THE OpenLR™ INITIATIVE

Open standard for universal encoding, transmitting and decoding of location information for Intelligent Transport Systems and location based content
Presentation Overview

1. High level introduction to OpenLR™
2. License model
3. Technical description
4. Test results
5. Contact
1. High level introduction to OpenLR™

a) Location Referencing in general
b) Current options and status
c) Objective of the initiative
d) Relevance of OpenLR™
e) Industry perspective & business bottlenecks
f) Examples of applications
1 a) Location Referencing in general

- The process of encoding a location is called Location Referencing.
- An obvious way of Location Referencing is using geographic coordinates.
- The coordinate system assumes identical maps at both sides of the system chain.
- If maps are different, matching (decoding) the location to the map of the receiving system may be inaccurate, ambiguous or impossible.
- OpenLR™ allows successful location encoding and decoding on different maps (different versions and vendors).
1 b) Current options and Status

- TMC locations are widely used, but they have some limitations:
  - Requires pre-coding
  - Time to market
  - Limited number of locations
  - Maintenance is time and cost intensive
  - Not suitable for most other applications

- TPEGloc used by public broadcasters is less suitable for safety warnings
  - No standardised encoding rules

- Deployment of AGORA-C faces business issues
  - Uncertainty of commitment by the market leaders
  - Unpredictable royalty and license model evolution
  - Let the market prove the concept
1c) Objective of the OpenLR™ initiative

- To unlock the barrier allowing the free and successful exchange of location-relevant content through introduction of a universal standard

- To enable market growth and enhance the successful deployment of a wealth of ITS and LBS applications, free of license fees and supported by leading industry players

- Quicker enhancement by the expert community, thanks to the Open Source Model
1 d) Relevance of OpenLR™ (I)
1 d) Relevance of OpenLR™ (II)

www & Wireless Networks
Delivery of Service content and updates

Service Providers & Service Aggregators
Map deviation alerts & Collection of dynamic Information

Infrastructure ITS Systems

Connected Vehicle & NAV Systems
Delivery of Service content and updates

COOPERATIVE SYSTEMS
1 d) Relevance of OpenLR™ (II)

- Without map agnostic Location Referencing (e.g. OpenLR):
  - the ITS Action Plan of the EC is not feasible;
  - emergency warning on non TMC pre-coded roads is impossible;
  - urban traffic information and urban traffic management will be impossible;
  - cooperative systems are not possible to implement.

- Furthermore, OpenLR may facilitate the roll-out of FCD, eSafety applications, the exchange of date between public and private sector and the deployment of tolling devices.
References to EU’s ITS Action Plan

- **Actions 1.1-1.5 on traffic information availability in Europe**: OpenLR™ facilitates deployment of harmonized public and private content cross-Europe.

- **Actions 2.1-2.4 on specifications, architectures, interoperability of ITS systems**: OpenLR™ could play the role of the universal standard for dynamic location referencing.

- **Action 3.1 on eCall**: OpenLR™ will allow more precise localisation and thus will reduce more fatalities.

- **Actions 4.1-4.5 on V-V and V-I cooperative system architectures and standards**: OpenLR™ allows optimization for all application areas and by all user groups without any royalties.

- **Actions 5.1-5.2 on security and liability**: OpenLR™ can be utilized in secure and trusted environments.

- **Actions 6.1-6.4 regulatory and organisational framework**: Institutions, road operators and public authorities should be aware that one single cross-application solution will invite industry to contribute and this is a prerequisite for mass market deployment.
1 e) Industry perspective and business bottlenecks

- Key element for deployment and roll-out of dynamic location referencing in a mass market is the support of the leading market players.

- Industry conditions for such support are:
  - An open and interoperable environment
  - No/limited royalty fees
  - No business limitations
  - No technical restrictions for user groups and individual users

- A cross-application single solution for dynamic location referencing will guarantee the lowest overall end-user price.

- Royalty fees in the value chain adversely affect system deployment.
1 f) Application Examples

- Coverage Increase with OpenLR™ in London urban area
1 f) Application Examples

- Coverage increase of OpenLR™ in the Netherlands
1 f) Application Examples

- Coding of motorway slip roads

Note: Slip roads are not part of German TMC tables
1 f) Application Examples

- Coding of Local Roads

Note: Local Roads are not part of German TMC tables
1 f) Application Examples

- Cooperative systems (V2V and V2I communication)

Source: car-to-car consortium
2. License Model

a) Open public software license
b) Hosting organization and maintenance
c) Special interest groups and individuals
d) Future IPR considerations
e) Status and roll-out
2 a) Open Public Software License

- OpenLR™ is made available on the basis of 'copyleft' principle
  - Enabling programmers to contribute improving and maintaining the ‘open standard’
  - GPLv2 permits to use software & library in proprietary programs

- The foundations of selected Software Licensing Model
  - The freedom to use the software in proprietary programs
  - The freedom to use the software for any purpose including commercial use
  - The freedom to change the software to suit your needs, including with own code which is not open source code
  - The open source code (original and modified) should always include the terms of use and the „owner of the changes” and this should never be deleted
  - No liability can be claimed from initiators and contributors

- The source code is published “as is”: no warranty is given by any of the initiators or contributors to the initiative to any user of the code

- License to partners asserting patents is withdrawn, license is subject to non-assertion clause
2 b) Hosting organisation and Maintenance

- OpenLR™ will be an open industry standard
- Major industry stakeholders are invited to cooperate
- Leadership role in enhancement and maintenance by TomTom
2 c) Special Interest Groups and Individuals

- Gatekeepers will decide which ‘copy-lefts’ will flow in the next generation of the open standard.

- It is up to the community to establish special interest groups for OpenLR™.

- Interest groups as well as individuals are entitled to submit ‘copy-lefts’.

- Interest groups may collect and take care of the requirements for their application area.

- Potential interest groups are:
  - TISA
  - Projects and Consortia, e.g. the Car-to-car-consortium
  - Public authorities
  - EBU
  - eSafety Forum
  - …
2 d) Future IPR Considerations

- As far as known OpenLR™ doesn’t infringe existing patents.
- Guarantee that there is no further IPR can never be given, but here counts together the users stand strong.
- License to partners asserting patents is withdrawn. License is subject to non-assertion.
- Large scale adoption of OpenLR™ will reduce the risk of asserting partners
2 e) Status and roll-out

- TomTom has filed patent applications for the core concept of OpenLR™

- TomTom disclosed the method free of charge under GPLv2 license and will lead the maintenance operation

- Documentation available
  - A White paper (under a Creative Commons License)
  - Open source reference implementation for encoder and decoder
  - License conditions

- Third parties are invited to test, implement and enhance OpenLR™.
3. Technical Description of OpenLR™

a) Design objectives
b) High level description
c) Explaining example
d) Prerequisites
e) Characteristics
f) Encoding & decoding steps
g) Data Format
h) Basic data format code size
i) Further Enhancement
3 a) Design Objectives of OpenLR™

- Originally designed for transferring traffic information from a center to in-vehicle systems and taken into account:
  
  - Map vendor and version independency
  - Covering all roads, including urban and low level roads
  - Minimum bandwidth usage
  - Communication channel independency
  - Maintenance independency
  - Potentially capable to replace TMC codes in future
  - Encoding and decoding independent from system operation location e.g. Service centre, in-vehicle systems, etc.

- Currently OpenLR™ focuses on line locations.
3 b) High level description

- **Main idea:** describing a line location completely with a concatenation of (several) shortest-paths
  - The concatenation of such shortest-paths shall cover the location completely
  - Each shortest-path is specified by information about its start and its end

- **Start/End information is combined in so called location reference points (LRPs)**
  - The LRPs are ordered from the start of the location to the end of the location
  - The shortest-path between two subsequent LRPs covers a part of the location
  - The concatenation of all such shortest-path(s) is called location reference path
3 c) Explaining Example (I)

- Basic idea: a concatenation of a shortest path between location reference points (LRPs) covers the location completely
- At least two LRP needed for start and end of the location
- Intermediate LRPs serve as a guide for the route calculation
3 c) Explaining Example (II)

- Basic idea: a concatenation of a shortest path between location reference points (LRPs) covers the location completely
- At least two LRP needed for start and end of the location
- Intermediate LRP serves as a guide for the route calculation
3 c) Explaining Example (III)

- Basic idea: a concatenation of a shortest path between location reference points (LRPs) covers the location completely
- At least two LRP needed for start and end of the location
- Intermediate LRPs serve as a guide for the route calculation
3 d) Prerequisites

- Map requirements on basis of GDF parameters
  - Functional road class (FRC)
    - indicating the importance in the network
  - Form of way (FOW)
    - indicating physical properties
  - Geometrical shape
    - lines shall not be abstracted by a straight line
  - Coordinates in WGS84
    - every node in the network should have coordinates
  - Length
    - indicating the real dimension along the geometrical shape

- The map attributes FRC and FOW need to be mapped to corresponding OpenLR™ values
  - OpenLR™ defines its own FRC and FOW values

- Line locations should be connected and ordered from the start of a location to the end of a location
  - if a driving direction is available then the location shall be traversable from its start to its end
3 e) Characteristics

- **OpenLR™ includes:**
  - Encoding of a location
  - Defining a data format for distributing the location information
  - Decoding the data format and finding back the location

- **OpenLR™ data format is**
  - Map-independent
  - Binary
  - Includes common map attributes: Coordinates, FRC, FOW, Length, Bearing

- **OpenLR™ focusses on:**
  - Shortest-path coverage only
  - Breaking down the number of map attributes
### 3 f) Encoding Steps

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check validity of the location to be encoded</td>
</tr>
<tr>
<td>2</td>
<td>Adjust start and end node of the location to represent valid map nodes</td>
</tr>
<tr>
<td>3</td>
<td>Determine coverage of the location by a shortest-path</td>
</tr>
<tr>
<td>4</td>
<td>Check whether the calculated shortest-path covers the location completely or not. Go to step 5 if the location is not covered completely, go to step 7 if location is covered</td>
</tr>
<tr>
<td>5</td>
<td>Determine position of a new intermediate location reference point so that the part of the location between the start of the shortest-path calculation and the new intermediate is covered completely by a shortest-path.</td>
</tr>
<tr>
<td>6</td>
<td>Go to step 3 and restart shortest path calculation between the new intermediate location reference point and the end of the location.</td>
</tr>
<tr>
<td>7</td>
<td>Concatenate the calculated shortest-path(s) for a complete coverage of the location and form an ordered list of location reference points (from the start to the end of the location)</td>
</tr>
<tr>
<td>8</td>
<td>Check validity of the location reference path. If location reference path is invalid then go to step 9, if location reference path is valid then go to 10.</td>
</tr>
<tr>
<td>9</td>
<td>Add a sufficient number of additional intermediate location reference points if the distance between two location reference points exceeds the maximum distance.</td>
</tr>
<tr>
<td>10</td>
<td>Create binary representation of the location reference</td>
</tr>
</tbody>
</table>
3 f) Encoding Steps

Diagram:
- Step 1: Validity check
- Step 2: Adjusting start and end
- Step 3: Calculate shortest path
- Step 4: Check location coverage
- Step 5: Determine intermediate(s)
- Step 6: Start shortest path calculation for the remaining part of the location
- Step 7: Form ordered list of location reference points
- Step 8: Check LRP validity
- Step 9: Add intermediate(s) to meet Rule -1 criteria
- Step 10: Create binary representation

Flow:
1. Location is invalid → Step 1
2. Location is valid → Step 2 → Step 3 → Step 4 → Step 5 → Step 6 → Step 7 → Step 8 → Step 9 → Step 10 → End
### 3 f) Decoding steps

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Decode binary data and check its validity</td>
</tr>
<tr>
<td>2</td>
<td>For each location reference point find candidate nodes</td>
</tr>
<tr>
<td>3</td>
<td>For each location reference point find candidate lines</td>
</tr>
<tr>
<td>4</td>
<td>Rate candidate lines for each location reference point</td>
</tr>
<tr>
<td>5</td>
<td>Determine shortest-path(s) between two subsequent location reference points</td>
</tr>
<tr>
<td>6</td>
<td>Check validity of the calculated shortest-path(s)</td>
</tr>
<tr>
<td>7</td>
<td>Concatenate shortest-path(s) to form the location and trim path according to the offsets</td>
</tr>
</tbody>
</table>
3 f) Decoding Steps
3 g) Data Format

- The OpenLR™ data format is binary and compact

- Binary data contains
  - Header (including version information)
  - Ordered list of location reference points
  - Offsets (if applicable)

- Location reference points consist of
  - Coordinates
  - Attributes (FRC, FOW, bearing)
  - Checksum (to ensure proper decoding)
3 h) Basic data format code size

- Code size depends on the number of location reference points and offset information.
- Offset information would add 1 or 2 bytes per location.
- Compression techniques being used.
- Absolute and relative coordinates.
- Intervals instead of concrete values (distance, bearing).

<table>
<thead>
<tr>
<th>LRPs</th>
<th>Bytes (without offsets)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>37</td>
</tr>
<tr>
<td>6</td>
<td>44</td>
</tr>
<tr>
<td>7</td>
<td>51</td>
</tr>
<tr>
<td>8</td>
<td>58</td>
</tr>
</tbody>
</table>
3 i) Further enhancement

- The open source community will drive enhancement according to application needs:
  - Point and Area locations
  - Different data formats e.g. XML, …
  - Special requirements to support integration in TPEG and future versions of TPEG
  - Positioning aspects (GPS, Galileo)
  - …
4. Test Results

a) General conditions of the test examples
b) Examples with data sizes
c) Data size and success rate
d) Map agnostic success comparison
4 a) General conditions of the test examples

- OpenLR™ is tested for line locations being covered by TMC and also on non-TMC roads
- The encoder maps: Map sources from Tele Atlas are used (different versions)
- The decoder maps: Map sources from Tele Atlas and from NAVTEQ sources (different versions)
- Test results cover the accuracy of the OpenLR™ method and the code size
  - Achieved in TomTom implementation environment
4 b) Test Result: Motorway slip roads

- Motorway: sliproad at „Kreuz Stuttgart“ (A8 / A81)
- Location: non-TMC
- Data size: 16 bytes
- Location length: 972m
4 b) Test Result: Local Road

- Local road: Stuttgart, Germany, 4 streets
- Location: non-TMC
- Data size: 30 bytes
- Location length: 808m
### 4 c) Data size and success rate

<table>
<thead>
<tr>
<th>Test set</th>
<th>Nr. of locations</th>
<th>Encoder Average data size</th>
<th>Decoder [map source: TA 2008.04]</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMC paths (1h traffic feed, NL) [map source: TA 2007.04]</td>
<td>4867 (unique: 1663)</td>
<td>16.8 bytes</td>
<td>&gt; 99%</td>
</tr>
<tr>
<td>Non-TMC paths (random, NL) [map source: TA 2008.07]</td>
<td>1000</td>
<td>19.9 bytes</td>
<td>&gt; 98%</td>
</tr>
</tbody>
</table>

- **Success rate:** correctly decoded locations
  - Encoder and decoder location are equal
- **Average data size:** average number of bytes per location
  - Data includes offsets if applicable
- **Error detection rate:** detection of incorrectly decoded location
  - Decoder rejected correctly a location which couldn't be decoded due to big map differences
### 4 d) Map agnostic success comparison

<table>
<thead>
<tr>
<th>Test set</th>
<th>Success rate</th>
<th>Error detection rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TMC paths</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[map source: TA 2007.04]</td>
<td>&gt; 99% (TA)</td>
<td>&gt; 56% (TA)</td>
</tr>
<tr>
<td></td>
<td>&gt; 93% (NT)</td>
<td>&gt; 55% (NT)</td>
</tr>
<tr>
<td><strong>Non-TMC paths</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[map source: TA 2008.07]</td>
<td>&gt; 98% (TA)</td>
<td>&gt; 94% (TA)</td>
</tr>
<tr>
<td></td>
<td>&gt; 93% (NT)</td>
<td>&gt; 87% (NT)</td>
</tr>
</tbody>
</table>

- Encoding examples are available.
- OpenLR™ gatekeepers are happy to receive additional test results

TeleAtlas (TA) map source 2008.04
NAVTEQ (NT) map source 2008.04
Contact

- www.tomtom.com/openlr

- TomTom International B.V.
  Theo Kamalski
  theo.kamalski@tomtom.com

Thank you for your attention