



# I-95 Corridor Coalition

## Traffic Message Channel Codes: Impact and Use within the I-95 Corridor Coalition's Vehicle Probe Project



*December 2015*

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# TRAFFIC MESSAGE CHANNEL CODES: IMPACT AND USE WITHIN THE I-95 CORRIDOR COALITION'S VEHICLE PROBE PROJECT

DECEMBER 2015

## *Summary Report*

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*December 2015*

## Executive Summary

Traffic Message Channel (TMC) codes were established by industry as a standard means to convey location information in order to communicate traffic information. The TMC standard was developed prior to the prevalence of high-bandwidth wireless communication, when the primary method of wireless data communications was radio sidebands. In the current environment of broadband internet with numerous travel information applications, TMC codes, though dated, remain the only standardized coding method to uniquely identify roadway segments for the purpose of conveying traffic and other information. Prior to 2008, when the I-95 Corridor Coalition launched its Vehicle Probe Project, TMC codes were used within industry, but not within public agencies in North America. With the adoption of probe data services by departments of transportation from providers such as INRIX, HERE, and TomTom, public agencies are also now exchanging data using the TMC location reference system. With the increased use of TMC codes as a result of its Vehicle Probe Project, the I-95 Corridor Coalition authorized this white paper to address concerns voiced by its members about the use of TMC codes. The objectives of this paper were to:

- Document the source, governance and intellectual property issues related to long term use of the TMC codes by government agencies
- Explore the suitability of the TMC codes for a variety traffic data reporting, including use on arterials, ramps, and other facilities
- Recommend best practice and future direction to the Coalition including exploring alternative segmentation methods and possible representation in the TMC standards process

The material within were obtained primarily by consultation with industry experts, literature review, first-hand experience with manipulating various implementations of TMCs, and lessons learned through the Vehicle Probe Project (VPP) re-compete process.

### **TMC standards and governance:**

The TMC code standard is decades old and was originally developed to report traffic information in applications with minimal communications bandwidth. The standard has since been adopted to convey traffic on electronic maps for various traveler information systems such as online maps, personal navigation devices, and smartphone applications. At its core TMC code standard assigns reference nodes at significant points of departure in a road network, such as the intersections of major roadways or other primary landmarks such as political boundaries. Segments linking the reference nodes are assigned TMC codes. These codes are used to efficiently communicate traffic and other road attribute data specific to a segment.

ERTICO, the European equivalent of the Intelligent Transportation Society (ITS) of America, hosts the standards body that governs TMCs as well as a variety of additional industry standards related to the conveyance of traffic information to the public. The Traveler Information Services Association

(TISA), operating under the ERITICO umbrella, maintains the TMC standards, and reviews TMC location reference sets for conformance to standards.

Specifically for North America, the North America Traffic Message Channel Code Alliance (NATMCCA) was formed as a result of auto industry concerns when satellite radio was being integrated as original equipment on vehicles. The NATMCCA created the dominant TMC code set for North America that is in common use today, and continues to maintain that code set. The electronic map makers, TomTom and HERE, are its primary participants. The standard only defines how codes are created and maintained, and as such any entity can create TMC codes and have them certified by TISA. The set of TMC codes created and maintained by NATMCCA are the TMC codes used for probe data procured through the Vehicle Probe Project.

### **Nature and Use of TMC codes:**

TMC codes were initially developed primarily for the freeway network, and have expanded overtime to include more of the secondary road network. Updates to the TMC code set for North America is first initiated by the NATMCCA consortium, then approved by TISA, and lastly implemented in mapping software prior to being available for use by the I-95 Corridor Coalition in the Vehicle Probe Project. The update cycle for TMC codes during the first phase of the VPP was not responsive to public agency needs. Availability of traffic data for newly opened roadways lagged by years, waiting for new TMC codes to be initiated, approved by TISA, and then implemented in electronic maps.

Although the TMC codes are standardized through the NATMCCA for North America, the precise geodetic beginning and ending points of TMC segments are not part of the TMC definition, but left to the interpretation of the electronic map makers. As a result, implementation of TMC codes from vendor to vendor do vary, and in some instances by a significant amount particularly for shorter segments. In addition to the variance in the TMC code definitions between map vendors, traffic vendors may report data using different methods, but still based on TMC codes. For example, INRIX uses internal and external TMC codes. This method reports traffic data between each break in access (such as from one on-ramp to next off-ramp). HERE reports traffic data from interchange to interchange, grouping segments between ramp entrances and exits to the roadway. An offset scheme within a TMC is employed if variance in traffic is detected within a TMC segment in order to more clearly define the location of congestion. Each method of reporting traffic data is based on a compliant TMC code set implementation. **As a result, a transportation agency that has integrated a data feed from one vendor cannot change vendors without considering integration costs associated with these differences.**

Because TMC segments reflect breaks in access, they often exceed five miles in length on the freeway network, outside the urban areas. The lack of data granularity within long segments typically is not a problem for traveler information applications, but does present challenges in other applications. Higher granularity may be needed to isolate the location of the slowdown or bottleneck between interchanges, direct emergency response to the location of a crash, or provide back of queue warnings. In response to such concerns, vendors offer a variety of alternate methods

to provide higher granularity traffic data, some are based on TMC codes (often times referred to as sub-TMC data) and other methods are based on segmentation methods completely apart from TMC codes. Both methods are typically vendor specific solutions.

The granularity, coverage and detail of TMC codes for arterials (non-freeway) vary with the TMC code definitions. The University of Maryland experience with TMC codes on arterials indicate that TMC segmentation can miss crucial intersections, and may not be updated as frequently as freeways to reflect changes in the arterial road network.

### **Recommendations to the Coalition and Future Directions:**

The growth in the use of outsourced probe data from companies such as INRIX, HERE, and TomTom has put additional pressure on vendors to investigate and remedy some of the issues that have arisen. Market pressure has helped to resolve a number of issues.

- Updates of the TMC codes for new facilities no longer lag behind by years, but are included in data feeds within a matter of months.
- Vendors have introduced alternative segmentation schemes to provide higher granularity and detail when needed.

Simple applications of probe traffic data, such as a traveler information web page, will likely continue to use TMC codes in unison with industry mapping products to streamline implementation. As probe traffic data is integrated into more agency applications (such as performance measures, Geographic Information System (GIS) tools, work zone management, or end of queue warning systems), integration of the vendors segmentation method (be it TMC codes, sub-TMC codes, or an alternate segmentation method) with an agency's in-house method for referencing roadways becomes critical.

- TMC codes will need to be aligned to the agency's internal referencing system, a process typically referred to as 'conflation'.
- If granularity is required greater than that available with TMCs, an additional vendor specific segmentation method will also need to be integrated.

TMC codes do exist for ramps between major freeways (interstate to interstate), but are not typically available at interchanges with other facilities. Public agencies should anticipate the use of vendor specific solutions for items such as ramp data not currently covered by TMCs, special use lanes, and other concerns not reflected in current TMC codes.

Recommendations for the Coalition moving forward:

- **Public agencies should continue to use TMC codes for the procurement and use of outsourced probe traffic data.** The TMC code standard, and the TMC code set as supported by the NATMCCA will continue to be viable for use by agencies. The TMC codes ‘sweet spot’ will be for applications primarily on freeways and other level high level principal arterials in which travel time and speed between intersections is sufficient.
- **Public agencies should consider alternate segmentation methods provided by vendors to enable applications requiring higher levels of granularity than that supported by TMC codes.** Although new roadways will be reflected in TMC code sets in a timelier manner than was previously demonstrated in the first phase of the VPP, these alternative segmentation options will be more responsive since they are not subject to the lengthy TMC process.
- **The I-95 Corridor Coalition should not pursue a new standard for segmentation of roadways to exchange traffic and other road attribute data at this time.** TMC codes and vendor specific segmentation schemes will continue as the primary methods to reference industry traffic data into the foreseeable future.
- Integration of outsourced probe data into agency applications (other than simple web based traveler information services) will require conflation, and incur its associated costs. **Public agencies should budget appropriately when considering any application requiring probe data.**
- **Collectively, the Coalition can benefit its members by:**
  - Developing and sharing educational material explaining the nature of TMC codes, alternatives to TMC codes, and associated implementation issues.
  - Providing a forum to share best practices and anticipated costs for integration of outsourced traffic data into agency applications and their associated GIS applications.
  - Encouraging the continued use and development of open standards (when available) in future procurements. Although a new segmentation standard is unlikely, standard methods to encode roadway segments and attributes would ease integration efforts and reduce cost.

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## Introduction

This white paper examines issues surrounding the use of Traffic Message Channel (TMC) codes faced by public agencies when procuring traffic data from probe data vendors, and integrating these data feeds into applications. The need to examine the TMC standards arose within the I-95 Corridor Coalition's Vehicle Probe Project (VPP), a multi-state traffic monitoring system that spans much of the Eastern Seaboard of the United States. The VPP relies on third party traffic probe data provided by INRIX, HERE and TomTom. The initial VPP procurement in 2008 exposed the need for a road segmentation standard to minimize data integration costs, facilitate the sharing of data between agencies, enable common tools for assessing performance, and for maintaining a long-term, and consistent historical data archive. The need was met by use of TMC codes for conveying traffic data for the roadway network. The second phase of the VPP, completed in 2014, expanded procurement of traffic data to three vendors (INRIX, HERE, and TomTom) and exposed the variation in the implementation of TMC codes between the various vendors. At present, TMC codes remain the prevailing standard within the traffic industry for standardizing road segmentation.

The objectives of this white paper include:

- Document the source, governance and intellectual property issues related to long term use of the TMC codes by government agencies.
- Explore the suitability of the TMC codes for traffic data reporting, including use on arterials, ramps, and other facilities.
- Provide recommendations to the I-95 Corridor Coalition concerning known issues, best practices and future direction.

This white paper reviews issues related to the TMC codes and presents recommendations to the I-95 Corridor Coalition. This effort was funded by the I-95 Corridor Coalition, enabled by a grant from the Multistate Corridor Operations and Management Program (MCOMP).

## Background

In 2006, the I-95 Corridor Coalition conceived of a traffic management system that could span the Eastern Seaboard of the United States, bringing a common operations picture to multiple jurisdictions in order to enable coordinated response to incidents and provide a robust data source for traveler information. The system went into production in July of 2008, and was termed the Vehicle Probe Project (VPP), since it relied on outsourced probe data as the backbone for traffic information. The outsourced probe data reported speed and travel time on roadway segments once per minute on an initial network of approximately 1500 miles of freeway and 1000 miles of non-freeway (arterial) roadways. The probe data provider for the first phase of the project (VPPI), was INRIX Inc. INRIX Inc. utilized Traffic Message Channel (TMC) codes as the standard method for conveying roadway traffic data. The geodetic coordinates of the endpoints of each TMC code were provided as implemented by electronic map making company, TeleAtlas (now TomTom). TMC codes were created by the commercial traffic industry to compactly communicate traffic data across low-bandwidth systems. Although initially



developed for use on radio side bands, in 2008 traffic applications were becoming increasingly electronic and distributed via the internet and various wireless data connections.

The roots of the TMC standard emerged from the ALERT-C protocol for conveying (encoding and broadcasting) information on radio sidebands. The ALERT-C protocol, now commonly referred to as Traffic Message Channel (TMC), is defined in the International Standards Organization (ISO) standard documents [1], [2] and [3]. From 2008 through 2014, the I-95 Corridor Coalition (the Coalition) utilized TMCs for the reporting of traffic information in its VPP system, which primarily was focused on the freeway system. Although traffic was reported for non-freeway facilities, it was not as heavily utilized by transportation agencies in their applications as were freeways. As a result of the VPPI, many transportation agencies within the Coalition became familiar with commercial TMC standards for traffic data.

In 2013, the Coalition initiated procurement of the second phase of the Vehicle Probe Project (VPPII), which was completed in 2014 and went live with data on August 1, 2014. Whereas the first phase of the VPP (VPPI) emphasized incident management and traveler information, VPPII extended the emphasis to include performance measurement and operations planning. Likewise, VPPII extended contract specifications to include critical arterial (non-freeway) corridors. Although VPPI procurement encompassed arterial roadways, contract specifications for data quality applied only to freeways. Most of the applications utilizing VPPI data were focused primarily on freeways. Within the VPPII, the Coalition placed increased emphasis on arterial data quality. As a result, the strengths and weakness of the TMC segmentation standard beyond freeways also became a concern. Prior to the adoption of outsourced traffic data (as introduced in VPPI), transportation agencies relied primarily on roadway segmentation scheme developed internally to each agency. As each agency's segmentation method was unique, sharing of data was problematic, and software and data tools had to be customized for each agency. With the introduction of outsourced traffic data, TMC codes emerged as an enabler of inter-jurisdictional data sharing, which has several distinct advantages:

- Industry maintained segmentation standards reduced procurement costs by alleviating the need to create (or transform) third party data products into agency-specific formats
- TMC codes provided a method to reference multiple traffic data sources, such as volume, speed, and travel time, to a common framework for analysis and application
- TMC standard codes are consistent and stable over time to allow for multi-year data comparison and analysis
- TMC codes provided a means to efficiently access VPP traffic data from adjoining jurisdictions. Data sharing is vital for cross-jurisdictional coordination (such as metropolitan areas that bridge state boundaries).
- Common data formats allowed for common tool development which assisted in the emergence of common performance measures. Likewise, the cost of software tools could be amortized across a larger base, providing economy of scale for application development
- TMC codes are maintained by an industry consortium (not internal agency resources) further reducing costs

- For freeway applications, the segmentation (the underlying logic that breaks the network into links and nodes) reflected access break points along the highway, which aligned well with traveler information

The Coalition's first six years of experience with TMC codes also revealed some challenges working with TMC segmentation. These challenges included:

- The granularity of TMC codes varied greatly. Some TMC segments were a fraction of a mile, and some spanned multiple miles. The inability to identify the location of incidents or work zones within long segments, or variation in traffic within long segments was considered a deficiency. Sub-TMC granularity or a different segmentation method which utilized shorter segments with less variability in length was desired.
- The creation of new TMC codes for newly constructed roadways or substantially improved facilities lagged by years. Examples from Maryland and North Carolina revealed that the TMC update process (including integration into digital maps) was unacceptably long.
- TMC segmentation on arterial (non-freeway) roadways was not as consistent as on freeways. Appropriate segment breaks, length of segment, and the ability to adequately reflect turning movements within intersections remained concerns on non-freeway facilities.
- Although standardization was welcome by public agencies, the proprietary nature of TMC codes remained an issue. Understanding the governance, ownership, and licensing of TMC codes was clouded at best.

Since the VPPII placed greater emphasis on non-freeway facilities, and was anticipated to support a broader array of agency applications such as performance measures and planning, resolution of the above issues was strategically critical to Coalition members. Furthermore, VPPII was awarded to multiple vendors. It was soon discovered that each vendor, though compliant to the contract specification for use of TMC codes, implemented the codes differently. The variation from vendor to vendor was much greater than anticipated. This was particularly evident in the validation effort, making the challenge of a fair evaluation of quality even more challenging.

## TMC Code Governance, Ownership and Licensing

The TMC standard is maintained by the Traveler Information Services Association, TISA. TISA's executive office is hosted by ERTICO, the European equivalent to ITS America. TISA is an international industry membership association, established as a non-profit company focused on proactive implementation of traffic and travel information services and products. TISA promotes industry standards with respect to traffic information and consumer traffic products including RDS-TMC and TPEGTM technologies. (See [www.tisa.org](http://www.tisa.org)) TISA is responsible for maintaining TMC standards and insuring that any TMC codes that are developed are compliant to the standard.

The standards maintained by TISA with respect to TMC codes serve as the guidelines to create TMC tables. A TMC table is a list of roadway points and corresponding segments encoded using the TMC standard. The specifications are laid out in ISO 14819-1, ISO 14819-2, ISO 14819-3, and ISO 14819-6.

These standards supply the procedure to segment roadways and to assign codes to segments. For example the TMC code '110N04615' can be broken down into 3 parts. The '110' is the area code, the 'N' denotes direction of travel (road specific, so it can be north to south, west to east or counterclockwise) and the '04615' is a linear number that identifies the road and segment uniquely within the area '110'. A TMC table definition provides the locations where the roadway is broken into segments, typically at crossroads or junctions. TMC tables provide a textual description of the TMC endpoints. The precise location where segments begin and end (typically provided in geodetic coordinates) is left to the interpretation of the map maker based on the information in the TMC tables. TMC tables are submitted to TISA for review and certification.

The North American TMC Code Alliance (NATMCCA) maintains the TMC table in common use for USA and Canada. Nothing prevents the creation of competing tables in North America. Multiple TMC table offerings are more common in other areas of the world. A TMC table contains a list of TMC codes, along with fields which bind codes to physical locations such as crossroads, landmarks and political boundaries. TMC tables define both points and segments that connect the points. The binding fields contain the geographic description of the location, and other pertinent information which can uniquely identify the location of the point and/or segment. These tables are created in accordance with the TISA standards mentioned above. See the ISO referenced documents for further details.

Although the standard is open, the licensing terms to use TMC tables that conform to the standard are determined by the table owners. TMC tables can be open or in the public domain if so licensed by the table. However, in North America, the TMC table maintained by the NATMCCA and is owned by the NATMCCA consortium. NATMCCA began with representatives from various industries, but is maintained primarily by the electronic mapping companies, TomTom and HERE. Licensing and use of the TMC tables is governed by the licensing agreement negotiated with the vendor, typically with respect to accessing the electronic maps used to display traffic information encoded using the NATMCCA TMC codes.

Within the VPP, traffic data conveyed using TMC codes also includes a listing of TMC code definitions with sufficient detail (and licensing) to conflate the TMC code segment to an agency's internal mapping system. Agencies may also use the VPP data with commercial electronic maps (which must be separately procured) that contain TMC layers. Note that the TMC tables themselves are rarely, if ever visible to the end customer. Each mapping company (HERE and TomTom) produce map layers that correspond to the North America TMC Table. The map layer allows traffic data encoded with TMC codes to be quickly and efficiently visualized. It is typically this mapping layer, and associated attributes, that are licensed to the customer.

## Variations in TMC Code Implementations

In North America, HERE and TomTom, as active members of the NATMCCA, jointly maintain a set of TMC code tables for roadway segments that is compliant to the TMC standard maintained by TISA. They are responsible for the inclusion of new roadways into the TMC tables and modification of the table to reflect changes in the geometry of existing roadways. Once the tables are updated, they are submitted

to TISA for review and approval. Then the changes are reflected in the electronic maps maintained by each company.

**Precise geodetic coordinates (latitude and longitude) are absent from TMC code base tables, so the exact endpoints of each segment are left to the discretion of map makers.** Key differences in interpretation originate from flexibility in choosing the location that marks the junction of two roadways, or the junction of a roadway with political or geographical landmark. As an example, on a freeway one company may interpret the junction of two roadways as the point where the two roads intersect such as an overpass, while another may choose the point where the ramp from one freeway merges with the other freeway. Although both interpretations satisfy the TMC code definition, the corresponding segments will not exactly coincide. Small variations in segment length for the same TMC code are observed simply due to the precision of the chosen geodetic coordinates. Even larger differences can arise if TMC code boundaries are not explicitly identifiable with physical landmarks. This occurs most frequently when political boundaries define TMC codes. One company may use the closest roadway intersection, while another chooses an identifiable landmark such as a bridge crossing.

Another difference in the implementations of TMC codes among traffic vendors is illustrated in Figure 1 below. One vendor, INRIX, provides traffic data for both external and internal TMC codes. An external TMC code represents the road segment between interchanges, typically from the last merge ramp of the upstream interchange to the first exit ramp of the downstream interchange. An internal TMC code represents the road segment within an interchange, typically from the first exit ramp to the last entrance ramp. As a result, external TMC codes segments tend to be longer than internal TMC codes segment, which are usually less than 0.5 miles. Noted that INRIX implements TMC codes using a mapping layer licensed from TomTom. In contrast, HERE, provides traffic data on unified TMC codes, not differentiating between internal and external segments. If traffic conditions differ significantly within the TMC code segment, the difference in speed are encoded using sub-TMC offsets in the data feed, a method unique to HERE. Figure 1 illustrates the differences that typically occur for a roadway segment between two intersections. Traffic data is reported by INRIX on two distinct segments representing the external and internal TMC segments as discussed above, while traffic data reported by HERE is for a single unified TMC segment. Note that the endpoints do not align precisely due to mapping differences between TomTom (used by INRIX) and HERE.

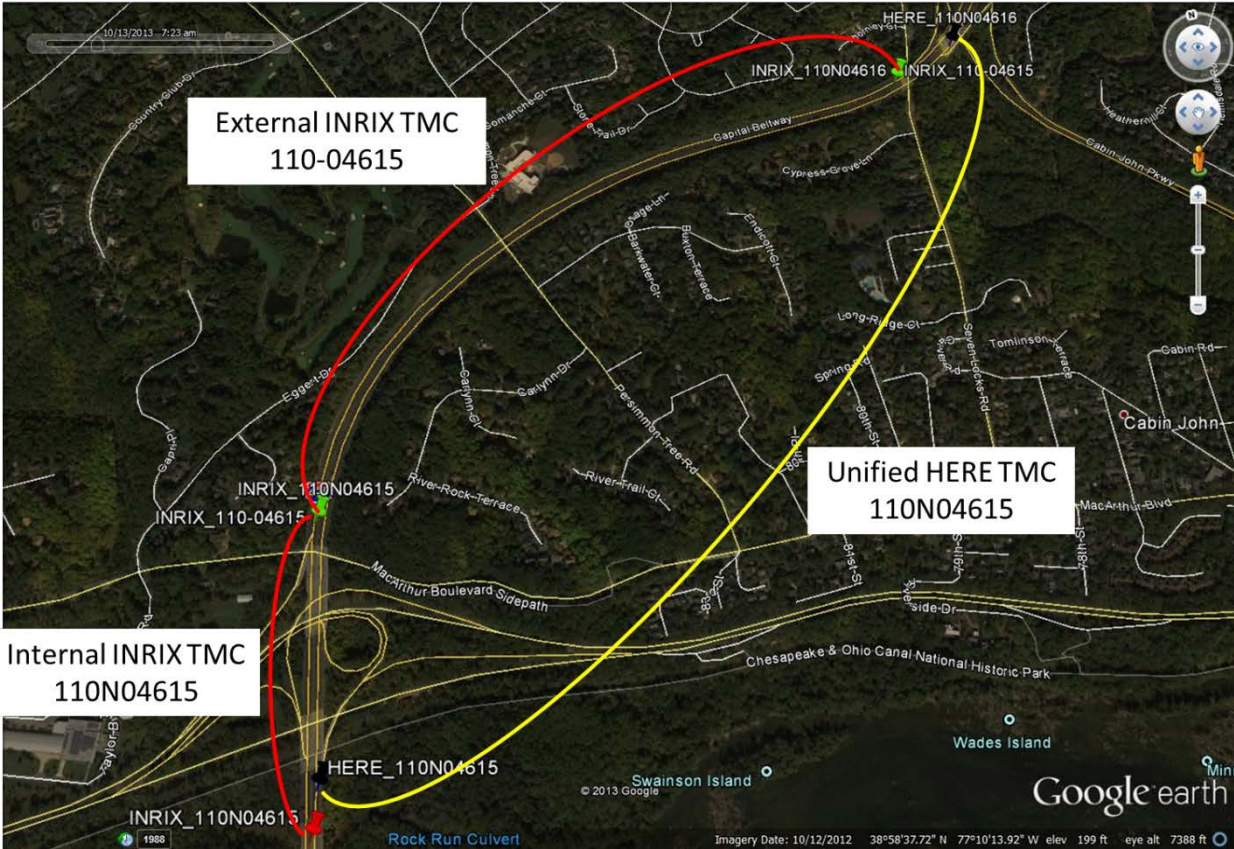


FIGURE 1. DIFFERENCES IN SEGMENTATION

In theory the sum of the lengths of external and internal segments from INRIX (using TomTom TMC definitions) should be equivalent to the length of the unified segment from HERE. The University of Maryland was able to run a comparison of segment lengths based on TMC nationwide listing available from INRIX and HERE. Figure 2a and 2b depict the relative agreement between the two data sets. For each segment on the National Highway System, the length of the HERE unified TMC code is plotted against the length of the combined external and internal TMC codes based on TomTom TMC definitions used by INRIX. Figure 2a presents the full extent of segment length which can reach up to 80+ miles. TMC codes of 20 miles or greater reflect the distance between interchanges on the interstate highway system in many rural western states. The agreement of TMC code lengths for segments greater than 20 miles is relatively consistent as evidenced by most of the points in Figure 2a falling on the 45° diagonal line. Figure 2b shows the agreement of TMC codes for lengths of 10 miles or less. Although the large majority of segments fall on or near the 45° diagonal line for segments less in Figure 2b, segment lengths can differ substantially as indicated by the data points that fall a significant distance from the 45° diagonal line.

These results underscore the nature of TMC codes. They were created to be accurate enough to convey traveler information to the general public. Traveler information is not significantly impacted by small differences in the precise location of segment endpoints. Such discrepancies can become more significant if the data is used for applications requiring greater precision.

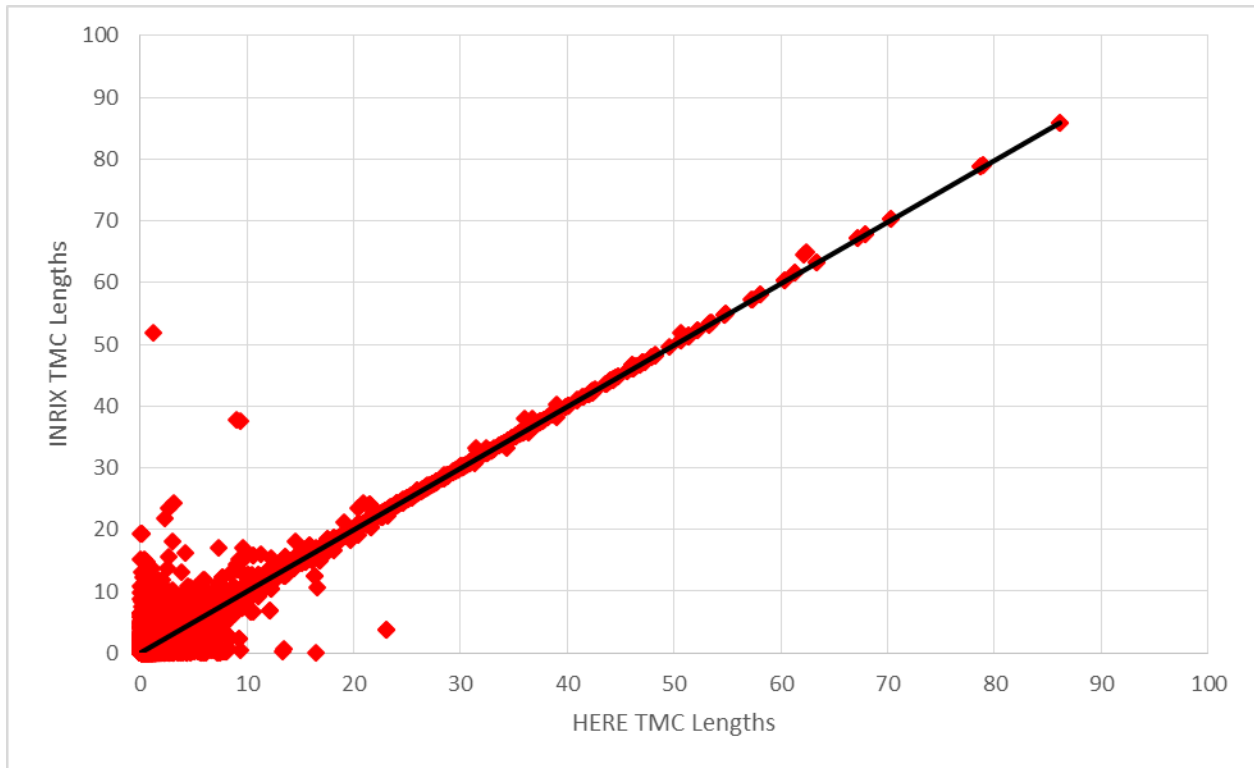


FIGURE 2A. LENGTH VS. LENGTH PLOT OF ALL TMC SEGMENTS ON NHS ROADS

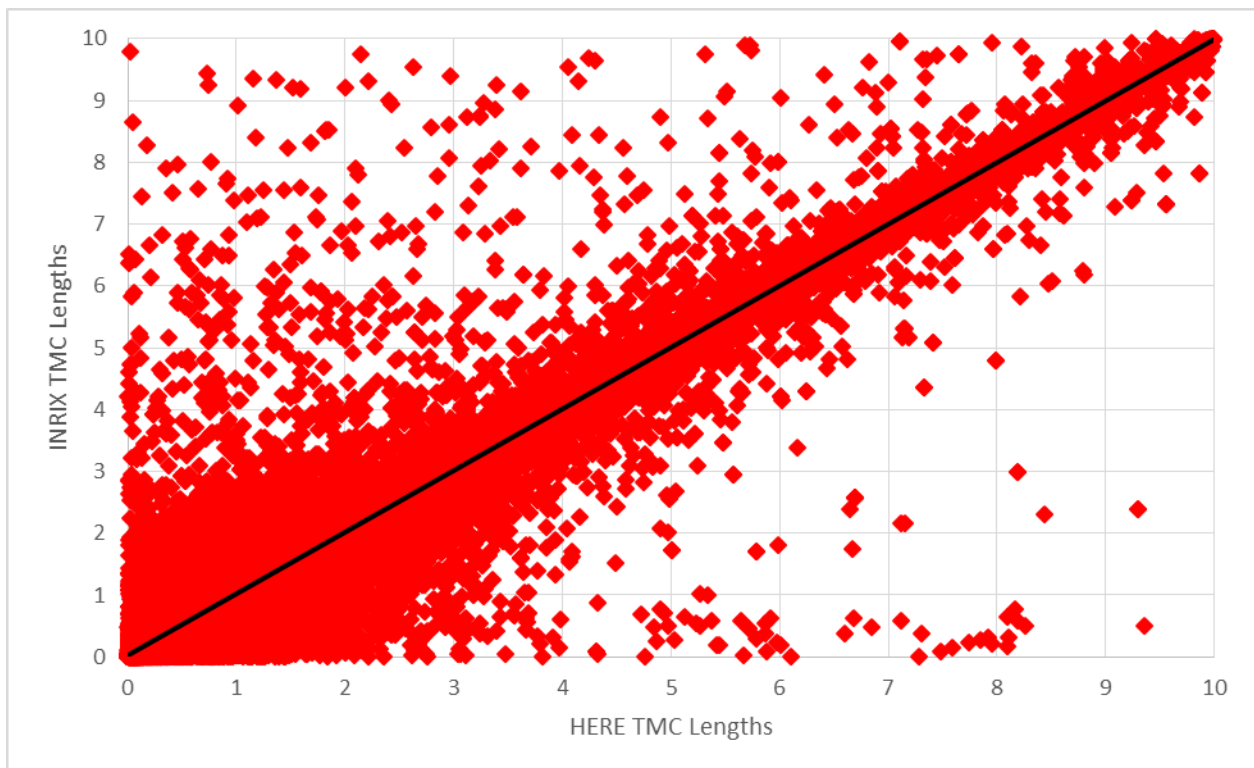


FIGURE 2B. FIGURE 2A ZOOMED TO SHOW 0-10 MILE LONG SEGMENTS ONLY



## Strengths and Deficiencies in TMC Codes

The strengths of a TMC code based segmentation are listed below:

- When transmitting road or traffic information specific to a roadway location, TMC codes reduces the amount of data that might otherwise have to be transmitted to identify the road segment. TMC codes were created for this purpose, such that traffic information for roadways could be efficiently transmitted on radio side bands, and are now used for electronic map referencing used extensively in smart phone and internet applications.
- Since TMC codes typically define segments that span the distance between roadway intersections. The intersection to intersection logic embedded in TMC codes is appropriate for traveler information and also reflects the data needed to perform minimal travel time routing, a function common to many navigational aids. If delay is experienced on a segment due to an incident, weather, or road construction, the impact on the TMC segment is reflected in a decreased speed or increased travel time, allowing algorithms to develop alternative routes for the traveler.
- TMC codes are maintained by an industry consortium, minimizing cost and preventing duplication of effort. As the codes are created to a standard, and used in industry as well as by transportation agencies accessing the data, the segmentation is consistent across multiple applications, and multiple entities. The cost to upkeep the codes (adding codes when new roadways are created, or adjusting codes due to major construction) are borne by a wider community, and thus more cost effective.
- TMC codes are maintained to the TISA standard, minimizing variation. Although variation does exist in implementation of the codes by traffic vendors and within mapping software (as witnessed in Figures 2a and 2b), the speeds reported by various traffic services based on TMC codes are generally interchangeable on various map representations. Traffic data from any vendor conveyed with TMC codes can be displayed on a map from any vendor that implements that same TMC code set.
- A key aspect of the TMC code standard is maintaining backward/forward compatibility. Once a TMC code is created, the standard requires that it be supported in future code sets (which the exception being if a road is no longer in service.) As a result, TMC codes remain valid over long periods of time, providing multi-year stability which is critical for performance measures applications that reflect traffic over a period of years.

The weaknesses of TMC codes are given below:

- The lengths of roadway segments may be too long or too short to support some applications. Although adequate for routing, TMC segments lengths greater than two miles make it difficult to identify the location of an incident or length of a queue. Short TMC code segments, particularly internal TMC segments that are fraction of a mile long, can be easily aggregated and present less of a problem than excessively long TMC code segments. **In response to the need for finer granularity, vendors have introduced alternate segmentation schemes and methods to**

**provide sub-TMC data. Note however, alternate segmentation schemes are not compliant to any specified standard, though it is likely their construction is informed by experience with TMC code standards.**

- Segments defined by TMC codes are inflexible. If an application requires a difference segmentation scheme, the traffic data from TMC codes will need to be aggregated or sub-divided appropriately from TMC code segments. Any static segmentation scheme will have the same weakness. The problem is compounded if the base segments are excessively long. Whereas shorter segments can be aggregated without loss of accuracy, sub-dividing longer segments can introduce sizeable error if traffic conditions are not homogeneous across the segment.
- **TMC codes segments are not available for all classes of roads.** The TMC standard and associated TMC tables were created primarily for the highest level roads (freeways and principal arterials). As roadways decrease in functional class, the likelihood that TMC codes exist for such roadways diminishes. Even though nothing prevents the NATMCCA from defining TMC codes for lower class roadways, note that TMC code standard was established primarily to reflect the through movement of traffic rather than local access, thus the emphasis on higher road classes. Not only are TMC less prevalent on lower class roadways, the structure of the TMC codes does not yield itself well to roadways with frequent points of access and frequent intersections.
- **The ability of TMC codes to reflect special use lanes (HOT, HOV, etc.) are mixed.** If special use lanes (such as High-Occupancy-Vehicle, High-Occupancy-Toll, local, or express) are separate road structures, TMC codes are typically defined separately from normal use lanes. If special use lanes exist on the same roadway, but are segregated only by striping or other traffic control devices, such facilities are likely not to have separate TMC codes from normal use lanes. This is not a limitation of the TMC codes, but rather a reflection of the nature of digital mapping where roadbeds are defined as nodes connected by lines, which cannot be broken out typically by lane. Today, there is also difficulty of differentiating traffic conditions by lane using probe technology, though in future the level of capabilities are expected to increase. If special use lanes are spatially separated such that data reported using Global Positioning System (GPS) technology can distinguish the lanes, then TMC codes can be created to report the data.
- **Reversible-flow lanes follow the same rules as other special use lanes. They will have TMC codes if they are on a separate roadway structure.** However, the TMC code standard alone has no method to convey the current direction of travel. If such information is conveyed by traffic vendors, it must be done so in the data feed, by delivering data that defines which direction of travel is open to vehicles.
- The ability of TMC codes to reflect ramps is limited to freeway to freeway interchanges, typically the intersection of Interstate grade facilities in North America. **An interchange between a freeway and a major arterial will rarely have TMC codes defined for ramp movements outside of major city centers.** Congestion involving ramp movements that impact mainline operations, such as queuing at the ramp that spills back to the right-hand lanes of the freeway, is difficult to encode and convey using TMC codes or any other link-node roadway representation that does



not distinguish lanes. More robust methods of reporting traffic are required to overcome this limitation.

- Updating of the TMC codes to include new and improved roadways typically lags by months. This is an improvement with VPPII which requires traffic data be available on new roads within six months. This multi-step process requires (a) the TMC alliance to create new TMC code definitions, (b) the new TMC codes be approved by TISA, and (c) the new codes must be realized in electronic maps before traffic data can be provided. Traffic vendors have overcome this lag time by providing data on new roads nearly instantaneously with alternate segmentation methods until the TMC codes are updated.

## Recommendations to the I-95 Corridor Coalition

The traffic data industry is evolving quickly with new products as density and granularity of probe data increases. The pace of innovation in this sector is progressing such that a new segmentation scheme is not likely in the near term. Based on experience working with traffic data from the three vendors under contract in VPPII, (INRIX, HERE, and TomTom), the following primary findings and recommendations are provided moving forward concerning the use of probe-based traffic data, and its use in member agency applications.

- **Public agencies should continue to use TMC codes for the procurement and use of outsourced probe traffic data.** The TMC codes ‘sweet spot’ will be for applications primarily on freeways and other level high level principal arterials in which travel time and speed between intersections is sufficient. Despite the minor differences in implementation by traffic data vendors and electronic map providers, TMC codes will continue to enable cost-effective data sharing across borders, allowing for applications that enable multi-jurisdictional situational awareness. The TMC code standard will also provide necessary stability to develop and track performance over long periods of time without concerns related to alternate (and often proprietary) segmentation methods offered by vendors.
- **Public agencies should consider alternate segmentation methods provided by vendors to enable applications requiring higher levels of granularity than that supported by TMC codes.** Although new roadways will be reflected in TMC code sets in a timelier manner than was previously demonstrated in the first phase of the VPP, these alternative segmentation options will be more responsive since they are not subject to the lengthy TMC process. These new methods from vendors will be required to access higher spatial granularity, as well as to implement new traffic data products and applications anticipated with probe data such as end-of-queue warning systems, lane specific traffic data, and arterial signal performance measures.
- **The I-95 Corridor Coalition should not pursue a new standard for segmentation of roadways to exchange traffic and other road attribute data at this time.** TMC codes and vendor specific segmentation schemes will continue as the primary methods to reference industry traffic data into the foreseeable future. Both will coexist, and agencies will need to access and use both methods. Previous discussions centering about encouraging the development of new standard,

or a revised TMC standard are not practical at this time. Any fixed length segmentation method will have 'sweet spots' for some applications, and be deficient for other applications.

- Whether traditional TMC codes (with their variation in implementation from vendor to vendor) or custom segmentation schemes from vendors that provide sub-TMC granularity, the integration of traffic data into agency applications will remain the burden of the transportation agency. The process of cross-referencing vendor provided data in a specific segmentation format to an agency, is termed conflation, will be required with any segmentation method, whether a custom segmentation method developed by the traffic data vendor, or a TMC segmentation method supported by a vendor. This expense should be considered in the application planning process. **Integration of outsourced probe data into agency applications (other than simple web based traveler information services) will require conflation, and incur its associated costs. Public agencies should budget accordingly.**

Collectively, it is recommended that the Coalition take the following actions to the benefit its members.

- **Develop and share educational material explaining the nature of TMC codes, alternatives to TMC codes, and associated implementation issues.** With the onset of the VPP, each vendor supports TMC codes (with some variation) as well as one or two alternate segmentation methods. As experience is gained by various Coalition members adopting and integrating data, work with early adopters to capture lessons learned.
- **Provide a forum to share best practices and anticipated costs for integration of outsourced traffic data into agency applications and their associated GIS applications.** Several agencies already have integrated data and incurred the cost of conflation. Anticipated costs, useful tools, and knowledge of available service providers is key information in application planning.
- **Encourage the continued use and development of open standards (when available) in future procurements with respect to the VPP.** Although a new segmentation standard is unlikely, standard methods to encode roadway segments and their attributes would ease integration and reduce cost. The VPP contract took the first step in this process, requiring vendors to provide a listing of their TMC codes segments which included geodetic end points in latitude and longitude. This proved critical in the VPP validation process, and in understanding the variation in between TMC codes sets.

## REFERENCES

- [1] Traffic and traveler Information (TTI) - TTI Messages via traffic message coding - Part 1: Coding protocol for Radio Data System - Traffic Message Channel (RDS-TMC), EN ISO 14819-1:2002.
- [2] Traffic and traveler Information (TTI) - TTI Messages via traffic message coding - Part 2: Event and information codes for Radio Data System - Traffic Message Channel (RDS-TMC), EN ISO 14819-2:2002.
- [3] Traffic and traveler Information (TTI) - TTI Messages via traffic message coding - Part 3: Location Referencing for ALERT-C, EN ISO 14819-3:2003
- [4] [www.tisa.org/about-tisa/services/tmc-location-request/procedure-tmc-location-table-certification/](http://www.tisa.org/about-tisa/services/tmc-location-request/procedure-tmc-location-table-certification/)

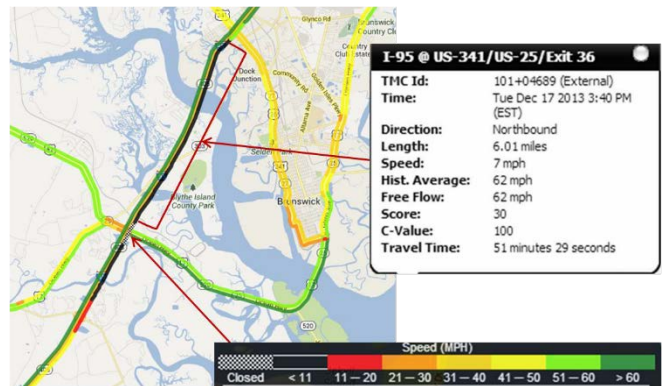
# Appendix- Vendor Segmentation Summaries

## INRIX

The following comes directly from the INRIX I-95 Vehicle Probe Project II Interface Guide Available here: <http://i95coalition.org/wp-content/uploads/2015/02/I-95-VPP-II-INRIX-Inteface-Guide-v1-Dec-2014.pdf?dd650d>

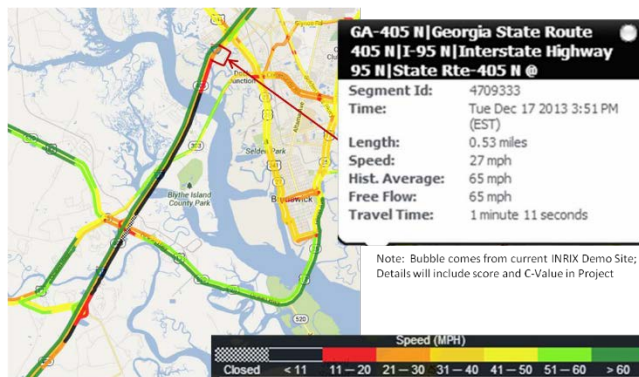
INRIX XD Segments, introduced in late 2013, mark a key upgrade for INRIX and its customers. While similar to TMC Segments in that they delineate a specific section of roadway, XD Segments are defined and maintained by INRIX. This allows INRIX to provide more road coverage (all FRC 1, 2, and 3 level roads, plus any higher FRC roads covered by TMCs), better segment resolution (no more than 1.5 miles in length, with no overlaps or gaps), and the ability to cover new roads more quickly.

As an example, this map uses INRIX data with TMC Segments. It shows two backups around a road closure.



TMC Segments

This second map, which uses INRIX XD Segments, includes more queue detail and more road coverage, including interchanges.



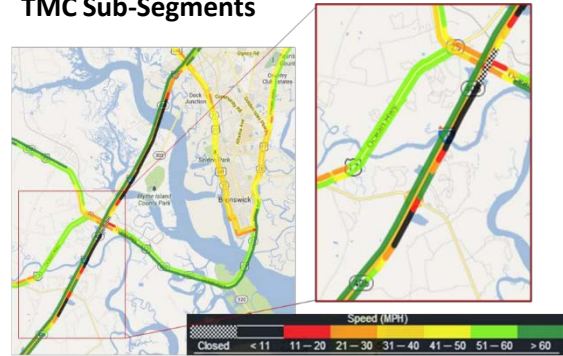
INRIX XD Segments

Sub-segment options for INRIX XD Segments and TMC Segments also further improve granularity, enabling greater resolution on any road covered by INRIX XD Segments or TMC Segments. The following maps illustrate the difference for TMC Segments and for INRIX XD Segments.

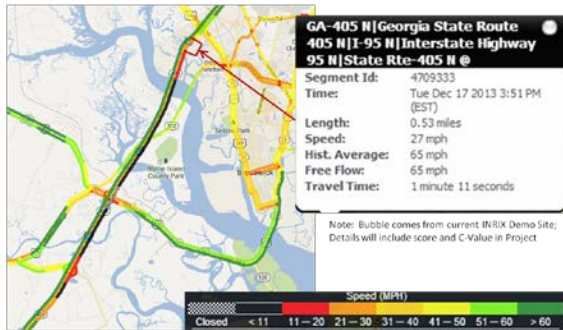
## TMC Segments



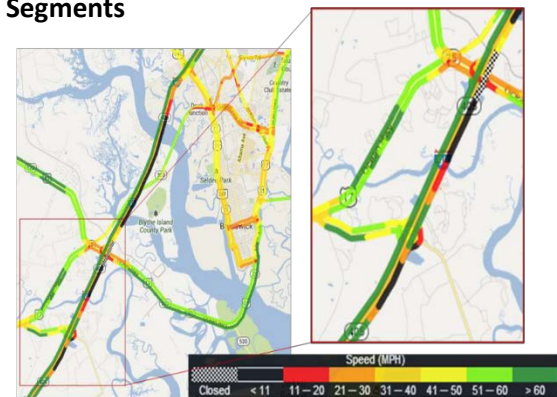
## TMC Sub-Segments



## INRIX XD Segments



## INRIX XD Sub-Segments



Both TMC and XD segments will be accessible in “sub-segment” granularity, with flexibility depending upon the use case and desired integration sophistication. Some API calls have optional parameters to allow the return of sub-segment speeds nested within the values returned for each segment. Sub-segment length can also be specified.

Another parameter will allow the user to determine when sub-segment speed values are returned based on the variance of the sub-segment speed from the full segment speed. Setting this parameter to zero mph would return all sub-segments. Setting it to 5 mph (for example) would only return sub-segment speeds where the difference from the segment speed is greater than 5 mph. This allows a user to determine the most effective way to return sub-segment data based on their particular use case. Returning all sub-segment data will create “fixed” segments that are easier to integrate; however, the size of the returned payload will also increase significantly.

## TomTom

The following was obtained directly from the OpenLR website available here:

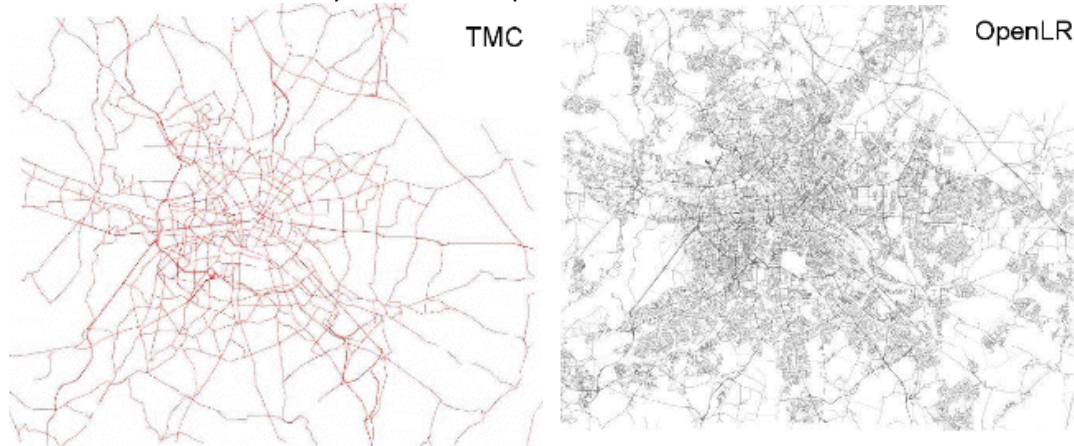
<http://openlr.org/introduction.html>

TomTom is launching OpenLR™ as royalty-free technology and open Industry Standard, and it invites the ITS Industry to join and adopt it.

This step will facilitate new business opportunities in various areas of Intelligent Transport Systems (ITS) such as traffic information services, map content exchange and Cooperative Systems where precise and compact dynamic location information is needed. The map-agnostic feature of OpenLR™ enables reliable data exchange and cross-referencing using digital maps of different vendors and versions.

OpenLR™ will help to enhance existing applications and will generate opportunities for new services. It is expected, that the universal location referencing technology will greatly support key actions of the ITS Action Plan of the European Commission.

TomTom will lead the further development and maintenance of the OpenLR™ system and invites the stakeholders in this industry to enhance OpenLR™ and contribute to its evolution.



Coverage Comparison TMC vs OpenLR™ location referencing (Main area of Berlin, DE)

### What is Location Referencing?

Communication of spatial information involves the communication of location information.

The communication chain of a machine readable location can be described as encoding the location at the sender side, transfer of the code to the receiving system and decoding the code at the receiver side.

The process of encoding a location is also called Location Referencing. This assumes a map on the sender side from which the location is encoded and a map on the receiver side in which the decoded location is found back. An obvious way of Location Referencing is using geographic coordinates. One important disadvantage of using coordinates is that it needs identical maps at both sides of the communication chain which often is not the case. As a consequence, the decoded location may not be found back in the receiver map, or decoding (i.e. map-matching) may be inaccurate or ambiguous.

### Introduction to OpenLR™

OpenLR™ is a method for location referencing which does not have this disadvantage. It accommodates requirements of communication of location between systems which have dissimilar maps. OpenLR™ is



communication channel independent. It takes bandwidth requirements into account in the sense that OpenLR™ requires minimal bandwidth.

OpenLR™ has been designed for the use case of transferring traffic information from a centre to in-vehicle systems, built-in or used as an add-on (PND, Smart Phone). The information transferred can consist of the current traffic situation at a certain location, a traffic forecast or special alerts. The corresponding locations are roads or a list of connected roads.

The most well-known and most used method to transfer traffic information today is called RDS-TMC. The Location Referencing used in RDS-TMC makes use of pre-coded locations. These pre-coded locations are added to the corresponding locations in the map by the map providers of the sending and the receiving map.

The process of encoding is looking up the location code in the map belonging to the relevant location. The process of decoding is finding back the location code in the map and looking up the corresponding location.

From the fact that RDS-TMC makes use of pre-coded location it follows that the amount of locations fit to be transferred is limited. OpenLR™ does not have that restriction. With OpenLR™ every location in a map can be transferred.

Key business and technical benefits of OpenLR™

- An open and royalty-free industry standard
- Open Source Model based on Apache license v2.0
- OpenLR™ Trade Mark available to use free of charge with the technology
- A map-agnostic dynamic location referencing method
- Applicable to the full road network, including secondary and urban roads
- Compact and bandwidth efficient data transmission

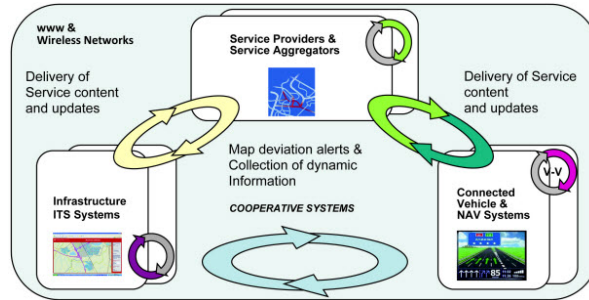
### Open Source

The goal of OpenLR™ is the wide-scale adoption by the industry at large. OpenLR™ is therefore proposed as an open standard in an Open Source framework. It will be usable for anyone dealing with locations and transmitting these between systems having dissimilar maps. OpenLR™ focuses on area, line and points locations.

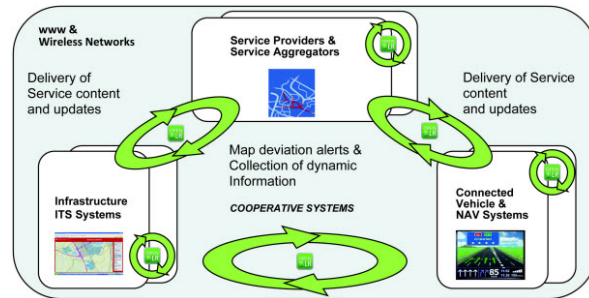
While the standard is developed and maintained by TomTom International B.V., everyone is invited to contribute to its further development.

### Why is OpenLR™ so important?

Dynamic location referencing is a requirement for many ITS and LBS (location based systems) systems and services. The use of various location reference methods will limit the interoperability of systems. A universal standard across a variety of applications will enable system integration and open the market for LBS.



**COLLABORATION MODEL WITHOUT STANDARDIZED DYNAMIC LOCATION REFERENCING**



**COLLABORATION MODEL WITH STANDARDIZED DYNAMIC LOCATION REFERENCING AS OPENLR™**

**HERE**

HERE is able to report traffic conditions on the most granular level using its sub-TMC and Dynamic Location Referencing features. HERE's sub-TMC feature increases granularity of traffic reporting as congestion is detected. Traffic is reported in smaller increments within a TMC to reflect real-time conditions that vary across the segment. The underlying traffic feed is based on individual map links, which are then aggregated to a TMC. These values can be individually reported when they differ from surrounding segments. This approach captures the natural segmentation of traffic speeds based upon real world conditions. This enables a universal approach on all road types based on the TMC referencing system and is not limited to the more arbitrary breakpoints of internal/external TMC codes. Sub-TMCs correspond to the accurate road geometry provided in the map and the actual location of variations in traffic speeds. Granular condition reporting is associated with road network features such as changes in lane configuration, ramps, curvature, and intersections, so HERE's approach to reporting granular conditions incorporates this fundamental knowledge of road network modeling.



The following figures help illustrate the difference between using the sub-TMC feature over TMC only reporting. In Figure 1, traffic is reported along the TMC segment showing an indication of moderate congestion along this segment.

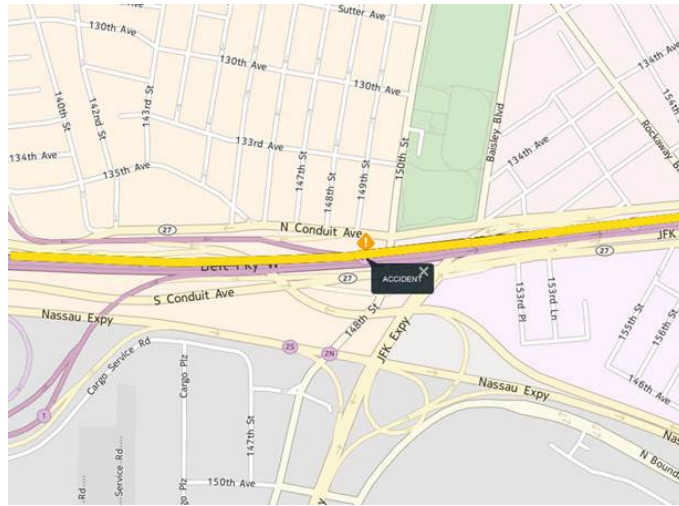


FIGURE 1. WITHOUT HERE SUB-TMC TRAFFIC

In Figure 2, traffic is reported using the sub-TMC feature. In this situation, there are varying real-time conditions within the TMC segment. Three conditions are identified within this TMC segment to show the moderate speed decrease approaching an accident, slower speeds closest to the accident, and then increasing speeds as vehicles pass the accident site. This granularity can be useful for traffic engineers to identify special circumstances. It can also be useful in alerting the traveling public.

When conditions remain consistent along a TMC and links are not exhibiting different travel conditions, then the whole TMC will be used for reporting speeds.

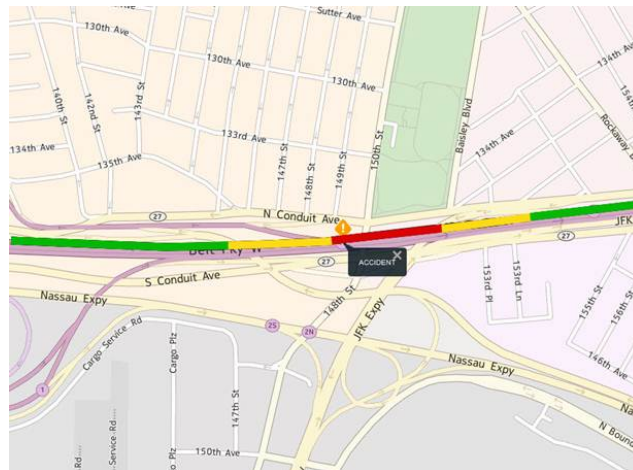


FIGURE 2. WITH HERE SUB-TMC TRAFFIC

The Figure 3 displays sub-TMC data in a Space-Time graph during an afternoon rush hour on three consecutive TMCs on a roadway as the traffic jam builds up. The y-axis of the graph is the distance along

the TMC segments and the x-axis of the graph is the time (in UTC). The location of the TMC start point is where the ID numbers appear in the graph on the left hand side.

During the beginning of the congested period, slow speed data only appears on short segments at or near the first intersection (TMC location 125P04873). As the afternoon progresses, the congestion messages expand to cover more of the TMC (125P04872) and a secondary traffic jam begins to build up approaching the next intersection (125P04874). This chart shows HERE sub-TMC messaging in action on a variable section of roadway across an afternoon rush hour.

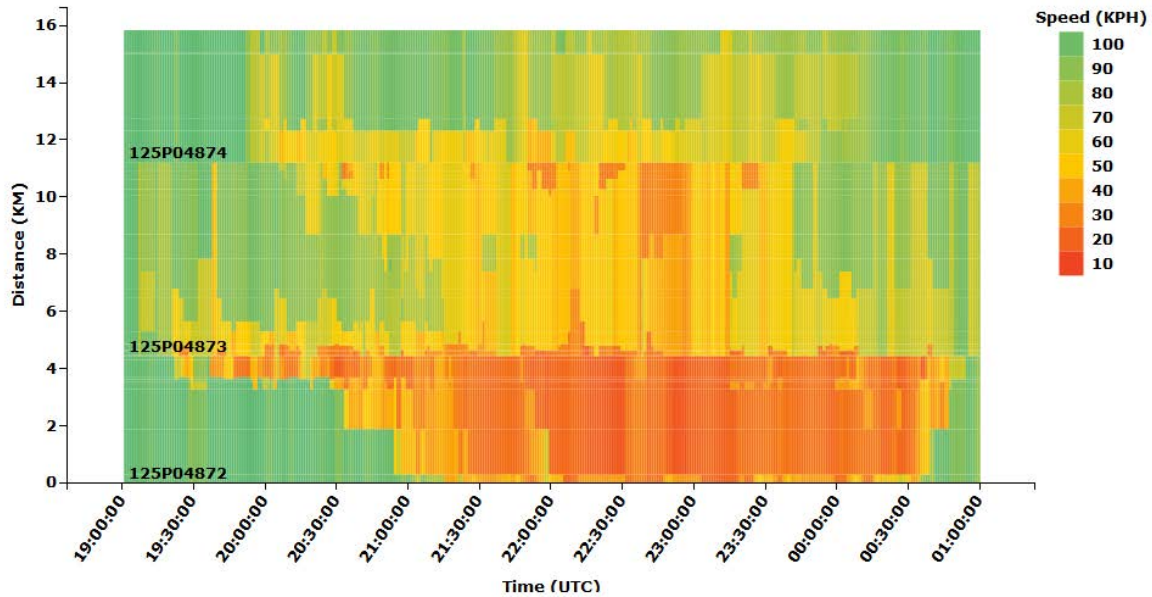


FIGURE 3. HERE SUB-TMC SPACE TIME GRAPH

TMC	ROAD NUMBER	CROSS STREET	ROAD DIRECTION	TMC LENGTH MILES	SPEED LIMIT
125P04872	I-40	US-15/US-501/Exit 270	WESTBOUND	2.756	65
125P04873	I-40	NC-86/Exit 266	WESTBOUND	4.202	65
125P04874	I-40	New Hope Church Rd/Exit 263	WESTBOUND	2.88	65

In addition to reporting using the TMC referencing system, HERE has the ability to add new roads rapidly to the surrounding road network and add real-time data to non-TMC coded roadways. There are two approaches to reporting traffic on newly opened roadways or for delivering traffic data that is necessary for our clients but not currently TMC coded. The first entails quicker addition of new TMC codes. The second approach entails using HERE’s Dynamic Location Referencing (DLR) to deliver data for new road on top of the underlying road network while new TMC codes are being implemented.

HERE has the ability to propose new TMC additions to the TMC Alliance and accelerate coding those additions into the map database so that traffic may be reported against the new TMC codes. New TMC codes are typically proposed via the Alliance and approved twice per year. Close coordination on the planning and alerting for the timing of new roads can help HERE shorten the timeframe for adding new TMC codes.

While using the TMC approach provides the best integration into the road network, HERE can offer other solutions for even shorter time frames. Dynamic Location Referencing, or DLR, is a method for describing locations without being constrained to a specific map or TMC code. HERE Traffic employs DLR referencing to report traffic on non-TMC-coded roads, when significant congestion is detected. This approach also enables traffic to be reported on new roads within one month.

DLR references latitude and longitude information for shapepoints of a segment. For that reason DLR consumes more bandwidth and processing than TMC-coded traffic reports do. Typically HERE uses this referencing system only where traffic conditions especially impact the end-user's experience. However, for important updates and significant roads that are in the process of having TMC codes assigned, HERE can also deliver 24x7 traffic coverage using DLR referencing as needed.

The importance of integrated map data in the processing and delivery of real-time traffic data cannot be understated. HERE has an ingrained culture of process and quality improvements and works closely with our customers on streamlining map and TMC update processes. HERE's update and quality management processes are designed to provide continuous delivery of fresh and accurate data to our customers and the traveling public.