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Connected Vehicles: an Innovative Transport Technology

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Abstract

The emergence of Intelligent Transportation Systems (ITS) has paved the way to new innovative prospects for improving the safety, operation, and environmental impact of transportation networks. Connected vehicle (CV), a ground-breaking initiative of "intelligent vehicles", emerging as the next wave of technology to further empower travellers. Among other benefits, this technology will help provide for increased capacity of existing transportation networks in addition to increased roadside safety for motorists through the development of an overall Intelligent Transportation System. However, before we can even consider how to integrate the technology of CV into our transport system, professionals must understand and realize its environment and how future cities to be created. This paper outlines the various aspects of the CV concept and how it will affect the transport system and urban environments over the next decade with the aim of providing transport directors and practitioners with an insight into this innovative technology. Two main types of short-range wireless communication are discussed namely Vehicle-to-Vehicle (V2V), and Vehicle-to-Infrastructure (V2I) communication. An overview of the evolution of the CV and its operational aspects are presented together with its application. The impacts and potential operational benefits of the CV are discussed. The best practices of CV initiatives are reviewed, the broader public perception of CV applications are investigated, and the various challenges to the CV technology are identified.

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1. Introduction: An overview on the evolution of the CV

The fundamental premise of the CV environment lies in the power of wireless connectivity among vehicles (referred to as V2V communications); vehicles and infrastructure (referred to as V2I communications); and Wireless communications for crash prevention, which improved mobility and environmental sustainability. A Connected Car may therefore be defined as "the presence of devices in an automobile that connect devices within the car/vehicles together or with devices, networks and services outside the car including other cars, home, office or infrastructure". In the early 2000s, the U.S. Department of Transportation (DOT) developed the Vehicle-Infrastructure Integration (VII) Program as a part of its Intelligent Transportation System (ITS) Program. The main goal of VII was the development of wireless V2V and V2I communication to significantly improve safety and mobility on the nation's roadways (ITS Joint Program Office RITA, 2010). To achieve this goal, the U.S. DOT proposed the use of dedicated short-range communications (DSRC) for V2V and V2I communications. DSRC works by using one-way or two-way short- to medium-range wireless communication radio channels tuned to the 5.9 GHz frequency (AASHTO, 2011). Since the technology of using DSRC was not yet available, the Federal Communications Commission (FCC) reserved the 5.9 GHz frequency for transportation safety applications. Since safety messages would not require the entire bandwidth, the remaining bandwidth could be used for non-safety applications like mobility (ITS Joint Program Office RITA, 2010) [1].

Currently, there are two views/approaches on the future of connected vehicles: the Google approach, where connected vehicles are viewed as fully automated, also called autonomous vehicles(AV) utilizing connectivity to drive themselves and the U.S. Vehicle Manufacturers approach, where connected vehicles still possess manual vehicle control while utilizing continuous real-time connectivity amongst vehicles and infrastructure.

V2V communications comprise a wireless network, where automobiles send messages to each other with information about what they're doing. This data include speed, location, direction of travel, braking, and loss of stability the range is up to 300 meters or about 10 seconds at highway speeds (not 3 seconds as some reports say), so it can be referred to as an accurate and reliable communication method [2].

Traffic signals or other stationary devices are called V2I, or vehicle to infrastructure. Often they are just rolled into the V2V umbrella. Terms for V2V such as Car-to-X, "internet of cars", "connected car" and the popular-press term "talking car." are used but V2V seems to be the phrase that's winning out [3].

V2V technology represents the next generation of auto safety improvements, its main benefit is crash avoidance which potentially warn drivers about dangerous situations that could lead to a crash. On the first cars, V2V warnings might come to the driver as an alert, perhaps a red light that flashes in the instrument panel. It might indicate the direction of the threat. Moreover, V2V could warn a driver that a vehicle up ahead is braking and he needs to slow down. The drivers will be able to see, hear and even feel the hazard signals through vibration of the seat [4].

2. Impacts and potential operational benefits of the CV

2.1. Impact on long range planning models

Connected vehicle technology will have a profound impact on the long range planning and land-use models used today. It will provide planners with a greater insight into each step than ever before leading possibly to more precise models and providing enhanced information for better decision making [5].

2.2. CV and geometric design of highways

Roads and signalized intersections are usually designed based on the behaviour and characteristics of human drivers. This human behaviour might differ vastly from the driverless vehicles' behaviour. Unlike people, automated vehicle uses sensor systems to locate itself along the path and communicate with other vehicles and/or infrastructure along the network. This element could lead to optimize the geometric design of highways enabling the use of minimum control radii, horizontal and vertical curves.