Thermal Mapping & Salting Route Optimization for Winter Road Maintenance

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8 June 2009
Outline

- Thermal Mapping
  - What is it?
  - How does it work?
  - Deliverable Options

- Route Optimisation
  - Key Benefits
  - How is Route Optimisation conducted?
  - Route Design
  - Deliverable Options
What is Thermal Mapping?

- Across a highway or runway network some sections of its surface will be consistently warmer or colder than others.
- Thermal Mapping identifies where these warm and cold sections are going to occur.
- In winter this information will help to identify areas likely to freeze.
- It is a vehicle based, ground survey technique.
- Surveys take place during the winter months at night.
How is Thermal Mapping conducted?

- Specially equipped vehicle
- Infrared thermometer automatically logs road surface temperatures
- Logging is distance based
  - vehicles travel at normal speed limits, with no disruption to surrounding traffic
- Data tagged with GPS coordinates
- Meteorological conditions monitored and recorded throughout survey
- Data processed and presented in desired format
How does Thermal Mapping work?

During the day, the sun heats up the highway surface.
At night, the highway surface cools.
Gives a diurnal energy cycle.
Window of opportunity for TMAP between about 2300 - 0600.
How does Thermal Mapping work?

- Diurnal energy cycle is a function of prevailing weather conditions and a series of influencing parameters at any given point, e.g.
  - Altitude
  - Proximity to water bodies
  - Aspect
  - Sky View factor (trees, building, bridges)
  - Urban heat island
  - Surface dressing

- Each of these factors (either alone or in combination) affects how much energy is received during the day, and how rapidly it is lost at night

- Because these parameters are generally fixed, under similar weather conditions the energy variation is repeatable and can be quantified
Thermal Mapping Sectors

- A Thermal Mapping vehicle can drive approximately 300km during its nightly window of opportunity
  - More on linear motorways, interstates
  - Less in urban environment

- Known as a SECTOR

- Some redundancy due to overlaps, turnarounds at spurs etc

- Of the ~300km surveyed, on average about 70% actually contracted, remainder non-contracted or overlap
  - Efficiencies higher in “circular” networks
  - Less efficient in urban or truncated networks
Thermal Mapping Planning and Sector Maps
Thermal Mapping Routes

- Sector is divided into 30-40km sections called ROUTES
- Normally 8 Routes in a Sector
- Routes inputted into a SatNav system
- Routes allow the weather to be regularly assessed
- Sectors & Routes always follow a set order and are planned to incorporate a series of overlapping sections
- Overlaps allow individual Route data to be compared and eventually related together as one overall network survey
Thermal Mapping Route Map
Weather Conditions

- Data collected under a combination of pre-defined weather types:

- **EXTREME**
  - Calm & clear nights where frost and ice is most likely to form
  - Worst-case scenario dd
  - Perhaps 15°-20°F variation

- **DAMPED**
  - Cloudy & windy
  - Differences not as pronounced as under Extreme conditions
  - Perhaps 5°-10°F variation

- **INTERMEDIATE**
  - Some cloud & wind
  - Perhaps 10°-15°F variation
Data Collection Results: Thermal Fingerprints
Deliverable Options

- Thermal Maps can be produced for inclusion in GIS environment (e.g., MapInfo TAB, Esri SHP file formats)
Deliverable Options

- Thermal Maps can be integrated with RWIS and Ice Prediction System
  - Produces dynamic forecast Thermal Maps based upon latest forecast and site specific information
Route Optimisation

- Winter consultancy focusing on treatment routes (anti-icing, de-icing and snow ploughing).

- Reasons for Route Optimisation:
  - **SAVE MONEY** - same network, less routes
  - Improve Safety
  - Records against **LITIGATION**
  - Changing operational criteria
  - Resource changes & rationalisation
  - Enhances Thermal Mapping information
  - Reduced environmental damage

- Can be stand-alone or integrated with other Vaisala modules

- Vaisala has over 15 years of Route Optimisation experience
How is Route Optimisation Conducted?

Two broad guiding concepts:

- **Thermal Routing**
  - Unique to Vaisala
  - Route design integrating THERMAL MAPPING
  - Individual routes treat roads with similar thermal characteristics
  - Enables **SELECTIVE TREATMENT** operations

- **Maximise Performance Efficiency**
  - Design routes which maximise the deployment and performance of resources
  - Aim to achieve optimum use of resources

Both options often result in route number reductions of 10-20%
Project Criteria & Constraints

- Once guiding concept and overall aims have been defined, need to identify current resources and constraints
- Basically…
  - What ROADS need to be treated?
  - What VEHICLES are available?
  - How much MATERIAL can these vehicles carry?
  - What DISTANCE can these vehicles treat?
  - How much TIME is available for each route?
  - How FAST can the vehicles travel?
- Then need to verify network – client input
Project Criteria & Constraints (cont.)

- What are the overall aims of the contract?
  - Reduction in routes?
  - Integrate Thermal Mapping?
  - Increase network coverage?
  - Respond to depot/vehicle changes?
  - Improve route efficiencies
  - Change in treatment time?

- How is treatment conducted?
  - Dry salt/prewetting
  - Precautionary/reactive

- What is the distance of the network and what sort of roads are involved?
  - Are multiple lanes covered in one pass?
  - What are the tolerances on filter lanes, splitters etc?
Project Criteria & Constraints (Cont.)

- What is the spread width & spread rate?
  - Are there calibration margins/tolerances involved?

- Where are the vehicles (depots: number & location)?
  - Maximum/minimum number of vehicles per depot
  - Can vehicles be moved between depots?

- How big are the vehicles (cubic capacity) & how many vehicles are available?

- What is the treatment time (how long have we got)?
  - How is treatment time recorded? Depot to depot or to last application of material?

- Where/how is treatment material stored?
  - Undercover or exposed?
  - What is its density (ie how much can you fit in a vehicle?)
Project Criteria & Constraints (Cont.)

- At what **speeds** do the vehicles operate?
  - Average treatment speeds
  - Average dead running speeds

- Route Optimisation has a proven track record of success, but cannot assume that methodology can simply be transferred to other countries

- **Legislation, legal framework**
  - What guidelines govern Winter Maintenance in CZ?

- **Current custom and practice**
  - How are things currently done?
  - Important to get end users involved from the outset.
Route Design

- Design DRAFT 1 Routes
  - Working set of routes;
  - Likely to be queries with these routes, but they are the starting point
  - Discuss and review with Client
  - Take on board any feedback, comments, change requests etc from Client

- Refine to DRAFT 2 Routes using this feedback
  - Discuss and review with Client

- After 2 Drafts, it is usually possible to finalise the routes. However, feedback loop will continue until Client is satisfied.
Deliverable Options: Route Maps
## Deliverable Options: Written Directions

**DEPOT: KETTERINGHAM**  
**ROUTE NUMBER : 37**

<table>
<thead>
<tr>
<th>Total km = 108.9</th>
<th>Zone = B/C</th>
<th>Time = 2:51</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out of Depot</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NON-SALT</strong></td>
<td>To start of treatment at junction of southbound A1054 and A146</td>
<td></td>
</tr>
<tr>
<td><strong>SALT</strong></td>
<td>Slip road onto A146 to Trumpery Lane, U-TURN</td>
<td></td>
</tr>
<tr>
<td><strong>NON-SALT</strong></td>
<td>Return along A146 to start of dual carriageway section</td>
<td></td>
</tr>
<tr>
<td><strong>SALT</strong></td>
<td>Dual carriageway section to B1332 junction, TURN RIGHT to access road U-TURN</td>
<td></td>
</tr>
<tr>
<td><strong>NON-SALT</strong></td>
<td>A146 to Trumpery Lane, STRAIGHT</td>
<td></td>
</tr>
<tr>
<td><strong>SALT</strong></td>
<td>A146, TURN RIGHT onto Slade Lane and Church Road to Church Meadow Lane, U-TURN</td>
<td></td>
</tr>
<tr>
<td><strong>NON-SALT</strong></td>
<td>Church Road and Slade Lane to A146, TURN RIGHT</td>
<td></td>
</tr>
<tr>
<td><strong>SALT</strong></td>
<td>A146, TURN LEFT onto Ashby Road, Mill Road &amp; Hall Road, U-TURN</td>
<td></td>
</tr>
</tbody>
</table>
Deliverable Options

- Consultancy Report - Cost Benefit Analysis
- Electronic image or GIS copies of routes
- SatNav routes for drivers
- Integration with Ice Prediction System
  - Routes “overlaid” with Thermal Mapping information
  - Forecast Thermal Maps for each route
  - Help decision-maker to see which routes require treatment
Product Benefits

- **Northern Ireland**
  - 7,500km, optimised 120 routes
  - Savings of £180k (EUR 257.4k) per winter (route reductions)
  - Further £356k (EUR 509.1k) through selective treatment

- **Flanders - Belgium Ministry**
  - 9,450km, optimised 297 routes
  - Approx. £62.5k (EUR 89.4k) route reduction savings per winter
  - Approx. further £722k (EUR 1032.5k) savings from using IceCast

- **Birmingham (UK)**
  - 1017km route numbers reduced from 32 to 26 (18% savings)
  - Have also undertaken consultancy reports on quality of their winter maintenance service.
  - Have recorded savings of £1.5m (EUR 2.15m) since undertaking Route Optimisation
Why Route Optimisation?

- Benefits of Route Optimisation:
- **SAVE MONEY** - same network, less routes
- Improve Safety
- Records against **LITIGATION**
- Changing operational criteria
- Resource changes & rationalisation
- Enhances Thermal Mapping information
- Reduced environmental damage