8	N/A	83.8	84.4	79.5
Cracking Intensity High	Agreement	70%	36.4	33.3	N/A	70	N/A	0	0	0	25.0	25.0	50.0	25.0	N/A	50.0	0	40.7

* The assessment of RMST for the ARS was being implemented throughout the survey year and hence analysis from all ARS sites for 2007/08 was not possible. The assessment will be fully available for the 2008/09 survey year.

SCANNER accredited surveys on local roads in England – accreditation, QA and audit testing – annual report 2007-08

The Department for Transport has appointed TRL as independent Auditor, to provide the quality assurance services defined in the SCANNER specification. TRL has carried out accreditation testing, quality audits, and provided independent advice and consultancy services to survey contractors, local highway authorities and the Department for Transport in relation to accredited SCANNER surveys carried out on the English local road network.

In addition to the SCANNER survey of the English local road network, further surveys are carried out on the Scottish local road network under a single survey contract and the Welsh Principal Road Network under a further contract. The work carried out in Scotland and Wales is fundamentally similar to SCANNER and has a similar requirement for Quality Assurance testing. TRL was requested to apply the SCANNER Quality Assurance procedures to the Scottish surveys and Welsh surveys in 2007/08.

This report summarises the results of the accreditation testing and quality audits carried out by TRL in England, Scotland and Wales in 2007/08, and also summarises the advice and consultancy provided during the year.

Other titles from this subject area

PPR205 Early life skid resistance – an assessment of accident risk. M J Greene and L Crinson. 2008

PPR315 Measuring skid resistance without contact. A Dunford. 2008

PPR299 Automated detection of fretting on HRA surfaces. S McRobbie and G Furness. 2008

PPR253 Investigation of the effects of pavement stiffness on fuel consumption. E Benbow, J Iaquinta, R Lodge and A Wright. 2008

PPR304 Recycled asphalt in surfacing materials: a case study of carbon dioxide emission savings. I Schiavi, I Carswell and M Wayman. 2008

TRL
Crowthorne House, Nine Mile Ride
Wokingham, Berkshire RG40 3GA
United Kingdom
T: +44 (0) 1344 773131
F: +44 (0) 1344 770356
E: enquiries@trl.co.uk
W: www.trl.co.uk

Published by

IHS
Willoughby Road, Bracknell
Berkshire RG12 8FB
United Kingdom
T: +44 (0) 1344 328038
F: +44 (0) 1344 328005
E: trl@ihs.com
W: http://emeastore.ihs.com

Price code: 3X

ISSN 0968-4093

ISBN 978-1-84608-775-2

9 781846 087752

PPR388