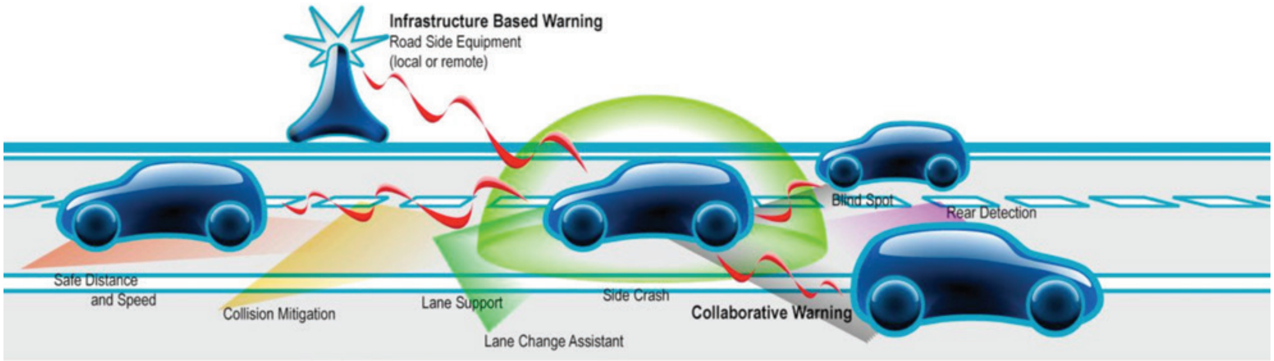
Vehicle-to-Vehicle/Vehicle-to-Infrastructure Control



Source: SAFESPOT Project funded by the European Commission

Problems related to the single, isolated automotive vehicle and its subsystems are challenging enough, but the research community is also exploring the "big picture" of intelligent road transportation—the system, or system of systems, consisting of many vehicles and their drivers interacting on roads. Two related topics are included in this vision:

- Vehicle-to-infrastructure (V2I) interaction
- Vehicle-to-vehicle (V2V) interaction

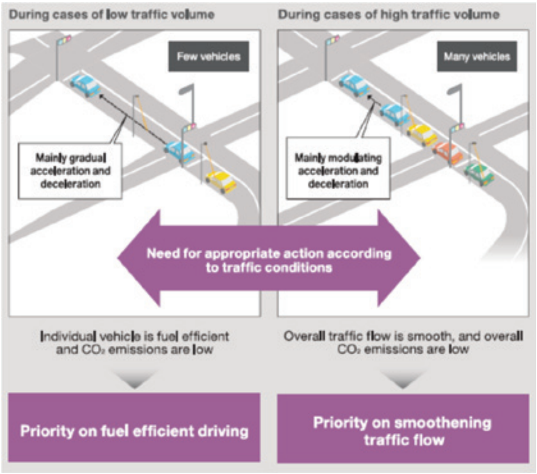
V2I and V2V promise revolutionary improvements in transportation—greater energy efficiency, less road construction, reduced collisions, and safety of vehicle occupants as well as pedestrians and bicyclists. Control is a key contributing discipline for both topics.

Vehicle-to-Infrastructure Control

In V2I, the infrastructure plays a coordination role by gathering global or local information on traffic and road conditions and then suggesting or imposing certain behaviors on a group of vehicles. One example is ramp metering, already widely used, which requires limited sensors and actuators (measurement of traffic density on a highway and traffic lights on ramps).

In a more sophisticated scenario, the velocities and accelerations of vehicles and intervehicle distances would be suggested by the infrastructure on the basis of traffic conditions, with the goal of optimizing overall emissions, fuel consumption, and traffic velocities. Suggestions to vehicles could be broadcast to drivers via road displays or directly to vehicles via wireless connections. Looking further ahead, in some cases suggestions could be integrated into the vehicle controls and implemented semiautomatically (always taking into account the restrictions on automatic vehicle driving imposed by the Vienna Convention on Road Traffic, discussed on the next page).

Some experts predict that the first V2I systems may be developed and deployed in the 2015–2020 time frame.



Source: Toyota USA

The figure at left shows two different traffic situations. In the left panel, traffic density is low and the central infrastructure-based controller acts to improve fuel efficiency and reduce emissions of individual vehicles, smoothing accelerations and decelerations; in the right panel, due to greater congestion, the infrastructure control is primarily concerned with depleting queues at intersections with an eye toward global fuel economy and emissions reduction.

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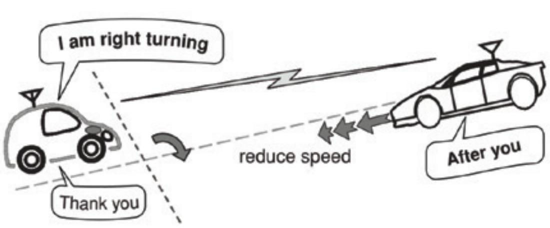
The Vienna Convention on Road Traffic

This international treaty, designed to facilitate international road traffic and increase road safety, was agreed upon at the United Nations Economic and Social Council's Conference on Road Traffic in 1968 and came into force on May 21, 1977 (http://www.unece.org/trans/conventn/crt1968e.pdf). The convention states that "Every driver shall at all times be able to control his vehicle," which conflicts somewhat with the automatic control concept. Systems such as anti-lock braking systems or electronic stability programs are acceptable because they do not take full control of the vehicle but rather help the driver to follow a desired path, possibly in situations where control of the vehicle has already been lost. Wider use of technological advances, however, will require amendment of the convention.

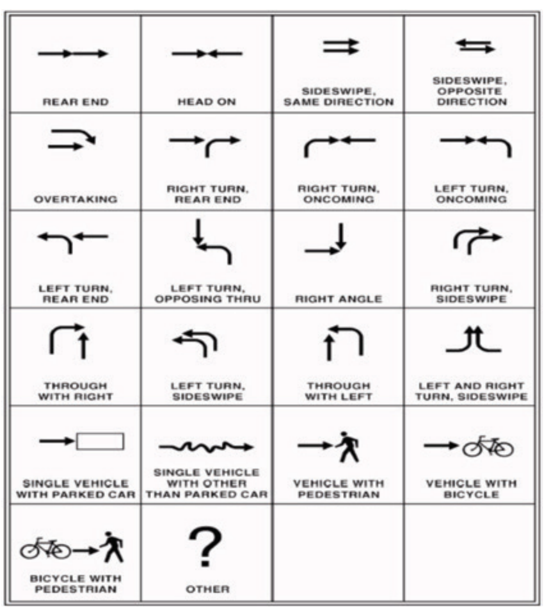
Vehicle-to-Vehicle Control

V2V, more difficult to realize because of its decentralized structure, aims at organizing the interaction among vehicles and possibly developing collaborations among them. At this level, information is interchanged and decisions are made on a "local" basis (e.g., among a group of vehicles in proximity to each other). The introduction of such information interchange requires an agreement among car manufacturers and suppliers in terms of communication technology, protocols, and the like, and efforts are under way in this direction (the CAR2CAR Consortium). The communication technology is based on IEEE 802.11, also known as Wireless LAN. A frequency spectrum in the 5.9-GHz range has been allocated on a harmonized basis in Europe in line with similar allocations in the U.S. (although the systems are not yet compatible).

In the V2V concept, when two or more vehicles or roadside stations are in radio communication range, they connect automatically and establish an ad hoc network enabling the sharing of position, speed, and direction data. Every vehicle is also a router and allows sending messages over multihop to more distant vehicles and roadside stations. The routing algorithm is based on the position of the vehicles and is able to handle fast changes of the network topology. Control technology comes into play at local and higher layers of the architecture. Uncertainties, delays, partial measurements, safety and performance objectives, and other aspects must be considered, and the system must be capable of making automatic or semiautomatic decisions, providing warnings/information and potentially effecting actions.



A V2V example (Source: N. Hashimoto, S. Kato, and S. Tsugawa, A cooperative assistance system between vehicles for elderly drivers, IATSS Research, vol. 33, no. 1, 2009, pp. 35-41)



A taxonomy of possible accidents illustrating the variety of situations that must be detected and handled optimally and robustly to avoid possibly dangerous situations (Source: SAFESPOT Project)