Comparison of 4G/LTE and DSRC Latency in a Real-World Environment

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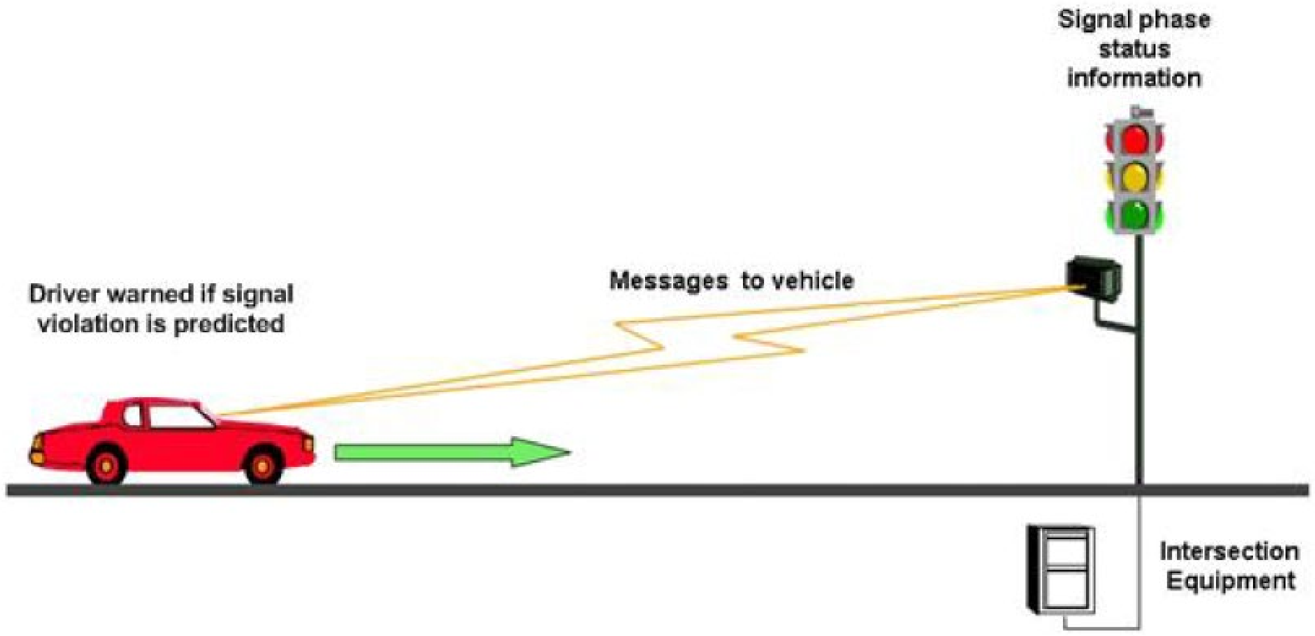
June 17, 2020

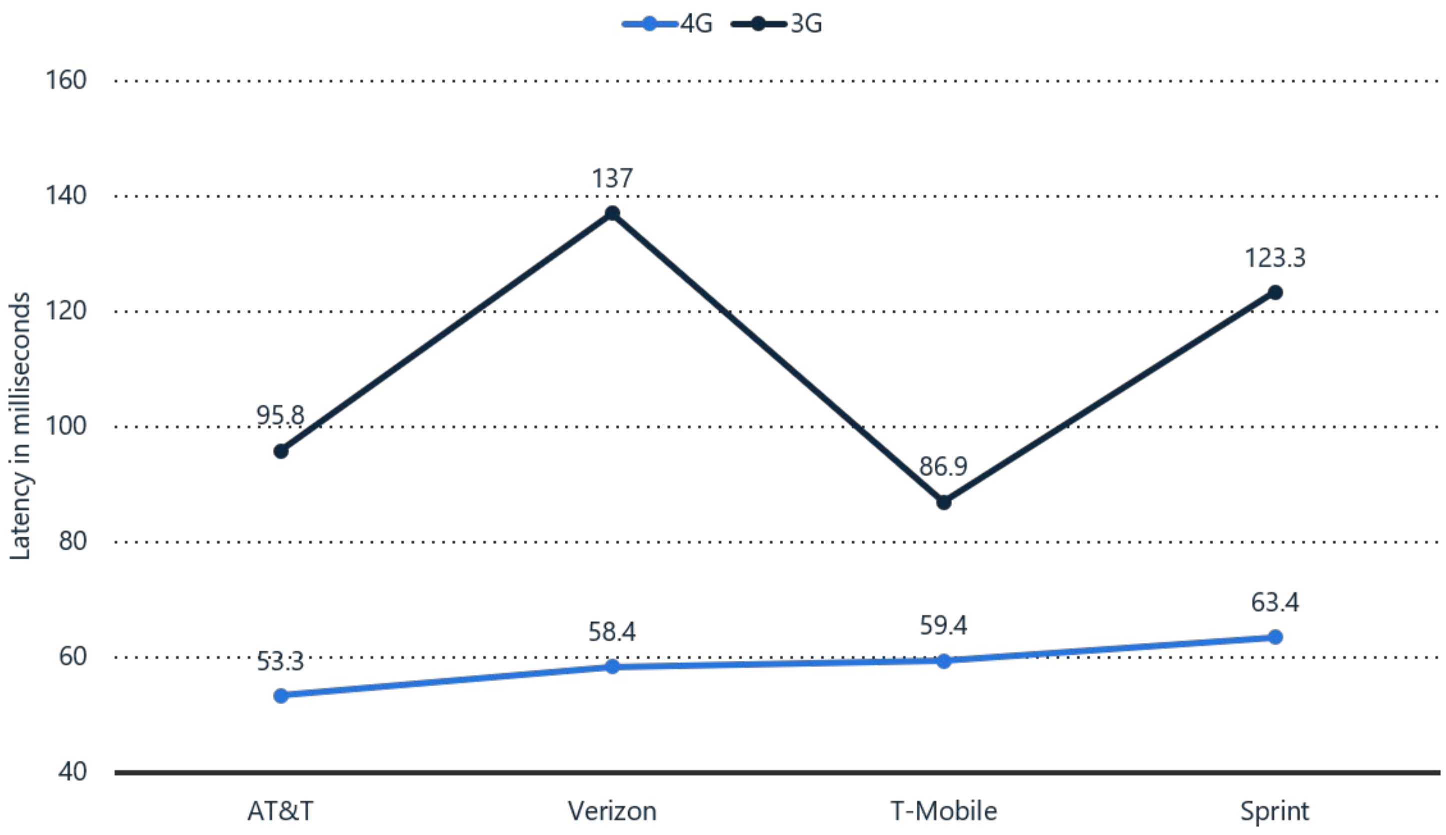
Background

- Conducted under Caltrans Funded Project – Red Light Violation Warning (RLVW) over Cellular



Source: CICAS-V Concept of Operations Document

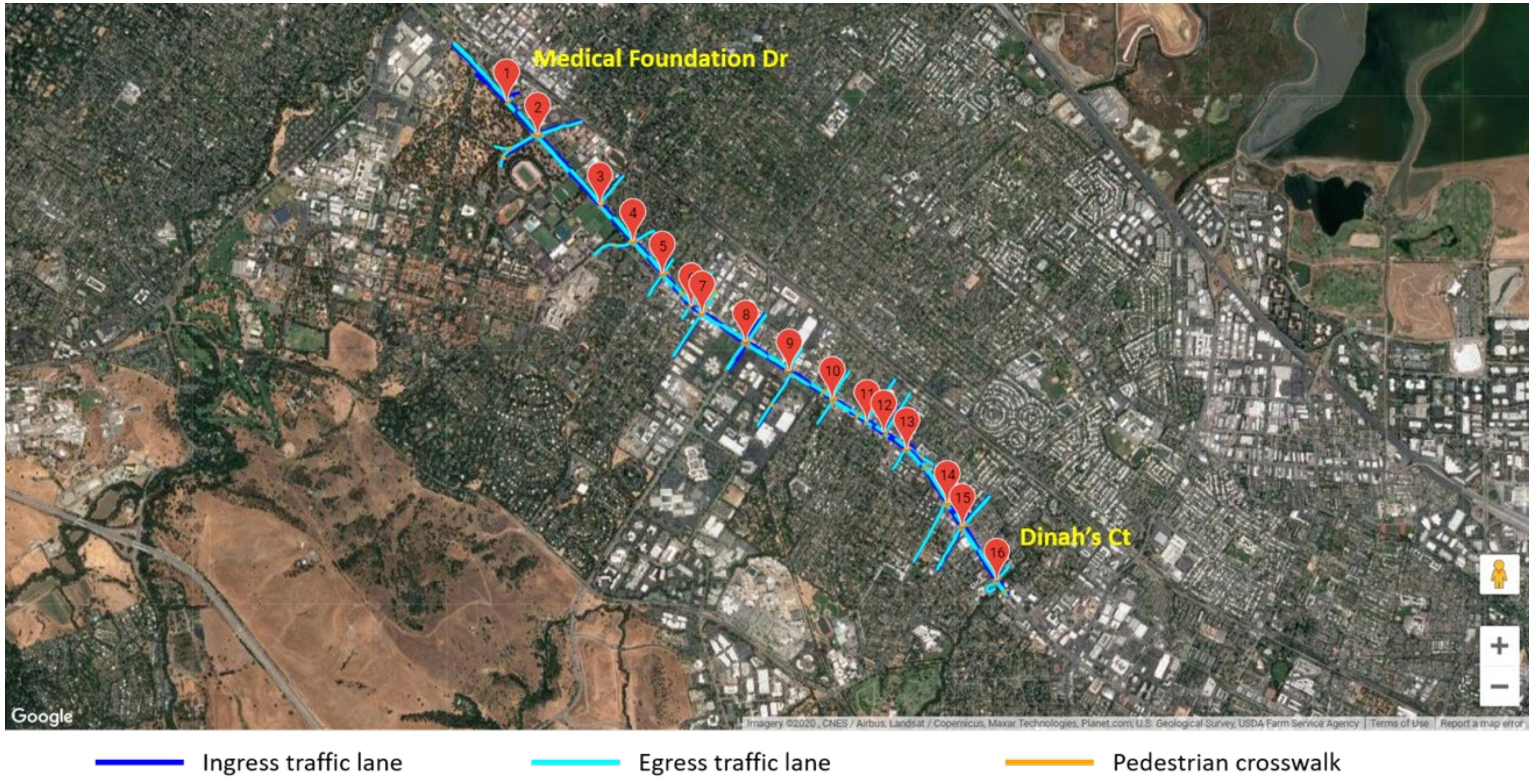
Average 3G and 4G Network Latency by Provider in the U.S. in 2018



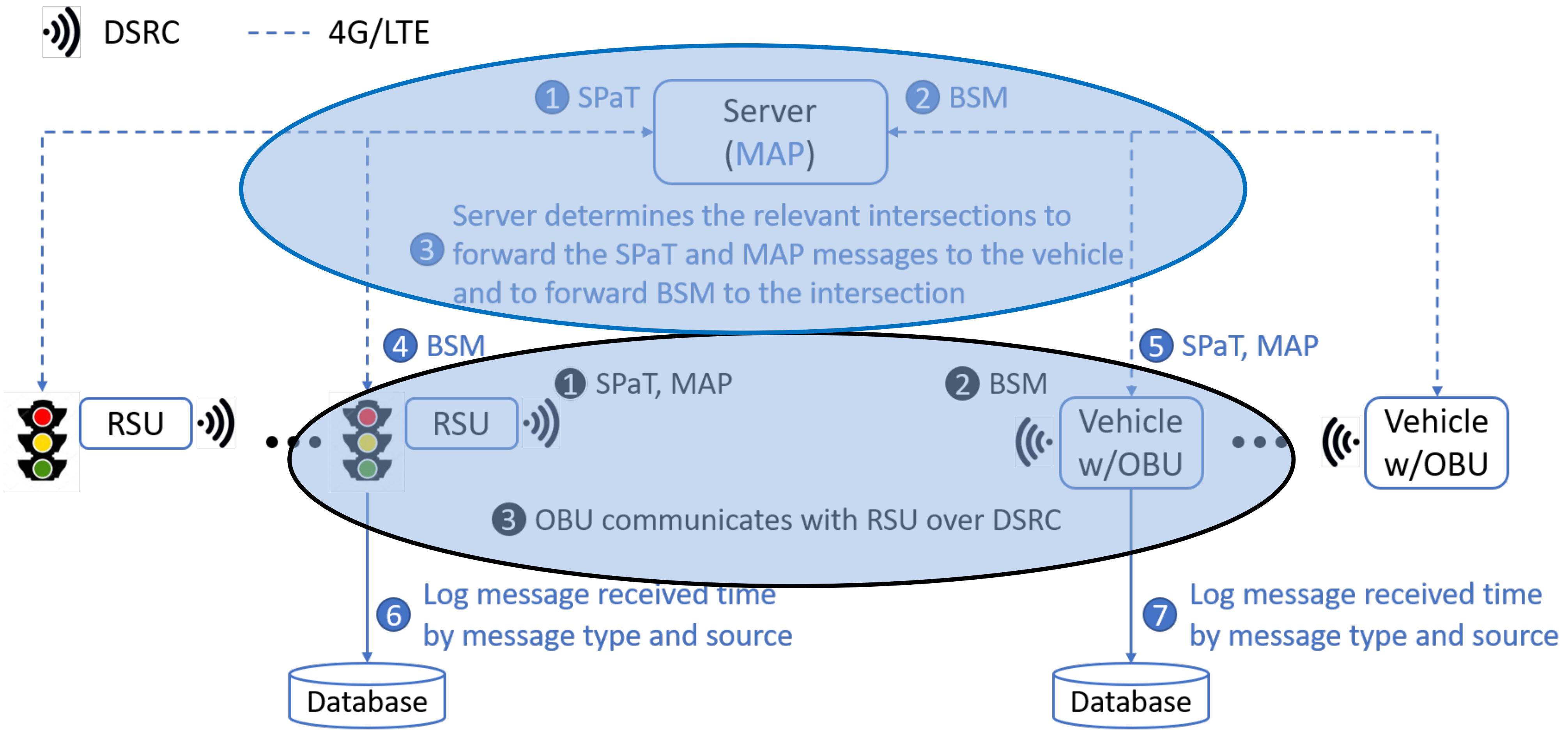
Source: Statista

Objective

- To quantify point-to-point communication latency over DSRC and 4G/LTE in the California CV Test Bed in Palo Alto



Conceptual Message Flow



- The Server is located at PATH Headquarters
- Same SAE J2735 message payloads are transmitted over DSRC and 4G/LTE

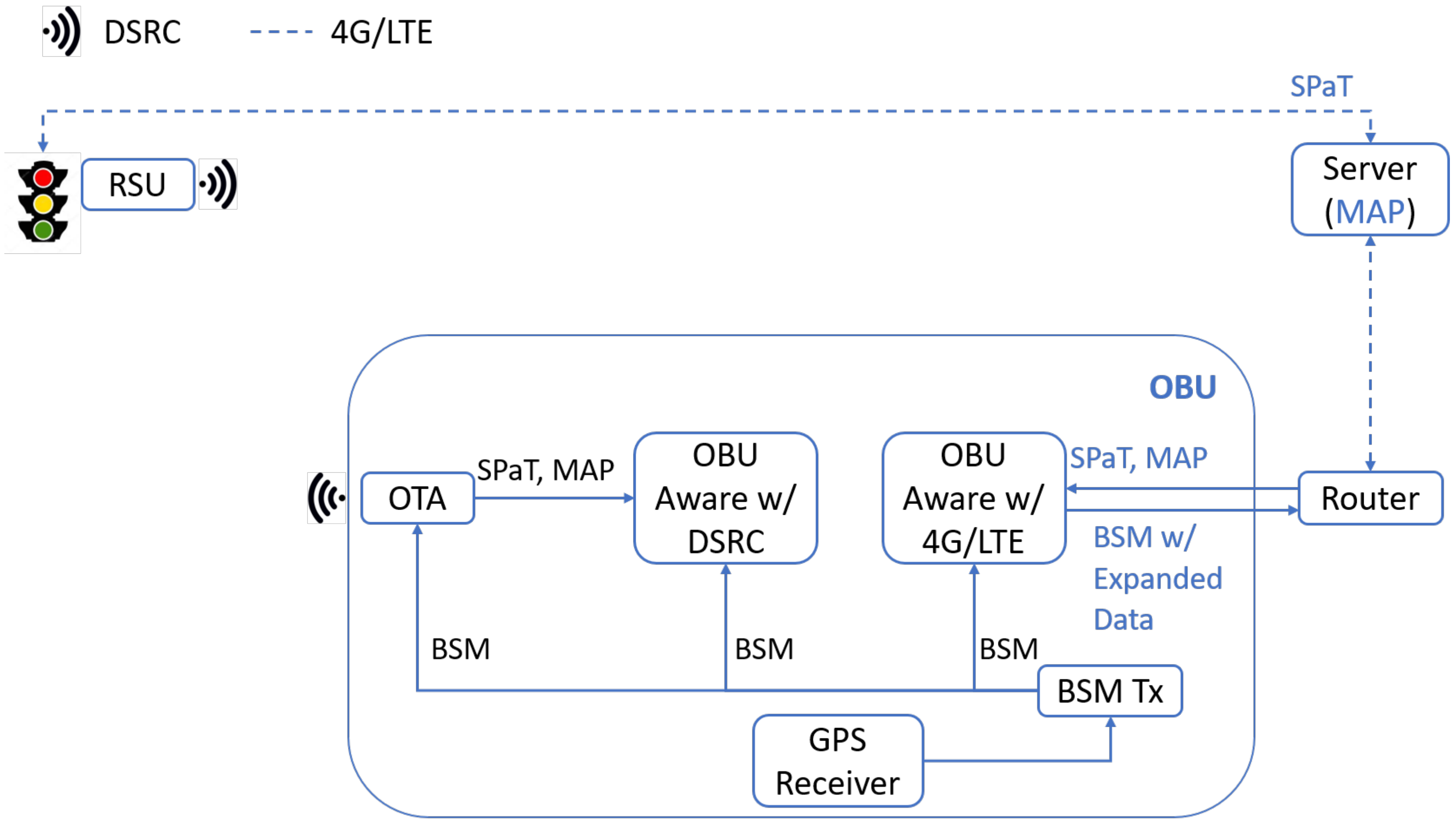
Server Identifying the Relevant Intersection w.r.t. the Location of a Connected Vehicle

- A connected vehicle is able to determine the MAP that the vehicle is traveling on and the IDs of its connecting intersections
- With 4G/LTE, the vehicle can send the ID of the current intersection and IDs of the connecting intersections to the server along with the BSM

BSM	Current Intersection ID	# of Received MAPs	IDs of Received MAPs	# Connecting Intersections	IDs of Connecting Intersections

- When the MAP of the current intersection is not available, the server sends the MAP of nearby intersections to the vehicle based on the proximity between vehicle location and intersection MAP reference point

Vehicle-Side Simultaneous Data Collection



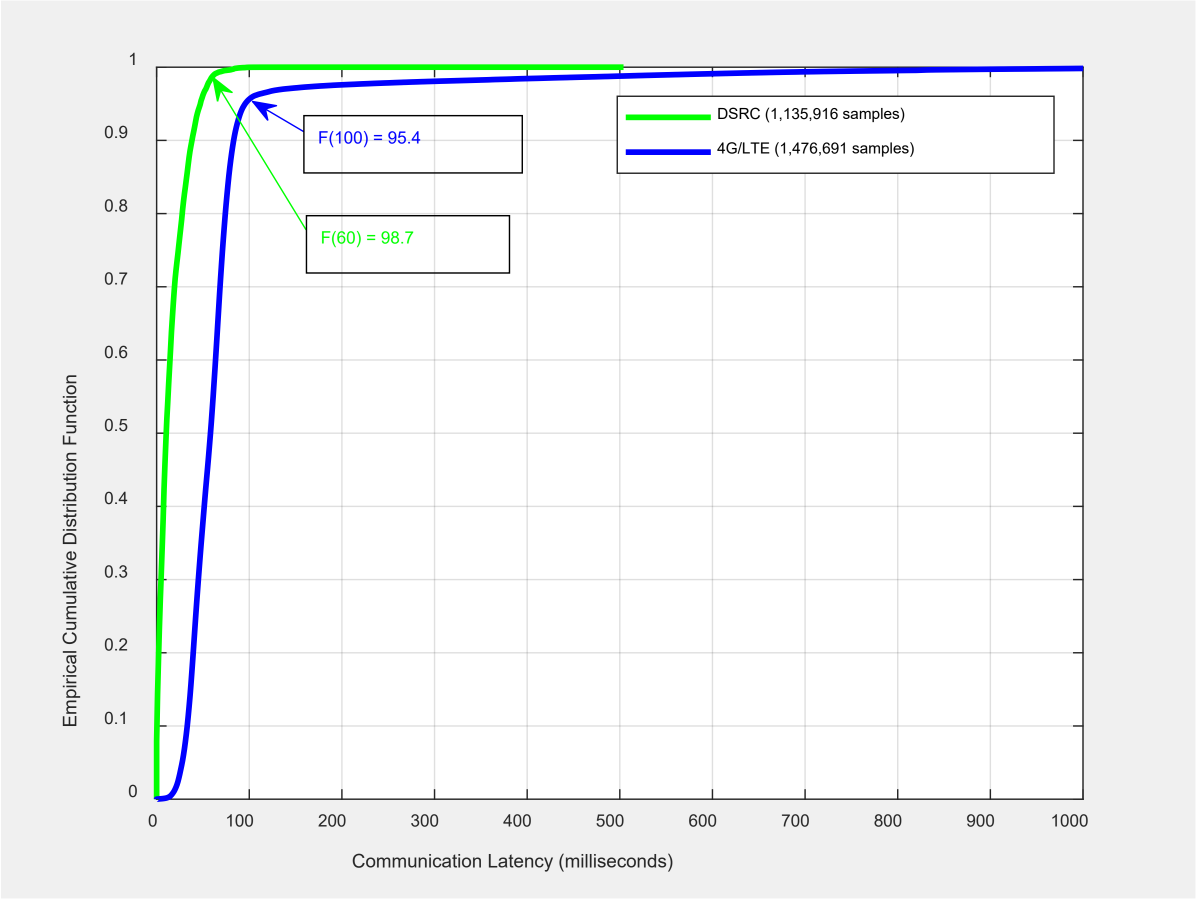
Filed Test Results

- Sample Size

Communications Link	Sample Size
DSRC	1,135,916
4G/LTE	1,476,691
Same SPaT Message Received on Both Links	716,018

- With DSRC, the vehicle receives SPaT messages from RSUs that are within the DSRC communication range, ranging from 0 to 4
- With 4G/LTE, the vehicle receives SPaT messages from the current and the connecting intersections

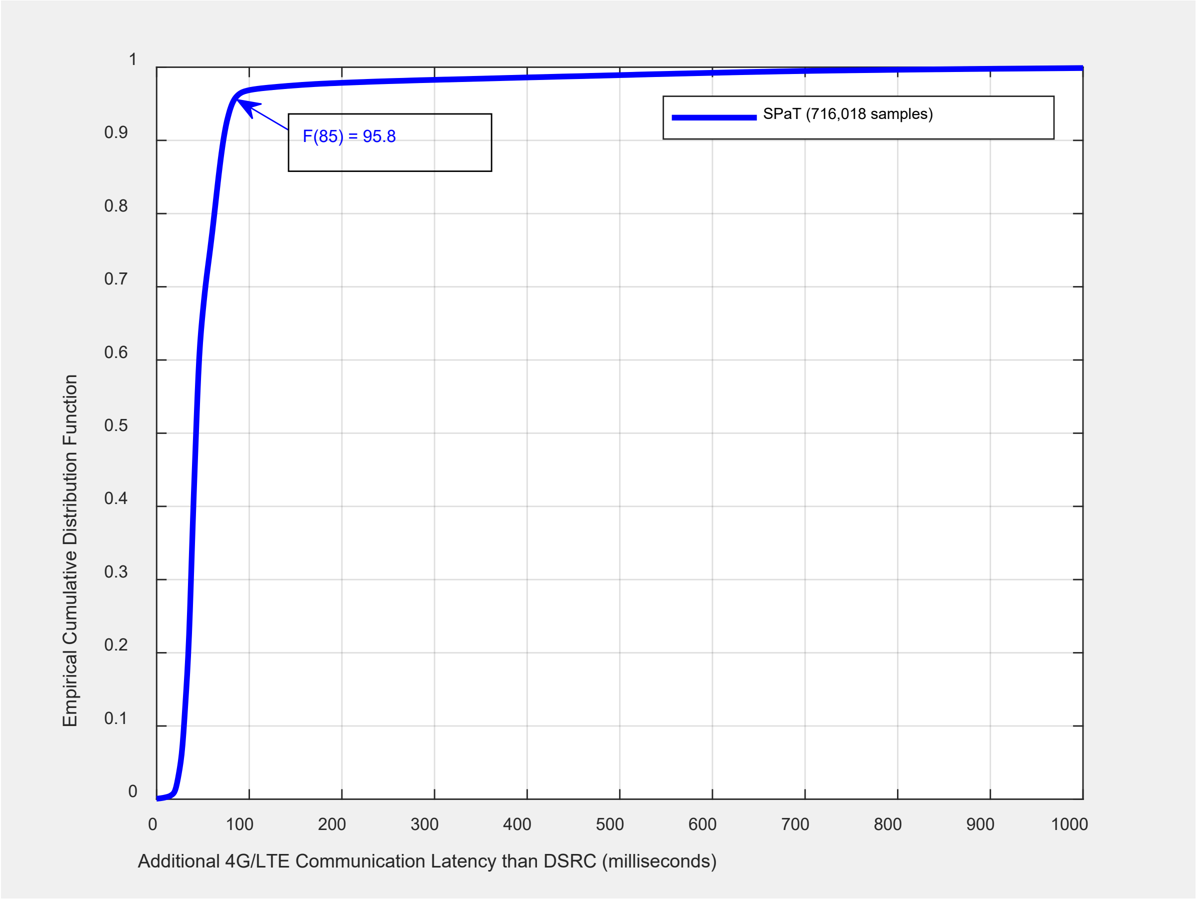
Comparison of Communication Latency over DSRC and 4G/LTE



ECDF – Empirical Cumulative Distribution Function

Communication latency = Message received time – Message created time

Communication Latency Difference



Communication latency difference = Message received time over 4G/LTE – (Same) Message received time over DSRC

Summary of Communication Latency

% of Time	Communication Latency (Milliseconds)	
	DSRC	4G/LTE
95%	< 48 ms	< 100 ms
98%	< 56 ms	< 280 ms
99.99%	< 100 ms	< 1500 ms

- 5.9 GHz band spectrum is critical for safety applications that require reliable and short communication latency
- Existing 4G/LTE could support mobility applications

Simultaneous In-Vehicle Display of V2I Information