General discussion

Integration of Software modules

Work-plan for next three months

Trans-European test

Agenda

Understanding RSI & Risk Assessment & Current Status  Tim McCarthy

Software Architecture - Data Handling & Feature Extraction
- Data Handling Issues  Paul Lewis
- Road Side Feature Extraction  Martin Rutzinger
- Road Surface Extraction  Conor McElhinney
- Road Geometry  Tim McCarthy

General discussion
- Integration of Software modules
- Work-plan for next three months
- Trans-European test

European Directive 2008/96/EC - Road infrastructure safety management

- The European Directive 2008/96/EC of the European Parliament and of the Council on road infrastructure safety management was issued on 19th November 2008 and represents a legal basis for RSI in the European Union. This EU-directive is compulsory for roads which are part of the trans-European road network (TEN). One of the reasons for issuing this directive was to ensure a high level of safety of the TEN-Network, which is of fundamental importance for the integration and cohesion of the European Union.

- Road infrastructure is one of the policy areas for improving road safety and should contribute to the reduction of the number of accidents. The aim was to halve the number of road accident victims in the European Union between 2001 and 2010.

- Fundamental for improving the safety of road infrastructure is establishing of appropriate procedures.
European Directive 2008/96/EC - Road infrastructure safety management

This EU-directive defines four types of instruments which should help to improve road safety:

- Road Safety Impact Assessment
- Road Safety Audit
- Safety Ranking and Management of the Road Network in Operation and
- Safety Inspections

“Safety Inspections” …… the member states shall carry out safety inspections on existing roads in order to identify the road safety related features and prevent accidents. These inspections should be performed periodically and by a competent entity.

What is a Road Safety Inspection (RSI)

- A Road Safety Inspection (RSI) is a systematic, on-site review, conducted by road safety expert(s), of an existing road or section of road to identify hazardous conditions, faults and deficiencies that may lead to serious accidents.
- A RSI is systematic – this means it is both comprehensive and carried out in a methodical way.
- A RSI needs to be carried out by an independent team with experience in road safety work, traffic engineering, road user behaviour and/or road design who are not involved in the maintenance of the road or road section.
- A RSI relates to an existing road not roads being constructed.
- A RSI is pro-active, trying to prevent accidents through the identification of safety deficiencies for remedial action rather than responding to recorded crashes.
- Road safety inspections are a safety management tool that can be implemented by road authorities as part of an overall safety process. RSI’s aim to identify potential problems so countermeasures can be applied to remove or minimise the chance of an accident occurring.
- This in turn will lead to reduced costs associated with accidents, to individuals, families and society. Inspections can lead to reductions in the likelihood of accidents, in the severity of any accident that does occur and, potentially, the need for costly remedial infrastructure work.
Road Safety Inspection

- Does not require accident data. Can be used to target/prioritise eg run-offs, more focus on surface/shoulder/hazards
- Not related to maintenance
- It is a systematic review/appraisal of road network, check-lists, analysis and countermeasures
- Take into account human factors (strain/workload, perception, speed choice, orientation/anticipation

Source: H Cullen, NRA 2010

NRA – RSI within Irish context - Some additional observations

- Extension of RSA (similar to Australia/NZ)
- Day/night time
- PIARC RSI guidelines 2007
- Roads inspected by trained auditors/inspectors
- Automate data collection/processing eg MMS, use of GPS/Sensors
- Interval of RSI & H/M/L priority
- Use of sineuosity
- Activie participation by CC/NRA
- Bi-directional survey

Source: H Cullen, NRA 2010

Existing RSI related initiatives

EuroRAP provides a safety rating for roads and highlights those sections with the highest risk of death and serious injuries.

EuroRap is part of the International Road Assessment Programme (iRAP), which is the umbrella organisation for a series of programs: AusRAP (Australian Programme), KiwiRAP (New Zealand’s programme) and usRAP (United States Road Assessment Program).
EuroRAP - Risk Maps

• This protocol provides risk ratings on maps that show the density of traffic collisions which caused death and life threatening injuries. Thus the categorisation of road sections is based on accident data.

• The visualisation on maps allows a simple identification of safe and unsafe road sections. They also allow a comparison of safety performance. The indicators are based on the road network, accident numbers or traffic flow. Currently there are four types of maps which are produced:
  - Risk per kilometre
  - Risk per vehicle kilometre travelled
  - Risk in relation to roads with similar flow levels
  - Economical potential for accident reduction

• The risk mapping protocol distinguishes between the following two types of risks:
  - Individual risk of road users and
  - Collective risk of a community.

EuroRAP – Star Ratings

The second protocol Star Ratings encompasses also the road infrastructure. This protocol evaluates the safety of the road section through its design in combination with the way traffic is managed on it. A scale for Star Rating is the Road Protection Score (RPS), which informs the vehicle drivers how well they are protected by the infrastructure from death or serious injuries in case an accident occurs.

Star Rating consists of the following components:
• Road Rating,
• Road Inspection,
• Road Protection Scores (RPS) and
• Star Ratings.

• Road infrastructure elements are classified based on their condition eg adequate or poor. Each categories is assigned a risk factor (this is the crash likelihood factor), eg the risk factor of an adequate delineation is 1.00, the risk factor of a poor delineation is 1.20. Therefore the risk of death or serious injury is 20% higher when the delineation is poor. This procedure already belongs to the next step of Star Rating, the Road Protection Score (RPS).

• Other infrastructure elements such as road signs, trees, poles and ditches can also influence the severity of an accident. Therefore crash severity factors are assigned to these elements eg, the relative risk for safety barriers is 1.75, whereas the relative risk for deep drainage ditches is 5.00 which is almost three times higher.

• The total risk is the combination of the likelihood of an accident occurring and the resulting potential consequence (injury severity).

• Not only are road infrastructure elements are taken into consideration that influence on the following three main types of crashes:
  - Run-off road
  - Head-on
  - Intersection based

Best Practice Guidelines on Road Safety Inspection

List of elements included in a RSI

• Quality of traffic signs (necessity, correctly placed, legible in the dark)
• Quality of road markings (visibility, consistent with traffic sign)
• Sight distances/presence of permanent or temporary obstacles
• Presence of traffic hazards in the near surrounding (trees, exposed rocks, etc.)
• Aspects of traffic operation (e.g. if road users adapt speed to local conditions)
### Defects identified by RSI - Rural

- 41 reports
- 365 remarks in total
- 45% roadside hazards
- 30% due to deficient guardrails

### Removing sight obstacles

- Cutting down trees/bushes
- Improvement in sight distance
- Mean speed, frequency of overtaking increases
- Drivers adapt behaviour
- Accident rate before: 0.31
- Accident rate after: 0.30
- Not statistical significant

### Roadside safety treatment

- Flattening of side slopes, removing fixed obstacles from the safety zone
- Flattening not always feasible, very costly
- Removing fixed obstacles: single-vehicle-off-the-road-accidents up to -44%

### Summary of Safety Effects

- All estimates refer to injury accidents
- Intervals due to local variation

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Accidents that are influenced</th>
<th>Expected accident reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removing sight obstacles</td>
<td>All accidents</td>
<td>0-5%</td>
</tr>
<tr>
<td>Flattening side slopes</td>
<td>Running-off-the-road</td>
<td>5-25%</td>
</tr>
<tr>
<td>Providing clear recovery zones</td>
<td>Running-off-the-road</td>
<td>10-40%</td>
</tr>
<tr>
<td>Guardrails along embankments</td>
<td>Running-off-the-road</td>
<td>40-50%</td>
</tr>
<tr>
<td>Guard rail end treatments</td>
<td>Vehicles striking guardrail ends</td>
<td>0-10%</td>
</tr>
<tr>
<td>Yielding lighting poles</td>
<td>Vehicles striking poles</td>
<td>25-75%</td>
</tr>
<tr>
<td>Signing of hazardous curves</td>
<td>Running-off-the-road in curves</td>
<td>0-35%</td>
</tr>
<tr>
<td>Correcting erroneous signs</td>
<td>All accidents</td>
<td>5-10%</td>
</tr>
</tbody>
</table>
Road Safety Audits and Inspections – Norway

**Safety zone /side area**
- Ditch profile (design).
- Manholes – protruding?
- Poles and pylons – type, breakaway design lacking?
- Trees – is trunk diameter more than 10 cm?
- Walls and noise barriers – hazardous guardrail terminals?
- Pillars – impact hazards?
- Guardrail (unnecessary/lacking, wrong (height, post spacing.), wrong guardrail terminals).

**Remaining sections (in addition to the side area)**
- Passing – passing opportunities and visibility.
- Stopping sight distance – check curves and adjacent terrain/vegetation.
- Signing – are there any superfluous or lacking signs?
- Markings – are profiled markings used?
- Illumination – lacking, adequate illumination level?

Intersections and access drives
- Sight zones at intersections and access drives – satisfactory?
- Intersections – location, design.
- Signing – directional signing, yield signing.
- Markings – correct, satisfactory?
- Pedestrian crossings – location, design, visibility.

**Bridges**
- Alignment of bridge approach – is it good?
- Visibility at crests – is it satisfactory?
- Intersections, ramps at bridge end – is visibility and alignment satisfactory considering speed level?
- Bridge railing – dimensioning, transition between road guardrail and bridge railing, visibility obstruction.
- Pedestrian and bicycle traffic – is this attended to?

**Tunnels**
- Alignment towards tunnel – is it satisfactory?
- Tunnel portals – do they have a safe design?
- ATC – is there a need?
- Road markings – are profiled markings used? Is there a need for LED lighting?
- Equipment – is there sufficient equipment and is it placed correctly?

Norway RSI (2005)
- **Area type** - does the road go through different area types? (concerns speed limits)
- **Speed limit** – does this vary and could there be occasion for changing the speed limit after the road safety inspection?
- **Possible standard jumps** – are there any pronounced jumps in the standard and in such case, should upgrading of parts of the section be considered?
- **Curvature and visibility** – is the section and adjoining areas such that stopping sight distance and passing sight distance requirements to a large extent remain unfulfilled?
- **Intersection types** – are intersection types appropriate with regard to traffic safety? Are the intersections of a uniform design?
- **Pedestrian crossings** – are they located correctly? Are crossings secured well enough? Are they given a uniform design along the section?
- **Guardrail** – are guardrails used extensively along the section? Can this be reduced? Are there many elements within the safety zone in need of protection? Are there rock cuts that must be safeguarded against and can this be done using guardrail?
- **Signing** – is directional signing uniform and continuous? (check intersection signing)
- **Road markings** – are profiled road markings being used? (should be considered)
- **Illumination** – are all sections and intersection areas in need of lighting illuminated?
- **Poles/pylons** – which pylon and pole types are used along the section? Are there large variations and should wooden poles be considered replaced or cables buried?

Road Accident Investigation, UK

<table>
<thead>
<tr>
<th>Rural Accident Type</th>
<th>Nature of Accident</th>
<th>Approximate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of Control (No Collision)</td>
<td>☐</td>
<td>30</td>
</tr>
<tr>
<td>Collision with Vehicle Intersecting at Junction</td>
<td>☐ ☐</td>
<td>20</td>
</tr>
<tr>
<td>Collision with Overhanging Vehicles</td>
<td>☐ ☐</td>
<td>30</td>
</tr>
<tr>
<td>Collision with Rear of Vehicle Ahead</td>
<td>☐ ☐</td>
<td>15</td>
</tr>
<tr>
<td>Collision with Non-Motorised Road User (eg pedestrians, cyclists and equestrians)</td>
<td>☐ ☐</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 2.1: Proportions of Rural Accident Types in Great Britain

<table>
<thead>
<tr>
<th>Nature of Accident</th>
<th>Typical Improvement Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ ☐</td>
<td>Vertical and horizontal realignment;</td>
</tr>
<tr>
<td>☐ ☐</td>
<td>Contemporary widening;</td>
</tr>
<tr>
<td>☐ ☐</td>
<td>Reflectors on roads and junctions;</td>
</tr>
<tr>
<td>☐ ☐</td>
<td>Raised rubber hatched road markings;</td>
</tr>
<tr>
<td>☐ ☐</td>
<td>Warning sign.</td>
</tr>
<tr>
<td>☐ ☐</td>
<td>Advance direction signs;</td>
</tr>
<tr>
<td>☐ ☐</td>
<td>Junction widening to improve visibility;</td>
</tr>
<tr>
<td>☐ ☐</td>
<td>Ghost island road markings for right turning lane;</td>
</tr>
<tr>
<td>☐ ☐</td>
<td>Coloured surfacing.</td>
</tr>
<tr>
<td>☐ ☐</td>
<td>Advance direction signs;</td>
</tr>
<tr>
<td>☐ ☐</td>
<td>Junction widening to provide right turning lane.</td>
</tr>
<tr>
<td>☐ ☐</td>
<td>Provision of crossing points;</td>
</tr>
<tr>
<td>☐ ☐</td>
<td>Provision of barriers;</td>
</tr>
<tr>
<td>☐ ☐</td>
<td>Provision of cycle lanes.</td>
</tr>
</tbody>
</table>

Table 2.2: Typical Improvement Measures
**Road Safety Risk Manager ARRB - Australia**

**Exposure** (number of vehicles / road users exposed to the hazard). Most road authorities have traffic count data within their road management systems, or the volumes can be estimated from site visits or road use information.

**Likelihood** (length of hazard, general crash risk at the location, the risk of the hazard and associated treatment and the risk of related road features at the site).

**Severity** (speed and crash types likely as a result of the hazard). Based on the hazard being assessed, the practitioner determines the crashes most likely to occur as a result of that hazard at that location. For example, poor skid resistance at an intersection will most likely lead to rear-end crashes and the possibility of adjacent approach crashes if a vehicle enters the intersection when the road is not clear. Where appropriate data are available, a review of the actual crash history at a location may assist in determining the appropriate crash mix.

**Treatment Details** (Initial cost, ongoing costs and treatment life)

Based on the actual treatment to be installed at the location, an estimate of the treatment cost, ongoing maintenance costs and treatment life is required. This information may be determined from previous contracts for similar treatments.
A methodological approach was developed for safety evaluation along rural roads with low-medium traffic volume. This approach uses both analytical procedures (relating to alignment design consistency models) and the “safety review” process.

Within the framework of this project a Safety Index (SI) is calculated. It measures the relative safety performance of a road section. The index contains three components of risk: “the exposure of road users to road hazards, the probability of a vehicle being involved in an accident and the resulting consequences should an accident occur”.

\[ SI = \text{Exposure Factor} \times \text{Accident Frequency factor} \times \text{Accident Severity factor}. \]

One source of risk……Road geometry

Sight Distance

Sight distance available from a point is the actual distance along the road surface, over which a driver from a specified height above the carriage way has visibility of stationary or moving objects.

**Stopping Sight Distance**

- Stopping sight distance shall be measured from a minimum driver’s eye height of between 1.05m and 2.00m, to an object height of between 0.26m and 2.00m both above the road surface.

Source Design Manual for Roads & Bridge, HA/NRA

**Full Overtaking Sight Distance (FOSD)** required for overtaking vehicles using the opposing traffic lane on single carriageway roads. Sufficient visibility for overtaking shall be provided on as much of the road as possible, especially where daily traffic flows are expected to approach the maximum design flows.

FOSD shall be available between points 1.05m and 2.00m above the centre of the carriageway as shown in Figure 4, and shall be checked in both the horizontal and vertical planes.

FOSD is considerably greater than stopping sight distance, and can normally only be economically provided in relatively flat terrain where the combination of vertical and horizontal alignment permits the design of a flat and relatively straight road alignment.
Obstructions to Sight Distance

Care shall be taken to ensure that no substantial fixed obstructions obstruct the sightlines including road furniture such as traffic signs. However, isolated slim objects such as lamp columns, sign supports, or slim footbridge supports of width 550mm or under can be ignored. Similarly, the effect of short intermittent obstructions, such as bridge parapets of minor roads under, can be ignored. Laybys should, wherever possible, be sited on straights or on the outside of curves, where stopped vehicles will not obstruct sightlines.

Superelevation

On radii less than those shown in Table 3, (Minimum R with superelevation of 5%), (ie. $V^2/r > 7$) superelevation shall be provided, such that:

$$S = \frac{V^2}{2.828 \times R}$$

Where :
- $V =$ Design Speed kph
- $R =$ Radius of Curve m.
- $S =$ Superelevation %.

In rural areas superelevation shall not exceed 7%.

Desirable Minimum Radius

The Desirable Minimum radii, corresponding with superelevation of 5% and radii below Desirable Minimum with superelevation of 7% are shown in Table 3 (ie $V^2/R > 14$ Desirable, 20 Absolute Maximum).

Transition Curve

The red Euler spiral is an example of an easement curve between a blue straight line and a circular arc, which shall be a segment of the green circle.

Transition curves shall be provided on curves the radius of which are less than that shown in Table 3, Minimal R without elimination of adverse camber & transitions. The basic transition length shall be derived from the formula

$$L = \frac{V^2}{46.7 \times q \times R}$$

Where:
- $L =$ Length of transition (m)
- $V =$ Design Speed (kph)
- $q =$ Rate of increase of centripetal acceleration (m/sec³) travelling along curve at constant speed V(kph)
- $R =$ Radius of curve (m)

$q$ should normally not exceed 0.3 m/sec³, although in difficult cases, it may be necessary to increase the value up to 0.6 m/sec³. On bends (sub-Standard curves for the appropriate Design Speed) the length of transition should normally be limited to 324R metre.

The Effect of Sight Distance at Horizontal Curves

Stopping Sight Distance: When the road is in a cutting, or at bridge crossings, it will be necessary to widen verges or increase bridge clearances to ensure that the appropriate stopping sight distance is not obstructed. Figure 6 shows the maximum central offset required with varying horizontal curvature, in order to maintain the Design Speed related stopping sight distances.
Full Overtaking Sight Distance:

Figure 7 shows the maximum central offset required with varying horizontal curvature, in order to maintain the Design Speed related FOSD’s.

It can be seen that the higher requirements of FOSD result in extensive widening of verges for all but relatively straight sections of road.

Design Speed

Alignment Constraint Ac: This measures the degree of constraint imparted by the road alignment, and measured by:

- Dual Carriageways: \( Ac = 6.6 + B/10 \)
- Single Carriageways: \( Ac = 12 - \text{VISI}/60 + 2B/45 \)

where:

- \( B \) = Bendiness Degrees/km
- \( \text{VISI} \) = Harmonic Mean Visibility m

Layout Constraint Lc: This measures the degree of constraint imparted by the road cross section, verge width, and frequency of junctions and accesses. Table 1 shows the values of Lc relative to cross section features and density of access, expressed as the total number of junctions, laybys and commercial accesses per km, summed for both sides of the road, where:

- \( L \) = Low Access numbering 2 to 5 per km
- \( M \) = Medium Access numbering 6 to 8 per km
- \( H \) = High Access numbering 9 to 12 per km

Mandatory Speed Limits: On rural derestricted up roads, i.e. with national speed limits of:

- Motorways and Dual Carriageways 70 mph 112 kph
- Single Carriageways 60 mph 96 kph

Vehicle speeds are constrained only by the physical impression of the road alignment, as described by Ac and Lc. The use of mandatory speed limits (together with more confined urban cross-sections) however, restricts speeds below those freely achievable, and will act as a further constraint on speed in addition to that indicated by Lc.

Current Status

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<th>Nr.</th>
<th>Milestones</th>
<th>Updated Due Date</th>
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<td>M1.1</td>
<td>Kick-off meeting Review project scope &amp; objectives</td>
<td>1st Oct 2009</td>
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<tr>
<td>M2.2</td>
<td>Initial Feature Extraction</td>
<td>26Feb10</td>
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<tr>
<td>M3.1</td>
<td>Road Safety Inspection Schemes Review</td>
<td>29Jun10 – 2nd Edit submitted</td>
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<td>M2.3a</td>
<td>Initial 3D Route Reconstruction</td>
<td>29Jun10 – Initial results</td>
</tr>
<tr>
<td>M3.2</td>
<td>Risk Assessment Review</td>
<td>29Jul10 – 2nd Edit submitted</td>
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<td>M3.3</td>
<td>Rule based risk assessment module (-3)</td>
<td>30Sep10 – In progress</td>
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<td>M2.2</td>
<td>Refined Feature Extraction (-3)</td>
<td>30Sep10 – In progress</td>
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<td>30Sep10 – In progress</td>
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<td>M2.3b</td>
<td>Refined 3D Route Reconstruction (-3)</td>
<td>30Sep10 – In progress</td>
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<td>M4.2</td>
<td>4 X Country Route Test &amp; Evaluation</td>
<td>31Oct10</td>
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<td>M4.3</td>
<td>Evaluation Report</td>
<td>30Nov10</td>
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<td>M5.3</td>
<td>Workshop</td>
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<td>30Sep10 – In progress</td>
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<td>4 X Country Route Evaluation</td>
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<tr>
<td>D5.2</td>
<td>5 X Publications (Journal/Conferences)</td>
<td>31st Mar 2011 – In progress</td>
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</tbody>
</table>

**Dissemination**

- Publications (ISPRS, AET (Glasgow Sept 2010)
- Web site – Undergoing update
- Public Lectures (DIT – Apr 2010, Newcastle, Jun 2010)

**Trans-National Test**

- M4/N4 from Kinnegad to Longford
- N52 from Delvin to Tyrellspass.

**NUIM – Ireland Trans-National Test – PMS/NUIM**

- Map showing routes M4/N4 and N52.
NUIM/IBI RouteMapper – Trans-National Test

NUIM/IBI, ITC Research Trans-National Test

Trans-national Test

NUIM/IBI RouteMapper – Trans-National Test

1. **A628**
   - HA Contact, Sandra Brown
   - A628 - HA Area-12, Oliver Goss A-One

2. **A4136**
   - Gloucestershire CC Contact: Cath Hawe Scott Tomkin

3. **N18 from Enschede to Groenlo (27 km)**
4. **N35 from Zwolle to Wierden (40 km)**
5. **N36 from Westerhaar-Vriezeveensewijk to Hardenberg (12 km)**
6. **N34 from Hardenberg to Ommen (13 km)**
7. **N48 from Ommen naar Hoogeveen (20 km)**

These are all roads that have (sections with) 2 star EuroRAP rating.

**Issues**
- Logistics/Survey Personnel
- Insurance
- Data Storage
- Data Processing

- Capture both LiDAR and Imagery on 100km road network sections
- Initially process 25km for each country & review
- NUIM/PMS Coordinate & operate testing in Ireland
- NUIM/IBI Coordinate & operate testing in UK/Netherlands & Austria
- Austria routes to be confirmed
Partner Update

- NUIM EuRSI now involves 4 staff + 1 X full-time postdoc
- ITC completed their WP April but continue to provide support
- NAST have completed initial reports but further edits required
- PMS will be involved in surveying & processing data
- IBI have begun collating datasets (Collision, Pavement Condition) and will be involved in surveying and processing data

Summary

- Project is running approximately 2 months behind schedule. This will be clawed back as software development is rolled out
- Partner man-time contribution is in excess of estimates in original proposal
- Biggest challenge is ensuring we develop a range of robust data processing algorithms together with suitable database/work-flow to handle the sheer volume of data generated by MMS
- Present focus is completing Phase-1 of prototype software.

END
EuRSI Road Geometry Extraction, Measurement & Classification

- **LiDAR Point Cloud & Survey Vehicle Navigation**
- **Detect, Extract, Categorise Road & Hard Shoulder**
- **Validate & Store Road & Perimeter Edge**
- **Extract & Store Road Surface LiDAR Points (TIN)**
- **Validate & Store Road Markings**
- **Compute & Store Road Centrelines, Lane-Width, Length, Hard shoulder/Perimeter**
- **Horizontal & Vertical Alignment (RCD)**
- **Cross-fall & Super-Elev.**
- **Link-Node Network Topology.**

---

Modeling Road Alignment

**Curve Fitting (2-D)**

- 1st \( y = ax + b \), 2nd, 3rd etc degree polynomial,
- Least Squares (linear, weighted, robust, non-linear)
- **B-splines** (constant, linear, uniform quadratic) - is a spline function that has minimal support with respect to a given degree, smoothness, and domain partition
- **Euler/Charlotte curve** – is a curve whose curvature changes linearly with its curve length
- **Cubic B-Splines** used to calculate 3D Stopping sight distance (Nehate and Rys, 2006; Ismail and Sayed, 2007)

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**Problem with Splines**

As shown in figure 3(a), the curve represents the road center line of an exit ramp from northbound highway I-580 to Bayview Avenue. It is constructed by the cubic B-spline based on the “node” positions. This curve seems to be well-described by the spline function, \( y = f(x) \). One can derive the road curvature by the following formula using this spline function:

\[
K(x) = \frac{1}{R(x)} = \frac{\left| \frac{d^2 y}{dx^2} \right|}{\left(1 + \left(\frac{dy}{dx}\right)^2\right)^{3/2}}
\]

where \( K(x) \) and \( R(x) \) are the resulting curvature and radius, respectively. Figure 3(b) shows the estimates of the curvature radius by this approach.

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Figure 8 Exit ramp from northbound I-580 to Bayview Ave. (Google map)

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Figure 9 (a) Preliminary curvature estimates by CCS algorithm (b) Preliminary estimates of curvature radius by CCS algorithm

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Li et al., 2008
EuRSI Horizontal Curve computation

- Run D-P algorithm (0.25) to smooth centre line
- Filter to classify as cw, ccw or straight
- Compute radius of curve

Original 1Hz data

Processed data

EuRSI Horizontal Curve computation

Blue symbols CW curves

Red symbols CCW curves

Software Integration

Note: Point removal
Examples of Software Applications for surveying roads and assessing risk
VIDKON inspection
- On-site inspection before actual RSI
- 2 pictures (roadway/side area) every 20m
- Preliminary inspection in the office (overview over the section)
- Signing, markings, intersection types, etc.

Proactive safety for Queensland’s local roads – NetRisk work begins

As part of the Queensland Roads Alliance NetRisk assessment and data collection initiative, work has begun on collecting road safety information on Queensland’s Local Roads of Regional Significance (LRRS).

The project aims to identify high risk locations on the LRRS through assessment of the road’s engineering features. This will allow councils to design targeted safety treatments that deliver the best value for money to the community.

As reported in the previous Briefing, this mammoth data collection task has been split between ARRB Group and RoadTek Network Services (a Government Business of the Queensland Department of Transport and Main Roads), with approximately 10,000 km of collection ahead of each organisation.

Collection has begun in Redlands, Gold Coast and other south east Queensland regions. All data is expected to be collected by October 2010 with the processed NetRisk and asset management information to be delivered to councils throughout 2010 and early 2011.

For this project, both ARRB and RoadTek are using Hawthorne 2000 Network Survey Vehicles, designed and built by ARRB’s Systems Division (see RoadTek vehicle article, page 4).

The Network Survey Vehicles simultaneously collect digital imaging, GPS, change, geometry and other infrastructure condition and inventory during a single pass of the vehicle. The data is collected at normal traffic speeds, eliminating the need for riskier on-site inspection practices and reducing unwanted congestion.

ARRB is undertaking all NetRisk assessments across the state, and the experienced NetRisk assessors will extract the required engineering information by reviewing the digital images captured during the drive-over survey. These calibrated images allow the team to measure widths, areas and offsets to hazards straight from the desktop. Based on a defendable robust engineering assessment a road safety risk score is calculated, highlighting potential hazards.

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PTV supports Road Infrastructure Safety Management

> Macro level (NSM) / high risk road sections
road network level
Safety analysis of road network determine high risk road sections based on traffic volumes and accident data (ESN results mapping)

> Micro level (BSM) / black spots
street segment or intersection
Sophisticated accident data examination due black spot analysis for police and road authorities.
Digital Road Data Standards

- Global, Geographic Data Files (GDF) 3.0 (CEN), most recent draft is GDF 5.0, ISO/DIS14825, June 2010. Different versions due to problems with semantics, proprietary content. ERTICO 2008 Define requirements for a European digital road map database, with agreed road safety attributes. Create a public-private partnership to produce, maintain certify and distribute this database
- Australia (2008) Digital Road Network, DRN, Linear road network
- Japan DRM Standard Format 21
- Others Simulation Industry eg OpenDrive

Road Network Data Structure

![Image of road network data structure](image-url)
**Road Side Feature Extraction**

- 3D Road Geometry incl. shoulder

**EuRSI Risk Assessment Architecture**

- MMS
  - 3D Road Geometry incl. shoulder
  - Road Side Feature Extraction
- External Data Sources
  - Collision Data
  - Pavement Condition
  - AADT
- Rule & Classification Schema
  - Hazard classification
  - Safety rules
  - Risk weightings

**EuRSI Phase-1 Mobile Mapping Software Architecture**

Algorithms & Functions
- Road surface extraction
- Road geometry & shoulder reconstruction
- Road side feature extraction

Software Engineering & System Integration
- Integration of ITC & NUIM s/w
- Standardising development environment & re-coding of various modules
- Survey Metadata
- Database Management
- GIS Functionality
- 3D Visualisation
- Data Quality
- Risk Assessment

Misc
- Data Standards
- Risk rule base
- Online Access
END