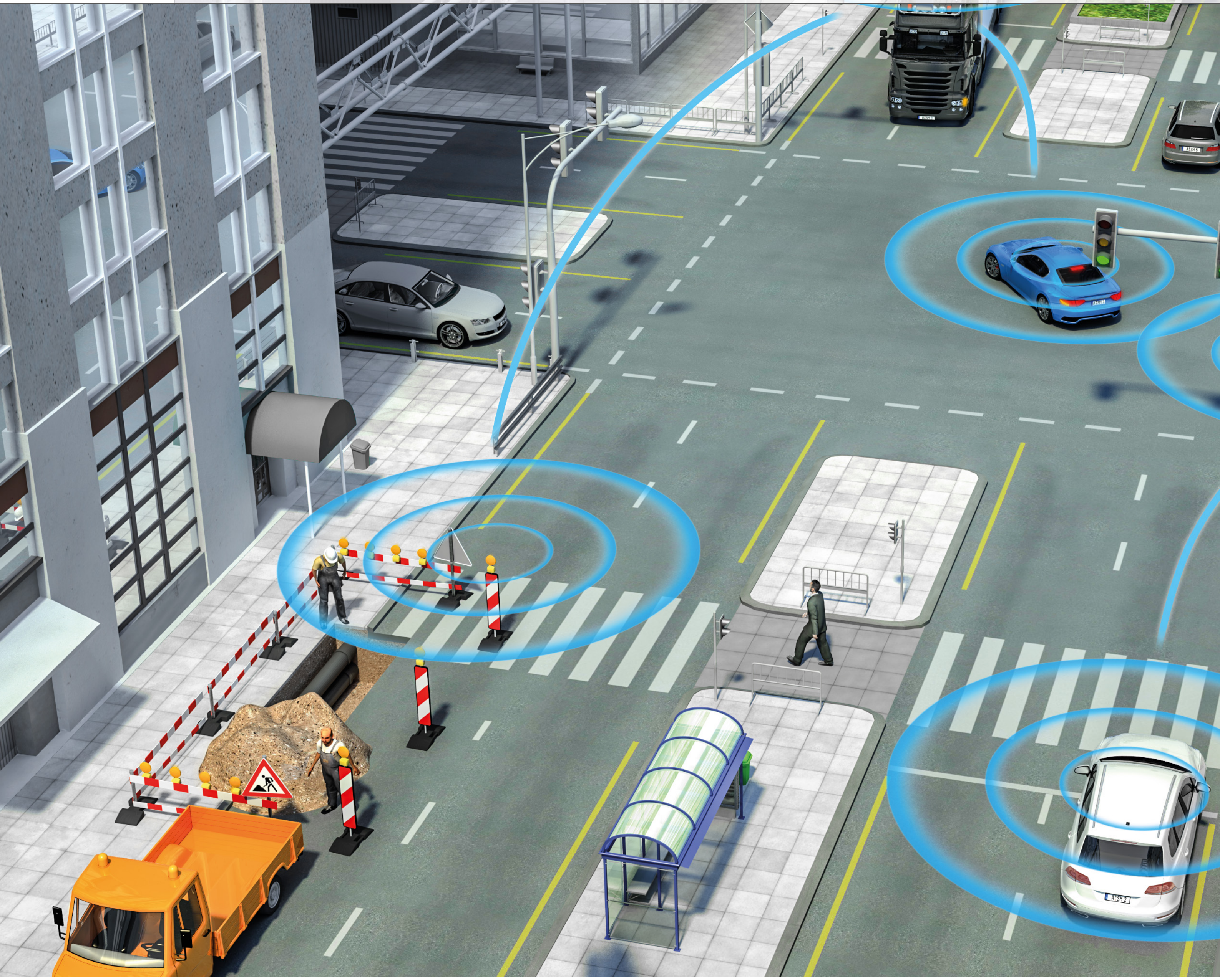

Model-based development of V2X applications

Everything on Screen

The introduction of V2X technology opens up numerous possibilities for enhancing safety and comfort on the roads while decreasing the amount of time and fuel spent. dSPACE has a tailored solution for developing and testing the related applications efficiently.

Today's driver assistance systems use environment sensors such as radar and cameras to scan the vehicle environment. But if the view of these systems is blocked, e.g., by other vehicles or large buildings at an intersection without a clear view, some information about the environment is missing (figure 1). With the introduction of V2X technology, these restrictions might become a relic of the past. The 'X' stands for other objects in the vehicle environment, not only other vehicles but also parts of the infrastructure, such as traffic lights and road signs. V2X technology, often referred to as C2X or Car2X, enables the exchange of information between all of these objects via ITS-G5 (IEEE 802.11p), the WLAN-based ad-hoc network standard. The exchanged data packages contain information about the position, speed, and driving direction or sudden events such as traffic jams, construction sites, or slick roads. The goal of introducing V2X technology is to increase traffic safety and driving comfort and to optimize the flow of traffic. The technology is therefore a further step towards autonomous vehicles.

Crucial: Cross-Border Strategies for Market Introduction

Introducing V2X technology is a great challenge for automobile manufacturers, because in order to achieve the goals mentioned above, 10% of the vehicles on the market have to use V2X communication. This is why vehicle manufacturers, suppliers, and tool providers such as dSPACE work together in the CAR 2 CAR Communication Consortium (C2C-CC) to formulate a joint strategy for introducing V2X and to define a European standard. This is done in close cooperation with the standardization groups ETSI and CEN, and harmonization groups from the EU, the US, and Japan. The main focus is not just on wireless communication, but also on aspects such as defining supported applications; standardized criteria for detecting traffic jams, fog, or slick roads; the definition of required data protocols; and a comprehensive data security concept. Companies in the US also put great effort into introducing V2X. The US standards resemble the European solution in many areas. In contrast to Europe, however, the US is discussing legally binding regulations. V2X will likely be introduced on the European and US markets in this decade.

Developing V2X Applications

The functions of V2X applications are usually developed through model-based development, e.g., with MATLAB®/Simulink®. The engineers focus on implementing and testing the actual application, not on implementing specific protocols and standards in the model. The new dSPACE V2X Blockset for Simulink therefore supports and provides easy access to the V2X world, from fast function development (rapid control prototyping) to testing complete applications (figure 2). The blockset provides dedicated blocks for preparing, coding, transmitting, decoding, and managing V2X messages (CAMs or DENMs). The contents of each message are provided as signal vectors in Simulink. To have a clear overview, the users can configure a filter so only the message contents that are required for an application are displayed in the model. The coding and

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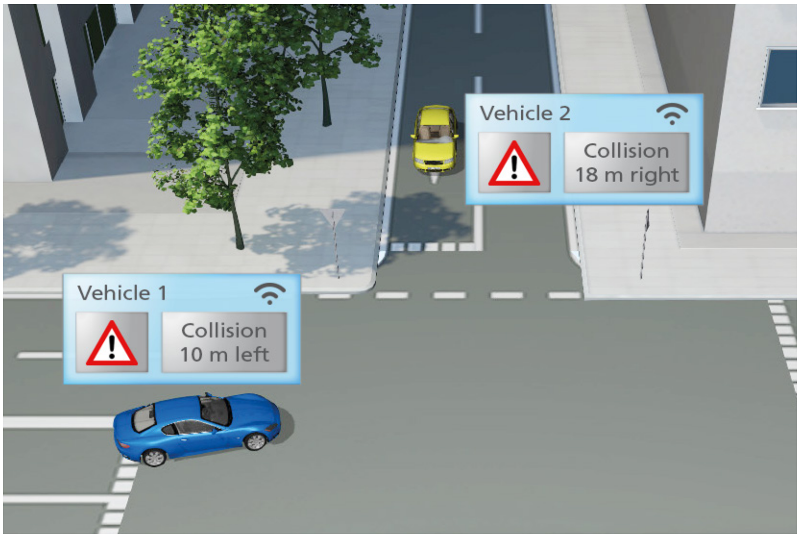


Figure 1: Vehicles exchange their motion data and calculate the probable paths. This example of an intersection assistant shows that the drivers are warned in time when there is the risk of a collision.

decoding blocks are automatically generated from the ASN.1 description standardized by ETSI. This ensures that the V2X blockset can easily be adjusted to new versions of the description file. The development platform, test platform, and dSPACE V2X Blockset are connected to the radio channel via a V2X hardware adapter, such as the MK5-OBU by Cohda Wireless. The adapter is connected via Ethernet UDP/IP and uses the standardized Basic Transport Protocol (BTP) to transmit messages. The GPS receiver in the MK5-OBU can be used to capture position data.

Developers can also use a dedicated blockset for evaluating GPS data according to the NMEA-0183 standard.

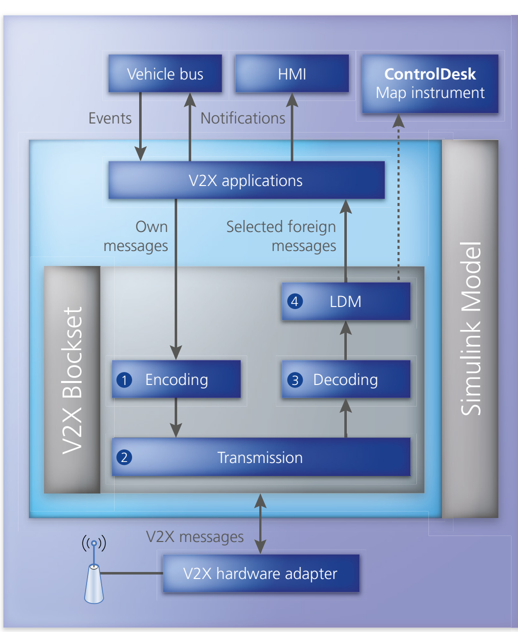
Efficient Message Management with Local Dynamic Map

A key factor for receiving V2X messages is the Local Dynamic Map (LDM). The map stores, manages and distributes all relevant information on the local traffic situation (vehicle positions, speed, the state of traffic lights, weather information, road slickness, etc.) and is updated continuously. The V2X applications first register at the LDM for receiving specific message contents, such as all DENMs with warnings against broken-down cars. The LDM then automatically assigns relevant information to the applications. If messages are obsolete or refer to objects that are too far away, they are discarded automatically.

Highlight: Map Instrument in ControlDesk

The V2X solution adds a specially developed map instrument to the

Figure 2: dSPACE V2X Blockset for developing and testing V2X applications.



1. In the first step, if a V2X application detects a relevant event, e.g., the end of a traffic jam, appropriate messages are prepared for sending. The messages are then converted to a compact format by using dedicated encoder blocks for CAM and DENM. After that, the messages are sent.

2. Transmission blocks are the link between the Simulink model and the V2X hardware adapter. They transmit messages via Ethernet (UDP/IP) in both directions using the Basic Transport Protocol (BTP) standardized by ETSI. The V2X adapter sends and receives messages in the form of WLAN packages according to the IEEE-802.11p standard.

3. Dedicated decoder blocks for CAM and DENM unpack received messages and forward them to the LDM or directly to a V2X application.

4. The LDM is the central collection and distribution unit for all received messages. It assigns only the required messages to each registered V2X application according to a standardized filter method. The messages created by the applications are transmitted to the final recipients via the vehicle bus or the HMI.

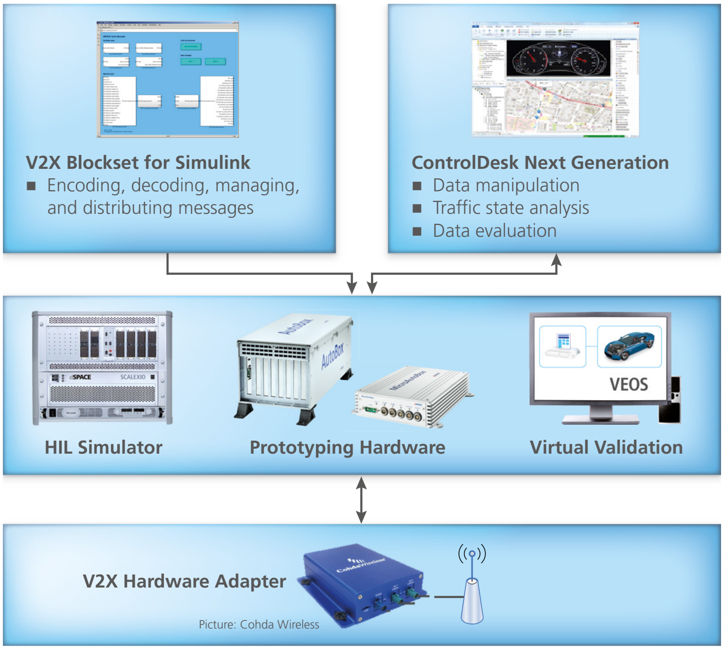


Figure 3: Development and test environment for V2X applications.

Summary and Outlook

With the new V2X solution, dSPACE meets the new requirements that V2X technology brings for development and test systems. The solution can be integrated seamlessly into existing tool chains and offers comprehensive support, from implementing a V2X application up to testing (figure 3). dSPACE is also planning to release a test catalog with a selection of the tests specified by the C2C-CC.

familiar ControlDesk features that support the application and test engineers in manipulating message contents, recording data, etc. The LDM feeds information into the map instrument and uses a map to show the current traffic participants in a V2X network and their movements. The instrument very clearly displays what the V2X application sees. The intuitive handling of the map instrument makes the data analysis much easier. ■

Glossary

Ad-hoc network	Wireless communication network that establishes itself spontaneously and configures itself independently.
ASN.1	Abstract Syntax Notation One. Description language for describing data structures.
BTP	Basic Transport Protocol. Data transport protocol for use in intelligent traffic systems.
C2C-CC	CAR 2 CAR Communication Consortium. Consortium of automotive manufacturers, suppliers, tool suppliers and research institutions with the goal of increasing the safety and efficiency of traffic on the roads through the use of cooperative and intelligent systems based on V2X.
C2X (Car2X)	Car-to-X. Synonym for ad-hoc communication in a traffic system. The ‘X’ stands for other vehicles and parts of the infrastructure, such as traffic lights and road signs (see V2X).
CAM	Cooperative Awareness Message. Message about the position, speed, type designation, state, etc., which each participant of the V2X network continually sends.
CEN	Comité Européen de Normalisation. European committee for standardization in all technical fields except electrical engineering and telecommunications (see ETSI).
DENM	Decentralized Environmental Notification Message. Message for specific events: e.g., accidents, danger spots, etc.
ETSI	European Telecommunications Standards Institute. European institute for telecommunications standards.
HMI	Human-Machine Interface. The interface between a machine and the person operating that machine.
IEEE 802.11p	Standard for establishing WLAN technology in vehicle ad-hoc networks. Known in Europe as ITS-G5.
LDM	Local Dynamic Map. Database for storing the current state of traffic in the vehicle environment.
NMEA 0183	A communications standard defined by the National Marine Electronics Association, which is also used for communication between GPS receivers and PCs or mobile devices.
OBU	Onboard Unit.
V2X	Vehicle-to-X (see C2X or Car2X).