Split-Lane Traffic Reporting at Junctions

Technical paper

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Executive summary

Split Lane Traffic Reporting at Junctions (SLT) from HERE is a major innovation in real time traffic reporting. The advanced algorithm of this GPS based technology is the first to detect divergent speeds and report traffic conditions on a multiple lane level before a junction.

SLT is developed by the HERE Traffic organization. HERE has produced the technology through global map research, the creation of two proprietary algorithms, the development of a validation logic to ensure reliability, and the design of a display for the HERE Maps API. Analyzing the global map, HERE found over 100,000 junctions where these divergent conditions can occur.

SLT uses the Multi-Modal Speed Detection and Magnitude (MDM) and the Dynamic SLT Aggregation (DSA) algorithms to process raw probe data as well as information from sensors and incident sources. MDM specifically determines whether there are differences in the speeds on distinct parts of the road, and if these differences are high enough to necessitate an SLT publication. Meanwhile, DSA calculates how much of the road leading up to the junction is experiencing multi-modality.

SLT reports can show three speed profiles: free-flowing traffic, slow moving lanes, and congestion. In cases of multi-modality, SLT will report two distinct speeds from these three choices, always showing a high speed and a low speed. Once available, SLT will automatically feed into the HERE Real-Time Traffic product and can be displayed to drivers to help them make an informed decision during this part of their route.

SLT improves the accuracy of estimated arrival times by detecting congestion free routes, helps drivers make better decisions, and contributes to intelligent traffic management solutions. It is a crucial step towards the development of full lane level traffic reporting and the enhancement of highly automated driving.

Introduction

Split Lane Traffic Reporting at Junctions (SLT) is the first technology to provide real time traffic reports on a multiple lane level. SLT improves routing times, gives drivers a clearer picture of the road ahead and allows them to make better driving decisions.

Traffic congestion costs time and resources. It raises business, consumer, and governmental expenses and adds to greenhouse gas emissions. These costs arise from increased fuel consumption, delayed deliveries, lost working hours, and higher frequencies of vehicle maintenance. For example:

2011
Congestion expenditures in Europe were equivalent to roughly 1% of the EU's gross domestic product (GDP),[1] or about €143 billion.

2014
Commuters in the US spent 6.9 million hours stuck in congestion, resulting in around $159.12 billion in costs[2].

1/3
of greenhouse gas emissions in the US have been attributed to transportation[3].

Optimizing traffic flow offers an opportunity to decrease unnecessary expenses and helps reduce environmental pollution by minimizing commute time.

The Intelligent Transportation Society of America states that improvements in communication technology and automated driving are methods to positively affect traffic. Advanced real time traffic reports and intelligent digital maps deliver the information necessary for smoother traffic conditions.

HERE Traffic monitors data from hundreds of sources 24 hours a day and seven days a week. Data is processed and updated every 60 seconds and published to onboard devices and consumer devices, delivering up-to-the moment information about traffic conditions, including congestion, road work and accidents. This is done with pinpoint accuracy to 10 meters. Current real time traffic products provide only the harmonic weighted average speed of all road lanes. With speed averaging, distinct speeds on lanes are lost. Differing speeds are often pronounced at major junctions and road splits. Understanding these conditions can be critical to accurate routing and travel time estimates. With the capacity to publish multiple lane traffic speeds, SLT is the first technology to solve this issue.

By providing real time traffic reports on a lane level, SLT improves situations where averaging the speeds of several lanes would omit important differences. An off-ramp could be experiencing heavy congestion while the traffic on the same road remains free-flowing. SLT measures traffic flow in such conditions and reports two different lane speeds where applicable.

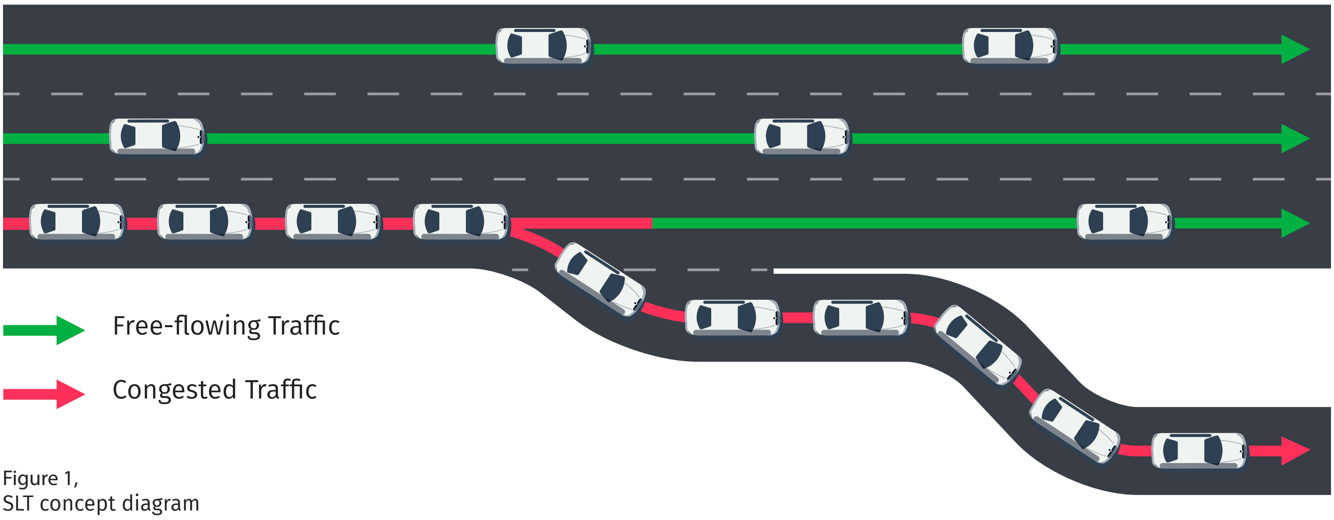
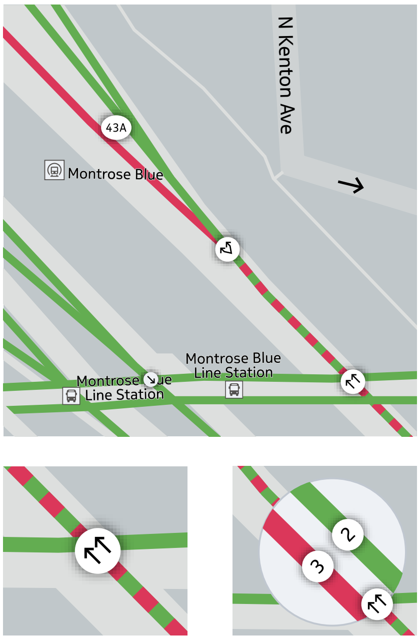


Figure 1,
SLT concept diagram

SLT contributes to road segments that are more detailed, as presented in the following use cases. The HERE Real-Time Traffic product will automatically receive SLT updates, and the divergent speeds can be displayed on the navigation systems in vehicles. As shown in Figure 2, in a suggested implementation, two arrows will display that there is more traffic information available at the lane level, making drivers approaching junctions aware of speed differences. This information gives drivers the chance to make informed decisions regarding the lane best suiting their needs, and presents the opportunity to avoid congestion. Additionally, awareness of congested conditions at upcoming junctions along a route will make ETAs more accurate and help provide better routing guidance. SLT will also contribute to incident reporting, allowing congestion to be indicated alongside other traffic reports.

The automotive industry has been awaiting an HD map capable of reporting on a full lane level. However, developments of such maps had until now required vehicles that are able to report their position with lane level accuracy. SLT technology accelerates the reporting of lane level traffic without dependency on high precision vehicle positioning.



Zoomed in view displays lane level traffic.

Double arrow alerts driver to more information.

Figure 2,
SLT interface
map design

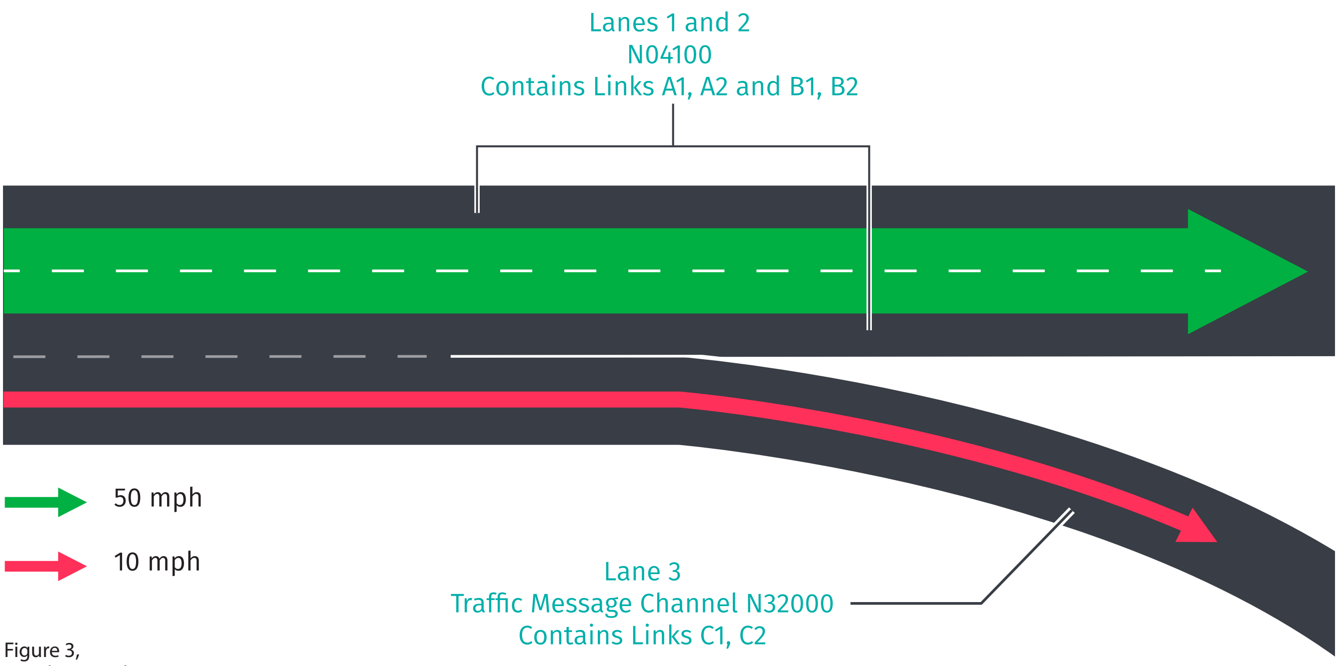


Figure 3,
Multi-modality example

Methodology

The team at HERE recognized the need for lane level accuracy at junctions through traffic test drives and traffic research. With a drive to continuously perfect HERE traffic, they set out to develop a solution.

The key innovation of SLT is based on the design and creation of an algorithm that solves the fundamental problem of reporting two different traffic speeds on a single road segment. The algorithm identifies divergent speeds before a junction by collecting raw data from a variety of sources including connected cars, smart phones and sensors. The results clearly label the sections of road that experience divergent speeds. The possible profiles differ between free-flowing traffic, slow moving lanes and heavy congestion.

SLT will be fed into HERE Traffic reports, making the data richer and providing a deeper level of information for drivers.

Development Process

The development required in building SLT involved the following steps (Each step is explained in further detail on the subsequent pages)

1. Researching the global map to identify instances where split lanes are possible and divergent conditions exist
2. Developing a Multi-Modal Speed Detection and Magnitude Algorithm (MDM), which detects differences in speeds
3. Creating a validat ion logic and a means to measure the reliability of a published SLT
4. Developing the Dynamic SLT Aggregation Algorithm (DSA), which determines how much of the road leading up to the junction exhibits speed differences
5. Designing the SLT display for the HERE Maps API

SLT Terminology Explained

Following the research of the global map for split lane locations with high chances of divergent speeds, a road topology of segments and links has been created based on the results.

During the research phase, HERE scanned maps for major junctions and highway splits across the world. Over 100,000 instances of divergent conditions were found, confirming that SLT will impact drivers on a regular basis worldwide.

Based on this research, the detection and interface architecture of SLT was designed, separating junctions into logical links and road segments.

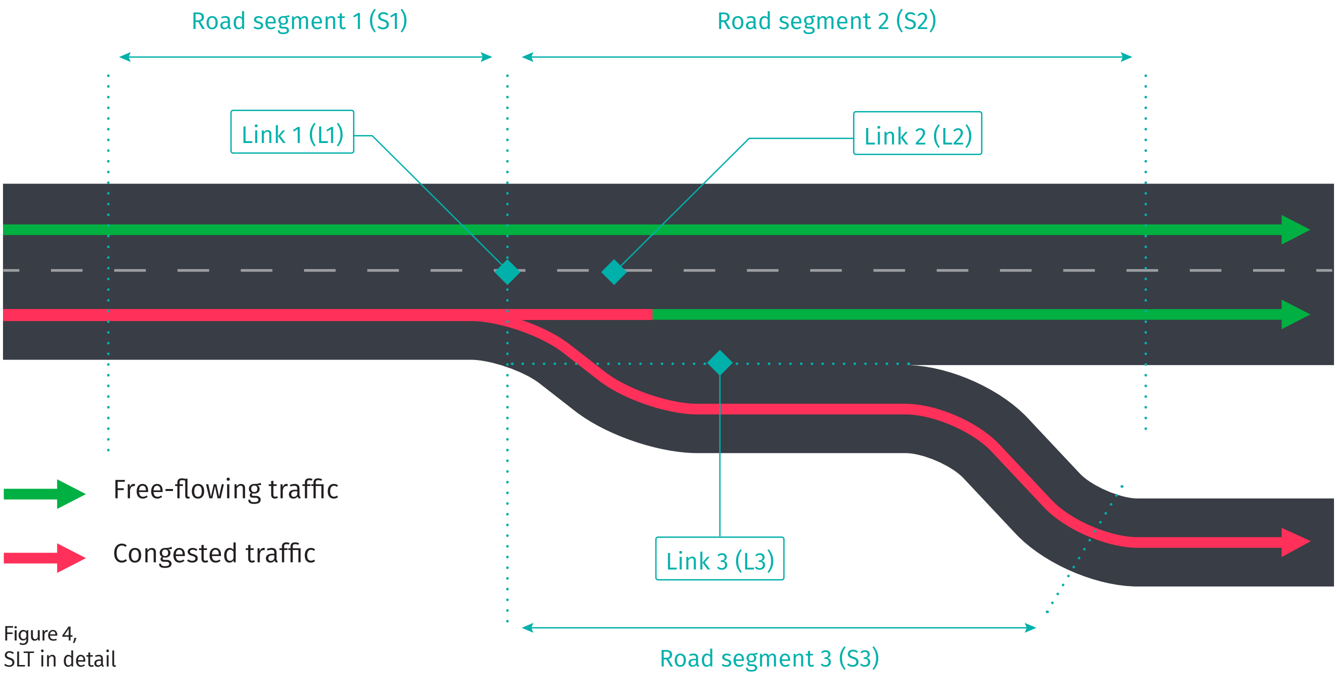


Figure 4,
SLT in detail

S1 - The first segment corresponds to the road that leads to the junction

S2 & S3 - The second two segments represent the non-ramp lanes and the off-ramp lanes. In cases with highway splits, they correspond to the left and right branches of the road.

L1 - The initial link at the point of a junction where two roads divide. A multi-modality publication occurs when different speeds are detected at L1.

Multi-modality is published in three possible speed profiles:

Green - Free-flowing traffic

Yellow - Slow moving lanes

Red - Heavy congestion

Any two contrasting speed profiles can be published in relation to each other, always showing a low speed (LS) and a high speed (HS).

The Multi-Modal Detection and Magnitude Algorithm (MDM) Explained

The MDM algorithm accurately measures speeds and the differences between speed clusters. MDM places data from moving vehicles into multiple speed cluster buckets and compares them. A cluster difference higher than a predetermined threshold indicates a significant level of multi-modality.

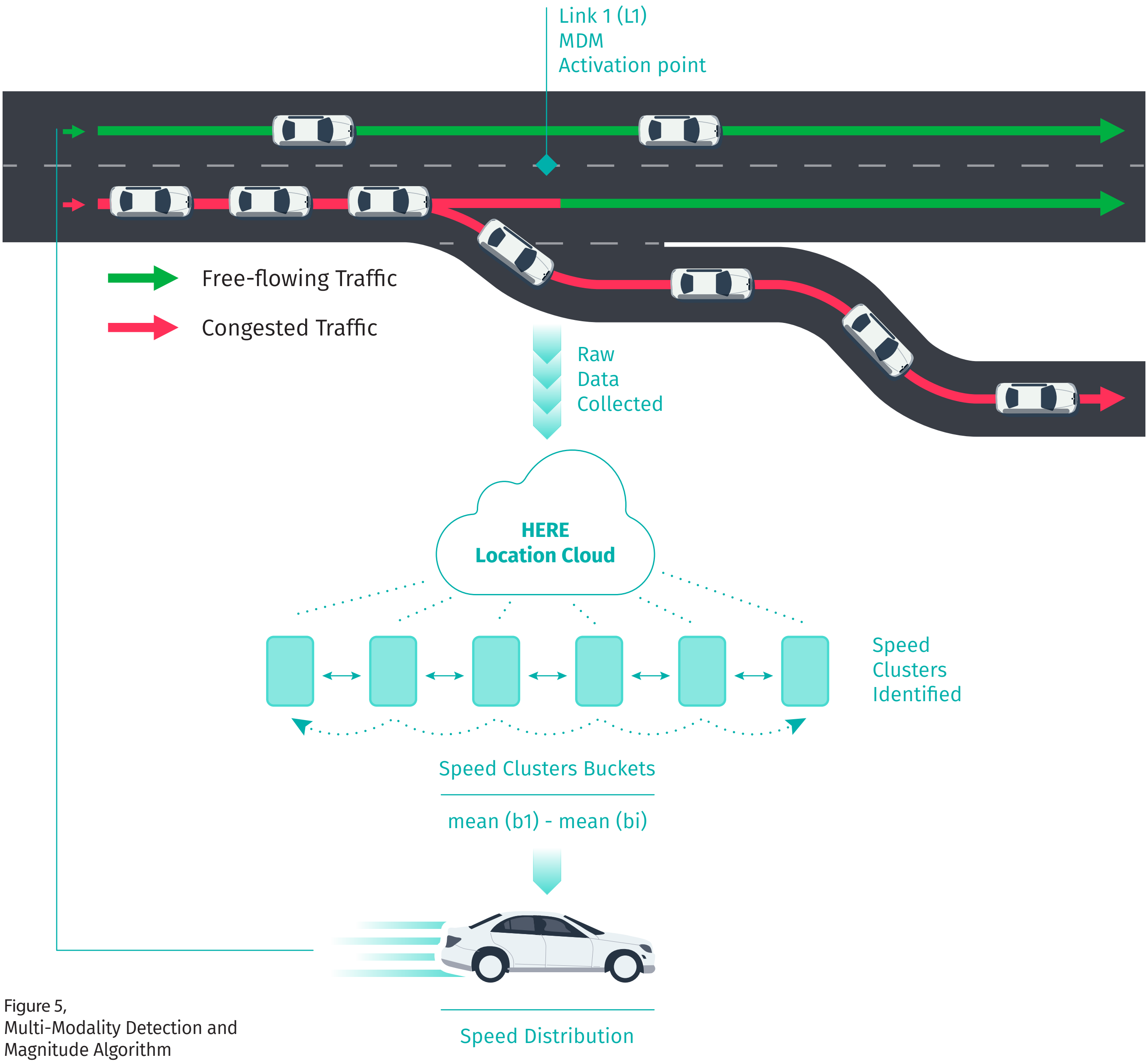


Figure 5,
Multi-Modality Detection and
Magnitude Algorithm

The Dynamic SLT Aggregation (DSA) Explained

For more accurate measurements, DSA breaks the road segment into links and works its way back from the divergent speed point until it locates the same speed across lanes.

If diverging speeds are detected at the junction, DSA is activated and scans the first road segment (S1) in real time. Starting from the initial link (L1), the DSA algorithm is initiated, evaluating probe data from the first road segment (S1). Figure 6 visualizes this process.

In Figure 6, the left and right roads beyond the split (S2 and S3) are showing multi-modality. The initial link (L1) is the point of activation. The probe data from the road leading up to the junction (S1) is scanned backwards from L1 by DSA to determine how much of the road before the ramp is multi-modal. To make the detection more accurate, S1 is divided into sub-links.

DSA scans the probe data from the road until it finds two subsequent links that show the same speed. Multi-modality is published starting at the link that is the last to show two different speeds.

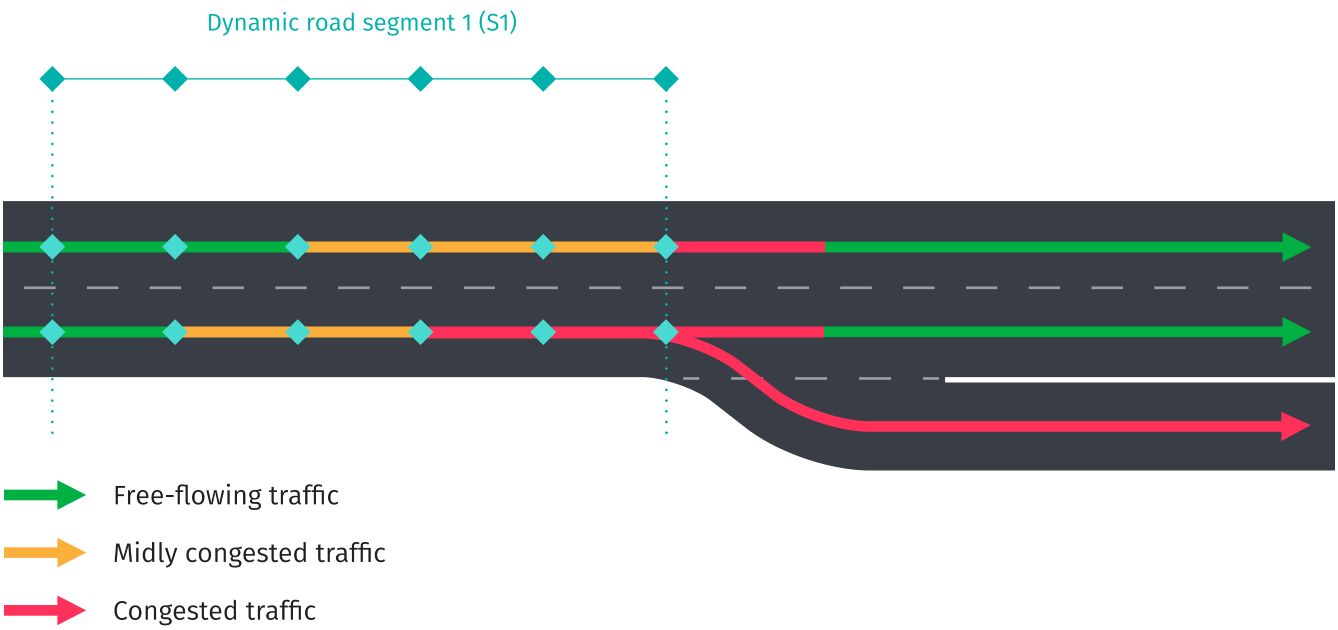


Figure 6,
Dynamic SLT Aggregation Algorithm

Results

HERE has identified over 100,000 junctions globally where divergent speeds are likely to exist, illustrating significant impact on drivers around the world. Testing SLT on road junctions across Europe and North America, HERE has come to better understand junction traffic and report it at a lane level when it occurs.

HERE has a real world testing program with over 150 tests drives performed globally on an annual basis. We drive over 180,000 KM or 6,000 hours on an annual basis. We invest in this process to look for ways to improve our traffic. We also employ a world class research team with access to state-of-the-art data modeling tools. The work from both these teams peaked an interest in enabling lane level granularity at junctions. Since developing the algorithm, the team has not only identified its occurrence at over 100,000 locations, but has rated the junctions based on the frequency at which multi-modality occurs. Breaking the information down, certain times of the day demonstrate higher divergent speeds. This occurs specifically during morning and evening rush hours. Data collected on 09 September 2014, for example, showed results from 1,007 junctions in North America and 865 in Germany. During the morning rush hour (8:20 am), 110 junctions in North America showed multi-modality and 52 of them exhibited congestion. In Germany, 400 junctions displayed multi-modality and 72 of these were congested.

Conclusions and future work

HERE SLT can help streamline traffic flow by measuring multiple lanes in real time. Continued work in this area focuses on expanding the capacities of SLT towards full lane level reporting and integrating it into highly automated driving.

By measuring, detecting, and publishing divergent speeds at junctions on a multiple lane basis, SLT will contribute significantly to the accuracy of HERE routing and real time traffic services, expanding dramatically the dynamic map content and services of HERE. Future work by the HERE Traffic team will focus on showing multiple lane traffic reports in HOV / car pool lanes and arterial roads.

Through processing speed profiles and raw data from moving vehicles, SLT will also enhance developments in highly automated driving (HAD). SLT offers vehicles with active cruise control the potential of smoother driving, more accurate guidance, and more precise ETAs. Further developments to HAD could provide solutions to the problems set up in the introduction: congestion and the related negative byproducts, such as costs, emissions, and lost time.

HERE is creating the world's leading location cloud and connecting a broad range of devices and software with intelligent maps for a better, more navigable life. It's this passion for world-class location products and services that is making cars more intelligent, journeys more cost effective, and roads safer.

To learn more, please visit **here.com**

About HERE Technologies

HERE, the Open Location Platform company, enables people, enterprises and cities to harness the power of location. By making sense of the world through the lens of location we empower our customers to achieve better outcomes – from helping a city manage its infrastructure or an enterprise optimize its assets to guiding drivers to their destination safely. To learn more about HERE, including our new generation of cloud-based location platform services, visit **http://360.here.com** and **www.here.com**

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