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SCANNER accredited surveys on local roads in England – accreditation, QA and audit testing – annual report 2009–10

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Transport Research Laboratory

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SCANNER accredited surveys on local roads in England - accreditation, QA and audit testing - annual report 2009-10

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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 in 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 by an independent auditor).

The Department for Transport appointed TRL as the 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 survey of the English local road network, SCANNER surveys are carried out on the Scottish, Welsh and Northern Irish local road networks under separate survey contracts. TRL was requested to apply the SCANNER Quality Assurance procedures to the Scottish, Welsh and Northern Irish surveys during 2009/10.

This report summarises the results of the accreditation testing and quality audits carried out by TRL in England, Scotland, Wales and Northern Ireland in 2009/10, and also summarises the advice and consultancy provided during the year.

The performance of the survey vehicles at the SCANNER accreditation generally met (or came sufficiently 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 further improvements be made. For this purpose TRL issued Improvement Action Plans with the accreditation certificates to the survey contractors.

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 2009/10 survey year advice was 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 sufficiently that they do not significantly affect the carrying out of SCANNER surveys or the use of the data.

The repeat surveys undertaken by TRL showed that the survey devices have either generally met the required levels of performance, or performed within the levels that were expected. In particular the measurement of the profile parameters (texture, rut depth and variance) has been highly repeatable and reproducible. For the measurement of location and of cracking the observed behaviour has shown the need for further improvement.

Although many issues were resolved, the work carried out during 2009/10 identified a number that would benefit from 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 their 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 initially stimulated by concerns about the consistency and reliability 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 automated condition surveys could replace visual condition surveys for the purposes of national performance monitoring of carriageway surface condition.

Therefore, for the financial Year 2004/05 the Department for Transport identified the 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) for the condition of the Principal Road Network. From April 2005 the DfT extended the survey to other classified roads. For this extended survey the original 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 that previously developed for TRACS and TTS surveys.

SCANNER surveys are currently 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 National Indicators (NI) for road condition NI168 (condition of principal roads) and NI169 (condition of other classified roads) in England. In order to generate these indicators, the SCANNER data must be provided by an accredited machine that complies with the requirements of the SCANNER Surveys for Local Roads Specification (UK Roads Board, 2009), hereafter referred to as the SCANNER specification. All survey devices to be used to produce the National Indicators 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 are 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. Like 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. From the 2008/09 survey year onwards the project has included the audit of the Scottish, Welsh and Northern Ireland road condition surveys. In addition to auditing, TRL provides advice to both local and national governments.

This report summarises the results of the accreditation testing and audits of the SCANNER survey contractors carried out during the 2009/10 survey year. The report also identifies the key issues that arose during the year and summarises the advice and guidance that was provided by TRL.

The 2009/10 survey year is the final full SCANNER survey year to be covered by TRL as SCANNER auditor under this project. Therefore a summary is also presented of the issues still outstanding at the end of the project.

2 Accreditation

2.1 The process

Since the commencement of the survey, SCANNER surveys have been carried out using traffic-speed devices that report the geographical position of the measurements, 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 rut depth, which is derived from the measurement of transverse profile).

Full SCANNER accreditation (undertaken for a new measurement device) comprises three sets of tests, undertaken on the Primary Test sites, the Network Routes, and the Crack and Rut sites. The Primary Test 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 SCANNER 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 used to examine more extensively the performance of the system in measuring cracking and rut depth.

SCANNER re-accreditation testing is undertaken by devices that have previously been accredited using the above tests. Re-accreditation testing is 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 with a reduced extent. In particular, no dedicated crack and rut sites are surveyed during the re-accreditation tests. Instead, these parameters are assessed on the Network Routes.

A more detailed description of the accreditation process is provided in the SCANNER Specification (UK Roads Board, 2009).

2.2 Revisions for 2009/10

Feedback from SCANNER survey contractors on the accreditation process highlighted concerns about the level and the timing of information provided during the period of testing on the progress of the accreditation. TRL therefore reviewed and improved the reporting procedures applied during the accreditation/reaccreditation process. Under the new procedures TRL delivers a formal progress report each week during the data analysis reviewing period (seven weeks for accreditation and four weeks for reaccreditation). The amount of information in the report increases each week as further data analysis is completed by the Auditor. By the end of the reporting period a final report is completed.

This procedure helps to keep survey contractors regularly informed of the progress of the assessment and provides details of any issues that may arise.

2.3 2009/10 Testing and issues arising

In the 2008/09 survey year there were eight survey devices with SCANNER accreditation certificates. These were all submitted for re-accreditation in 2009/10. In addition three brand new survey devices were also submitted for (full) SCANNER accreditation. All eleven SCANNER survey devices successfully gained accreditation for the survey year 2009/10:

- WDM RAV4 (re-accredited in February 2009)
- WDM RAV1 (re-accredited in May 2009)
- WDM RAV2 (re-accredited in May 2009)
- WDM RAV6 (newly accredited from May 2009)
- WDM RAV7 (newly accredited from June 2009)
- WDM RAV3 (re-accredited in July 2009)
- Yotta ARAN1 (re-accredited in July 2009)
- WDM RAV5 (re-accredited from August 2009)
- WDM RAV8 (newly accredited from September 2009)
- Jacobs RST26 (re-accredited in November 2009)
- Yotta ARAN2 (re-accredited in December 2009)

The SCANNER specification defines the performance requirements for the measurement of each survey parameter. Occasionally the survey vehicle is not able to satisfy these requirements in full. Where it is determined that this would not have a significant effect on the performance of the survey or the results, an accreditation certificate is issued together with an Improvement Action Plan (IAP). An IAP was issued for each survey vehicle in the 2009/10 accreditation tests, which specified the particular areas identified for improvement, and recommended timescales for the delivery of the improvements. The new style reporting process (outlined above) combined an accreditation report and the IAP in a single document.

The main issues highlighted in the IAPs in the 2009/10 accreditation tests are summarised below. Most vehicles had only a few issues - this list combines all the issues from all the vehicles:

- Distance measurement – variability in the reported distance associated with survey speed or geometry of the site
- OSGR co-ordinates – “drifting” of measurements on some sites
- Geometry data – evidence of calibration error and noise
- Longitudinal Profile Variance (LPV) – poor performance on some sites by some devices
- Transverse profile
    - Rut depth measurements - localised differences (greater than the specified requirements) between devices and between devices and the reference
    - New parameters (transverse unevenness and edge roughness) - differences (greater than the specified requirements) between devices and between devices and the reference
- Texture
    - Bias present in SMTD measurements
- Cracking – poor repeatability and reproducibility

The following paragraphs discuss, in detail, the issues identified during the accreditation/reaccreditation programme in the 2009/10 survey year. All the issues have been reported to the survey contractors concerned and some of them (the more important) issues have already been rectified. The remainder have been included in ongoing Improvement Action Plans (IAPs) for the vehicles.

Distance measured

Although the performance of the SCANNER devices was generally satisfactory they occasionally exhibit some problems in the measurement of distance on the site level tests.

Some devices showed evidence of the distance measurement altering slightly with differing survey speeds and/or time. One device reported different section lengths depending on the survey speed. Other devices appeared to vary the distance measured with time (small steady changes over the duration of the site level tests). One theory behind this particular variation in the measurement is that the site level tests are often carried out from “cold”, and as the tests progress the vehicle’s wheels and tyres warm up. This warming of the wheels might affect the distance measured by the devices (the distance encoders are connected to the vehicle wheels). Further investigation would be required to fully understand this behaviour.

Some devices demonstrated a lower level of repeatability on the more curved sections of the site level tests and when braking (when negotiating some corners).

OSGR co-ordinates

The vast majority of survey runs undertaken by the SCANNER devices demonstrated a good level of performance. All survey devices now have high grade inertial corrected dGPS measurement systems.

Occasionally it was seen that data drifted away from the reference on both the site level tests and Network routes. This was thought to be due to poor GPS satellite availability at the time of the survey.

Road Geometry

Gradient
The measurements from one device did not follow the “shape” of the reference as well as the other devices. There was some evidence of a small bias between some devices and the reference (and between the devices themselves). This is most likely to be due to slight differences in the calibrations.

Crossfall
There was some evidence of a small bias between some devices and the reference (and between the vehicles themselves). Again this is most likely to be due to slight differences in the calibrations.

Radius of Curvature
The requirements for the measurement of radius of curvature have often been difficult to meet and hence the assessment for 2009-10 was undertaken using the measurement of curvature.

It was occasionally found that the data from some of the devices was “noisy”, which sometimes led to a reduced level of repeatability.

It was found that, although the devices performed better against the reference standard when assessed using the curvature measurement (rather than radius of curvature), they often did not fully meet the requirements on the more difficult (curved) network level test site. This has led to some uncertainty as to how the average of the radius of curvature values is calculated. For example a relatively straight road can have a radius of curvature of -2000m or +2000m. It is often the case that the device will "flip" between these positive and negative values when on a straight road. The average of +2000 and -2000 is zero, which is a very tight radius of curvature. As the device is on a straight road a value of zero would be inappropriate and hence a logical decision (e.g. choosing either -2000 or +2000m) would need to be taken to ensure a consistent measure. The SCANNER specification does not define how the contractor should deal with these occurrences (where the readings alternate quickly between positive and negative numbers) therefore there is potential for differences in data reporting by the survey contractors.

Longitudinal Profile (Variance and Bump)

Two separate (and slightly different) measures of longitudinal profile variance (LPV) are currently reported (moving average LPV and enhanced LPV). The site level tests showed that the devices had higher levels of agreement when using the enhanced measure of LPV than the moving average measure.

On the site level tests it was often the case that the devices matched the reference data better for 3m variance than for 10m variance. For one device there was evidence that the performance varied with the survey speed. However, this device also demonstrated a variation in distance travelled with survey speed and it is thought that these two issues might be linked. For one survey contractor it appeared that the LPV measurements were less accurate when the device was measuring on bends rather than in a straight line.

There was at least one case of incorrect LPV invalidation rules (slow speed and deceleration cut offs) being applied to the reported LPV data. This resulted in LPV data being reported in the HMD file which should have been flagged as invalid.

The newer WDM RAV devices (RAV5, 6, 7 & 8) all measure the longitudinal profile variance using the HRM (or TRL) principal using a 2 metre measurement beam (RAVs 3 & 4 also use the HRM method, but a 4 metre beam). During the accreditation of RAV5, 6, 7 & 8 it was found that the profile delivered from these devices did not accurately measure the shape of the artificial profiles used during accreditation. WDM have stated that this is due to the way the profile data is filtered before delivery. It is currently not known whether this filtering will affect the reporting of the bump measure.

The bump measure has been found to have a low level of repeatability and reproducibility. Checks have shown that all survey contractors are calculating the measurement correctly from the raw profile and therefore this is a measurement issue, not a calculation issue. It is thought that variation in driving lines, combined with localised narrow bumps that may not always be covered, are causing these differences. A slight variation between the measurement line taken in different survey runs may be enough to trigger a bump in one survey run and not the other. However, some agreement between machines has been noted at the network level. The different measurement devices report bumps in similar parts of a survey (but not necessarily at exactly the same place). Therefore the measure may be more useful in identifying areas of very poor ride quality, rather than individual bumps.

Transverse Profile (Rut depth and SCANNER transverse profile parameters)

Rut depth

Rut depth is calculated by the survey contractors (using their own algorithms) from the transverse profile data. The SCANNER parameters (cleaned rut depth, transverse unevenness, edge roughness) are calculated by the survey contractors (using specified algorithms) from the transverse profile data.

The assessment of rut depths shows that the measurement is often susceptible to localised variation between repeat survey runs (by the same device) and between different survey devices. It is thought that the main reason behind these variations is differing driving lines followed by the devices. This can result in either under reporting or over reporting of the rut depths on the site. There were also some occasions where a small bias (1-2mm) was noted between different survey devices. This is often more noticeable in the offside rut depth measurements. The cause of this is currently not known.

The SCANNER accredited survey fleet currently includes two different types of transverse profile measurement system.

- Static, single point laser systems (which use ≥20 static lasers on a transverse profile that covers a 3.2m survey width)
- Projected line laser systems (which use 2 laser "scans" each of ≤2m wide which are joined together to give a total survey width between 3.2 and 4m). These systems can record ~1000 points in the transverse profile. The SCANNER specification requires that ≤99 points should be delivered for transverse profile data. This means that higher resolution profiles are re-sampled before delivery within the RCD (see below).

The comparison of these two different types of measuring devices has not demonstrated that one is significantly better than the other. As noted last year (Werro et al 2009), issues were identified with the performance of some of the new (WDM) projected line measurement systems. When the individual transverse profiles (delivered in the RCD files) were examined, it was found that the two halves of the transverse profile were not correctly aligned with each other, causing a "step" to be seen in the middle of the profile. This presence of this step artificially raised the reported measurement of rut depth. There were also some cases of individual transverse profiles reporting erratic profile shapes (and/or spikes at the edge of the profile). WDM has improved the calibration procedures (for all the newer style RAVs) in order to remove the likelihood of these steps occurring. This has also improved (although not completely eliminated) rutting inconsistencies seen across the WDM RAV fleet.

SCANNER transverse profile parameters

For the measurement of cleaned rut depth the survey contractors use an algorithm to calculate the rut depth from a "cleaned" transverse profile. Both the transverse profile cleaning algorithm and the rut depth calculation are defined in the SCANNER specification. The measurement of cleaned rut depth was designed to provide a more consistent rut depth measurement by reducing the ambiguities seen in the nearside rut depth measurements caused by kerb like features (which often artificially raise the reported rut depths). The cleaning process attempts to identify these features and remove them from the transverse profile before calculating the rut depths. Analysis shows that all the survey contractors have implemented these algorithms correctly.

Analysis of the performance of the cleaned rut depth parameter has shown this new measure to have provided some improvement over the normal rut depth measurements. However, there were still some significant differences seen between the different survey devices (and compared with the reference data). The 2009 accreditation tests have further shown that the cleaned rut depth measurement does not always improve the rut depth measurements. Detailed investigations have identified some areas where further improvements in both the cleaning algorithm and the rut depth calculations are required.

The introduction of the new SCANNER parameters has also identified issues with the consistency of the transverse unevenness and edge roughness parameters across the whole SCANNER survey vehicle fleet. The reference device and the "older" SCANNER survey devices use the static point laser systems to measure the transverse profile. This is based on research undertaken in 2004 (Nesnas et al). Analysis of the transverse profiles from higher resolution "scanning" devices has shown the transverse unevenness measure depends on the number of profile points reported. The more transverse profile points used in the calculation the higher the measurement of transverse unevenness reported. Until a permanent solution to this problem has been identified it has been agreed that the higher resolution transverse profile measurement systems will resample their profiles down to about a 20 point profile in order to match the majority of the accredited vehicles and the reference device more closely. This should ensure that the transverse unevenness values reported across the SCANNER survey fleet are consistent. The high resolution measurement devices must process all of the SCANNER transverse profile parameters using the lower resolution transverse profiles. The accredited transverse profile resolution for each device is listed on the SCANNER certificate. In the longer term, TRL is undertaking some research (leading on from an earlier WDM investigation) that proposes a method of calculating transverse unevenness that is independent of the number of profile points used for the measurement.

It has also been found that the high resolution measurement systems report higher values for the measurement of edge roughness than the point laser systems. In the current definition, the measurement of edge roughness uses the original transverse profile provided by the device, and it seems that, even if the profile is sampled down to a lower number of points, the high resolution measurement systems report higher values for edge roughness. Further research is required to understand the reasons behind these differences but there is some evidence to suggest that it may be linked to vehicle movement (in the vertical axis, i.e. "bouncing"). WDM is currently working on a method that filters some of this vehicle movement out of the profiles and hopefully reduces the values reported. For this year, both the higher resolution and the lower resolution devices were accredited to deliver these measurements.

Texture and SCANNER Texture parameters

The measurement of SMTD was generally good, with all devices showing high levels of repeatability and reproducibility. Two devices showed small biases when compared to other survey devices (including the reference). For one device the bias was small enough not to be of concern. For the other device a temporary correction factor was agreed, to ensure the device delivers SMTD data of the correct magnitude. A permanent solution to this issue is being investigated by the survey contractor.

Further localised differences were seen when comparing the fleet of survey vehicles. Some vehicles occasionally report slightly higher (or lower) texture measurements than other devices. It is currently uncertain why these differences occur but it may be due to differing driving lines being taken by the survey vehicles.

The measurement of MPD and RMST was generally acceptable from all the SCANNER devices. However, it has been noted that although the devices meet, or come close to, the requirements for the measurement of RMST (and the derived parameters) this measurement generally appears to be less repeatable (and reproducible) than SMTD or MPD.

Cracking

The measurement of cracking continues to be the least consistent of all the SCANNER survey parameters. At times the SCANNER devices can display very consistent levels of performance whereas at other times this is not the case. When comparing survey runs completed on different days, or when comparing different survey devices, localised areas of (significant) differences can sometimes be observed. These differences can be seen when comparing different vehicles from the same survey contractor and when comparing different survey contractors against each other.

From in depth analysis of the data it can be seen that there are still some areas where the devices struggle to correctly identify the cracking present, examples of both under and over reporting of cracking can be identified. The reporting of non crack features as cracking (false positives) was also regularly identified.

Examination of the crack maps from one of the new WDM devices showed that the cracks were being reported on the wrong side of the road. This was investigated by WDM who found that the cameras had been incorrectly labelled by the equipment manufacturer. The error was corrected.

It is generally thought that the survey devices are repeatable if the environmental conditions of the two surveys are the same, i.e. driving line, surface moisture content, other features (e.g. detritus). Unfortunately the crack detection systems are very sensitive to any changes in survey conditions. All survey contractors would benefit from improvements in their crack detection systems and hence there are requirements to improve in all the IAPs.

File Formats, Data processing and other issues

The following formatting issues were identified with data files submitted for accreditation:

- Incorrect survey start and end times in HMDIF files
- Distance measured data reported at an incorrect resolution in the RCD file

Other issues identified with accreditation data sets:

- Insufficient lengths of data in the RCD file - The longitudinal profile data in the RCD file was found to be insufficient for the survey length. The survey contractor reprocessed the data (which corrected the problem). It should be noted that the contractor concerned generates the HMDIF in a separate data stream to the RCD and hence the RCD files are not regularly used for routine data delivery.
- Evidence of "special treatment" for re-accreditation data - One contractor was over reporting the rut depth data on one of the SCANNER road routes. This issue was highlighted to the contractor concerned who investigated the problem. They found that this particular data set had been processed with an incorrect "parameters" file, which was causing the problem. A new data set was prepared and a better performance obtained. This suggested that the accreditation data set had been processed in a different manner to the standard delivery of SCANNER data. The purpose of the accreditation process is to test the contractor's ability to deliver SCANNER data to their clients and "non standard" data processing will not test this. It was pointed out to the contractor that all accreditation data sets should be processed through the contractor's standard SCANNER processes.
- TRL Reporting (of performance to contractors) - TRL improved the feedback procedures to provide clearer information to the survey contractors on what actions are required during and after accreditation. Before the improvement this information had often been provided informally (over the phone or by email) and it was noted that TRL was sometimes slow in delivering formal feedback. The improved feedback process has further developed through the survey year and a new weekly reporting process has been introduced. The re-accreditation process takes four weeks to complete. The new process means that a formal report is delivered to the contractor at weekly intervals. The report is a "snapshot" of the analysis completed at the end of the current week. Further details of the completed analysis are added and so the report builds up in content each week. At the end of the four week period the device is either awarded SCANNER accreditation or it is refused. The weekly reporting process means that any issues can be dealt with as and when they are identified and hence there are no "surprises" for the contractor at the end of the four week approval period.

3 Provision of advice to local highway authorities

3.1 Advice to local highway authorities during procurement of SCANNER surveys

In the two previous survey years, the majority of enquires received from local highway authorities were in connection with the accreditation status of the survey contractors. These types of enquiries have reduced significantly as the reaccreditation process has settled down. The reaccreditation process allows for the devices to undertake reaccreditation testing before the current certificate expires, which allows devices to have continuous accreditation. Therefore, as long as the device is successful at the reaccreditation tests, the survey contractors always have a valid accreditation certificate. A number of enquiries have been received from local highway authorities requesting a copy of their SCANNER Contractor's accreditation certificate. All SCANNER certificates are now placed on the PCIS website (www.pcis.org.uk).

3.2 Advice provided to local highway authorities on SCANNER

The following subsections summarise four in-depth technical investigations carried out by TRL. Brief (unpublished) reports of these investigations have been supplied to the local authority concerned and the DfT's project manager.

3.2.1 Change in intensity of cracking data

During the latter part of the 2008/09 survey year one local highway authority noted that the levels of cracking reported on their network had significantly reduced when compared to the previous year. This was reported to the survey contractor and to TRL, who both investigated the issue. The investigation found that the quality ("contrast") of the downward facing images collected by the SCANNER device had slowly deteriorated over a period of time. The onboard vehicle quality assurance process had not identified this gradual change in image quality. The result of this slow change had meant that, as the contrast reduced, so did the level of cracking being reported by the system. This deterioration occurred towards the end of the 2008/09 survey year and as such a maximum of 12 highway authorities could have been affected by this issue.

The measurement system was corrected (during routine maintenance undertaken before the system was reaccredited), which meant that the 2009/10 SCANNER survey data was not affected.

The cause of the issue was identified too late to allow corrections to be introduced before the publication of the 2009 NI figures. The survey contractor identified a method for increasing the contrast of the affected images to a level similar to that which was expected from a correctly functioning device. TRL investigated the cracking levels reported from these corrected images and it found that the corrected images produced cracking levels similar to that expected from the system when functioning "normally". Therefore the survey contractor was requested to reprocess (and redeliver) the cracking data to the 12 affected authorities. This revised data could be used by the authorities when reviewing cracking data trends or when producing the 2010 NI figure.

To ensure the SCANNER device was functioning correctly after the correction the auditor placed the survey contractor under a period of "intense scrutiny". This involved the auditor reviewing the 2009/10 SCANNER cracking data collected by this particular survey contractor before they were delivered to the client. The intense scrutiny was carried out on the SCANNER data from 11 Local authorities and the distribution of cracking values was analysed. For some of the authorities a more in depth analysis was carried out which involved comparing the 2009/10 cracking data to that collected in previous surveys. It was found that the system was behaving as would be expected and therefore the intense scrutiny restrictions were lifted.

3.2.2 Unexpected change in NI results

When calculating the NI for 2009/10, an Authority reported that they saw a decrease in value of 2% from the previous year, despite very little maintenance having taken place. Whilst this change was within the range predicted by the SCANNER consistency measures for such a NI (±3%), an investigation was requested to determine whether anything in particular had caused such the change in the NI

There was evidence that the measurements of texture, and to a smaller extent, cracking and LPV, had affected the NI. The texture (SMTD) measured in 2009/10 was, on average 0.14mm higher than it was in 2008/9. It was found that the 2008/9 texture had contributed to the RCI on this network, where the 2009/10 texture did not. The difference appears to have been caused by a bias in the data, not simply random error.

It was recommended that attempts be made to identify the source of the bias in the texture data, to determine whether this could be avoided in the future.

At the completion of this investigation it was noted that, over the last few years, there have been a number of Auditor investigations into unexpected changes in their NI (BVPI) figures. These have identified some evidence that not all users have a full understanding of their UKPMS system and the NI calculations. Therefore it was also recommended that Authorities take care when obtaining NIs, and consider formal training in this area for all personnel operating their UKPMS systems.

3.2.3 Investigation into rut depths reported on very narrow roads

A rural highway authority raised a question regarding the rut depths reported by the SCANNER survey on a number of their C roads. Large rut depths were being reported, particularly in the offside, on a number of roads which were considered to be in relatively good condition. TRL undertook an investigation to determine the cause of these large values and it was found that:

- The high offside rut depths were only being reported on single track roads (with a kerb/verge present on the offside)
- The survey contractor's rut depth calculation was not correctly catering for these verges when calculating the offside rut depths
- There were also differences seen between the contractors cleaned rut depth calculation and those calculated by the auditor.

As a result of the investigation:

- Changes to the contractor's rut depth algorithm were made to correct the differences seen in the offside rut depth measurements and improve the overall performance on such roads.
- Although the measurement of cleaned rutting behaved as expected, further improvements to the SCANNER cleaned rutting algorithm were proposed to improve performance on narrow roads.

3.2.4 Data fitting issues

In 2009 an urban highway authority started to look at their SCANNER data in more detail. They overlaid the SCANNER data on to their (GIS) network using the OSGR coordinates reported in the survey data. Although the majority of the SCANNER data was reported to be in the locations that was to be expected there were a number of instances where this was not the case. They also plotted the OSGR data from the 2008 survey and again identified some similar issues. Errors included:

- Locations where the survey vehicle appeared to be on a different road from the client's network but the data had been labelled as being on the network.

- Locations where the start and end points had been inaccurately entered by hand during the survey, leading to the processed data being incorrectly located along the section. These were sometimes compounded by an approach being taken at roundabouts where the data was incorrectly included (roundabouts should not be included in SCANNER surveys), thereby displacing the next length of survey data along the road (some of these examples included cases where the survey data appeared to have been misattributed within one way systems)
- Lane 1 and lane 2 surveys both labelled as CL1
- Data being delivered for a particular section when it was reported in the survey report as being "not surveyed".

It seemed that the root cause of almost all these instances was poor quality control on fitting survey data to the network by the survey contractor. TRL attended a meeting with the client and survey contractor to discuss the issues concerned. TRL also carried out an audit of the survey contractor to review their data collection and processing procedures. The main conclusions of the investigation were:

- Insufficient network information had been provided by the client to the survey contractor to allow efficient surveys to be undertaken.
- Insufficient communication had taken place between survey contractor and the client to highlight the issues identified with the network and the consequences this would have on the quality of the delivered data.

The Auditor produced a number of recommendations from the study.

For the survey contractor:

- The survey contractor should liaise closely with the client during the planning stages to ensure that all the relevant network information is obtained. Clients should be reminded of their obligations regarding the provision of information and contractors could help them to understand the implication of poor network information on achieving good SCANNER surveys.
- For urban survey routes containing many short sections, a revised approach to route generation was suggested. Only well defined, unambiguous, section change points should be included in the route, and the operators can then concentrate on locating these points. Short sections between these change points could be fitted using appropriate fitting processes, provided that the number of sections inserted does not exceed the levels defined in the SCANNER specification.
- When undertaking fitting the requirements of the SCANNER specification should be followed. Fitting issues should be raised with the client. This could be via a "data fitting report" created during processing that highlights where network (and fitting) issues were identified.
- Coverage reports should be delivered to clients to highlight areas where survey data was unavailable.
- Software enhancements should be considered by the contractor such as optimising their GPS overlaying facility (in the data fitting software) to enable better checking of the fitting of survey data to specific network sections.
- The survey contractor should re-consider the benefits of fitting the survey data using OSGR co-ordinates.

All local highway authorities should be encouraged to:

- Update their networks to provide SCANNER survey contractors accurate and sufficient information to complete the surveys (the information that should be provided is outlined in Volume 2 of the SCANNER specification).
- Ensure correct text descriptions are provided for section change points
- Define the OSGR coordinates for section start points
- Provide as much supporting information as possible to the survey contractor (for example maps, shape files, diagrams, videos)

- In the long term, consider how to define the network to better suit traffic-speed surveys. e.g. ensuring that roundabouts have their own sections and that the joining section change points are appropriately located
- Liaise with the survey contractor at all stages of the survey process. This would allow for the early and satisfactory resolution of any problems or issues that may arise.
- Consider carrying out quality tests of SCANNER fitted data as a matter of routine soon after the data is delivered by SCANNER contractors. State in their SCANNER contracts that this will be carried out.

4 Advice and guidance provided to survey contractors

4.1 Survey contractor's meetings

A meeting between the Auditor and the survey contractors provided the opportunity to discuss ongoing issues. This meeting was held at TRL (12th November 2009) and was attended by the SCANNER Client's Representative and all survey contractors. The purpose of these meetings was to discuss issues of general concern. The following items were discussed:

- Issues that had arisen during Accreditation
- Issues that had arisen during the QA programme
- Survey progress
    - SCANNER - The Scottish experience
- The results of detailed investigations undertaken by the Auditor and SCANNER project manager, these included:
    - Changes in BVPI – case studies
    - Reporting of high offside rut depths on narrow C roads
- Proposed changes to the specification
- Future SCANNER requirements and issues
- The status of the review of the SCANNER accreditation and QA contract being undertaken by Atkins.

A number of private meetings were held with individual survey contractors to discuss specific issues concerned with the accreditation process, as and when required. There were two particular meetings held at the request of TRL to review individual contractor's QA procedures.

4.2 Review of survey contractor QA procedures

4.2.1 Contractor 1

As a result of the investigation in to the change of cracking intensity (as discussed in section 3.2.1), TRL visited the office of the survey contractor concerned. A discussion was held on the general Quality Assurance procedures used for all their SCANNER surveys and data processing. Recommendations on these procedures were made by the Auditor.

4.2.2 Contractor 2

As a result of the investigation in to the data fitting issues (as discussed in section 3.2.4), TRL also visited the office of this survey contractor. A discussion was held on their general Quality Assurance procedures used for all their SCANNER surveys and data processes. Some recommendations on these procedures were made by the auditor.

4.3 Other auditor involvement with survey contractors

There is currently no requirement for the external auditing of the downward facing images collected by the SCANNER devices. The monitoring of the quality of the images is the responsibility of the survey contractors. During the survey year TRL reviewed (and commented on) these procedures for each survey contractor.

As part of this review TRL also conducted a review of the survey coverage reports delivered by the survey contractors. It was found that these reports were often not delivered to the clients, and when they were the information contained within them was sometimes incomplete. Recommendations were made where improvements were required.

One survey contractor had set up a new data processing stream for their SCANNER data (using new processing software and operating personnel). TRL worked with the contractor to ensure that this process was operating correctly and that the system was operating to the specification requirements.

5 Advice and guidance provided to SCANNER project management

Regular progress meetings were held with the SCANNER Client's Representative at approximately monthly intervals throughout the survey year. These meetings reviewed any issues that had arisen and discussed how they would be resolved. In addition, regular survey progress reports (see Section 5.1) were provided for reporting to other interested parties (The Roads Board 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, Welsh and Northern Irish local highway authorities)

TRL also supported the Client's Representative in carrying out investigations into any issues raised by local authorities on the quality of their SCANNER data.

A list of proposed specification changes was prepared by TRL for circulation to all SCANNER stakeholders for discussion at the SCANNER contractor's liaison meeting held in May 2010.

When required, TRL also provided information, advice and support to Atkins (who were carrying out the review of the SCANNER QA project).

5.1 Progress reporting

The survey contractors supplied TRL with weekly progress reports on the amount of SCANNER surveys completed. This was collated in an overall progress chart and delivered (monthly) to the Client's Representative. This data enabled the Client's Representative to assess the overall progress of the survey contractors in completing their contracted surveys.

Figure 1 shows the cumulative daily survey totals for England reported to 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 103,307 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 2009/10 the total length surveyed in England reported to the Auditor was 105,437 km, this meant that 102% of the expected survey length 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 in previous years, it was apparent that many local highway authorities requested surveys above the minimum requirements.

It can be seen from Figure 1 that the progress on the English SCANNER survey at the start of the survey year was slow. This initial slow survey rate in England can be put down to the fact that a higher number of WDM SCANNER vehicles were surveying in Scotland than in previous years. After this initial slow start, part way through the survey year (August 2009) the survey progress surpassed the 'ideal target', mainly due to the addition of 3 new vehicles to the SCANNER fleet. Progress remained above the target line, with all contractors finishing their surveys in England by the middle of March.

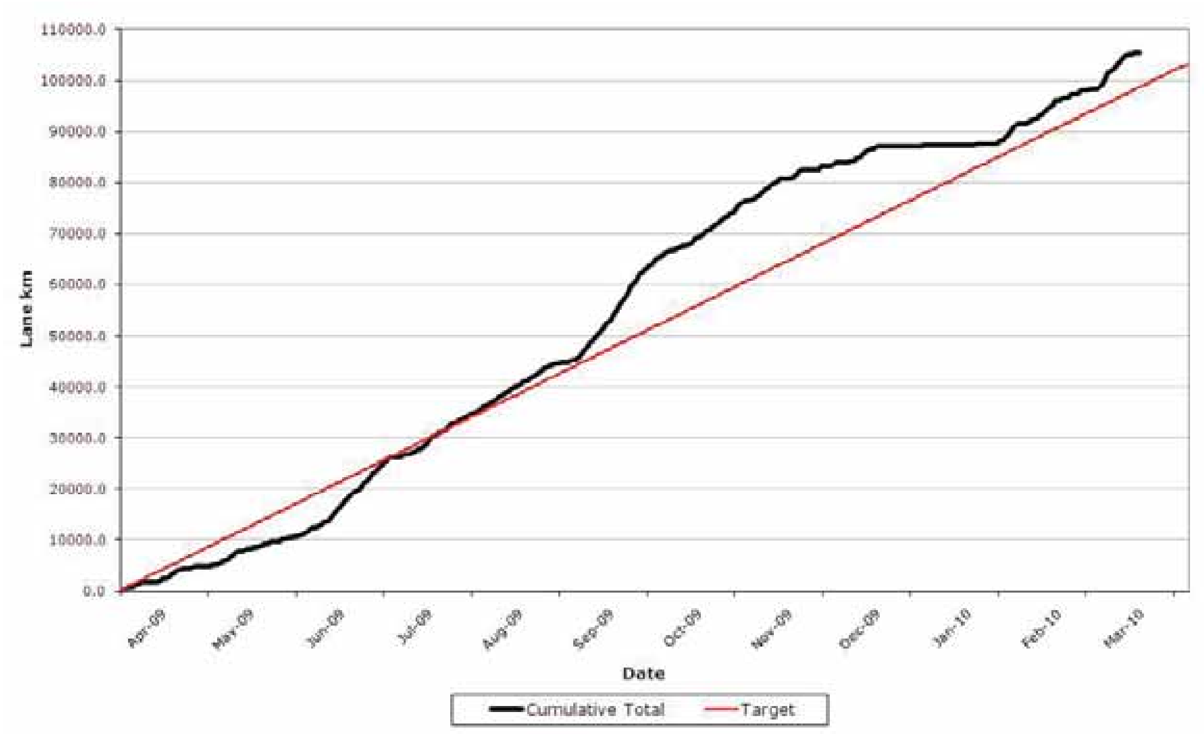

Figure 1: Cumulative daily totals for all survey contractors, with expected target 2009/10 for England.

For the 2009/10 SCANNER survey year the Welsh Assembly awarded a new survey contract (to YottaDCL). The late award of this contract and some adverse weather conditions meant that it would be difficult to complete the required surveys by the end of April 2010. The Welsh Assembly therefore awarded YottaDCL a two month extension to complete the 2009/10 surveys. However, this meant that, for this contractor, the start of their 2010/11 surveys was delayed. Table 1 shows the start and end dates for each survey contractor for the 2009/10 survey year.

Table 1: Survey year dates for each survey contractor

Survey Company	Start date of 2009/10 surveys	End date for 2009/10 surveys	Start date of 2010/11 surveys
Jacobs	2nd April 2009	30th October 2009	7th June 2010
WDM	13th March 2009 (Scotland) 1st April 2009 (England)	15th March 2010	12th March 2010 (Scotland) 5th April 2010 (England)
YottaDCL	7th April 2009	30th May 2010	31st May 2010

Figure 2 shows the cumulative daily survey totals for England, Scotland, Wales and Northern Ireland. The total length (in lane km) of the network to be surveyed in the 32 Scottish local highway authorities was estimated to be 24,247 km. The total length of the network to be surveyed in the 22 local highway authorities for Wales was estimated to be 11,301 km. As with the previous survey year the Northern Ireland Road Service let one contract for local roads, of 2,631 km. Adding these to the English total (103,307 km) gives an overall total of 141,486 km, as shown by the maximum value of the red 'Target' line in Figure 2.

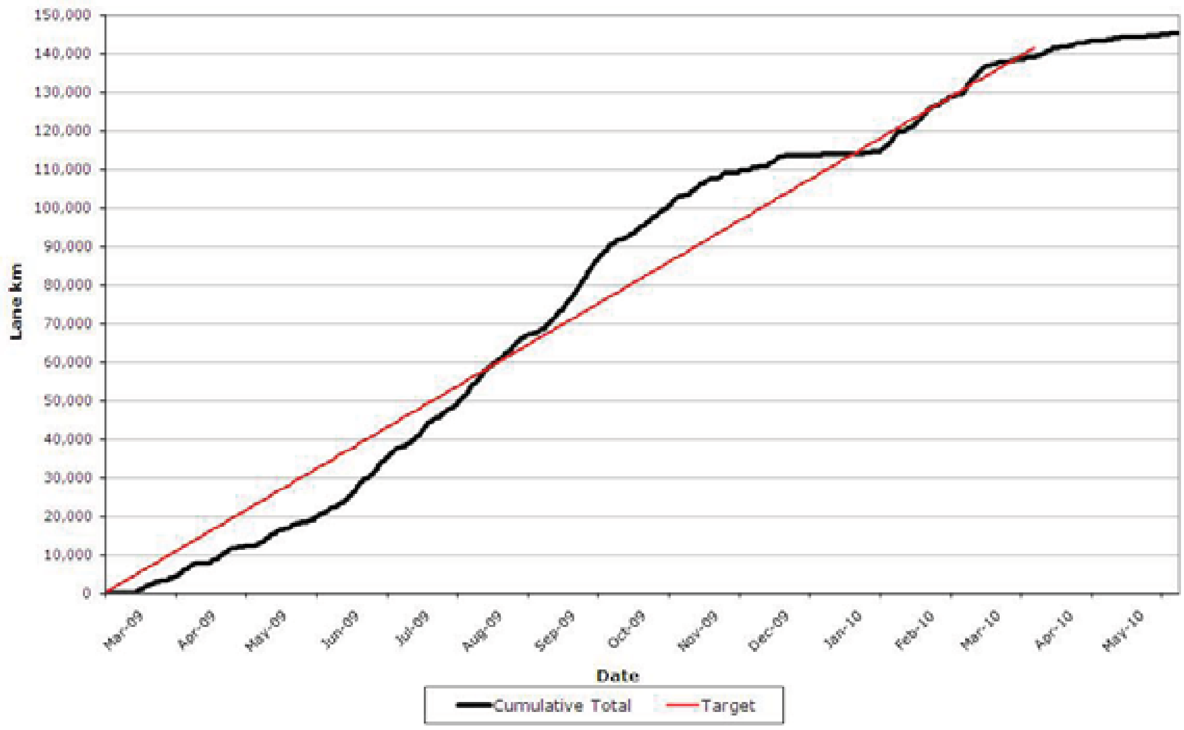

Figure 2: Cumulative daily totals for all the survey contractors with expected target 2008/09 for England, Scotland, Wales and Northern Ireland.

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 devices are maintained and re-accredited, which reduces the time available for surveying. Other factors include inclement weather, local highway authorities requesting additional surveys, use of night working, equipment breakdowns, the number of survey vehicles operating and the class of roads being surveyed. Table 2 shows the average survey rates achieved in each of the of the five survey years in England. These values are calculated from the actual survey figures provided by the survey contractors.

Table 2: Vehicle productivity by year (England only)

Survey year	Total survey length (lane km)	Number of accredited devices	Average survey length per device (lane km)	Average daily survey length per device (lane km)
TTS 2004/05	48,579	2	24,290	67
SCANNER 2005/06	69,718	4	17,430	48
SCANNER 2006/07	97,513	7	13,930	38
SCANNER 2007/08	90,989	7	12,998	36
SCANNER 2008/09	100,890	8	12,611	35
SCANNER 2009/10	105,437	11	9,585*	26*

**2009/10 rates assume that all vehicles were available all year, but the newly accredited vehicles were only available later in the year. Therefore the average survey length achieved per vehicle will be higher than the figures listed.*

From Table 2 it can be seen that for previous survey years the survey rate per vehicle dropped initially but has been reasonably stable for the last three years. The most likely reasons for this drop (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). It can also be seen from Table 2 that there has been a significant drop in survey rate per vehicle for the 2009/10 survey year, this is due to only a small increase in the total survey lengths and the inclusion of 3 newly accredited survey vehicles.

The overall length of the road network surveyed has generally increased since 2004 (see Figure 3 and Figure 4). This increase is mainly due to two factors;

- The mandatory survey requirements have increased through the years.
- Many local authorities request more than the minimum amount of surveys.

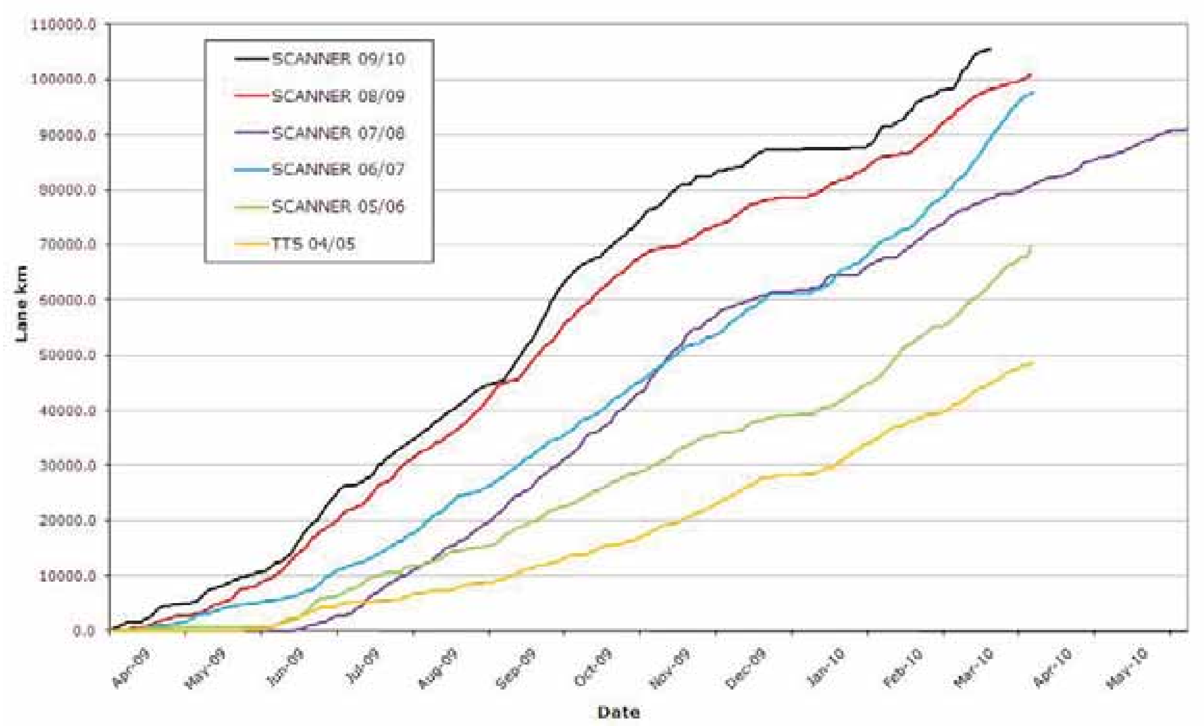

Figure 3: Survey progress in England during the four years of TTS/SCANNER surveys.

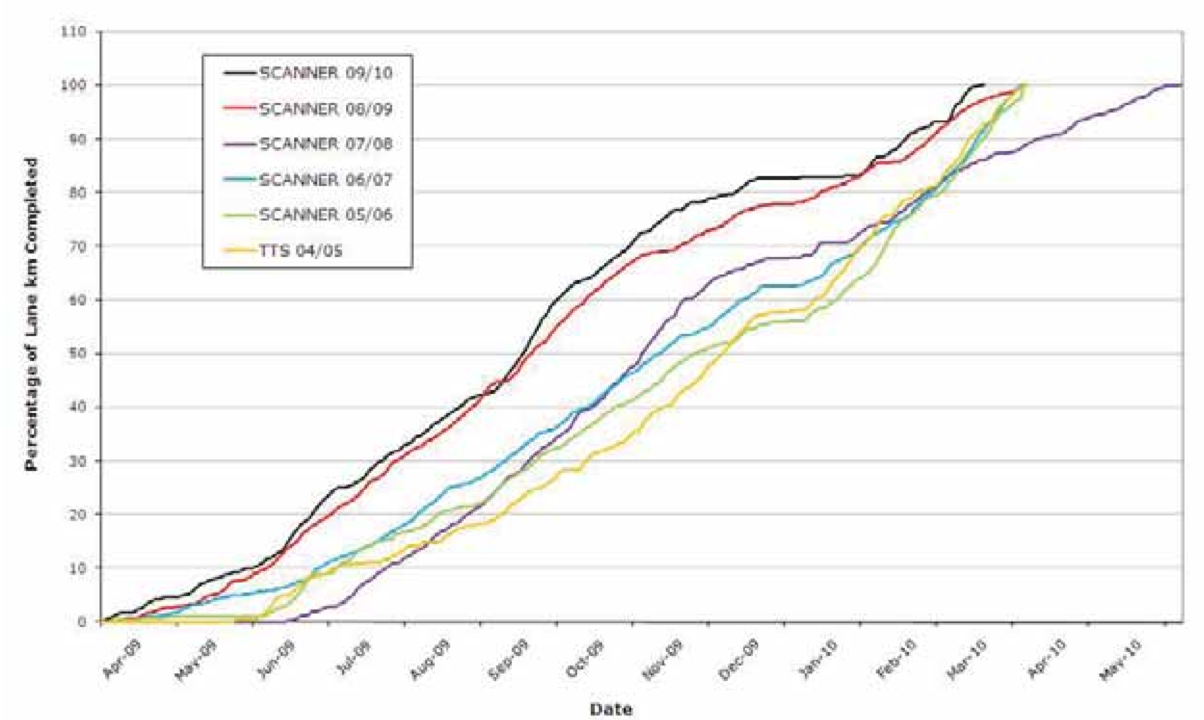

Figure 4: Normalised survey rates in England during the four years of TTS/SCANNER surveys.

As shown in Figure 5 the proportion of B and C class roads surveyed has increased since the original TTS surveys. For the last 2 years of SCANNER surveys some surveys were conducted on unclassified ("U") roads.

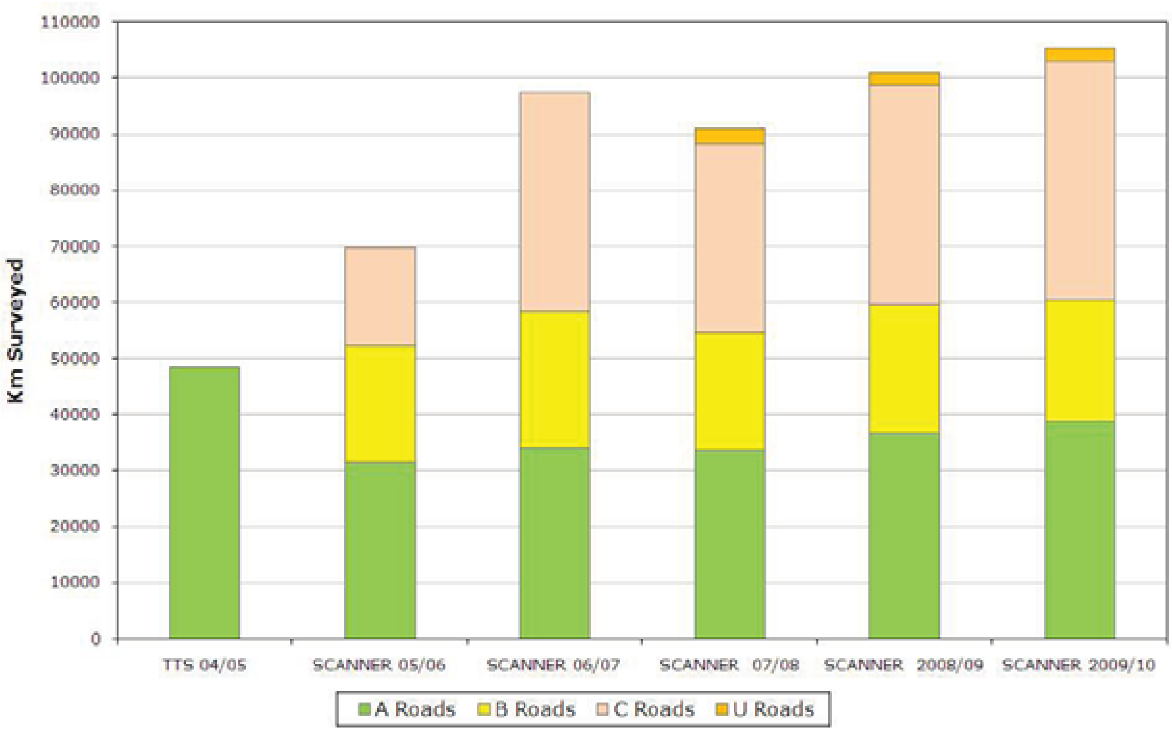

Figure 5: Proportion of overall survey length by road classification for England.

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.

Requests for information were also received from potential new SCANNER contractors. TRL met with these parties and offered advice and information on the SCANNER survey and their proposed approach to the surveys.

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 2009/10 SCANNER survey was carried out on the basis of assessing each survey contractor and their devices.

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 accreditation or reaccreditation 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 lengths to be repeated. The survey contractor is then required to perform a second survey of that length and deliver the data to the Auditor for comparison. The first run undertaken 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 2009/10 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 the reference data for cracking on ARS was provided by manual analysis of the images of the road surface collected by the HARRIS1 survey device.

For both types of repeat surveys (CRS and ARS) all parameters contained within the SCANNER survey data were tested for accuracy. 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.

SCANNER survey contractors were supplied with feedback on the repeat surveys using QA status reports delivered at approximately monthly intervals. The reports contained a summary of how many CRS and ARS had been requested, delivered and processed, and 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 along with more detailed feedback on areas for improvements or monitoring.

For confidentiality, the following paragraphs refer to the accredited survey devices as "SCANNER vehicles" only. 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

Contractor's daily, weekly and monthly checks are intended to rapidly highlight any drift or sudden 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 planned surveys. The survey contractor will survey this length and store the results as the first action of the day. After the day's planned surveys have been completed 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 changes in the performance during the day will be highlighted.

Weekly and monthly checks are also performed in a similar manner over a reference site. This approach is used to highlight any drift in equipment calibration and capture any changes over longer periods. 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). It is recommended that contractors select test sites that are lightly trafficked so that large changes in the measured parameters do not occur during the survey year.

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

1. The checks were performed onboard before deciding whether to continue surveying.
2. The checks were performed remotely (e.g. in the hotel or office) but on the same day.
3. The checks were performed remotely some days after the survey (e.g. in the office), 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.

TRL carried out spot checks on the daily, weekly and monthly checks throughout the survey year. For the 2009/10 SCANNER survey year a total of 26 daily, 13 weekly and 10 monthly checks were requested from the survey contractors. No significant issues were identified.

7.2 Repeat surveys

The sites for CRS were selected by the survey contractors according to a set of criteria proposed by TRL. Approximately once a month TRL contacted each of the survey contractors and requested that a repeat survey be carried out within a set time period (usually within the following week). The type of road and exact location were usually left for the survey contractor to decide. This prevented any additional travelling time being expended to return to a location to repeat a survey. However, TRL would sometimes define the road classification or environment type (Urban/Rural), to ensure a suitable range of survey conditions were covered. The survey contractors were asked to provide the processed data for the two separate survey runs to TRL within two 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 reports. Sites were chosen on the basis that they would hopefully include a variety of challenging road features. The survey contractors were asked to provide TRL with the site details (route files, maps, etc - the same instructions as given to their survey teams) so that TRL could carry out the reference survey with HARRIS1. The TRL and contractor's 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 the contractors 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 68 CRS and 11 ARS were analysed in England, Scotland, Wales and Northern Ireland (see Table 3, Table 4 and Figure 6).

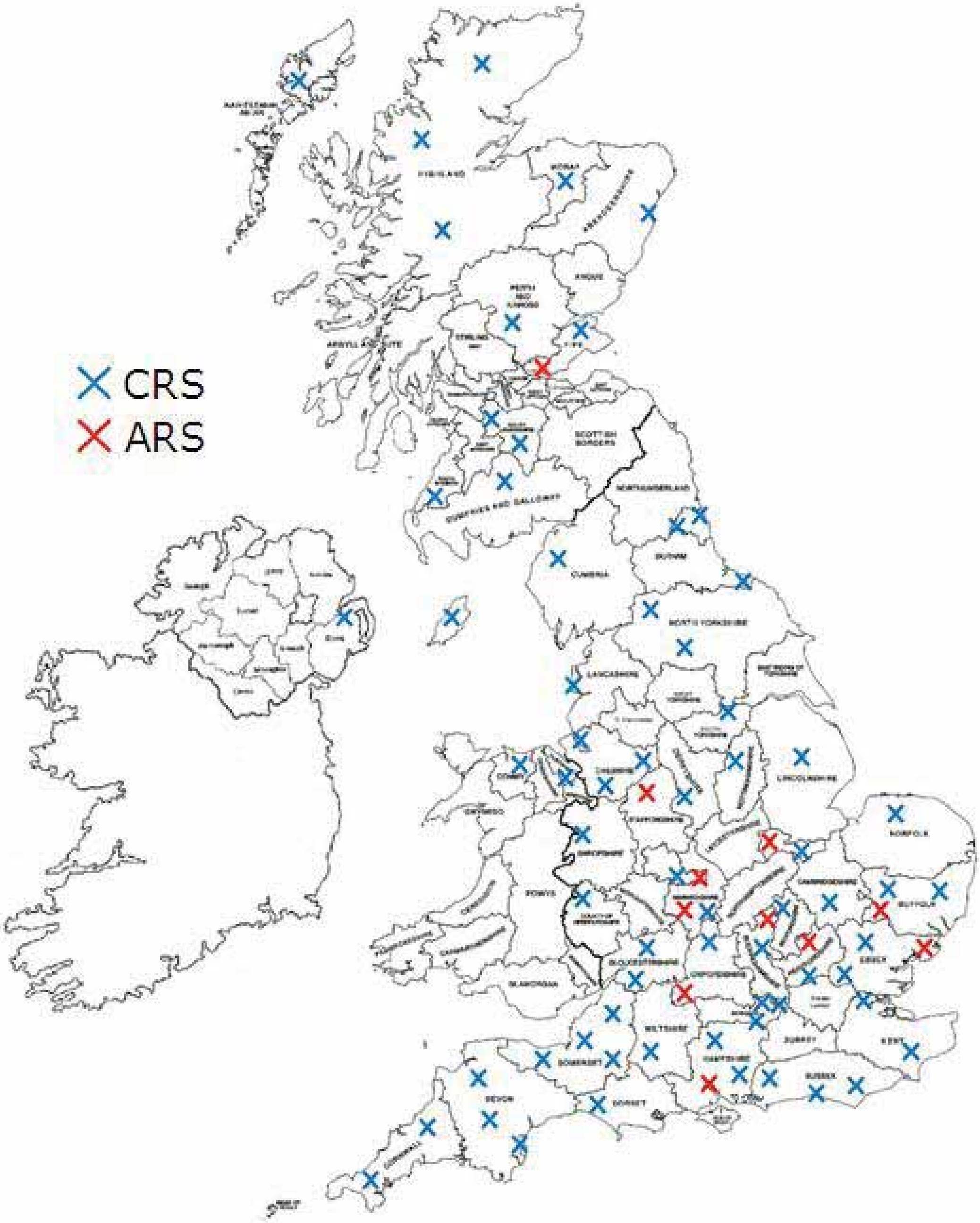

Figure 6: Repeat survey sites requested during 2009/10.

Table 3: Contractor's Repeat Survey sites (CRS)

Site	Road	Local Highway Authority	Site	Road	Local Highway Authority
1	A452	Solihull	35	B6403	Lincolnshire
2	A534	Cheshire	36	B1366	Redcar & Cleveland
3	A561	Liverpool	37	B5261	Blackpool
4	A523	Cheshire	38	B3051	Hampshire
5	A4	Slough	39	B2166	West Sussex
6	A608	Nottinghamshire	40	B7056	South Lanarkshire
7	A189	North Tyneside	41	B4521	Herefordshire
8	A548	Conwy	42	B4027	Warwickshire
9	A528	Flintshire	43	B4378	Shropshire
10	A745	Dumfries & Galloway	44	B1383	Essex
11	A726	South Lanarkshire	45	B4035	Gloucestershire
12	A595	Cumbria	46	B3163	Dorset
13	A834	Highlands	47	B914	Fife
14	A44	Gloucestershire	48	B4017	Oxfordshire
15	A759	South Ayrshire	49	B1396	Doncaster
16	A13	Essex	50	B482	Buckinghamshire
17	A833	Highlands	51	B1134	Norfolk
18	A867	Western Isles	52	B1040	Peterborough
19	A338	Wiltshire	53	B1096	Cambridgeshire
20	A13	Thurrock	54	B556	Hertfordshire
21	A95	Moray	55	B2163	Kent
22	A2	Northern Ireland	56	C36	Derbyshire
23	A956	Aberdeen City	57	C330	Hampshire
24	A269	East Sussex	58	C0324	Gateshead
25	A977	Perth & Kinross	59	C5140/C56	Brighton & Hove
26	A392	Cornwall	60	C56	Highlands
27	A381	Devon	61	C7607	Wokingham
28	A4	Windsor & Maidenhead	62	C62	North Yorkshire
29	A37/A361	Somerset	63	C0091	Cornwall
30	A7	Isle of Man	64	C925/C926/ C927/C929	Suffolk
31	A59	North Yorkshire	65	U103	Devon
32	A379	Torbay	66	U1601	Somerset
33	A146	Suffolk	67	U4620	Somerset
34	A603	Bedfordshire	68	U4302	Somerset

Table 4: Auditor's Repeat Survey sites (ARS)

Site	Road	Local Highway Authority	Site	Road	Local Highway Authority
1	A45	Coventry	7	B5500	Staffordshire
2	A6121	Rutland	8	B4005	Swindon
3	A425	Warwickshire	9	B1063	Suffolk
4	A907	Fife	10	C129	Milton Keynes
5	A33	Southampton	11	C14	Hertfordshire
6	B1033	Essex	-	-	-

7.2.1 Changes to Parameter Analysis

As with the 2008/09 survey year it was decided to continue with the changes made to the comparison method for both radius of curvature and whole carriageway cracking. For radius of curvature the assessment was carried out using the more stable measure of curvature. For the whole carriageway cracking analysis, the method previously used of calculating the differences in cracking levels reported was continued.

It was also decided to use the new CRS approach for the assessment of cracking in this year's ARS. However, although this method generally improved the ARS performance, there were occasions where this was not the case. Therefore for the ARS assessment the performance figures using the old comparison method have also been included below.

7.2.2 Performance

For this year's report the repeat surveys have been grouped together (CRS and ARS) and the performance of the vehicles are assessed in terms of the measurement of the individual survey parameters. The SCANNER survey parameters have been collated into four groups:

- Location referencing
- Geometry
- Parameters (rutting, longitudinal profile, texture, cracking)
- Other/New parameters

It is hoped that this will make the report easier to follow and will group together the parameters often considered to be most important (those used for the RCI calculation).

General comment

Generally very good agreement was seen between the 2 data sets received for the CRS. Some examples of this good repeatability are seen in Figure 7. 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. Again for the ARS, there was generally good agreement seen between the SCANNER device and the independent survey vehicle. Examples of the reproducibility seen between the devices are seen in Figure 8.

The performance obtained in the CRS and ARS are discussed in relation to the above four groups in the following sections.

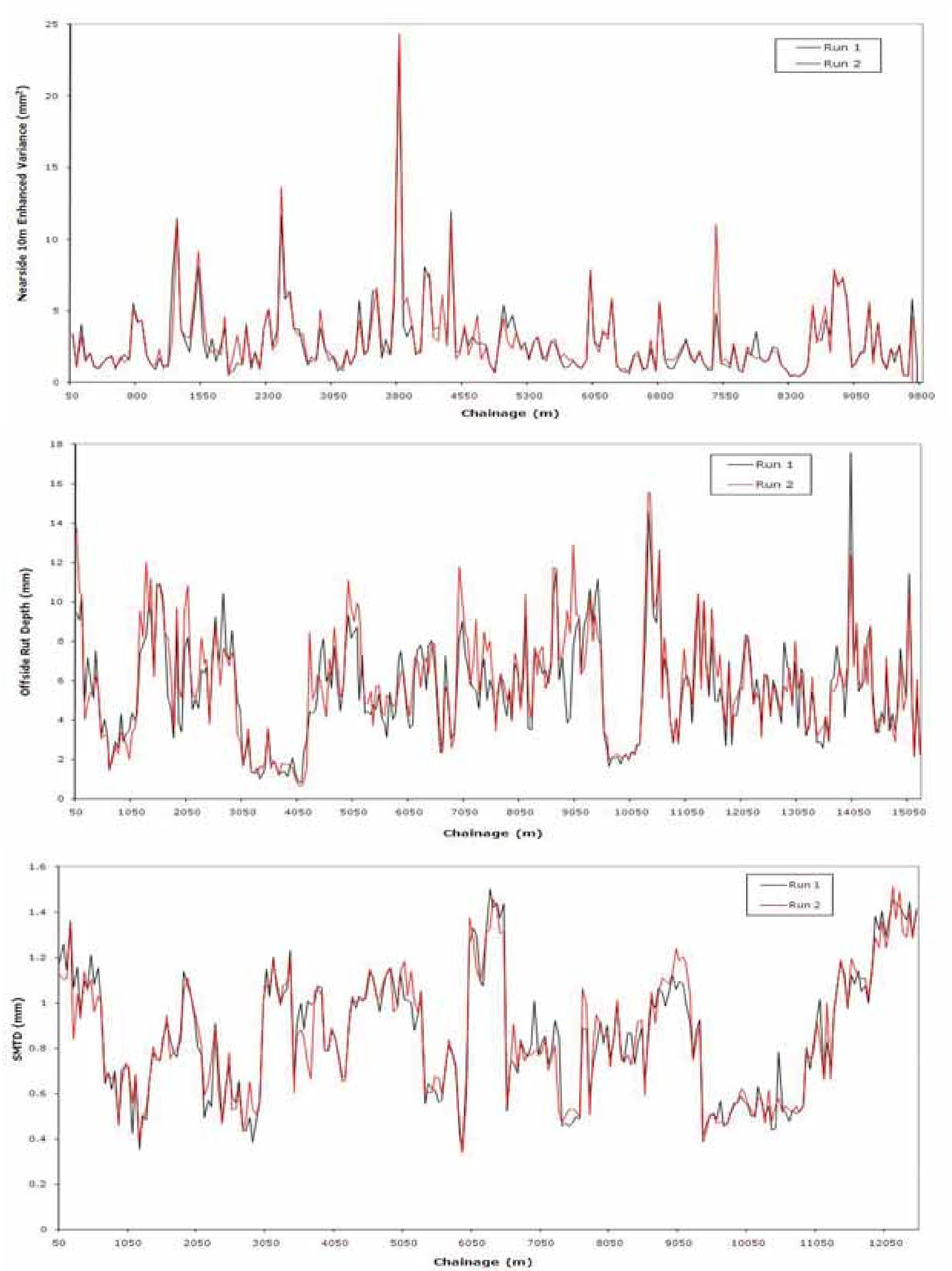

Figure 7: Sample CRS data (one from each survey contractor) showing high levels of repeatability – nearside 10m enhanced longitudinal profile variance (top), offside rut depths (middle), and SMTD texture measurement (bottom).

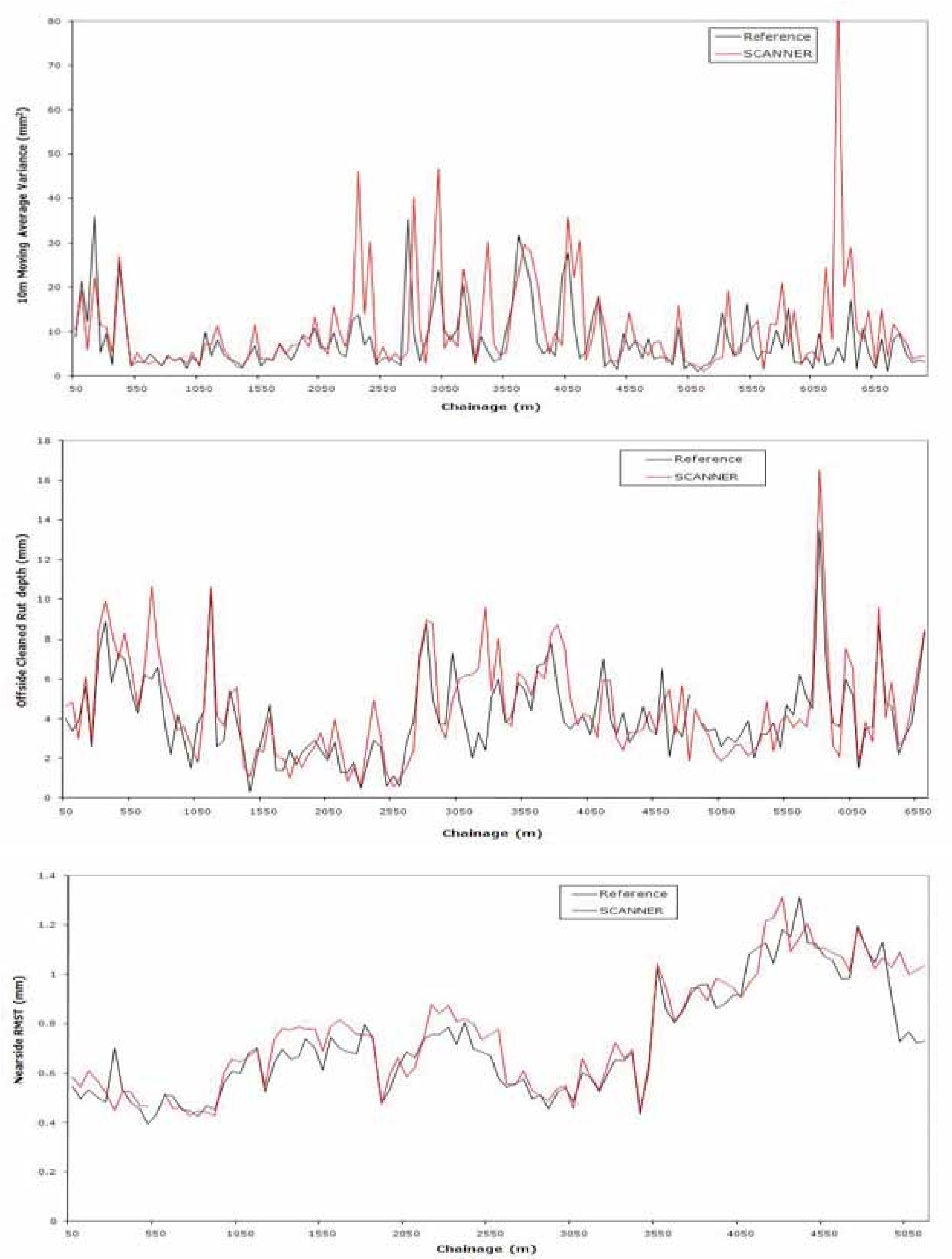

Figure 8: Sample ARS data (one from each survey contractor) showing high levels of reproducibility – nearside 10m moving average longitudinal profile variance (top), offside cleaned rut depths (middle), and nearside RMST texture measurement (bottom).

Location Referencing

For the measurement of distance travelled a very good performance was seen in the CRS (see Table 5). This is to be expected as both the surveys are fitted to the same network lengths and therefore the systems always achieve a performance of 100%. However, the performance for the ARS was more variable (see Table 6). It should be noted that in the ARS the fitted lengths are compared to the reference lengths recorded by the reference device (manually corrected using the forward facing video). 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 of…"). Therefore any large differences (indicated by a low performance in Table 5), suggests that there were significant discrepancies between the network definition and the length measured in the reference survey. It should be also noted that for 3 of the ARS sites N/A is present in Table 6 as assessment of these parameters was not possible. This was due to poor section/network definitions received for these sites. Because of these poor network definitions TRL was unable to locate the section start points to a level of accuracy considered acceptable for use in this test. In these cases manual alignment of the data collected in two surveys was carried out in order to assess the performance of the other parameters.

There were some survey runs that performed to a lower standard than expected in the assessment of OSGR co-ordinates. These differences can be caused by either poor measurements, poor data processing or by poor alignment of the survey data. For the CRS it appears that the main factor reducing the performance seen is the poor alignment of the survey data to the network and reflects the fact that the length fitting process, which gives apparently perfect measured lengths, hides real errors in location referencing.

For the ARS, the poor agreement between the Auditor's and survey contractor's section lengths and hence OSGR data is probably the most notable area of concern. Assuming that we have confidence in the reference data (as noted above this was checked using the forward facing video), we can assume that the differences between the reference location of the section change points and survey contractor's reported location for the section change points 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 were recorded manually (using a "push button") in most SCANNER 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 location referencing.

Table 5: CRS Location Reference performance

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
Section Lengths	65% horizontal errors	±5m or 0.1%	100	100	100	100	100	100	100	100	100	100
Section Start – OSGR co-ordinates	65% horizontal errors	±5m	100	90	100	75	100	86	100	100	100	45
Section Start – Altitude	65% differences	±5m	100	100	100	75	100	100	100	100	100	100
OSGR co-ordinates	65% horizontal errors	±7m	98	100	100	85	100	95	100	100	100	67
Altitude	65% differences	±7m	100	100	100	91	100	100	100	100	100	100
Parameter	**Target**	**Range**	**Site 11**	**Site 12**	**Site 13**	**Site 14**	**Site 15**	**Site 16**	**Site 17**	**Site 18**	**Site 19**	**Site 20**
Section Lengths	65% horizontal errors	±5m or 0.1%	100	100	100	100	100	100	100	100	100	100
Section Start – OSGR co-ordinates	65% horizontal errors	±5m	60	81	79	83	39	55	26	22	56	83
Section Start – Altitude	65% differences	±5m	96	100	100	100	100	91	100	100	100	100
OSGR co-ordinates	65% horizontal errors	±7m	75	88	91	74	53	52	56	59	59	72
Altitude	65% differences	±7m	100	100	100	99	100	97	100	100	98	100
Parameter	**Target**	**Range**	**Site 21**	**Site 22**	**Site 23**	**Site 24**	**Site 25**	**Site 26**	**Site 27**	**Site 28**	**Site 29**	**Site 30**
Section Lengths	65% horizontal errors	±5m or 0.1%	100	100	100	100	100	100	100	100	100	100
Section Start – OSGR co-ordinates	65% horizontal errors	±5m	39	75	31	62	52	67	51	81	38	0
Section Start – Altitude	65% differences	±5m	100	100	100	100	100	100	100	100	100	100
OSGR co-ordinates	65% horizontal errors	±7m	54	78	41	79	31	77	49	83	41	0
Altitude	65% differences	±7m	100	100	100	100	100	100	100	100	100	100
Parameter	**Target**	**Range**	**Site 31**	**Site 32**	**Site 33**	**Site 34**	**Site 35**	**Site 36**	**Site 37**	**Site 38**	**Site 39**	**Site 40**
Section Lengths	65% horizontal errors	±5m or 0.1%	100	100	100	100	100	100	100	100	100	100
Section Start – OSGR co-ordinates	65% horizontal errors	±5m	80	51	100	90	100	100	100	100	42	70
Section Start – Altitude	65% differences	±5m	100	100	92	100	100	100	100	100	100	100
OSGR co-ordinates	65% horizontal errors	±7m	98	76	100	100	100	100	100	100	54	99
Altitude	65% differences	±7m	100	100	100	100	100	100	100	100	99	100

Note: Performance values reported in black text meet the requirements
Performance values reported in pink text nearly meet the requirements (within 5%)
Performance values reported in red text fail to meet the requirements

Table 5(continued): CRS Location Reference performance

Parameter	Target	Range	Measured Performance (%)									
			Site 41	Site 42	Site 43	Site 44	Site 45	Site 46	Site 47	Site 48	Site 49	Site 50
Section Lengths	65% horizontal errors	±5m or 0.1%	100	100	100	100	100	100	100	100	100	100
Section Start – OSGR co-ordinates	65% horizontal errors	±5m	86	21	58	71	60	33	64	43	50	78
Section Start – Altitude	65% differences	±5m	100	86	100	86	100	100	91	100	100	100
OSGR co-ordinates	65% horizontal errors	±7m	85	38	98	97	97	69	69	78	85	76
Altitude	65% differences	±7m	100	100	100	86	100	100	96	100	100	100
Parameter	**Target**	**Range**	**Site 51**	**Site 52**	**Site 53**	**Site 54**	**Site 55**	**Site 56**	**Site 57**	**Site 58**	**Site 59**	**Site 60**
Section Lengths	65% horizontal errors	±5m or 0.1%	100	100	100	100	100	100	100	100	100	100
Section Start – OSGR co-ordinates	65% horizontal errors	±5m	67	25	0	80	96	100	100	100	88	64
Section Start – Altitude	65% differences	±5m	100	100	100	100	91	100	100	100	100	100
OSGR co-ordinates	65% horizontal errors	±7m	100	44	6	100	92	100	100	100	100	97
Altitude	65% differences	±7m	100	100	100	100	98	100	100	100	100	100
Parameter	**Target**	**Range**	**Site 61**	**Site 62**	**Site 63**	**Site 64**	**Site 65**	**Site 66**	**Site 67**	**Site 68**	**-**	**-**
Section Lengths	65% horizontal errors	±5m or 0.1%	100	100	100	100	100	100	100	100	-	-
Section Start – OSGR co-ordinates	65% horizontal errors	±5m	54	75	89	92	100	100	75	67	-	-
Section Start – Altitude	65% differences	±5m	69	92	100	85	38	100	100	83	-	-
OSGR co-ordinates	65% horizontal errors	±7m	87	83	100	75	95	100	98	100	-	-
Altitude	65% differences	±7m	89	99	100	90	56	100	100	98	-	-

Note: Performance values reported in black text meet the requirements
Performance values reported in pink text nearly meet the requirements (within 5%)
Performance values reported in red text fail to meet the requirements

Table 6: ARS Location Reference performance

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
Section Lengths	65% horizontal errors	±5m or 0.1%	67	N/A	22	N/A	65	N/A	50	40	33	40	22
Section Start – OSGR co-ordinates	65% horizontal errors	±5m	67	N/A	44	N/A	32	N/A	22	20	33	67	29
Section Start – Altitude	65% differences	±5m	100	N/A	100	N/A	91	N/A	100	60	83	78	13
OSGR co-ordinates	65% horizontal errors	±7m	90	N/A	69	67	67	N/A	32	59	60	86	35
Altitude	65% differences	±7m	100	N/A	100	43	100	N/A	100	61	98	100	16

Note: Performance values reported in black text meet the requirements
Performance values reported in pink text nearly meet the requirements (within 5%)
Performance values reported in red text fail to meet the requirements

Geometry

As can be seen from Table 7 and Table 8 a very good performance was seen for both the measurements of gradient and crossfall with all the SCANNER devices exhibiting high levels of repeatability (CRS) and reproducibility (ARS).

When looking at the performance of both gradient and crossfall for ARS there was occasionally evidence of a small bias (~0.5%) for some of the devices when compared to the reference device (HARRIS1). This is thought to be due to the 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.

Although the switch to the assessment of the measure of curvature seems to have improved the overall performance level achieved by the SCANNER devices, there are still some cases where the requirements are not met. From the analysis of the curvature performance achieved from CRS, lower levels of performance have been seen for sites that are more curved in nature. This explains why a better performance is generally seen for surveys undertaken on A roads which are likely to be straighter than B or C class roads. It was also noted that one of the contractors performed considerably better than the other contractors for this parameter.

Table 7: CRS Geometry performance

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
Gradient	65% differences	±1.5% or 10%	100	100	100	100	100	100	100	100	100	100
Crossfall	65% differences	±1.5% or 10%	100	100	100	100	99	100	100	100	100	99
Curvature	65% differences	±0.0015m^{-1}	94	85	91	88	82	89	92	91	96	60

Parameter	Target	Range	Measured Performance (%)									
			Site 11	Site 12	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18	Site 19	Site 20
Gradient	65% differences	±1.5% or 10%	100	100	100	100	99	100	98	100	98	100
Crossfall	65% differences	±1.5% or 10%	100	100	98	98	96	99	97	98	98	100
Curvature	65% differences	±0.0015m^{-1}	57	62	64	66	52	65	52	64	55	43

Parameter	Target	Range	Measured Performance (%)									
			Site 21	Site 22	Site 23	Site 24	Site 25	Site 26	Site 27	Site 28	Site 29	Site 30
Gradient	65% differences	±1.5% or 10%	100	100	98	100	93	100	97	100	100	99
Crossfall	65% differences	±1.5% or 10%	97	99	100	100	93	98	97	99	99	99
Curvature	65% differences	±0.0015m^{-1}	62	61	54	56	64	73	59	52	57	48

Parameter	Target	Range	Measured Performance (%)									
			Site 31	Site 32	Site 33	Site 34	Site 35	Site 36	Site 37	Site 38	Site 39	Site 40
Gradient	65% differences	±1.5% or 10%	100	99	100	99	100	100	100	100	100	100
Crossfall	65% differences	±1.5% or 10%	100	98	100	100	100	100	96	97	97	94
Curvature	65% differences	±0.0015m^{-1}	53	58	66	74	92	95	64	82	52	42

Parameter	Target	Range	Measured Performance (%)									
			Site 41	Site 42	Site 43	Site 44	Site 45	Site 46	Site 47	Site 48	Site 49	Site 50
Gradient	65% differences	±1.5% or 10%	99	99	99	100	100	95	100	100	100	100
Crossfall	65% differences	±1.5% or 10%	99	96	99	100	99	97	100	100	100	97
Curvature	65% differences	±0.0015m^{-1}	60	58	58	70	60	52	51	56	56	50

Parameter	Target	Range	Measured Performance (%)									
			Site 51	Site 52	Site 53	Site 54	Site 55	Site 56	Site 57	Site 58	Site 59	Site 60
Gradient	65% differences	±1.5% or 10%	100	100	100	100	100	100	100	100	100	100
Crossfall	65% differences	±1.5% or 10%	99	96	89	100	94	100	100	100	100	99
Curvature	65% differences	±0.0015m^{-1}	48	38	35	61	43	79	94	90	84	51

Parameter	Target	Range	Measured Performance (%)									
			Site 61	Site 62	Site 63	Site 64	Site 65	Site 66	Site 67	Site 68	-	-
Gradient	65% differences	±1.5% or 10%	100	97	100	100	99	100	100	100	-	-
Crossfall	65% differences	±1.5% or 10%	98	98	100	100	100	98	99	100	-	-
Curvature	65% differences	±0.0015m^{-1}	41	46	49	51	41	31	49	48	-	-

Note: Performance values reported in black text meet the requirements
Performance values reported in pink text nearly meet the requirements (within 5%)
Performance values reported in red text fail to meet the requirements

Table 8: ARS Geometry performance

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
Gradient	65% differences	±1.5% or 10%	96	92	92	89	96	98	100	93	94	95	90
Crossfall	65% differences	±1.5% or 10%	97	96	75	93	89	88	99	90	96	98	80
Curvature	65% differences	±0.0015m^{-1}	52	48	51	38	27	49	66	42	44	23	25

Note: Performance values reported in black text meet the requirements
Performance values reported in pink text nearly meet the requirements (within 5%)
Performance values reported in red text fail to meet the requirements

RCI Parameters

For the majority of the parameters used within the RCI (variance, rut depth, texture and cracking) a generally good performance was seen for both the repeatability (CRS) and reproducibility (ARS) tests. The results can be as can be seen in Table 9 to Table 12.

Table 9: CRS RCI parameters performance

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
LPV - 3m NS moving average	65% fractional errors	±0.6	95	96	95	94	95	95	99	100	98	93
LPV - 10m NS moving average	65% fractional errors	±0.7	97	99	97	99	97	99	100	100	100	96
NS Rut depths	65% differences	±3mm	100	98	91	98	96	99	87	94	97	94
OS Rut depths	65% differences	±3mm	100	96	95	96	99	100	99	98	97	96
Texture - SMTD	65% differences	±0.25mm	99	98	97	100	98	97	100	99	99	99
Cracking Intensity	65% differences	±0.1	32	82	61	77	43	73	72	80	42	84
Parameter	**Target**	**Range**	**Measured Performance (%)**									
			Site 11	Site 12	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18	Site 19	Site 20
LPV - 3m NS moving average	65% fractional errors	±0.6	95	94	95	89	92	88	95	98	89	100
LPV - 10m NS moving average	65% fractional errors	±0.7	98	97	98	92	94	92	97	99	93	99
NS Rut depths	65% differences	±3mm	92	96	91	94	90	97	89	97	90	95
OS Rut depths	65% differences	±3mm	99	99	99	100	98	98	99	99	98	98
Texture - SMTD	65% differences	±0.25mm	97	96	98	98	92	98	98	100	96	100
Cracking Intensity	65% differences	±0.1	83	79	93	84	93	77	85	80	51	91

Note: Performance values reported in black text meet the requirements
Performance values reported in pink text nearly meet the requirements (within 5%)
Performance values reported in red text fail to meet the requirements

Table 10 (continued): CRS RCI parameters performance

Parameter	Target	Range	Measured Performance (%)									
			Site 21	Site 22	Site 23	Site 24	Site 25	Site 26	Site 27	Site 28	Site 29	Site 30
LPV - 3m NS moving average	65% fractional errors	±0.6	95	95	88	93	86	97	92	90	94	96
LPV - 10m NS moving average	65% fractional errors	±0.7	94	99	93	97	90	97	92	98	95	97
NS Rut depths	65% differences	±3mm	89	97	90	97	88	98	89	99	96	90
OS Rut depths	65% differences	±3mm	98	98	88	100	97	100	100	98	99	97
Texture - SMTD	65% differences	±0.25mm	98	98	99	100	91	98	99	100	96	99
Cracking Intensity	65% differences	±0.1	83	15	81	70	82	21	39	56	89	35
Parameter	Target	Range	Measured Performance (%)									
			Site 31	Site 32	Site 33	Site 34	Site 35	Site 36	Site 37	Site 38	Site 39	Site 40
LPV - 3m NS moving average	65% fractional errors	±0.6	97	89	99	94	96	98	81	96	87	91
LPV - 10m NS moving average	65% fractional errors	±0.7	99	93	99	97	99	99	97	100	93	98
NS Rut depths	65% differences	±3mm	88	97	99	96	99	100	100	92	98	89
OS Rut depths	65% differences	±3mm	93	99	100	99	98	100	99	99	100	98
Texture - SMTD	65% differences	±0.25mm	100	100	100	99	99	99	98	98	100	97
Cracking Intensity	65% differences	±0.1	53	47	N/A	38	87	89	40	91	70	82
Parameter	Target	Range	Measured Performance (%)									
			Site 41	Site 42	Site 43	Site 44	Site 45	Site 46	Site 47	Site 48	Site 49	Site 50
LPV - 3m NS moving average	65% fractional errors	±0.6	90	87	94	93	92	94	95	96	87	94
LPV - 10m NS moving average	65% fractional errors	±0.7	98	93	98	98	97	96	100	98	96	99
NS Rut depths	65% differences	±3mm	94	95	96	92	92	92	96	97	98	94
OS Rut depths	65% differences	±3mm	97	97	100	96	99	99	100	97	100	99
Texture - SMTD	65% differences	±0.25mm	100	98	98	96	100	100	98	100	98	96
Cracking Intensity	65% differences	±0.1	85	62	67	75	70	90	65	72	59	79
Parameter	Target	Range	Measured Performance (%)									
			Site 51	Site 52	Site 53	Site 54	Site 55	Site 56	Site 57	Site 58	Site 59	Site 60
LPV - 3m NS moving average	65% fractional errors	±0.6	97	93	94	95	90	89	97	98	91	94
LPV - 10m NS moving average	65% fractional errors	±0.7	97	93	94	99	93	96	100	98	100	99
NS Rut depths	65% differences	±3mm	91	95	91	96	92	98	96	97	96	91
OS Rut depths	65% differences	±3mm	100	99	99	95	96	95	100	100	98	97
Texture - SMTD	65% differences	±0.25mm	99	97	98	98	96	100	100	100	99	99
Cracking Intensity	65% differences	±0.1	67	60	88	75	36	94	75	65	38	55

Note: Performance values reported in black text meet the requirements
Performance values reported in pink text nearly meet the requirements (within 5%)
Performance values reported in red text fail to meet the requirements

Table 11 (continued): CRS RCI parameters performance

Parameter	Target	Range	Measured Performance (%)									
			Site 61	Site 62	Site 63	Site 64	Site 65	Site 66	Site 67	Site 68	-	-
LPV - 3m NS moving average	65% fractional errors	±0.6	86	98	64	98	98	95	96	96	-	-
LPV - 10m NS moving average	65% fractional errors	±0.7	95	100	72	99	99	97	99	99	-	-
NS Rut depths	65% differences	±3mm	96	93	94	90	94	94	94	94	-	-
OS Rut depths	65% differences	±3mm	100	97	99	60	93	99	100	99	-	-
Texture - SMTD	65% differences	±0.25mm	93	99	41	97	95	100	100	100	-	-
Cracking Intensity	65% differences	±0.1	61	48	37	59	61	71	61	49	-	-

Note: Performance values reported in black text meet the requirements
Performance values reported in pink text nearly meet the requirements (within 5%)
Performance values reported in red text fail to meet the requirements

Table 12: ARS RCI parameters performance

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
LPV - 3m NS moving average	65% fractional errors	±0.6	98	75	72	84	77	78	96	89	72	82	80
LPV - 10m NS moving average	65% fractional errors	±0.7	89	82	70	90	78	83	58	90	94	81	89
NS Rut depths	65% differences	±3mm	99	90	80	87	83	77	99	91	79	86	59
OS Rut depths	65% differences	±3mm	99	96	89	96	92	93	81	98	89	94	90
Texture - SMTD	65% differences	±0.25mm	99	96	95	93	87	91	100	96	92	94	95
Cracking Intensity (New method)	65% differences	±0.1	N/A	73	82	81	24	67	98	43	62	52	88
Cracking Intensity – Low level (Old method)	70% agreement	N/A	N/A	86	80	82	85	91	81	80	76	83	87
Cracking Intensity – High level (Old method)	70% agreement	N/A	N/A	56	33	9	43	33	0	50	25	43	9

Note: Performance values reported in black text meet the requirements
Performance values reported in pink text nearly meet the requirements (within 5%)
Performance values reported in red text fail to meet the requirements

In the CRS the measurement of moving average profile variance (3m and 10m), rut depths (NS and OS), and SMTD showed very high levels of repeatability. This is illustrated in Figure 9 which shows the distribution plots of the differences between these survey parameters reported in the two survey runs. It can be seen that the distribution curves for all vehicles are centred on (or near to) zero, indicating that no device has a significantly different behaviour from the others.

For the ARS, although the statistical performances are generally within the required tolerances for reproducibility, a higher level of variation is seen when looking at the normalised distribution plots in Figure 10.

In the ARS a wider distribution pattern is seen for the measurement of rut depth in the nearside wheel path to that seen in the offside wheel path. This type of behaviour is expected as the measurement of rut depth has shown to be more variable in the nearside wheelpath. This is probably because the current systems are susceptible to the driving line taken by the vehicle and hence the measurement position on the road. In particular, the measurement of kerbs (and verges) in the transverse profile can have a significant effect if they are not subsequently identified (and removed) from the nearside rut depth calculations.

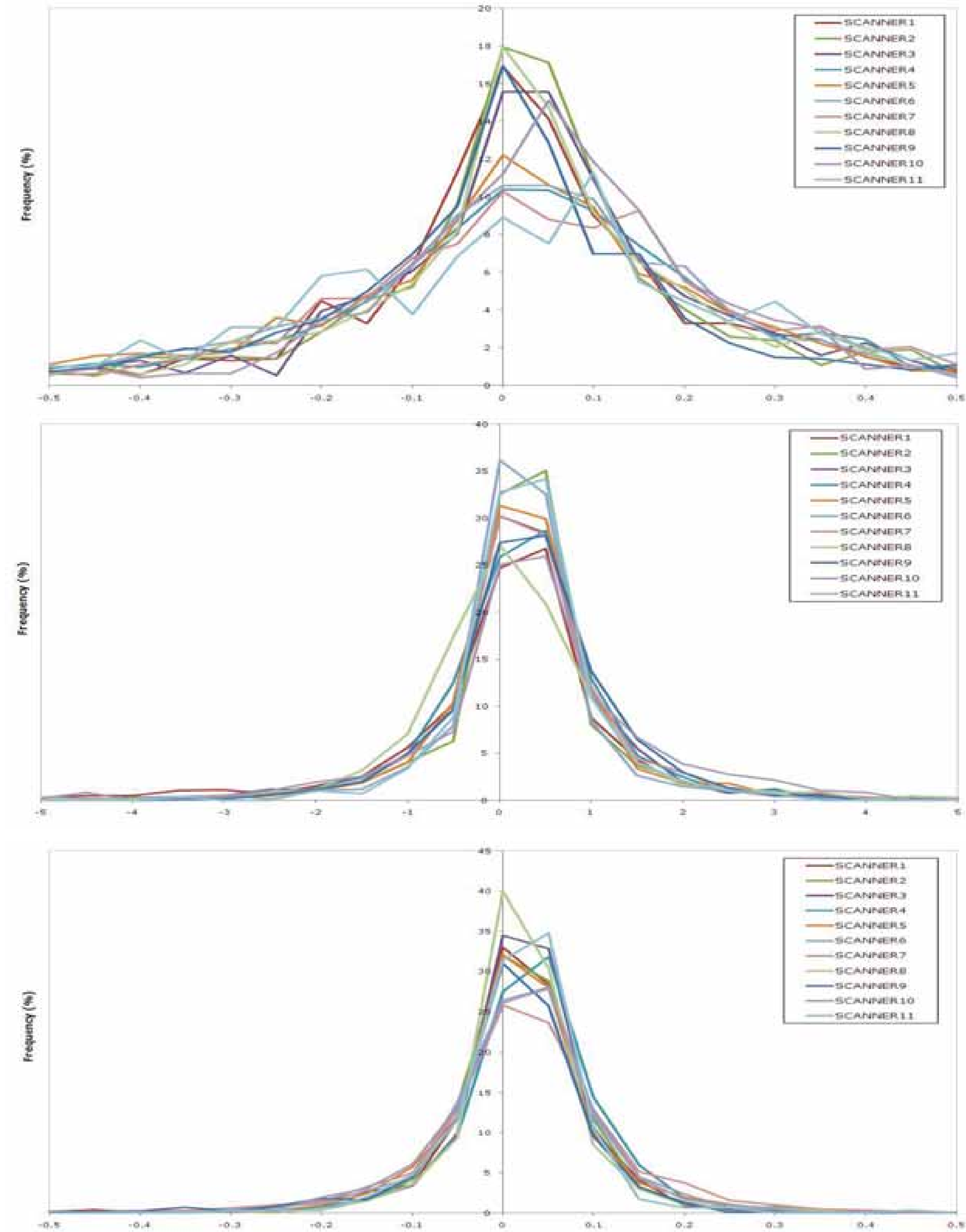

Figure 9: Normalised Distribution plots from CRS data showing high levels of repeatability for all the SCANNER devices – nearside 3m moving average longitudinal profile variance (top), offside rut depths (middle), and SMTD texture measurements (bottom).

Note: For the comparison of LPV data, differences are used when the variance is below 0.5mm^2 and fractional errors are used above this value.

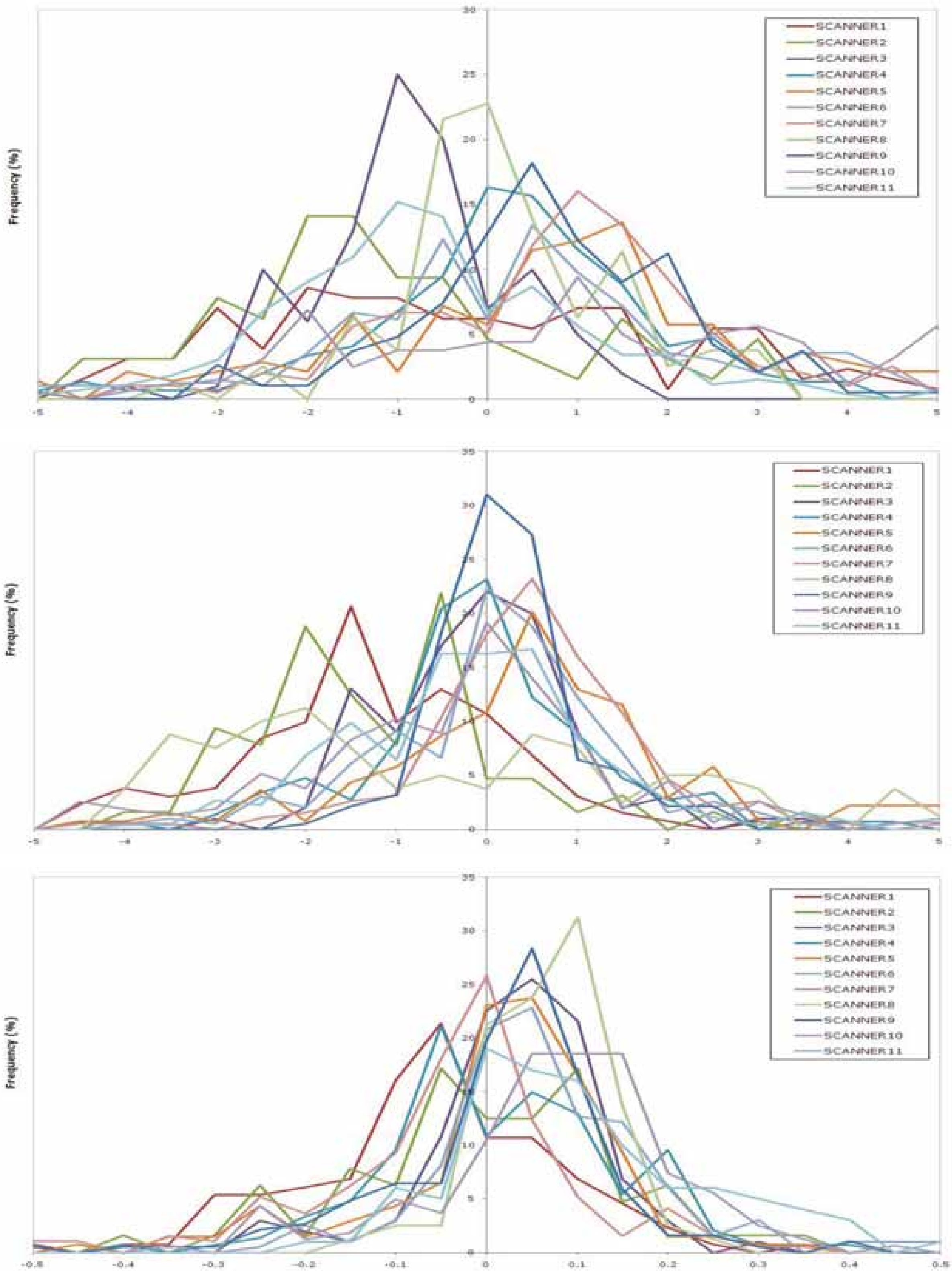

Figure 10: Normalised Distribution plots from ARS data showing levels of reproducibility for all the SCANNER devices - nearside rut depths (top), offside rut depths (middle) and SMTD texture measurements (bottom).

It can also be seen (in Figure 10) that there are small biases (~ 1mm to 1.5mm) present in the measurement of both nearside and offside rut depths for some of the devices. An example of a bias in nearside rutting can be seen by the purple line, in the top graph, in Figure 10 which is labelled SCANNER3. This bias can also be seen in Figure 11 (below) showing that SCANNER device is reporting higher levels of nearside rutting than the reference for the majority of ARS site 1. Two of the devices also displayed a small bias for the measurement of offside rutting (red and green lines in middle graph of Figure 10 and labelled SCANNER1 and SCANNER2 respectively). Although these performances met the ARS requirements, the presence of a bias is undesirable and further monitoring of these devices is recommended.

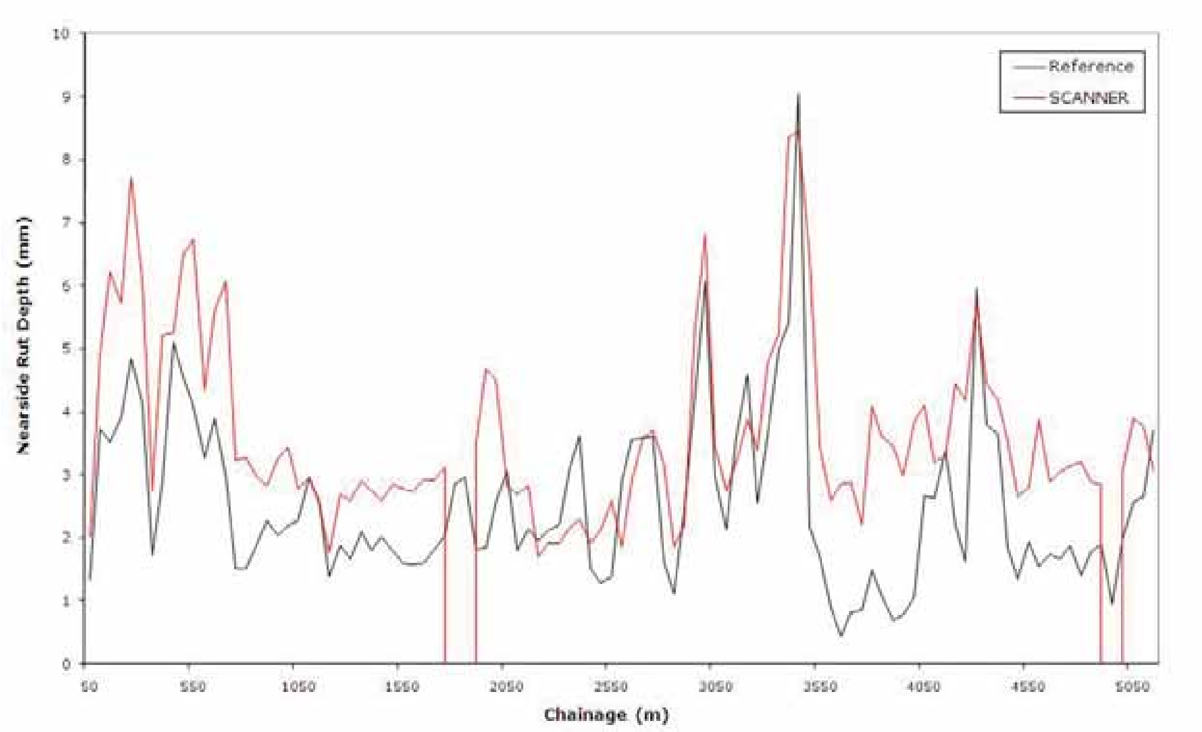

Figure 11: Plot of NS rut depths from ARS site 1.

The distribution of the differences between ARS texture measurements (SMTD) is also displayed in Figure 10. It can be seen that, although the SCANNER device distributions are typically centred close to zero, one device shows evidence of a 0.1mm bias (green line on bottom graph labelled SCANNER8). Although the performance meets the requirements of the specification the presence of a bias is undesirable and the contractor has been made aware of this issue.

Although nearly all of the RCI parameters were measured within tolerance in the CRS (except cracking) it can be seen from Table 9 and Table 13 that a low performance was exhibited for SMTD, MPD, NS & OS RMST on CRS site 63. This lower level of performance was due to large difference between the reported texture in both runs for the first half of the site. It can be seen from Figure 12 that the SMTD reported in Run 2 was much higher than would be typically expected on any road (SMTD is usually less than approximately 2mm). This issue was reported to the contractor concerned, who stated that this had already been flagged by their internal QA and the site was scheduled to be resurveyed.

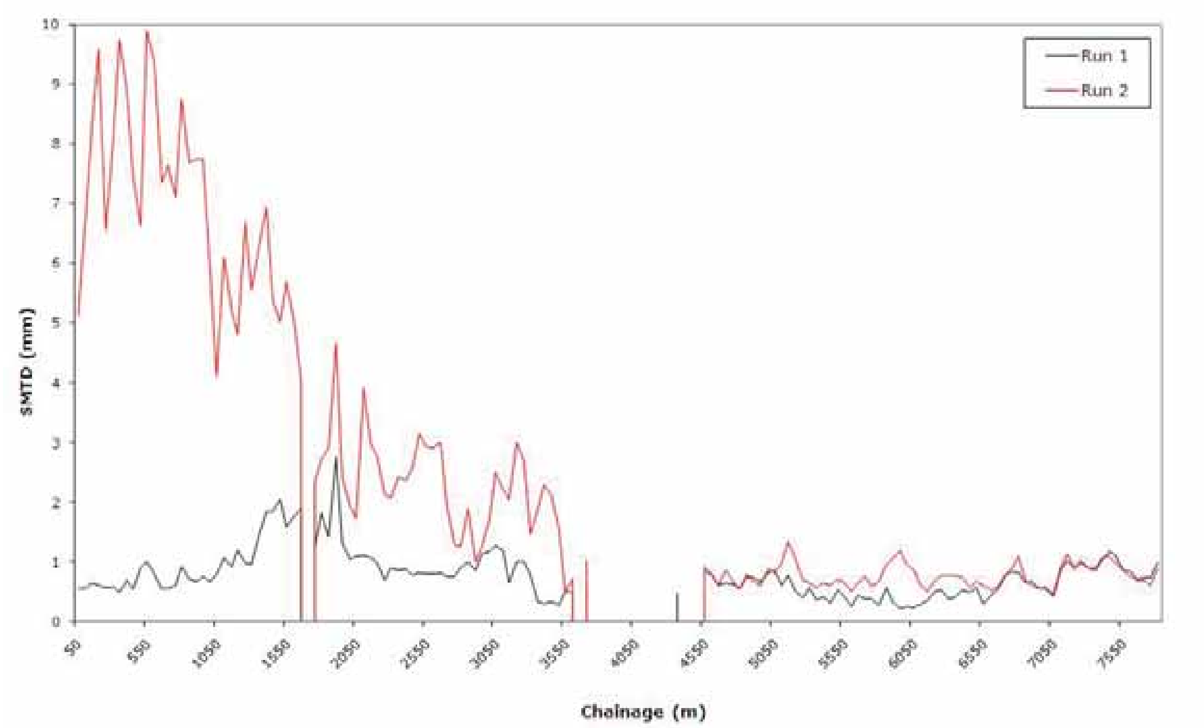

Figure 12: Plot of SMTD from CRS site 63.

It has been regularly reported that the measurement of cracking is less repeatable (and reproducible) than the other SCANNER parameters. Previous years have shown that this measurement is susceptible to changes in the driving line and/or the environmental conditions. An example of this variation can be seen in Figure 13 where the cracking reported for the initial survey was much higher than the repeat survey. Upon delivery of this data the contractor concerned highlighted that the initial survey was carried out while the road surface was still damp in places.

Although the new assessment method for the measurement of cracking introduced for the CRS assessment of repeatability gives a much fairer comparison than the previous method, there were still some instances where a statistical "failure" of the requirements was seen despite the fact that there was good "visual" comparison of the data. This can be seen in Figure 14, showing the cracking reported on CRS site 5. Good graphical agreement is seen, yet a statistical performance of only 43% agreement was achieved.

Furthermore, although the new assessment method appears to give a more realistic performance for the measurement of cracking on the majority of sites, it appears that this method is not as good for sites containing high levels of cracking. Further improvements to the assessment method are therefore recommended.

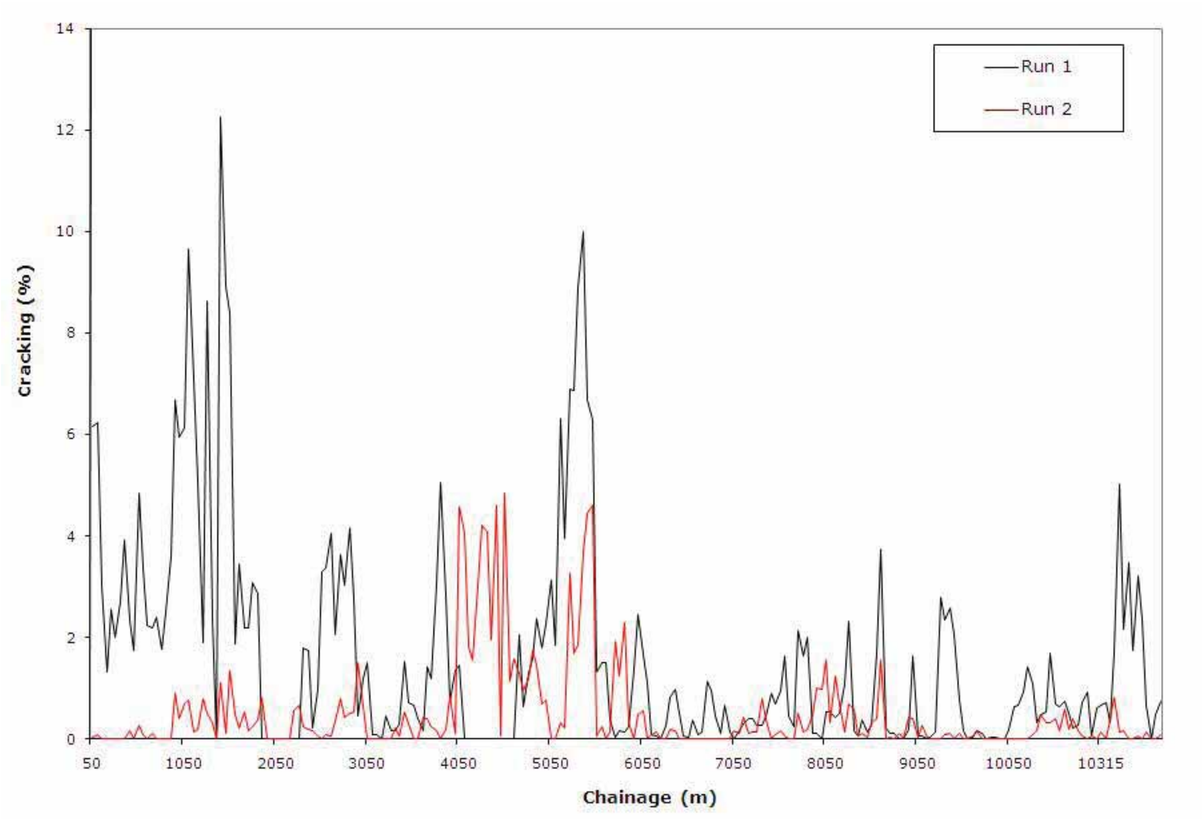

Figure 13: Plot of Percentage Cracking from CRS site 26.

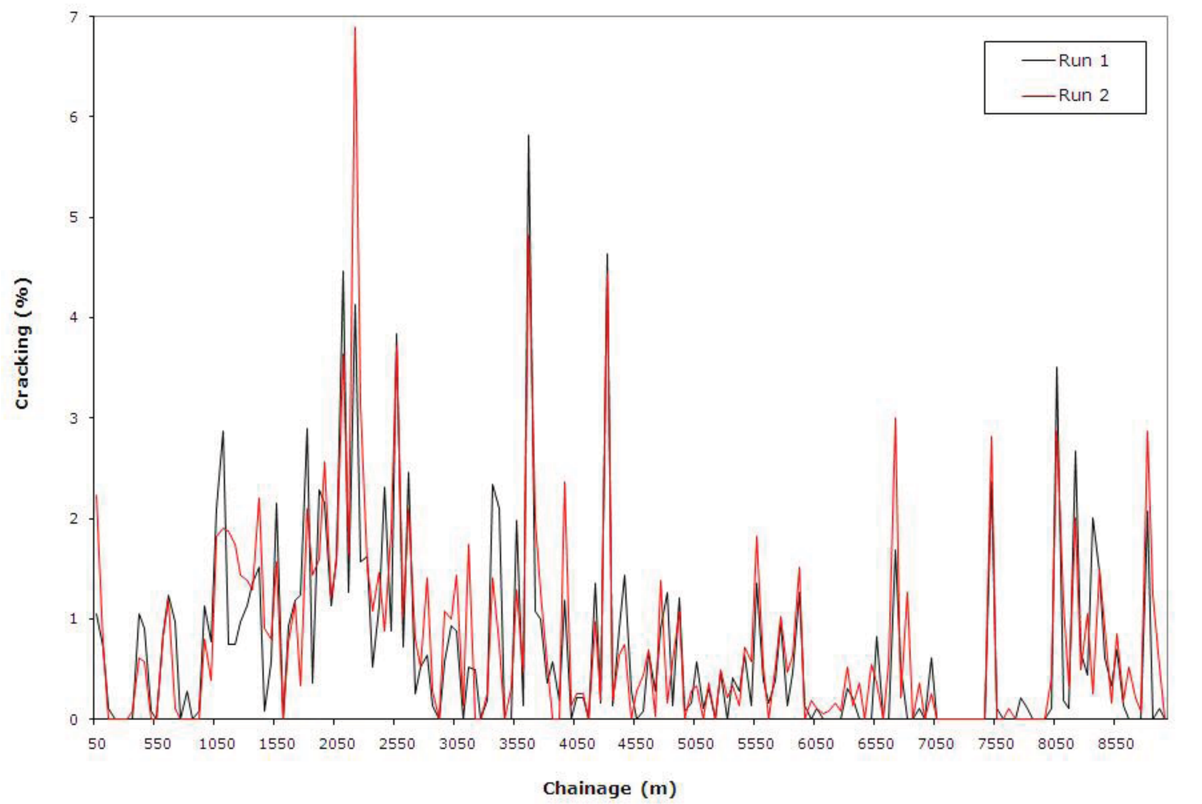

Figure 14: Plot of Percentage Cracking from CRS site 5.

For the 2009/10 survey year it was also decided to use the new cracking comparison method for the ARS. However, it can be seen from Table 12 that both the new and old assessment methods have been reported. The performance figures reported using the old comparison method show that the SCANNER systems are more reproducible in the areas of low level cracking than in areas of high level cracking. This may be due to the relatively low amounts of high level cracking reported on the test sites and therefore the high level comparisons are generally carried out on a small number of data points.

It is noted that applying the new comparison method can give a better overall representation of the performance over an entire site. This can be demonstrated by the performance figures reported in Table 12 for ARS site 5 and Figure 15. Here the old method report good agreement at the low level and reasonable agreement (in the context of SCANNER) at the high level. However, the new comparison method clearly highlights the overall poor performance on this test site, as shown in Figure 15.

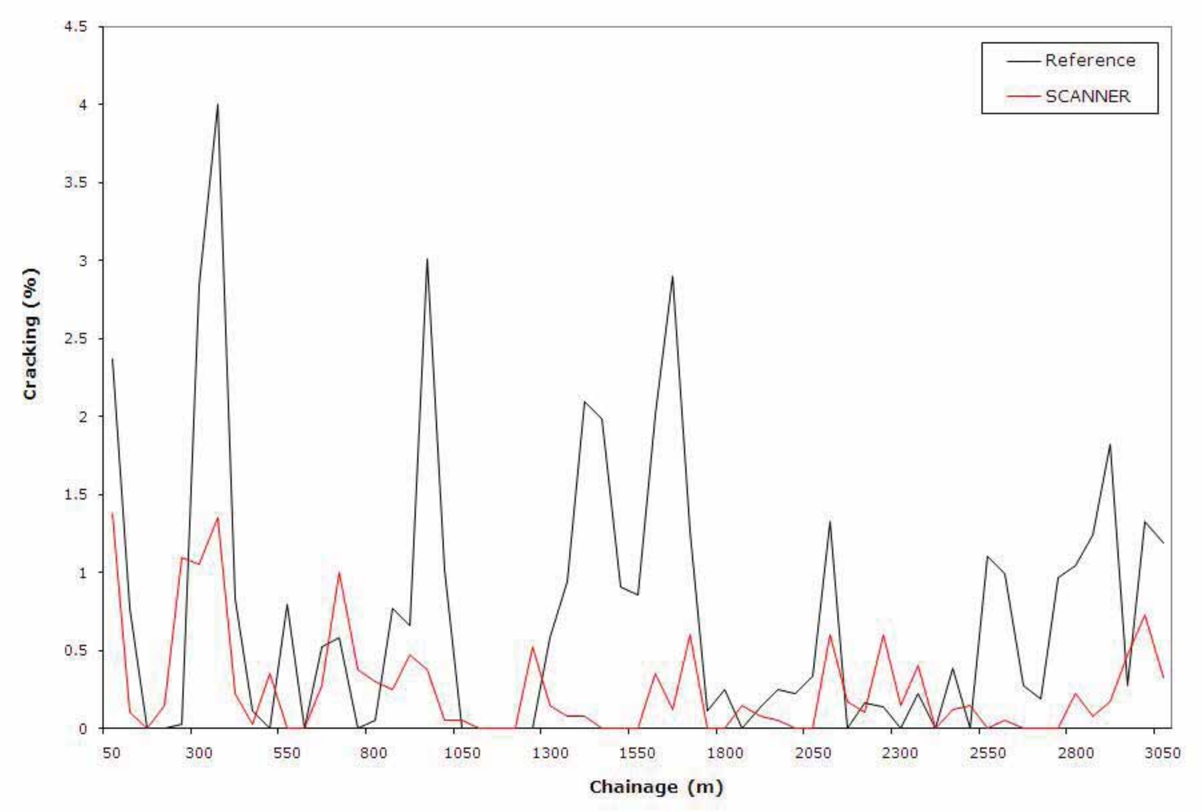

Figure 15: Plot of Percentage Cracking from ARS site 5.

Overall the cracking reported in 2009/10 showed similar levels of performance to that seen in previous SCANNER survey years. The performance of the SCANNER devices was affected by localised areas of both under and over reporting of cracking. There were also many cases where 'non-crack feature' such as road markings and traffic loops were reported as cracking.

Other (New) SCANNER Parameters

Generally very good level of repeatability and reproducibility is seen for all the SCANNER devices for the "new" SCANNER measurements (nearside and offside (NS & OS) enhanced variance, NS & OS cleaned rut depth, NS MPD, and NS, middle and OS RMST).

The levels of performance achieved for the CRS and ARS undertaken during the survey year are listed in Table 13 and Table 14.

Note: the remaining parameters of bump, transverse unevenness, edge roughness and texture variability do not currently have performance requirements. It should be noted that performance requirements for transverse unevenness and edge roughness were published in October 2009 and these will be introduced for the 2010/11 surveys. These parameters are discussed further at the end of this section.

Table 13: CRS Other parameters performance

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
LPV - 3m NS Enhanced	65% fractional errors	±0.6	97	96	94	95	93	95	100	99	98	94
LPV - 10m NS Enhanced	65% fractional errors	±0.7	97	99	94	100	95	97	100	99	99	95
LPV - 3m OS Enhanced	65% fractional errors	±0.6	97	99	98	98	97	97	100	100	99	95
LPV - 10m OS Enhanced	65% fractional errors	±0.7	99	99	98	97	99	96	100	100	99	94
NS Cleaned Rut depths	65% differences	±3mm	100	98	89	99	95	99	94	99	94	96
OS Cleaned Rut depths	65% differences	±3mm	100	96	91	95	98	100	99	99	95	94
Texture - MPD	65% differences	±0.25mm	99	98	95	99	94	95	98	99	96	97
Texture - NS RMST	65% differences	±0.25mm	99	99	98	100	100	99	100	100	100	100
Texture - Mid RMST	65% differences	±0.25mm	100	100	98	98	100	99	99	100	100	100
Texture - OS RMST	65% differences	±0.25mm	99	100	100	100	99	100	100	100	99	100
Parameter	**Target**	**Range**	**Measured Performance (%)**									
			Site 11	Site 12	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18	Site 19	Site 20
LPV - 3m NS Enhanced	65% fractional errors	±0.6	93	94	96	91	91	90	95	100	89	99
LPV - 10m NS Enhanced	65% fractional errors	±0.7	96	97	96	90	93	89	95	96	91	99
LPV - 3m OS Enhanced	65% fractional errors	±0.6	97	98	96	94	97	97	100	100	79	97
LPV - 10m OS Enhanced	65% fractional errors	±0.7	99	100	97	96	95	95	99	96	89	98
NS Cleaned Rut depths	65% differences	±3mm	95	100	94	95	99	98	95	100	93	93
OS Cleaned Rut depths	65% differences	±3mm	99	99	100	99	98	99	100	98	95	100
Texture - MPD	65% differences	±0.25mm	96	97	91	97	85	95	86	98	93	100
Texture - NS RMST	65% differences	±0.25mm	100	100	100	99	99	99	99	100	100	100
Texture - Mid RMST	65% differences	±0.25mm	100	100	100	99	99	99	100	100	100	100
Texture - OS RMST	65% differences	±0.25mm	100	100	100	100	100	100	100	100	100	100

Note: Performance values reported in black text meet the requirements
Performance values reported in pink text nearly meet the requirements (within 5%)
Performance values reported in red text fail to meet the requirements

Table 13: CRS Other parameters performance

Parameter	Target	Range	Measured Performance (%)									
			Site 21	Site 22	Site 23	Site 24	Site 25	Site 26	Site 27	Site 28	Site 29	Site 30
LPV - 3m NS Enhanced	65% fractional errors	±0.6	97	95	89	92	87	98	94	89	99	92
LPV - 10m NS Enhanced	65% fractional errors	±0.7	94	98	91	95	87	97	92	97	95	96
LPV - 3m OS Enhanced	65% fractional errors	±0.6	99	95	92	95	96	97	96	97	99	96
LPV - 10m OS Enhanced	65% fractional errors	±0.7	97	95	93	96	93	96	95	99	99	100
NS Cleaned Rut depths	65% differences	±3mm	95	99	90	96	91	100	98	99	96	91
OS Cleaned Rut depths	65% differences	±3mm	97	100	94	100	97	100	100	99	99	95
Texture - MPD	65% differences	±0.25mm	92	95	95	98	88	82	97	99	93	97
Texture - NS RMST	65% differences	±0.25mm	100	99	99	100	99	100	99	100	100	100
Texture - Mid RMST	65% differences	±0.25mm	100	100	100	100	98	99	100	100	100	100
Texture - OS RMST	65% differences	±0.25mm	100	100	100	100	100	100	100	100	100	100
Parameter	Target	Range	Measured Performance (%)									
			Site 31	Site 32	Site 33	Site 34	Site 35	Site 36	Site 37	Site 38	Site 39	Site 40
LPV - 3m NS Enhanced	65% fractional errors	±0.6	99	90	100	96	99	97	88	96	93	88
LPV - 10m NS Enhanced	65% fractional errors	±0.7	99	91	100	95	98	97	89	99	91	94
LPV - 3m OS Enhanced	65% fractional errors	±0.6	98	97	99	99	98	98	87	95	88	89
LPV - 10m OS Enhanced	65% fractional errors	±0.7	98	96	99	99	99	98	84	97	89	90
NS Cleaned Rut depths	65% differences	±3mm	96	99	99	100	96	98	99	99	100	89
OS Cleaned Rut depths	65% differences	±3mm	93	97	100	100	96	100	99	100	100	99
Texture - MPD	65% differences	±0.25mm	96	98	97	99	97	99	91	94	99	89
Texture - NS RMST	65% differences	±0.25mm	100	100	100	100	99	99	99	99	100	99
Texture - Mid RMST	65% differences	±0.25mm	100	100	100	100	100	100	98	100	100	99
Texture - OS RMST	65% differences	±0.25mm	100	99	100	100	100	99	100	94	100	99
Parameter	Target	Range	Measured Performance (%)									
			Site 41	Site 42	Site 43	Site 44	Site 45	Site 46	Site 47	Site 48	Site 49	Site 50
LPV - 3m NS Enhanced	65% fractional errors	±0.6	95	89	93	93	90	97	98	97	87	93
LPV - 10m NS Enhanced	65% fractional errors	±0.7	93	91	94	95	94	96	98	98	93	98
LPV - 3m OS Enhanced	65% fractional errors	±0.6	93	93	90	97	100	92	96	96	98	92
LPV - 10m OS Enhanced	65% fractional errors	±0.7	88	94	94	99	99	96	97	97	96	96
NS Cleaned Rut depths	65% differences	±3mm	99	95	99	97	94	99	96	96	97	98
OS Cleaned Rut depths	65% differences	±3mm	96	94	99	99	100	99	100	98	99	99
Texture - MPD	65% differences	±0.25mm	95	91	95	94	99	96	97	98	95	93
Texture - NS RMST	65% differences	±0.25mm	100	100	100	100	100	100	100	100	97	98
Texture - Mid RMST	65% differences	±0.25mm	100	100	100	100	100	100	100	100	100	100
Texture - OS RMST	65% differences	±0.25mm	100	100	100	100	100	100	100	100	100	100

Note: Performance values reported in black text meet the requirements
Performance values reported in pink text nearly meet the requirements (within 5%)
Performance values reported in red text fail to meet the requirements

Table 13: CRS Other parameters performance

Parameter	Target	Range	Measured Performance (%)									
			Site 51	Site 52	Site 53	Site 54	Site 55	Site 56	Site 57	Site 58	Site 59	Site 60
LPV - 3m NS Enhanced	65% fractional errors	±0.6	95	96	94	95	90	88	96	99	90	94
LPV - 10m NS Enhanced	65% fractional errors	±0.7	97	93	94	100	94	90	96	98	95	95
LPV - 3m OS Enhanced	65% fractional errors	±0.6	91	93	91	97	94	96	100	100	96	99
LPV - 10m OS Enhanced	65% fractional errors	±0.7	98	87	93	98	95	96	100	100	97	99
NS Cleaned Rut depths	65% differences	±3mm	91	97	95	96	95	95	99	97	95	98
OS Cleaned Rut depths	65% differences	±3mm	100	99	99	100	98	95	100	100	99	99
Texture - MPD	65% differences	±0.25mm	99	94	95	97	88	95	100	97	94	94
Texture - NS RMST	65% differences	±0.25mm	100	99	99	100	99	100	100	100	100	100
Texture - Mid RMST	65% differences	±0.25mm	100	100	99	100	99	100	99	100	100	100
Texture - OS RMST	65% differences	±0.25mm	100	100	100	100	100	99	99	100	100	100

Parameter	Target	Range	Measured Performance (%)									
			Site 61	Site 62	Site 63	Site 64	Site 65	Site 66	Site 67	Site 68	-	-
LPV - 3m NS Enhanced	65% fractional errors	±0.6	82	96	67	100	96	97	95	90	-	-
LPV - 10m NS Enhanced	65% fractional errors	±0.7	92	99	65	99	99	94	98	96	-	-
LPV - 3m OS Enhanced	65% fractional errors	±0.6	92	96	70	99	99	99	100	93	-	-
LPV - 10m OS Enhanced	65% fractional errors	±0.7	96	98	67	100	99	98	99	92	-	-
NS Cleaned Rut depths	65% differences	±3mm	98	90	99	90	99	99	96	99	-	-
OS Cleaned Rut depths	65% differences	±3mm	100	88	99	70	95	98	98	98	-	-
Texture - MPD	65% differences	±0.25mm	88	92	23	94	87	96	95	99	-	-
Texture - NS RMST	65% differences	±0.25mm	97	99	50	98	100	100	100	100	-	-
Texture - Mid RMST	65% differences	±0.25mm	100	99	58	100	100	94	100	100	-	-
Texture - OS RMST	65% differences	±0.25mm	100	100	99	100	100	99	100	99	-	-

Note: Performance values reported in black text meet the requirements
Performance values reported in pink text nearly meet the requirements (within 5%)
Performance values reported in red text fail to meet the requirements

Table 14: ARS Other parameters performance

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
LPV - 3m NS Enhanced	65% fractional errors	±0.6	97	90	86	89	83	81	100	90	77	84	78
LPV - 10m NS Enhanced	65% fractional errors	±0.7	94	78	71	81	82	79	90	89	85	86	87
LPV - 3m OS Enhanced	65% fractional errors	±0.6	99	96	94	93	78	92	99	94	93	98	76
LPV - 10m OS Enhanced	65% fractional errors	±0.7	95	89	78	90	90	89	94	95	96	94	66
NS Cleaned Rut depths	65% differences	±3mm	100	91	85	83	87	87	100	96	75	83	52
OS Cleaned Rut depths	65% differences	±3mm	98	95	86	86	92	94	75	99	95	86	85
Texture - MPD	65% differences	±0.25mm	97	82	82	76	90	89	95	91	75	75	89
Texture - NS RMST	65% differences	±0.25mm	98	28	99	85	77	96	100	88	96	89	97
Texture - Mid RMST	65% differences	±0.25mm	87	5	88	77	83	95	99	82	99	72	98
Texture - OS RMST	65% differences	±0.25mm	97	90	99	98	90	94	100	93	97	94	96

Note: Performance values reported in black text meet the requirements
Performance values reported in pink text nearly meet the requirements (within 5%)
Performance values reported in red text fail to meet the requirements

Again as with the RCI parameters the newer SCANNER parameters showed very high levels of repeatability. This is illustrated in Figure 16, which shows the distribution plots of the differences between these survey parameters reported in the two survey runs. It can be seen that the distribution curves for all vehicles centre on (or near to) zero and that there are no devices showing a significantly different behaviour from the others.

For the ARS, although the statistical performances generally fall within the tolerances for reproducibility, a higher level of variation is seen when looking at the distribution plots, as can be seen in Figure 17. These distribution plots highlight two machines that are outliers from the fleet, SCANNER3 (purple line) in the middle MPD graph and SCANNER4 (blue line) on the bottom RMST graph.

Figure 18 shows the MPD data from ARS site 1 which was surveyed by SCANNER3. It can be seen that the device reports the MPD values approximately 0.1mm lower than the reference (this difference is also highlighted in Figure 17). It should be noted that although this performance does meet the QA requirements (Table 14) the presence of any bias is undesirable.

Figure 19 shows the middle RMST data from ARS site 2 which was surveyed by SCANNER4. It can be seen that the device reports the RMST values approximately 0.4mm lower than the reference (this difference is also highlighted in Figure 17). In this instance the device fails to meet the QA requirements. The contractor concerned has been informed and asked to investigate the issue. The results of this investigation have yet to be reported.

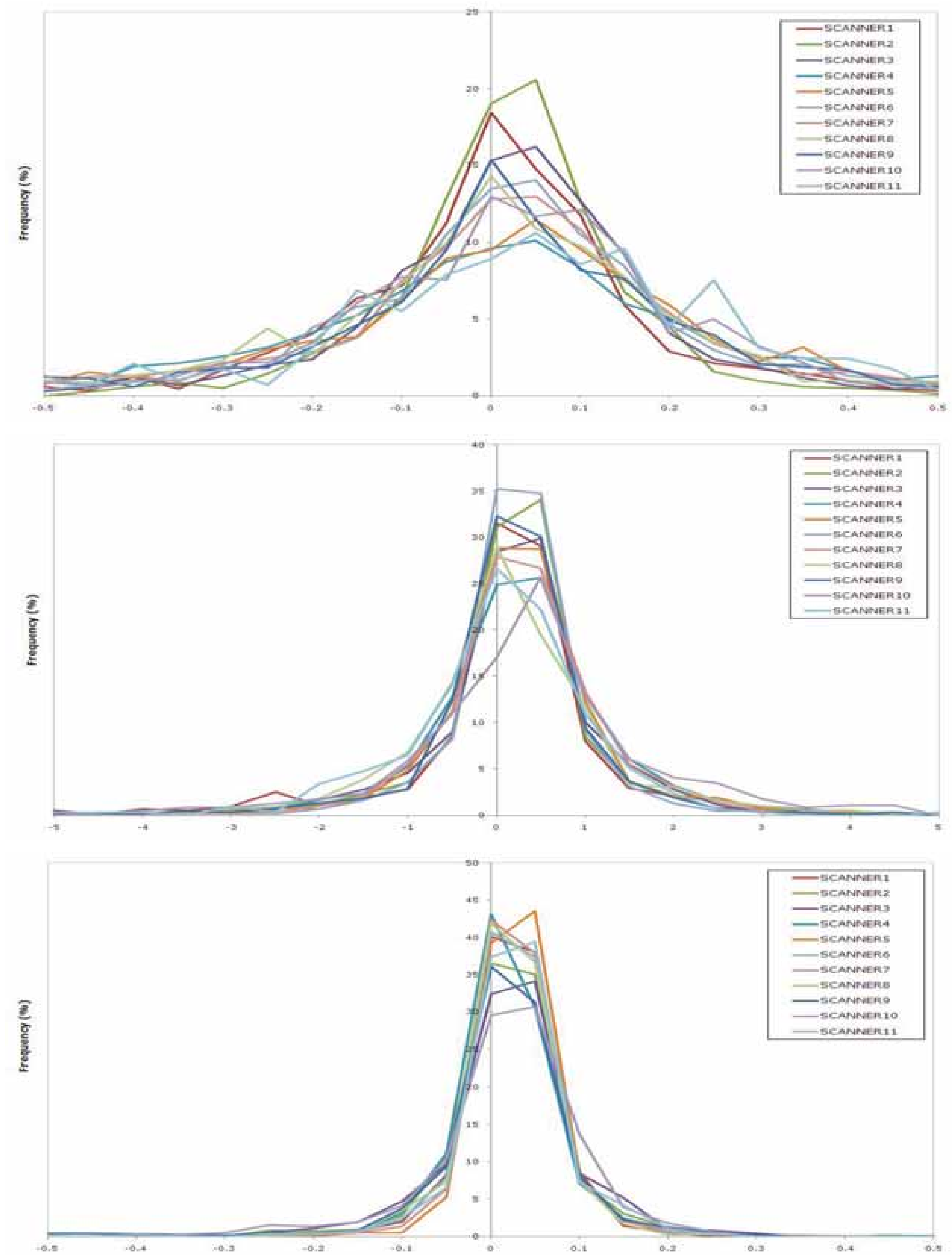

Figure 16: Normalised Distribution plots from CRS data showing levels of repeatability for all the SCANNER devices – 10m offside enhanced variance (top), nearside cleaned rut depth (middle) and nearside MPD (bottom).

Note: For the comparison of LPV data, differences are used when the variance is below 0.5mm^2 and fractional errors are used above this value.

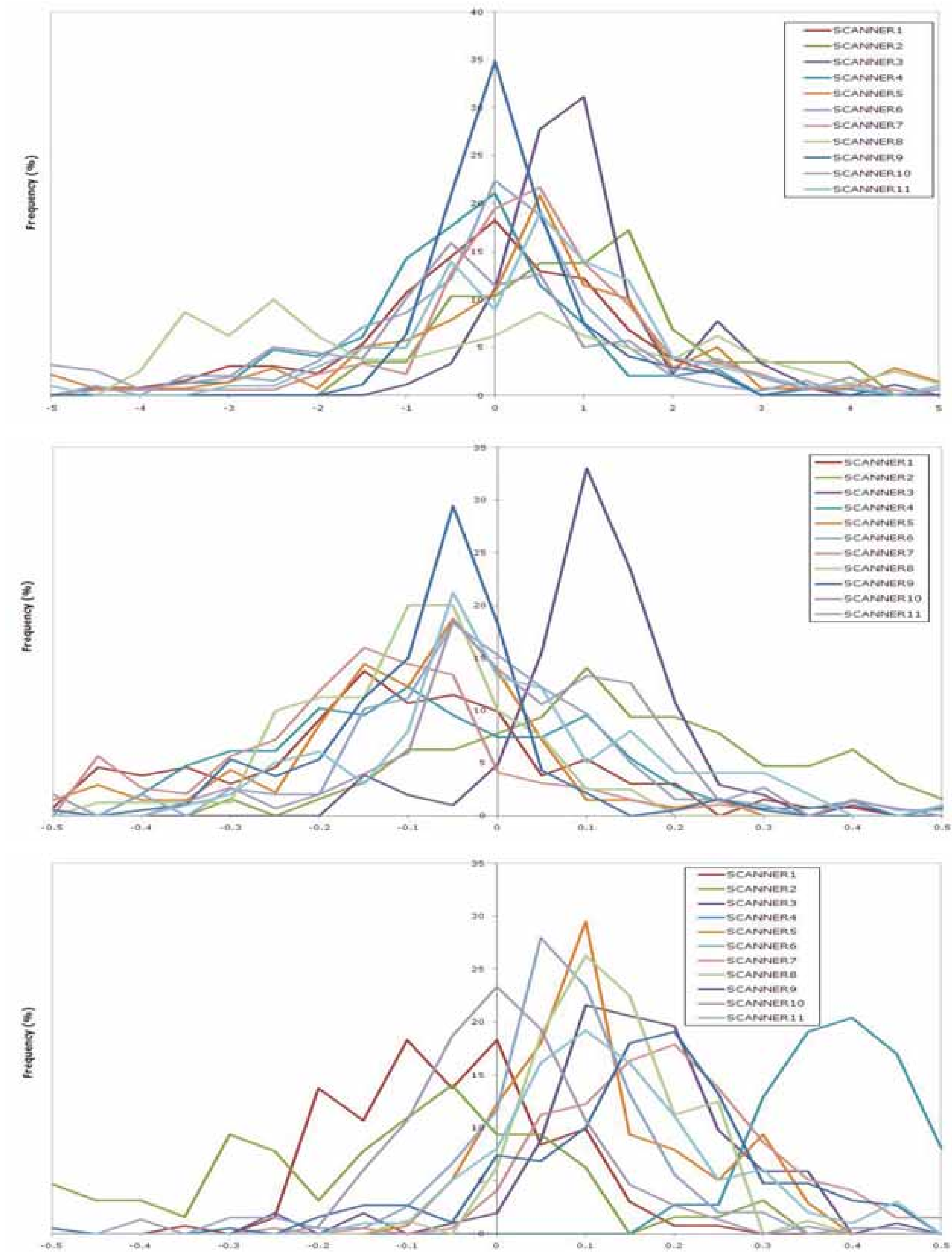

Figure 17: Normalised Distribution plots from ARS data showing levels of reproducibility for all the SCANNER devices - offside cleaned rut depths (top), MPD texture measurement (middle) and middle RMST texture measurements (bottom).

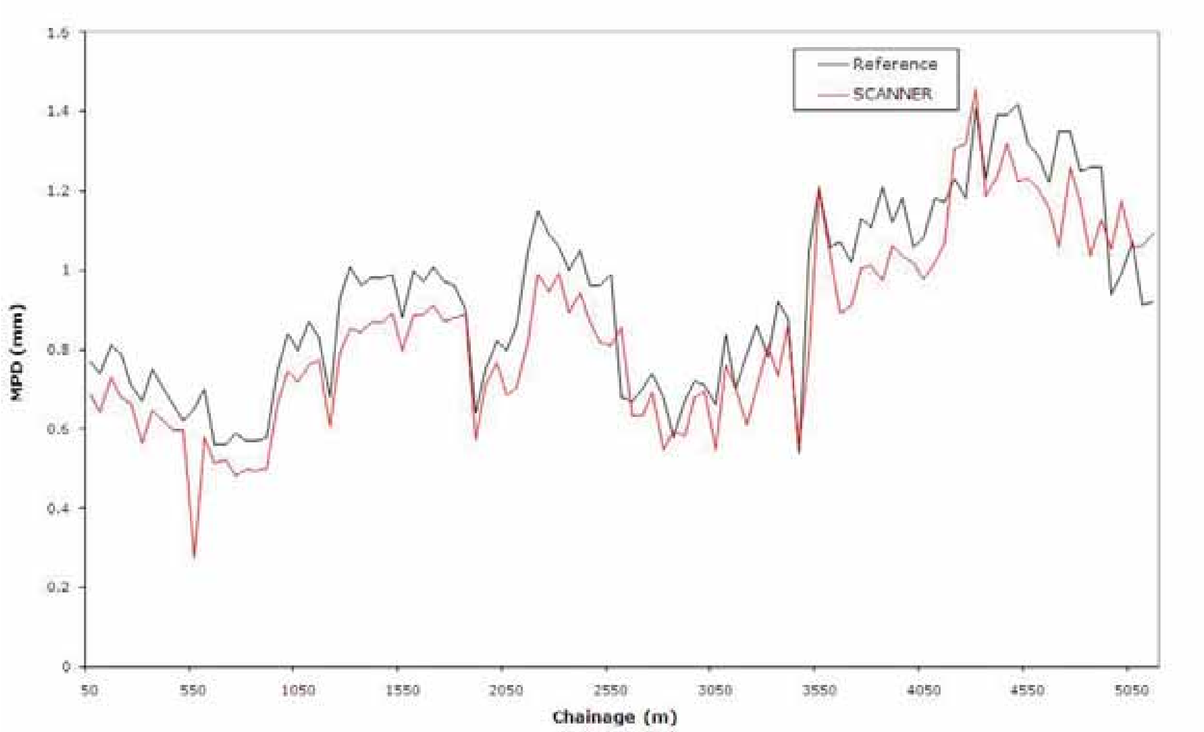

Figure 18: Plot of MPD from ARS site 1.

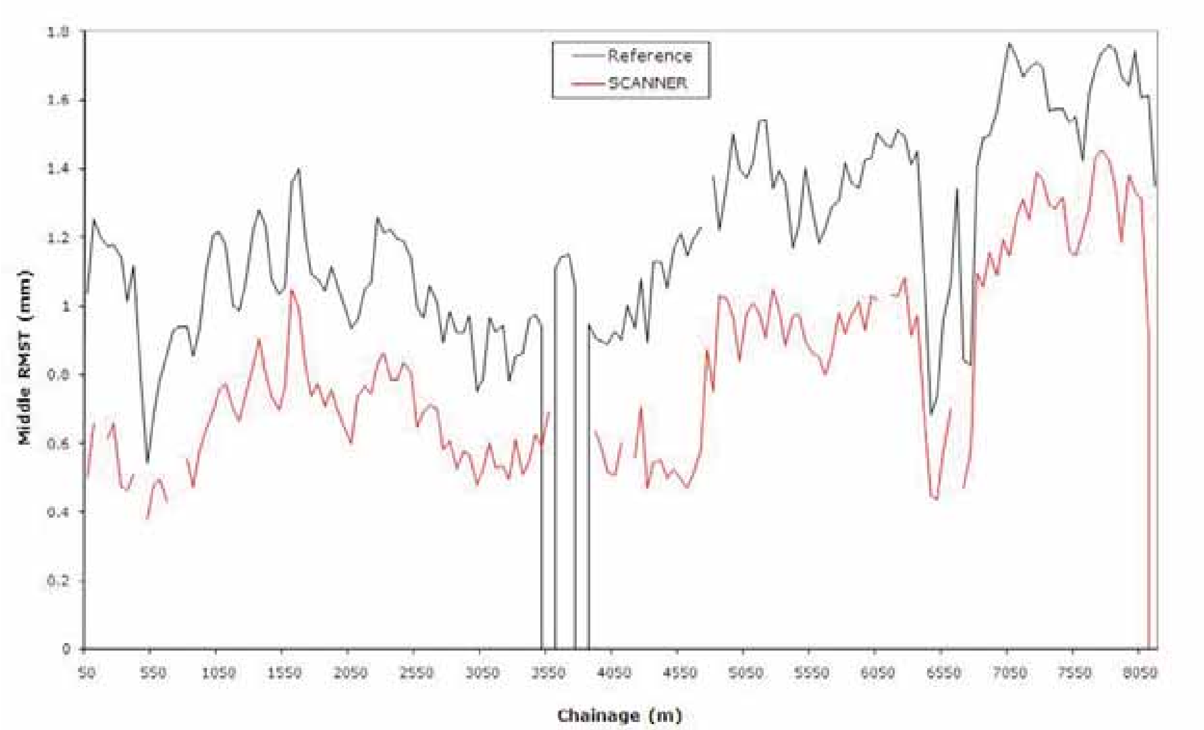

Figure 19: Plot of Middle RMST from ARS site 2.

Not all of the new SCANNER parameters included for the 2009/10 survey have performance requirements defined in the specification. However, these parameters have been analysed and visually assessed with the following observations noted:

- As noted in Section 2.3 the bump measure is not very repeatable or reproducible at the 10m data reporting level. There is evidence to suggest that it may be a more reliable tool in identifying areas of poor ride quality rather than individual bumps.
- Visual analysis of the transverse unevenness and edge roughness data from the CRS showed high levels of repeatability. As discussed in Section 2.3 there are some consistency issues seen across the SCANNER fleet for the edge roughness parameter.
- The assessment of the three lines of RMS variance, RMS percentiles (5^{th} and 95^{th}) and the RMS variance 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 and have not been statistically assessed as part of the accreditation and QA programme. Visual assessment of the data has shown that these parameters are not very repeatable. Cracking data in particular is known to be susceptible to driving line and/or environmental conditions.

7.3 Summary of repeat surveys

The repeat surveys have shown 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, rut depth 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 not to the extent that accreditation should be withdrawn or surveying suspended (i.e. until corrections are made).

Summary observations include:

- The accuracy of location 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 solution of simply stretching data to fit regardless 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 depend 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 (GPS), and can be reduced in adverse conditions.
- For geometry, longitudinal profile variance, rut depths and surface texture all survey machines generally performed satisfactorily on the test routes.
- For the RCI parameters the survey machines were generally performing satisfactorily on the QA test routes although there were some sites where not all the survey parameters met the requirements. In more cases than not this was the cracking data, which is well known to be a less repeatable measurement than the other survey parameters. There was the occasional site where other parameters (LPV and rut depths) did not fully meet the requirements. These parameters are susceptible to change with vehicle driving line. The surveys identified with the most issues were on C roads, which are generally narrower and more variable in nature (bumpier, more curved etc) and hence it was harder to repeat the survey following exactly the same line as the reference run.
- 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 runs carried out using the reference device. The variation in performance is not desirable, but is consistent with the level of performance that has come to be expected from these systems in their current state of development, and is a measurement that requires significant further improvement.
- The measurement of the new SCANNER parameter “bump” was not very repeatable or reproducible.
- Although the measurement of the new SCANNER parameters derived from RMST displayed good statistical performance for both repeatability and reproducibility tests, there were some as yet unexplained small differences observed on some of the test sites which require further investigation.

8 Consistency

During the yearly Accreditation test, each SCANNER device is required to survey two road routes; one consisting of a rural dual carriageway, known as SRR1 (SCANNER Road Route 1), which is 27km in length. The other is based on a mix of local urban and rural roads, roughly 32km in length, known as SRR2 (SCANNER Road Route 2). The 2009/10 data from these two routes, for each of the SCANNER devices was used to assess the consistency of the parameters used in the RCI calculation.

Once a device has been accredited they continue to be assessed throughout the year, under the Quality Assurance (QA) process. QA consists of Auditors Repeat Surveys (ARS) and Contractors Repeat Surveys (CRS), as discussed in previous sections of this report. Data from these tests has also been used for the consistency analysis. The length of ARS and CRS carried by each device is given in Table 15.

Table 15: Length of road class in ARS and CRS for each contractor

Device	Length contained in ARS (and for which reference cracking was available)	Length contained in CRS
Jacobs RST26	6,220m (5,330m)	44,610m
Yotta ARAN1	3,200m (2,610m)	60,770m
Yotta ARAN2	4850m (0m)	49,630m
WDM RAV1	7,880m (4,000m)	86,060m
WDM RAV2	7,180m (5,070m)	76,990m
WDM RAV3	9,860m (4,040m)	75,650m
WDM RAV4	10,180m (5,460m)	88,100m
WDM RAV5	4,230m (4,220m)	44,460m
WDM RAV6	9,180m (4,300m)	61,440m
WDM RAV7	4,370m (2,370m)	31,070m
WDM RAV8	5,150m (2,790m)	21,850m

8.1 Reference data

For the two SCANNER Road Routes (SRR1 and SRR2) two sources of reference data were used:

1) **Data collected by the Highways Agency's HARRIS1**. Surveys of the road routes were carried out by TRL using HARRIS1 to measure each of the SCANNER survey parameters. Note that, for the assessment of cracking, reference data is typically obtained via manual analysis of the HARRIS1 images. However, this data was only available for SRR1. Therefore a dataset of cracking data for SRR2 was obtained using the machine average cracking provided by the SCANNER survey vehicles. **MA1** – average cracking value of all machines, and **MA2** – average cracking value of all machines, excluding the machine with the maximum average cracking value, and that with the minimum average cracking value (to remove the effects of outliers).
2) **Machine average data**. This reference dataset was obtained by averaging the data from all machines, (excluding HARRIS1) for each parameter. The machine average RCI was calculated from average parameter values.

For the ARS, HARRIS1 data was available for reference for all routes but reference cracking data was only available for those sites chosen to be crack sites. For sites where there was no reference cracking data available, cracking was excluded from the RCI calculation.

When calculating the consistency of a device with respect to reference data, it is assumed that this reference data is the true value. With the reference datasets used herein, this is not really the case, since the HARRIS1 and device average data are themselves subject to error. However, they are considered to approximate the true measurement value for the purposes of this work.

8.2 Consistency of Individual Parameters

As stated above, in the accreditation tests, data is collected by all machines and by the reference machine, HARRIS1, on the two road routes. Therefore, equivalent data was available for all devices, from which bias and random error could be calculated. The results of this calculation are presented herein.

Table 16 summarises the bias and random errors obtained on the SCANNER Road Routes for each SCANNER device.

In Table 17 the biases and random errors shown in Table 16 are put into context, in terms of the range of values that could be expected from the machines, given a known reference measurement. As an example, for nearside rut depth, the reference vehicle, HARRIS1 reports an average value of 6.31mm. WDM RAV2 has a bias of -0.49mm and a random error of 0.091mm. Therefore the range of values (95% confidence) that the WDM machine could report is:

RAV2 value range = "true value" + bias ± confidence on bias ± random error

$$= 6.31 + -0.49 \pm 0.091 \pm 0.091 = 5.82 \pm 0.182,$$

giving a minimum value of 5.64mm and a maximum of 6.00mm.

Table 16: Consistency of parameters for all devices

Contractor and Device	Parameter	Bias from HARRIS1	Bias from device average	Confidence on bias and Random Error
Jacobs RST26	Nearside Rut (mm)	-1.22	-0.08	0.037
	Offside Rut (mm)	0.75	0.44	0.030
	3m LPV(mm^2)	0.24	-0.04	0.128
	10m LPV (mm^2)	12.83	8.81	3.467
	Texture (mm)	0.068	0.051	0.003
	Cracking (%)	-0.017 (MA1) -0.016 (MA2)	-0.002	0.007
Yotta ARAN1	Nearside Rut (mm)	-0.48	0.65	0.027
	Offside Rut (mm)	1.20	0.88	0.019
	3m LPV(mm^2)	-0.20	-0.49	0.030
	10m LPV (mm^2)	0.96	-3.06	0.164
	Texture (mm)	0.043	0.027	0.002
	Cracking (%)	-0.020 (MA1) -0.019 (MA2)	-0.005	0.004
Yotta ARAN2	Nearside Rut (mm)	-0.53	0.60	0.022
	Offside Rut (mm)	0.71	0.40	0.020
	3m LPV(mm^2)	-0.07	-0.36	0.041
	10m LPV (mm^2)	1.17	-2.86	0.178
	Texture (mm)	0.051	0.035	0.002
	Cracking (%)	-0.012(MA1) -0.010 (MA2)	0.004	0.004
WDM RAV1	Nearside Rut (mm)	-1.19	-0.05	0.062
	Offside Rut (mm)	-0.01	-0.32	0.021
	3m LPV(mm^2)	0.47	0.19	0.074
	10m LPV (mm^2)	3.87	-0.15	0.397
	Texture (mm)	0.036	0.020	0.002
	Cracking (%)	0.036 (MA1) 0.038 (MA2)	0.052	0.005

Table 16 continued: Consistency of parameters for all devices

Contractor and device	Parameter	Bias from HARRIS1	Bias from device Average	Confidence on bias and Random Error
WDM RAV2	Nearside Rut (mm)	-0.49	0.65	0.091
	Offside Rut (mm)	-0.17	-0.48	0.022
	3m LPV(mm^2)	0.40	0.12	0.072
	10m LPV (mm^2)	2.89	-1.13	0.303
	Texture (mm)	-0.007	-0.024	0.002
	Cracking (%)	-0.049 (MA1) -0.048 (MA2)	-0.033	0.003
WDM RAV3	Nearside Rut (mm)	-0.15	0.99	0.073
	Offside Rut (mm)	0.22	-0.10	0.020
	3m LPV(mm^2)	0.90	0.61	0.169
	10m LPV (mm^2)	3.44	-0.58	0.289
	Texture (mm)	-0.008	-0.024	0.002
	Cracking (%)	-0.064(MA1) -0.062 (MA2)	-0.048	0.003
WDM RAV4	Nearside Rut (mm)	-1.22	-0.09	0.070
	Offside Rut (mm)	-0.03	-0.34	0.018
	3m LPV(mm^2)	1.42	1.14	0.476
	10m LPV (mm^2)	12.04	8.01	3.163
	Texture (mm)	-0.004	-0.020	0.002
	Cracking (%)	-0.010 (MA1) -0.009 (MA2)	0.005	0.004
WDM RAV5	Nearside Rut (mm)	-1.91	-0.77	0.052
	Offside Rut (mm)	-0.56	-0.87	0.031
	3m LPV(mm^2)	0.13	-0.15	0.050
	10m LPV (mm^2)	1.60	-2.43	0.238
	Texture (mm)	0.017	0.001	0.002
	Cracking (%)	-0.014 (MA1) -0.013 (MA2)	0.002	0.004
WDM RAV6	Nearside Rut (mm)	-2.06	-0.92	0.047
	Offside Rut (mm)	1.08	0.77	0.031
	3m LPV(mm^2)	-0.20	-0.49	0.031
	10m LPV (mm^2)	0.12	-3.90	0.119
	Texture (mm)	-0.007	-0.024	0.002
	Cracking (%)	-0.028 (MA1) -0.027 (MA2)	-0.012	0.003

Table 16 continued: Consistency of parameters for all devices

Contractor and device	Parameter	Bias from HARRIS1	Bias from device Average	Confidence on bias and Random Error
WDM RAV7	Nearside Rut (mm)	-2.50	-1.36	0.045
	Offside Rut (mm)	0.56	0.25	0.023
	3m LPV(mm^2)	-0.12	-0.41	0.037
	10m LPV (mm^2)	1.71	-2.31	0.185
	Texture (mm)	-0.007	-0.023	0.002
	Cracking (%)	-0.024 (MA1) -0.025 (MA2)	0.040	0.004
WDM RAV8	Nearside Rut (mm)	-0.79	0.34	0.037
	Offside Rut (mm)	-0.33	-0.64	0.023
	3m LPV(mm^2)	-0.04	-0.32	0.034
	10m LPV (mm^2)	1.07	-2.95	0.184
	Texture (mm)	-0.005	-0.021	0.002
	Cracking (%)	-0.030 (MA1) -0.028 (MA2)	-0.014	0.003
Machine Average	Nearside Rut (mm)	-1.14	N/A	0.017
	Offside Rut (mm)	0.31	N/A	0.008
	3m LPV(mm^2)	0.28	N/A	0.052
	10m LPV (mm^2)	4.02	N/A	0.539
	Texture (mm)	0.016	N/A	0.001
	Cracking (%)	-0.016 (MA1) -0.014 (MA2)	N/A	0.001

Table 17: Example ranges of values for each device, for a specific value measured by HARRIS1

Parameter		Nearside rut depth(mm)	Offside rut depth(mm)	3m LPV (mm^2)	10mLPV (mm^2)	NS SMTD (mm)	Whole Carriageway Cracking (%)
Average HARRIS1 value[1]		6.31	4.14	2.03	11.33	1.061	0.157
Jacobs, RST26	Min	5.02	4.83	2.02	17.23	1.123	0.125
	Max	5.17	4.95	2.53	31.09	1.134	0.154
Yotta, ARAN1	Min	5.77	5.30	1.77	11.96	1.100	0.128
	Max	5.88	5.37	1.89	12.62	1.108	0.146
Yotta, ARAN2	Min	5.73	4.81	1.87	12.14	1.109	0.137
	Max	5.82	4.89	2.04	12.85	1.116	0.154
WDM, RAV1	Min	4.99	4.09	2.35	14.41	1.092	0.183
	Max	5.24	4.17	2.65	16.00	1.102	0.204
WDM, RAV2	Min	5.64	3.93	2.29	13.61	1.049	0.102
	Max	6.00	4.01	2.58	14.83	1.058	0.114
WDM, RAV3	Min	6.02	4.31	2.59	14.19	1.048	0.088
	Max	6.31	4.40	3.26	15.35	1.058	0.099
WDM, RAV4	Min	4.95	4.07	2.50	17.04	1.052	0.140
	Max	5.23	4.14	4.41	29.69	1.062	0.154
WDM, RAV5	Min	4.30	3.52	2.06	12.45	1.074	0.136
	Max	4.51	3.65	2.26	13.40	1.083	0.150
WDM, RAV6	Min	4.16	5.16	1.76	11.21	1.050	0.122
	Max	4.34	5.28	1.89	11.69	1.057	0.135
WDM, RAV7	Min	3.72	4.66	1.83	12.67	1.050	0.173
	Max	3.90	4.75	1.98	13.41	1.058	0.189
WDM, RAV8	Min	5.44	3.77	1.93	12.04	1.052	0.121
	Max	5.59	3.86	2.06	12.77	1.059	0.134

Notes:
[1] The HARRIS1 value is the average value reported on the test sites
[2] based on manual analysis for SRR1 and device average for SRR2 (MA1)

8.3 Consistency of RCI

The consistency of the Revised RCI has been calculated on datasets collected by the SCANNER machines during the accreditation test (SRR1 and SRR2) and also the QA process (ARS and CRS).

Note that within the QA process, ARS and CRS are carried out on a machine by machine basis, because the machines do not survey the same parts of the network. For each ARS, there is one dataset from a SCANNER machine, and an equivalent dataset from HARRIS1. Therefore the ARS measures reproducibility. Because the routes surveyed are different for each machine, the biases calculated for each machine are not directly comparable. For the CRS, we have two surveys from the same machine and route, with the routes again being different for each machine. Therefore the CRS measures repeatability. Thus, random error can be calculated from these but again these are not directly comparable between the machines.

8.3.1 RCI Consistency on SCANNER Road Routes 1 and 2

Table 18 shows the bias and random error obtained in the RCI for each machine on the SCANNER accreditation sites SRR1 and SRR2.

Table 18: Consistency of the RCI on the SCANNER Road Routes

Contractor and device	Bias from HARRIS1 (MA1)	Bias from HARRIS1 (MA2)	Bias from device Average	Confidence on bias and Random Error
Jacobs RST26	-8.31	-7.97	-4.36	0.520
Yotta ARAN1	-7.40	-7.06	-3.44	0.403
Yotta ARAN2	-7.24	-6.91	-3.29	0.431
WDM RAV1	-3.35	-3.01	0.61	0.577
WDM RAV2	-4.99	-4.65	-1.03	0.622
WDM RAV3	-4.24	-3.90	-0.29	0.574
WDM RAV4	-5.53	-5.19	-1.58	0.525
WDM RAV5	-6.89	-6.55	-2.94	0.522
WDM RAV6	-9.01	-8.67	-5.05	0.428
WDM RAV7	-6.64	-6.30	-2.69	0.478
WDM RAV8	-9.19	-8.85	-5.23	0.394
Machine Average	-3.95	-3.62	N/A[1]	0.301

Notes:
MA1: machine average cracking used for SRR2; MA2: machine average cracking used for SRR2 after removing outliers
[1] Note that the machine average bias is not 0, as the RCI for the Machine average has been calculated from average parameter values, it is not the average RCI value.

8.3.2 RCI Consistency on Auditors' and Contractors' Repeat Surveys

Table 19 shows the bias and random errors in the RCI for each machine, calculated on the ARS and CRS respectively. Note that, where manual reference cracking data was not available for some of the ARS sites, cracking data was not included in the RCI calculation.

Table 19: Average RCI bias and random error, calculated from ARS and CRS data, respectively, for each SCANNER device

Contractor and Machine	Bias from HARRIS1, where reference cracking available) (ARS data)	Bias from HARRIS1, where reference cracking not available) (ARS data)	Confidence on bias and Random Error (CRS)
Jacobs RST26	0.71	-0.16	0.61
Yotta ARAN1	-0.67	2.99	0.34
Yotta ARAN2	N/A	-0.48	0.29
WDM RAV1	-0.32	-1.55	0.44
WDM RAV2	0.73	-0.66	0.46
WDM RAV3	-0.21	-2.56	0.39
WDM RAV4	0.02	6.72	0.41
WDM RAV5	-0.86	-8.26	0.41
WDM RAV6	-1.99	17.59	0.48
WDM RAV7	-1.46	-1.91	0.50
WDM RAV8	0.21	-4.08	0.89

8.4 Consistency of NI

8.4.1 Consistency of NI on SCANNER Road Routes

The consistency of the NI on the SCANNER Road Routes has been calculated and the results obtained shown in Table 20. Table 21 places the biases and random errors shown in Table 20 into context, in terms of the range of values that could be expected from the machines, given a "reference NI". As an example, the reference vehicle, HARRIS1 reports a NI of 5.24% (using machine average for SRR2 cracking data). Yotta's ARAN1 has a bias of -1.69% and a random error of 0.26%. Therefore the range of values (95% confidence) that the Yotta machine may report is:

ARAN1 value range = "true value" + bias ± confidence on bias ± random error

= 5.24 + -1.69 ± 0.26 ± 0.26 = 3.55 ± 0.52,

giving a minimum value of 3.02% and a maximum of 4.07%.

Table 20: Consistency of NI on SCANNER Road Routes

Contractor and Device	Bias from HARRIS1 (MA1)	Bias from HARRIS1 (MA2)	Bias from device average	Confidence on bias and Random Error
Jacobs RST26	-2.72%	-2.62%	-0.77%	0.29%
Yotta ARAN1	-1.69%	-1.59%	0.26%	0.26%
Yotta ARAN2	-1.91%	-1.81%	0.04%	0.25%
WDM RAV1	-0.11%	-0.01%	1.84%	0.39%
WDM RAV2	-0.23%	-0.12%	1.73%	0.41%
WDM RAV3	0.03%	0.13%	1.98%	0.40%
WDM RAV4	-1.15%	-1.05%	0.81%	0.34%
WDM RAV5	-1.53%	-1.42%	0.43%	0.31%
WDM RAV6	-2.64%	-2.54%	-0.68%	0.30%
WDM RAV7	-2.21%	-2.11%	-0.26%	0.29%
WDM RAV8	-3.01%	-2.91%	-1.06%	0.23%
Machine Average	-1.96%	-1.85%	N/A	0.20%

Notes
MA1: machine average cracking used for SRR2; MA2: middle 6 machine average cracking used for SRR2

Table 21: Example ranges of NI values for each machine, given a reference value

	Jacobs, RST26	Yotta, ARAN1	Yotta, ARAN2	WDM, RAV1	WDM, RAV2
"True" NI[1]	5.24%	5.24%	5.24%	5.24%	5.24%
Min	1.92%	3.02%	2.82%	4.35%	4.19%
Max	3.10%	4.07%	3.83%	5.90%	5.83%

	WDM, RAV3	WDM, RAV4	WDM, RAV5	WDM, RAV6	WDM, RAV7	WDM, RAV8
"True" NI[1]	5.24%	5.24%	5.24%	5.24%	5.24%	5.24%
Min	4.46%	3.41%	3.09%	2.00%	2.45%	1.76%
Max	6.07%	4.76%	4.33%	3.19%	3.60%	2.69%

Notes
[1] True in this case is the HARRIS1 NI value for the network, using manual analysis for cracking on SRR1 and machine average for SRR2 (MA1).

The results of this investigation may be used to source parameters for use in UKPMS for the reporting of the consistency of individual SCANNER survey vehicles. The parameters for use in UKPMS are given in Table 22 (note-machine average cracking (MA1) has been used as the reference on SRR2).

Table 22: Consistency parameters for NI, required for UKPMS

Contractor and Machine	Maximum bias, ε_{max} (m)	Minimum bias, ε_{min} (m)	Random Error, s (m)
Jacobs RST26	-0.0243	-0.0302	0.1149
Yotta ARAN1	-0.0143	-0.0195	0.1022
Yotta ARAN2	-0.0166	-0.0217	0.0991
WDM RAV1	0.0028	-0.0050	0.1514
WDM RAV2	0.0018	-0.0063	0.1599
WDM RAV3	0.0043	-0.0037	0.1580
WDM RAV4	-0.0081	-0.0149	0.1324
WDM RAV5	-0.0122	-0.0184	0.1214
WDM RAV6	-0.0234	-0.0294	0.1167
WDM RAV7	-0.0193	-0.0250	0.1119
WDM RAV8	-0.0278	-0.0325	0.0909
Machine Average	-0.0175	-0.0216	0.0788

To calculate the maximum bias, for the above table, the error on the bias is added to the average bias, for example taking the results given in Table 20 for RST 26, and then converting from % to m, the maximum bias for this device is:

$$\varepsilon_{max} = average\ bias + error\ on\ bias = -2.725\% + 0.293\% = \ -2.432\% \ \equiv -0.0243\text{m}$$

Similarly, the minimum bias is the average bias minus the error on the bias e.g. for RST26:

$$\varepsilon_{min} = average\ bias - error\ on\ bias = -2.725\% - 0.293\% = \ -3.018\% \ \equiv -0.0302\text{m}$$

The random error statistic, $s = {}^{s_D}/_{\sqrt{2}}$, where s_D is the standard deviation of within-machine difference (i.e. the difference between repeat runs carried out by the same device).

8.4.2 Consistency of NI on ARS and CRS

The consistency of the NI has also been calculated using data from the ARS and CRS surveys and the results obtained shown in Table 23.

Table 23: Consistency of NI on Repeat Surveys

Contractor and Device	Bias from HARRIS1, where reference cracking available (ARS data)	Bias from HARRIS1, where reference cracking not available (ARS data)	Confidence on bias (CRS)	Random Error (CRS)
Jacobs RST26	1.41%	0.72%	0.53%	0.18%
Yotta ARAN1	-0.17%	1.00%	0.28%	0.11%
Yotta ARAN2	N/A	-0.22%	0.22%	0.08%
WDM RAV1	-0.44%	2.14%	0.36%	0.17%
WDM RAV2	0.56%	-2.02%	0.37%	0.17%
WDM RAV3	0.14%	-3.66%	0.32%	0.14%
WDM RAV4	0.14%	5.88%	0.33%	0.16%
WDM RAV5	-0.50%	-5.63%	0.40%	0.13%
WDM RAV6	0.66%	2.80%	0.37%	0.15%
WDM RAV7	-0.61%	-0.63%	0.51%	0.14%
WDM RAV8	0.00%	-1.35%	0.71%	0.17%

8.5 Consistency - Conclusions

Consistency ranges for the SCANNER parameters, RCI and BVPI (now NI) were published in 2008 (Benbow & Wright, 2008). These ranges were calculated using data obtained in the 2006/07 accreditation, which was delivered by the 5 devices accredited at the time: Yotta ARAN1, Jacobs RST26, WDM RAV1, WDM RAV2 and WDM RAV3. The results for these vehicles are summarised in the columns/rows headed 2006/07 in Table 24 and Table 25 for the SCANNER parameters and RCI respectively. Note that the RCI calculation used for these calculations was based on the original RCI, which has now been replaced by the "Revised RCI" calculation, for the current 2009/10 survey year.

The results for the consistency ranges for the SCANNER parameters and RCI for all vehicles assesses in 2009/10 are summarised in the columns/rows headed 2009/10 in Table 24 and Table 25 for the SCANNER parameters and RCI respectively. Table 24 shows that the devices continue to report values for nearside and offside rut depth, texture and cracking to a similar level of consistency as those delivered in 2006/7.

However, because RST26 and RAV4 both showed a fairly large bias from the reference device (HARRIS1) for the measurement of 3m and 10m LPV, as well as a larger random error than those seen during the 2006/07 testing (see Table 16). These vehicles have been treated as outliers and not used in the calculation of the overall values shown in Table 24. With the removal of these outliers it can be seen that the remaining devices continue to report values LPV to a similar level of consistency as those delivered in 2006/7.

Table 24: Consistency ranges for parameters calculated on 2006/7 and 2009/10 SCANNER Road Route accreditation data

Parameter	Range of bias from HARRIS1		Range of bias from Device Average		Range of Random Errors	
	2006/07	2009/10	2006/07	2009/10	2006/07	2009/10
Nearside Rut depth (mm)	-1.54 to 1.14	-2.50 to -0.15	-1.35 to 1.27	-1.37 to 0.99	0.03 to 0.06	0.02 to 0.09
Offside Rut depth (mm)	0.46 to 1.66	-0.56 to 1.20	-0.46 to 0.73	-0.87 to 0.88	0.02 to 0.04	0.02 to 0.03
3m LPV (mm^2)	0.01 to 0.45	-0.20 to 0.9*	-0.19 to 0.24	-0.49 to 0.61*	0.05 to 0.08	0.03 to 0.17*
10m LPV (mm^2)	1.83 to 4.33	0.12 to 3.87*	-1.42 to 1.09	-3.90 to 0.15*	0.19 to 0.44	0.12 to 0.40*
NS SMTD (mm)	-0.07 to 0.05	-0.008 to 0.07	-0.07 to 0.06	-0.02 to 0.05	0.002 to 0.007	0.002 to 0.003
Whole Carriageway cracking	N/A	N/A	-0.12 to 0.25	-0.05 to 0.05	0.003 to 0.01	0.003 to 0.007

*excluding the two outlying devices for this measure

Table 25 shows that the RCI values produced from the devices' data from 2009/10 were slightly more consistent than for the 2006/07 data on the SCANNER road routes and the biases seen are of the same order, for the ARS, whilst the random errors are generally smaller for the CRS. This may be due to the difference in RCI calculation between the two years.

A comparison of the consistency values required for UKPMS, for 2006/7 and 2009/10 is shown in

Table 26. It can be seen that, for the average machine, the range of bias values is about the same for 2009/10 as for 2006/7, as is the random error.

It can be seen that there is a much bigger range in the bias on the BVPI/NI this year, including for the SCANNER Road Routes. It may be that the change to the calculation of the RCI has caused this effect, or for the ARS, that the routes analysed from 2006/07 were not representative of the general network. Further investigation into this is recommended.

Table 25: Consistency ranges for Original RCI and BVPI, calculated on 2006/7 accreditation data and ranges for Revised RCI and NI for 2009/10 data

	SCANNER Road Routes			ARS	CRS
	Range of bias from HARRIS1	Range of bias from Device Average	Range of Random Errors	Range of bias from HARRIS1	Range of Random Errors
Original RCI* (2006/7)	-10.11 to -3.78	1.53 to 8.72	0.32 to 0.80	0.25 to 5.64	1.01 to 2.98
Revised RCI* (2009/10)	-9.19 to -3.35	-5.23 to 0.61	0.39 to 0.62	-4.16 to 1.17	0.29 to 0.89
BVPI (2006/7)	-0.82% to -0.11%	-0.82% to 0.85%	0.28% to 0.39%	-4.04% to 3.37%	0.00% to 4.92%
NI (2009/10)	-3.01% to 0.03%	-1.06% to 1.98%	0.23% to 0.41%	-5.63% to 5.88%	0.22% to 0.71%

*Calculated using Machine Average cracking (MA1) for SRR2

Table 26: Comparison of machine average consistency values required for UKPMS

	BVPI (2006/07)	NI (2009/10)
Maximum bias, ε_{max} (m)	0.0006	-0.0175
Minimum bias, ε_{min} (m)	-0.0534	-0.0216
Random Error, s (m)	0.7507	0.0788

9 Conclusions

This report summarises the work carried out by the SCANNER Auditor (TRL) in the 2009/10 survey year. This included undertaking accreditation and quality assurance testing, and providing advice to a number of stakeholders, including the Department for Transport, local highway authorities and SCANNER survey contractors.

9.1 SCANNER Survey data

The accreditation tests have successfully assessed the measurements of the SCANNER data collected by each survey device against a reference obtained using either a reference level method (such as the Walking Profiler for longitudinal profile), or a the HARRIS survey vehicle, which is treated as the reference for the purpose of SCANNER accreditation. However, a number of concluding observations can be made for some of the parameters.

- Although the assessment of the measurement of curvature (instead of radius of curvature) has seen an improvement, there are still some issues seen on the more curved sites. It is thought that there may be some differences in the methods used to average the data by different survey vehicles.
- Both the accreditation and the Quality Assurance tests have highlighted problems in the measurement of cracking. There is an underlying variability in the crack measurements. This variation in cracking data has been shown to be responsible for unexpected changes in BVPI (NI) values.
- It has been shown that enhanced variance is a more stable measure than moving average variance. However, there are still concerns over the reproducibility and repeatability of the bump measure.
- There is evidence to suggest that cleaned rut depths are slightly more reproducible than standard rut depths. However, case studies have shown that the cleaned rut depth measurement can still report erroneously high values, and the cleaning is not applied at all for offside rut depths.
- The high resolution transverse profile measurement systems have been shown to be inconsistent with low resolution devices in the measurement of transverse unevenness and edge roughness. Currently the differences in transverse unevenness are being temporarily resolved by re-sampling the higher resolution systems down to a lower resolution (~20 point profile). This may not be a satisfactory long term solution.
- There are differences between the edge roughness values provided by different types of equipment. These will probably not be resolved by the re-sampling proposed above.
- Because different devices use different methods to measure RMST, differences have been observed between RMST measurements provided by these devices. This could affect the use of this data in the measurement of surface deterioration, which was a long term objective of the measure when it was originally developed in the SCANNER research programme.

9.2 Undertaking and delivering SCANNER surveys

Network 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 and the results. The survey contractor will fit the SCANNER data to the network to ensure that the data will load into UKPMS. A poorly defined network detracts from the value of the data, its usefulness for identifying lengths for investigation and, in particular, for trend analysis. This is demonstrated by the findings of the case study discussed in section 3.2.4. Poor network definition and poor location referencing have been highlighted in each annual SCANNER audit report and will continue to be problems until they are addressed both by the survey industry and Local Authority clients. In Local Authorities the need is to make sure the network is well defined and accurate, ideally with details provided in terms of geographical location. In survey contractors the need is to take particular care to record section changes accurately and to continue to apply this care right through the fitting process. Ideally survey contractors should make use of geographically defined networks wherever possible. However, it would appear that the previous recommendations to the SCANNER industry to use geographical referencing to locate section change points, has not been taken up as widely as would be liked.

QA Audits: The ongoing QA process has successfully monitored the activities and behaviour of the SCANNER contractors throughout the survey year. This has helped to provide confidence (e.g. via ongoing progress reports) that the annual survey would be completed on time, whilst providing reassurance that the data continues to meet a high level of accuracy. Even as the SCANNER survey matures, the ongoing monitoring has continued to identify problems with contractor's data, as demonstrated by the issues identified with the measurement of cracking and rutting in section 3.2. However, it is noted that issues are sometimes only identified a significant time after the surveys have been carried out, despite the ongoing CRS and ARS. To reduce the risk of this occurring would require the QA auditor to have up to date access to the survey data, as delivered to the client.

Future QA: The Accreditation and QA carried out under this project will end in September 2010. The absence of an accreditation and auditing body could present a number of problems:

- There may be no accredited vehicles (Local Authorities currently request SCANNER accreditation certificates before awarding survey contracts).
- All SCANNER survey vehicles have Improvement Action Plans (IAP) to achieve the required level of performance. There may be no checking on progress on making improvements.
- Ongoing checks (between annual reaccreditations) to confirm that existing survey equipment maintains the high standards achieved at accreditation will no longer be carried out or independently assessed. Issues and problems, currently identified as part of the audit will go undetected. The quality of the survey data could deteriorate.
- Survey progress, currently reported by the auditor, will not be monitored.
- Collation of data for national reporting may be more complex.

9.3 Assessing Consistency

The consistency values of the RCI survey parameters reported in 2008/09 are similar to those reported in 2006/07, although there were two survey device outliers. The calculated RCI values on the SCANNER road routes are more consistent than for 2006/07. The biases on the ARS are generally much larger than in 2006/07. There is also a much larger range in the bias on the NI than there was in 2006/07. It may be that:

- The change to the calculation of the RCI has caused this effect,
- The ARS routes analysed from 2006/07 were not representative of the network as a whole.

10 Summary of issues outstanding at the end of the project

Many of the issues identified, including those 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. However, this work has highlighted a number of issues that are yet to be addressed. The 2009/10 SCANNER survey year was the final year in which TRL was the SCANNER auditor under the existing contract. Therefore a summary is presented below of the issues that were outstanding at the end of the project, with suggestions on how these might be taken forward.

10.1 The Specification for SCANNER (accreditation and QA)

Although technical changes have been proposed to the SCANNER specification, these have not yet been completed and work on some revisions has not yet started. The following areas need to be addressed:

- Clarify the method to be used to average curvature data.
- Improve the definition of cleaned ruts and include cleaning in the offside to improve performance on narrow roads.
- Define a new method of calculating transverse unevenness that is independent of the number of transverse profile points used.
- Identify the causes of differences between edge roughness results reported by the different measurement systems and introduce an approach to resolve this.
- Identify the causes of differences between RMST measurements provided by different devices and introduce an approach to resolve this.
- Complete the proposed revisions to the QA process to define a QA audit in which the auditor will have up to date access to the survey data (as delivered to the client), and hence enable early identification of issues.

It is recommended that this work to improve the current SCANNER specification should be completed under the current PCIS support contract or as a specific research task.

10.2 Delivering Accreditation, Quality Assurance and Audit

The Auditor role currently provides a service in three main areas:

- Accreditation and re-accreditation of SCANNER vehicles
- Quality Assurance and Audit of SCANNER surveys (and survey contractors)
- Technical advice on the SCANNER requirements to all stakeholders

It is unclear how these services will be provided in the absence of an auditor or accreditation body at the end of this project. It is therefore suggested that:

- An approach is developed to enable independent accreditation of SCANNER survey vehicles to continue. Accreditation was mainly funded by SCANNER survey contractors, in part supported by the DfT (through this project). In future costs of establishing and "maintaining" reference sites and data (which was funded as part of the DfT contract) could be included in the charges to the so that the accreditation process could become fully self-funding.
- An approach is developed to continue the quality assurance checking of the SCANNER survey. At the beginning of this project it was recognised that it would be impractical for each individual local authority to commission independent QA and audit and therefore the QA and audit was fully funded centrally by DfT, and carried out on a sample basis. It is recommended that the sampling approach

continue, as this is the most cost effective approach. However, a method of funding independent QA and audit will be required in the future.

- The technical “advice” component of the current QA project has included a wide range of tasks, such as detailed technical advice on the SCANNER specification, in-depth investigations into SCANNER data (case studies), acting as independent intermediary between contractor / employer, attendance (providing both presentations and advice) at industry conferences / workshops and hosting a forum for survey contractors to discuss the survey requirements. This has been a valuable part of the project and it is recommended that an arrangement to provide such advice continue. This could be supported as an additional task within in a wider project, such as the current PCIS support contract or as part of any proposed independent QA and audit projects.

10.3 Using SCANNER data

The project has identified a number of technical issues with SCANNER data. The following areas need to be addressed:

- Support and encourage the use of geographical referencing in SCANNER surveys (rather than push button referencing) with an aim to making this a requirement.
- Consider the transfer from using moving average longitudinal profile variance to enhanced longitudinal profile variance, in maintenance assessment and the SCANNER RCI.
- Determine how the bump measure should be reported and used by local highway authorities.
- Investigate whether an alternative to cracking could be introduced to assess surface deterioration.
- Investigate how cracking data is used in the SCANNER RCI, potentially reducing its influence.
- Review the suitability of the current approach to the calculation of consistency of SCANNER.
- Investigate the performance of SCANNER on narrower roads (e.g. narrower C and U roads). Investigate how suitable the surveys are for these roads (is the data accurate, relevant and reliable?). Potentially, devise a more suitable data set for these types of road, building on the recommendations of previous work on “mini SCANNER”.

It is recommended that these developments could be supported through either specific research tasks (in particular the cracking and mini SCANNER issues), or as additional tasks on other projects.

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SCANNER accredited surveys on local roads in England – accreditation, QA and audit testing – annual report 2009–10

The Department for Transport has appointed TRL as the 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 survey of the English local road network, SCANNER surveys are carried out on the Scottish, Welsh and Northern Ireland local road networks under separate survey contracts. TRL was requested to apply the SCANNER Quality Assurance procedures to the Scottish, Welsh and Northern Irish surveys during 2009/10.

This report summarises the results of the accreditation testing and quality audits carried out by TRL in England, Scotland, Wales and Northern Ireland in 2009/10, and also summarises the advice and consultancy provided during the year.

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