ADAS HIL FOR SENSOR FUSION

altran

Content

This white paper was written in collaboration with

Abstract

As vehicles move towards autonomous capability, there is rising need for hardware-in-the loop (HIL) test capability to validate and verify functionality of ADAS system which are anticipated to play a central role for autonomous driving. This paper highlights an overview of the ADAS HIL with Sensor Fusion concept together with sharing key learnings from initial research efforts and highlighting the main features and elements (system level) of the application.

1. What Is Sensor Fusion?

Today, many cars have multiples Advanced Driver Assistance Systems (ADAS) based on different sensors like radar, camera, LIDAR or ultrasound. Normally, each of the sensors perform a specific function and only in rare situations they send information with each other. Information that the driver receive are proportional to the number of sensors installed and, together with smart algorithms, potentially can be used for autonomous function.
Sensor Fusion is the mixture of information from different sensors in order to perceive a clearer view of the surrounding environment. This is a necessary condition to move towards more reliable safety functionality and effective autonomous driving systems.

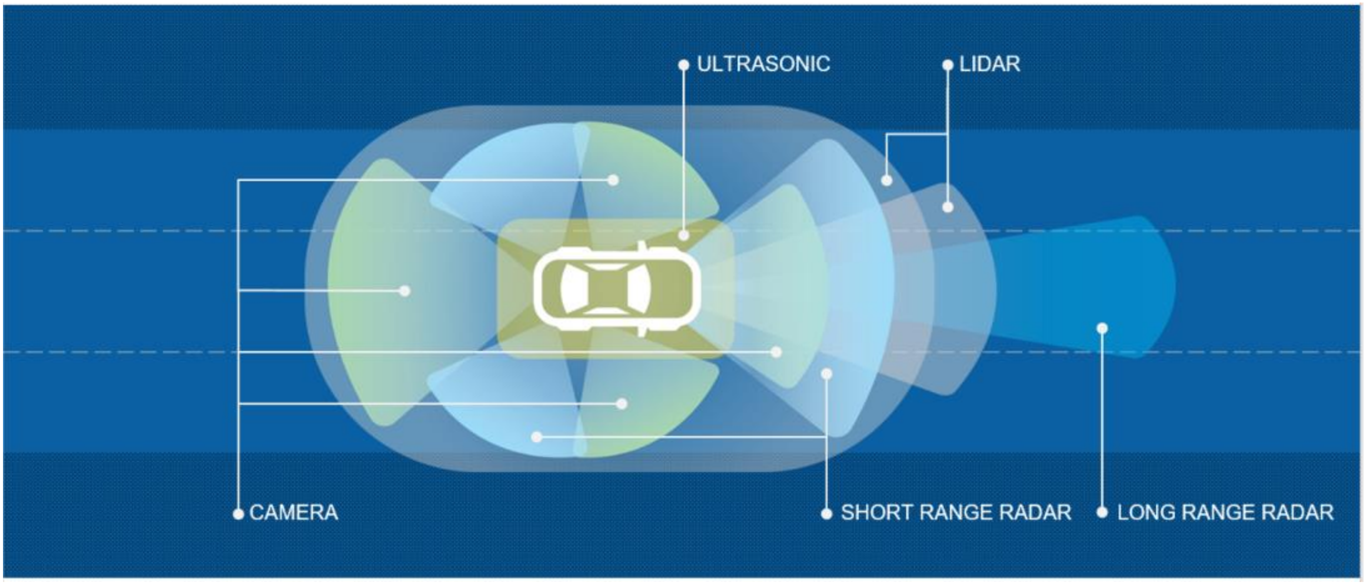

Figure 1. A “View” of the Environment surrounding a Car.

2. Where we need Sensor Fusion?

Sensor Fusion can be relevant with all types of sensors. A typical example is the fusion between information provided by a front camera and a front radar. A camera that works in the visible spectrum has problems in several conditions like rain, dense fog, sun glare and absence of light, but has high resolution and can be used to recognize colors (i.e. Road Marking) and Road Signs, while the radar, even if it does not have a high resolution, is very useful for far distance and it is not sensitive to environment conditional.
Typical ADAS functions that use the Sensor Fusion of front camera and radar are:
- Adaptive Cruise Control (ACC): is a cruise control system for the vehicle, adapting the speed at the traffic condition. The speed is reduced when the distance from the vehicle ahead drops below the safety threshold, and when the road is free again the ACC will bring the vehicle at the set speed.
- Autonomous Emergency Braking (AEB): it works on the braking system by reducing the speed in case of a certain collision or by alerting the driver in critical situations.

3. AHTES: ADAS HIL Test Environment Suite

For the validation of complex systems, it is necessary to set up an appropriate Test Environment, which should effectively stimulate the sensors in order to verify the behavior of the vehicle under similar conditions as the real ones.
Altran Italia has integrated an innovative Vehicle Radar Test System (VRTS) based on National Instruments technologies and a 3D virtual road scenario simulator into a “Hardware In the Loop” set-up to produce a scenario-based test capability application that is fully synchronized between Camera and Radar in order to verify the “sensor fusion”.

BENEFITS

- Real Production Software under test (no change in calibration)

- Suitable to support different kind of Radar / Camera sensors : just a change in the setup

- Modular approach : in the bench can be integrated other ECUs as brake control unit, electrical steering

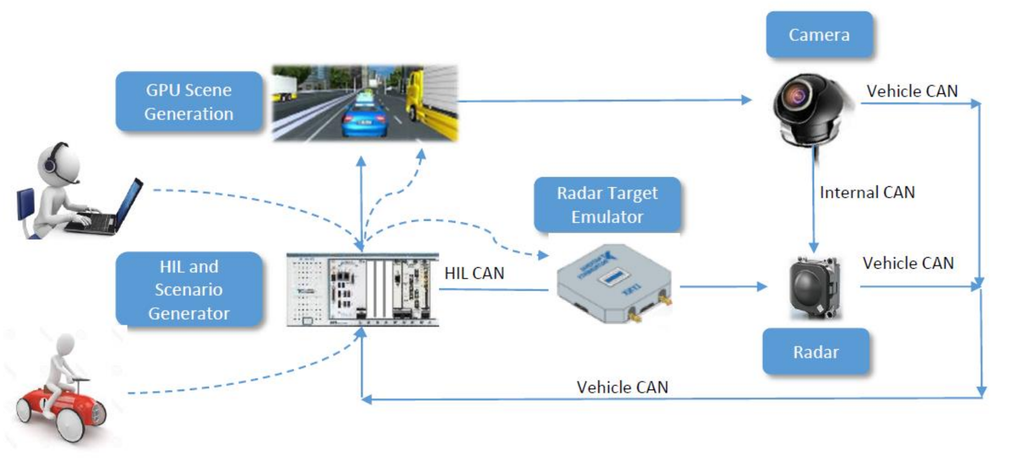

Figure 2: ALTRAN-NI ADAS HIL Test Solution

The 3D scenario is based on the Unity Graphic Engine and is fully configurable, including parameters like: number of lanes, lighting conditions, and track type are just a few of the things you can change.
The graphic engine reproduces the scene seen from a camera placed on a windshield of a vehicle and can be modified depending on the height from the ground and the field of view of the camera. It is also possible to show an obstacle (a vehicle) at a distance from the camera at a defined speed.

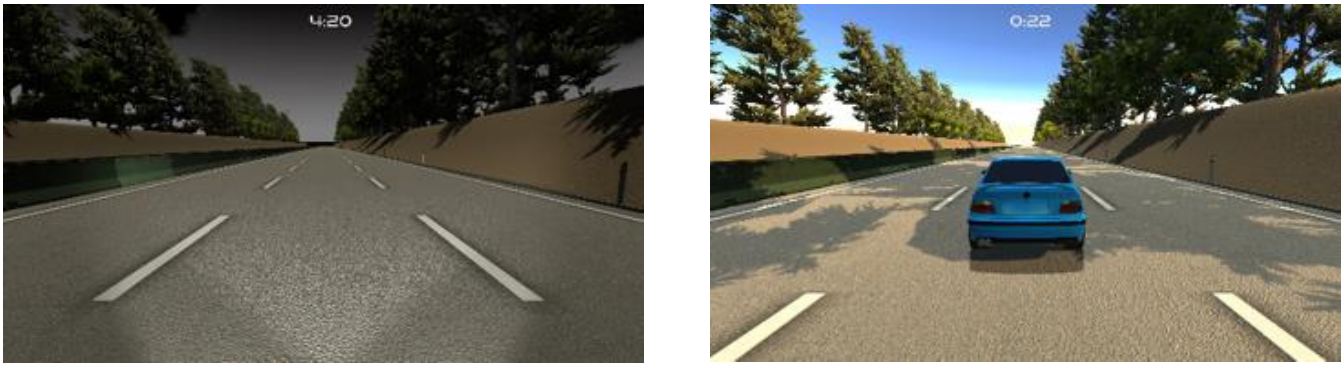

Figure 3: Unity Graphic Engine Scenario

For the vehicle control, the graphical engine receives the position of the brake pedals and throttle position in addition to the steering angle. A PXI System acquires these data in addition to signals come from Steering Wheel and Pedals (Logitech G29). The dynamic vehicle model is integrated within the graphics engine and is highly configurable.

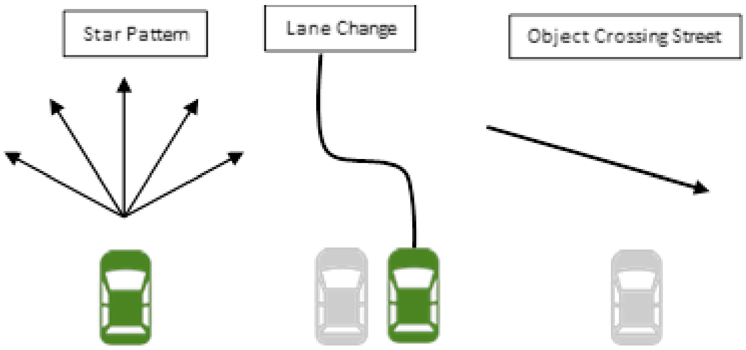

Figure 4: Standard Maneuvers

Per the selected obstacle scenario (with some examples above as a starting point), the graphic engine provides output information needed by the VRTS to produce the RF signal, in addition to the vehicle speed. All input/output information are exchanged with the PXI through a proprietary protocol and they can be changed as needed.
A CAN communication with NI PXI-8512/2 was used in this setup to retrieve information from the scenario generator about radar targets (Distance, RCS, Angle of arrival, Speed). The PXI-8512/2 is a two port High-Speed CAN/CAN-FD

Interface for PXI systems used for transmitting and receiving CAN bus frames at 1 Mbit/s even if the board could reach 8 Mbit/s. The information was sent to the Obstacle Generator only if the information about the targets change between consecutive readings.
In addition to sending the data to the Obstacle Simulator and acquiring pedal and steering signals, PXI also emulates the CAN messages necessary for radar and camera, and those sent from them on vehicle network over the private one. CAN messages are synchronized with the 3D virtual scenario and RF Target Generator so there is the correct environment to validate contemporary camera and radar.

4. Component Level overview

Brief description of each system component and connection/bus communications:

Radar ECU

- The main task of the radar sensor is to detect objects and measure their velocity and position relative to the movement of the host radar-equipped vehicle.
  The Radar sensor is a monostatic multimodal radar and uses the 76 gigahertz (GHz) frequency band and uses six fixed radar antennas. The sensor can detect other vehicles at roughly 250 meters. The radar is equipped with a heated lens which ensures full sensor availability, even in poor weather conditions, such as snow and ice.
  The relative speed of objects is measured using Doppler effect (shift in frequency between the reflected and transmitted signals) and distance to the object can be determined by the time lag.
  The ECU takes care of the sensor fusion with the information from the camera and is responsible of functions such as ACC and AEB.

Camera ECU

- La Camera ECU acquires images of surrounding environment and provides several information like distance from lanes and objects distance. Several information is sent to the Radar ECU for the sensor fusion, but in some case, the Camera ECU works alone, (i.e. Road Sign, Lane Keeping) so it sends CAN messages on the Vehicular CAN network.

Video Scenario Generation

- Video Scenario Generation is a simulator that includes a vehicle system that receive input from PXI-8512/2 through a CAN communication and transmits info about the simulated environment.
  The signals generated during simulation are the radar info (Distance, RCS, Angle of arrival and Speed) and are calculated in real-time based on what is shown on screen.
  Through the control panel in the second screen it is possible to handle connection with PXI-8521/2, change weather conditions, adjust radar position, spawn a new vehicle with defined speed and distance.

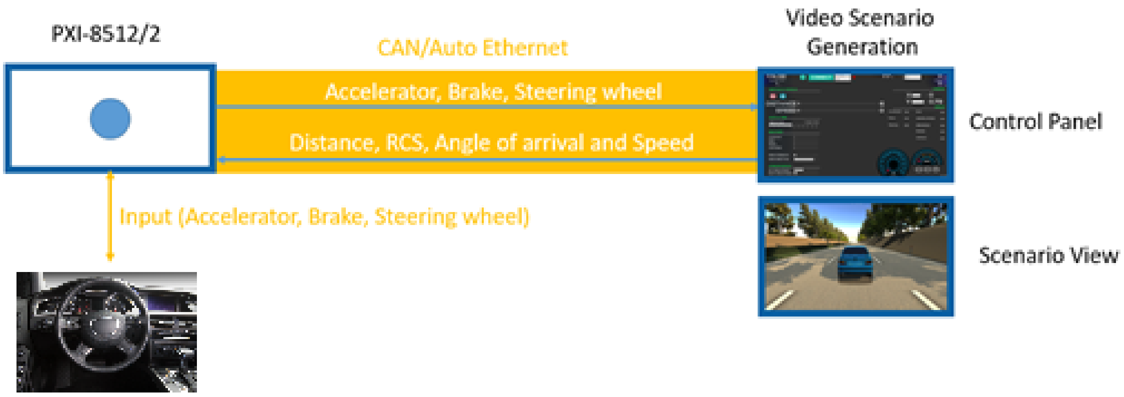

Figure 5: Vehicle communication Emulation

This simulator has been developed using Unity 3D engine, a cross platform game engine by Unity Technologies. Using a modularized approach the video scenario can be easily integrated with every third-party platform, plugin or device like the Logitech G29 shown in the previous image.

New features are included in the software development roadmap, such as:

- Environment change (uphill road, galleries, etc)
- Day/night conditions
- Lane feature edit
- Highway entry or exit
- Guard rail customization

RF Platform – VRTS

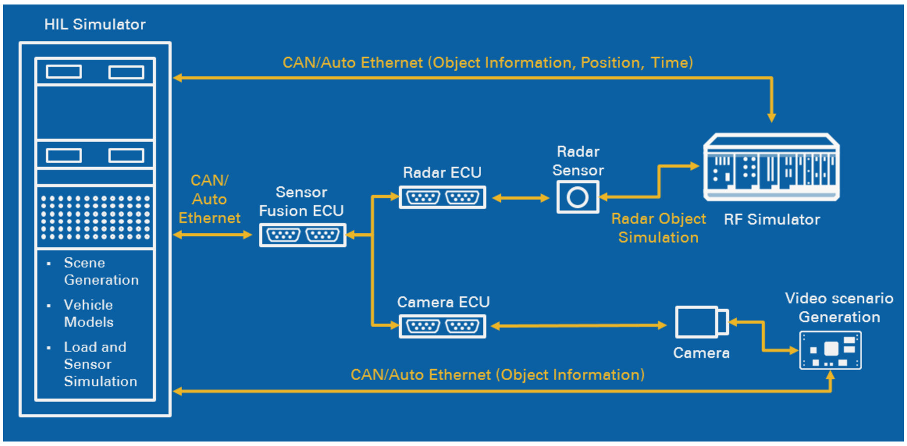

Figure 6: ADAS HIL Test Environment

The VRTS is a Vehicular Radar Test System used in HIL system for testing and measurements. The flexibility, modularity, and scalability of the VRTS enables users to easily integrate it with other I/O as part of a comprehensive HIL tester for radar design and test applications, and to use the same system for both target emulation and radar device measurements – lowering the cost of device and system test. The system is capable of:

- RF Measurements for sensor performance verification
- Signal Analysis: EIRP, noise, beam width, frequency
- Chirp Analysis: linearity, overshoot, recording, tagging
- RADAR Target simulator for sensor functional verification
- Single and multiple targets
- Fixed and variable distance
- Multiple object scenarios (distance, velocity, size and angle of arrival)
- Customizable target scenarios

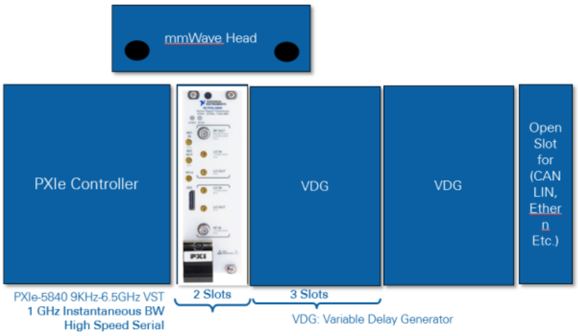

Figure 7: 2-Target 1-Angle System Architecture

In figure 7, the setup with 1 PXIe-5840 (Vector Signal Transceiver) and 1 mmWave Head is capable of generate 2 Targets with the same angle of arrival. Thanks to the PXI platform flexibility the system could be easily extended to cover multiple targets with multiples angles of arrival. In figure 8, the configuration with 4 PXIe-5840 and 4 mmWave Heads can simulates up to 8 different targets with 4 angles of arrival.

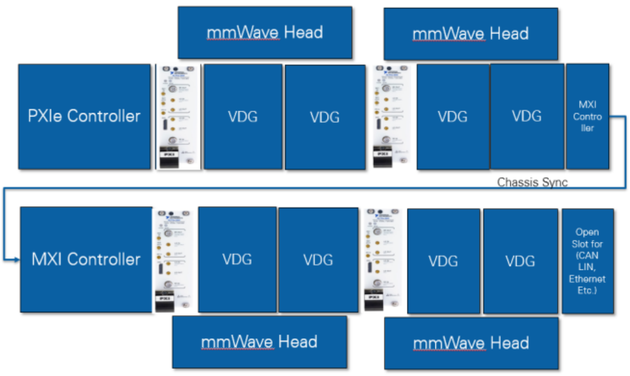

Figure 8: 8-Target 4-Angle System Architecture

The VRTS chassis can be integrated with standard Automotive bus communication (CAN or LIN) or other type of industrial communications required for the HIL system. The VRTS platform modularity allow car makers to test complex real test scenarios due to the possibility to handle multiple angles of arrival. Standard maneuvers provided by NCAP guidelines can be tested automatically saving testing time and effort.

5. Conclusion

AHTES has highlighted how it is now feasible to validate in laboratory systems like RADAR and Camera that works standalone or integrated.
Both components are safety critical considering the features implemented so the possibility to test in the lab before conducting vehicle tests is a crucial security step, but it is important remember also all the advantages of a validation of this type:

- anticipate validation at a stage prior to the vehicles availability, it allows corrective actions that otherwise would come too late
- Overall development time is greatly reduced because test can be start before vehicles availability
- Development costs are reduced by having a system that can work for all day, 7 days a week.
- No-regression tests can be carried out in times and costs not comparable if vehicles would be used

Although AHTES was born for verification and validation, its use is not limited to these scopes; in fact, it can be used to calibrate ECUs in order to define a first useful set for vehicle testing.

ADAS Systems can be fully integrated with other NI Hardware products for HIL such as the Switch Load Signal Conditioning platform (SLSC) for standardization and routing of the signal, switching loads, and signal conditioning. With NI VeriStand each component can be integrated in a framework capable to configure and interact with Real Time HIL systems.

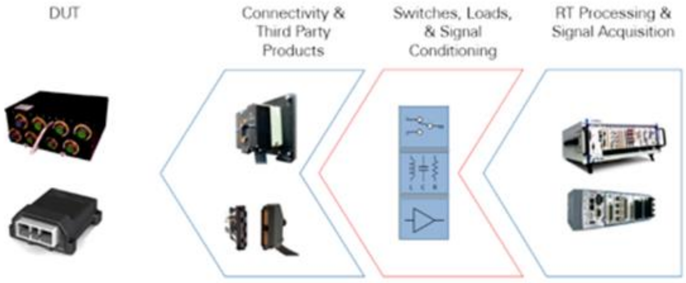

Figure 9: How SLSC fits into an HIL system

NI has also extended its platform with an ecosystem of industry-leading partners in the connected car and advanced vehicle technology space. Such as infotainment test, battery management system test, V2X communication, vehicle noise and vibration analysis.

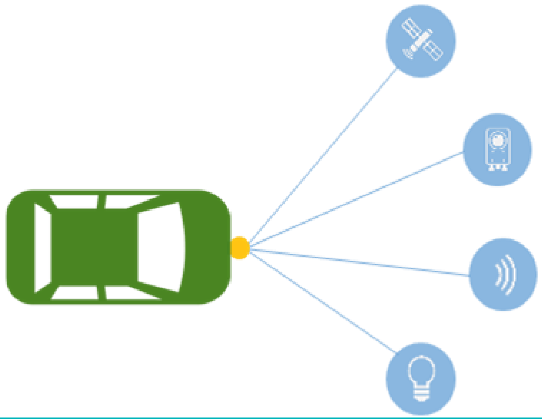

Figure 10: VX2, Lidar, GNSS for the "connected car"

6. Resources

- NI Demonstrates ADAS Test Solution for 76–81 GHz Automotive Radar
- Altran Group
- M3 Systems for GNSS Simulation
- Using The SLSC Architecture To Add Additional Elements To The Signal Path Of A Test System

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Authors:
Mario Amoruso (National Instruments)
Stefano Caiola (National Instruments)
Giuseppe Doronzo (Altran Italia)
Marino Difino (Altran Italia)

Reviewers:
Ram Mirwani (National Instruments)
Matteo Moriotti (Altran Italia)
Davide Palandella (National Instruments)