Online and Offline Validation of ADAS ECUs

With CANape Option Driver Assistance
Agenda

Introduction
Validation of ADAS ECUs
Time Synchronized Recording
From Signals to Data-Objects
Object Overlay and GFX Configuration
Analyzing of Measurement Files
Capture Data-Objects and Raw-Data from ADAS Sensors
More Information about Vector ADAS Products
Introduction

What are Advanced Driver Assistance Systems?

- Driver assistance systems are electronic components in vehicles for
  - Assisting the driver
  - Enhancing safety
  - Improving convenience and economy

- Different sensors acquire the vehicle's surroundings
  - The sensor data is then analyzed and merged in the ECUs

- Large quantities of data from different sensors must be visualized and validated
  - Radar, lidar, ultrasonic, laser and video-based systems
Introduction

CANape Solutions for Advanced Driver Assistance Systems (ADAS)

ADAS Road and Laboratory Validation
Online and offline verification by overlaying objects on video, map and scene view

ADAS Logging
Scalable ADAS Logging Software and Hardware
Introduction

Different Use-Cases

- Validate object recognition algorithms
  - Implemented in ECU e.g. ACC, "stop and go" systems, lane detection ...
  - With the help of **object overlaying**
  - **Online** during test drives and **offline** with recorded data

- Typical user groups:
  - OEM engineer who receives ADAS system/ECU from supplier
    - **Validation of ECU functionality**
    - Fine tuning of parameterization for a particular vehicle
  - Engineer at supplier with similar assignment
    - Validation & calibration
    - **No development** of algorithms inside the ADAS system
Introduction

Different Use-Cases

- High-end logging of complete ADAS car sensorics
  - Collecting ADAS sensor raw data or ECU internal data
  - From different sensor vendors
  - Handling of high data rates and time synchronous recording

- Typical user groups:
  - OEM engineer who develops autonomous driving cars
    - Running of test fleets for collecting data
    - Validation of ECU functionality in simulations with real measured data
  - Engineer at supplier with similar assignment
Introduction

Vector solution for measurement, calibration and validation

**CANape** - Time synchronized measurement and calibration of ECUs

- Synchronized measurement and recording of
  - ECU internal Signals
  - Radar, Lidar and other sensors
  - Video sources
  - GPS devices
  - ...

**Measurement:**
- Video camera
- GPS

**Driver Assistance ECU**

**ADAS sensor:**
- Radar
- Lidar
- Infrared
- Video
- Ultrasonic

**Video/GPS**

**CAN / Ethernet / XCP signals**
It’s difficult to validate a radar object in a graphical or numerical window.

There are several questions like:
- Is this detection correct?
- Is the detected object a car, pedestrian, tree…?
- Where are all detections?
- ...

CANape Option “Driver Assistance”
Validation of ADAS ECUs

Vector Solution for Measurement, Calibration and Validation

CANape - Time synchronized measurement and calibration of ECUs
+ Option “Driver Assistance”

ADAS sensor:
- Radar
- Lidar
- Infrared
- Video
- Ultrasonic

Measurement:
- Video camera
- GPS

Driver Assistance ECU

Video/GPS

CAN / Ethernet / XCP signals
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Recording of Sensor Data and Video Sources (Context Camera)

- ADAS ECU delivers the results in **signals** or as **data-objects** (serialized signal stream) on busses
  - Position in X-, Y- and Z-coordinates
  - Detected lanes and position
  - Signs ...
- Additional integrated cameras in the car recording the situation

- CANape measures the ECU data via CAN, Ethernet, XCP on CAN, VX1000 ...
  - Time synchronization of video frames to other measurement data
  - CANape is optimized to handle high frame rates with low CPU usage
Recording of Sensor Data and Video Sources (Context Camera)

- Adding camera device in “Device Configuration”
  - New camera device
    - Multimedia signal is available
    - Multiple cameras can be added
      - USB Cameras with Direct show
      - AXIS Cameras with F44 main unit
  - Multimedia signal
    - can be assigned to recorder
    - storage path can be set
Recording of Sensor Data and Video Sources (Context Camera)

- Multimedia signal in “Video Window”
- Live view during run-time
- Global measurement cursor
- Support of different compressors
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Time Synchronized Recording

▶ **From Signals to Data-Objects**

Object Overlay and GFX Configuration
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Definition of Data-Objects

- A data-object is an instance of defined classes
  - It could be a measurement data-object or a measurement file data-object
  - Existence of data-objects is optional

- Classes
  - Definitions of one or multiple data-objects
  - Can consist of structures

- Data-object list/container
  - List of multiple instances of a class

- Often the data-objects are send
  - **serialized** and signal based
  - distributed to many messages

- **Deserializing** of the data-objects on receiver side necessary
From Signals to Data-Objects

Object-Oriented with “Signal-Object Adapter”

- Creation of new data-objects and classes based on signals with the “Signal-Object-Adapter”

- GUI-based creation of new classes and Data-Object instances
- One Signal-Object Configuration for each device or MDF4 file
For the conversion from signals to objects a converter type could be defined depending on serializing type on transceiver site. There are three ways that data objects can be send on the bus:

- **Default**
  - Trigger point (TP) of an object or object list is reached after each signal is received at least once.

- **Modulation**
  - Objects are based on modulation of signals.
  - Count (C) defines for each cycle how many modulations of the signals their have been.

![Diagram of signal-object adapter](image-url)
For the conversion of objects out of measurement files the converter type could be defined. The last received value of each signal is used.

Sequence
- Objects based on a sequence of signals
- Count (C) defines for each cycle how many signals for each property are considered
- The last received value of each signal is used
New type for data-objects in the measurement configuration and MDF4 files available

Online during measurement

Allow the deserialization of data stream into an object based representation

Offline out of signal based measurement file
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Object Overlay and GFX Configuration

Data-Object-Oriented Overlay

- Graphical object overlay for detected ADAS objects like vehicles, lane markers, traffic signs ... for multiple sensors
- Integration of the new ADAS views which support the data-object-oriented overlay
  - Video view, Map view, Scene view and ADAS Explorer
- Object-oriented GFX objects are global in the current project
  - No need to define GFX objects for each view
  - In the ADAS Explorer the GFX objects could be enabled/disabled for each view
Object Overlay and GFX Configuration

Object-Oriented Object Overlay - Available GFX-Objects

- Overlay of images / bitmaps to visualize
  - Ego- and detected vehicles
  - Traffic signs
  - User specific icons (danger, attention etc.)

- Available for all views
  (Scene, Video, Map)
Object Overlay and GFX Configuration

GFX Editor to Configure the Graphical Objects

Available Data-Objects in project

List of configured Overlay Objects

Type of Overlay Object and Selection

Properties window to change object properties
To calibrate the camera to the test objects, various points with known position must be assigned on the monitor:

- Manual or guided video calibration available
- The corresponding coordinates must be specified for each individual point
- Different building place or angles for reference system and original sensor

"Bad" calibrated camera

"Good" calibrated camera
Guided Camera Calibration Process

- New “Vector Camera Calibration Tool”
  - Guided calibration process
  - Only a chessboard with known dimensions and number of fields is needed
  - 10 or more pictures with different angle and distance
  - Calibration file is generated for normal and fish-eye cameras

- Graphical overlay of detected fields and test object for quality check
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Retrieval of Signal Conditions and Automated Analyzing

- More and more measurement files with thousands of signals are recorded
  - It is not possible to validate all data live during measurement
  - How to find specific conditions and signal combinations in big archives?
  - Calculation of functions and scripts based on signals are complex
    - Not possible to calculate during runtime
    - Post calculation to find specific conditions for different use-cases

- Braking lights detected
  &
  Lane Type is solid

- List of all “Hits”
- Marker and fast navigation
Retrieval of Signal Conditions and Automated Analyzing

- CANape offers the possibility to load measurement files in the same project used for recording
- Object overlay is possible for online and offline validation
  - For video and GPS windows
- Functions and scripts can be used for
  - searching for specific condition
  - automated analysis
- Printing and reporting of results direct out of CANape
- Data mining functionality for analyzing more than one measurement file
Retrieval of Signal Conditions and Automated Analyzing

- Full support of GFX Editor
  - Creation of new objects from signals or function results

- Using possibilities of newest CANape versions with old measurement files
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The Challenge – Logging of Multi-Sensor and Fusion ECUs of Multiple Suppliers

- How to handle high data rates of:
  - Radar Raw Data
  - Laser scanner
  - Mono/Stereo cameras
  - „Classic“ XCP signals

- Limitations may apply
  - Computer resources
  - Disk space/writing performance
  - CPU usage
  - Available sensor integration

How to log the complete car environment with data rates of several GBytes/s?
Solution – CANape as Scalable Recorder for the Complete Environment

Solution: Distributed High Performance Recording

- A special designed standalone recorder for one specific device
- Multiple DHPR can be used in parallel
  - One measurement file for each DHPR
  - All created MDF files are time synchronous
  - Easy access to file distributed file content via loading the complete measurement

- Advantages:
  - Integration of new sensors and sources in CANape independent of CANape release
  - CANape replaces all individual loggers
  - Optimized PC resource and storage usage
  - Measurement rates of several GBytes/s
  - Synchronized logging distribution to multiple PCs

- Please contact us for project based sensor integration
# DHPRs on a Single PC

Capture Data-Objects and Raw-Data from ADAS Sensors

## CANape

- XCP
- Buslogging
- Reference Camera
- etc...

###DHPRs

- **XCPonETH** (e.g. Fusion ECU)
- **VX1000 XCP/RIF** (e.g. Radar)
- **Front camera (ME chip)**
- **Lidar (UDP decoding)**
- **Customer specific (e.g. UDP)**

###One Measurement

All MDF are recorded time synchronous

<table>
<thead>
<tr>
<th>MDF</th>
<th>MDF</th>
<th>MDF</th>
<th>RIF</th>
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###One Measurement

<table>
<thead>
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<th>PC</th>
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- Time synchronization
- Start / Stop Measurement
- Trigger
- Data backchannel

TCP
Capture Data-Objects and Raw-Data from ADAS Sensors

**DHPRs distributed on Multiple PCs**

- XCP
- Buslogging
- Reference Camera
- etc...

- XCPonETH (e.g. Fusion ECU)
- VX1000 XCP/RIF (e.g. Radar)
- Front camera (ME chip)
- Lidar (UDP decoding)
- Customer specific (e.g. UDP)

- CANape
  - Time synchronization
  - Start / Stop Measurement
  - Trigger
  - Data backchannel

- XCP DHPR
- XCP/RIF DHPR
- Video DHPR
- Lidar DHPR
- UDP DHPR

**One Measurement**

All MDF are recorded
time synchronous
Sensors from multiple vendors deliver data via their own Ethernet protocols
- Without using standardized automotive databases/descriptions
- Referring to – and re-using – application software internal data structures
- Highly flexible for the (software) developer with such a data source

→ But: How to bring such data into the measurement tool?

**Solution: CANape Protocol Decoder**
- Customizable decoder DLL
  - Decodes signals and data objects, based on the user specific Ethernet protocol specification
- Plugin in CANape
  - Plugin = tile in the device configuration
- Supports UDP and TCP

→ Implementation of user-specific Protocol Decoders will be realized by Vector as projects
Capture Data-Objects and Raw-Data from ADAS Sensors

Supported DHPR Devices out of Different Areas

- Radar (RAW Data, XCP, proprietary)
- LIDAR (Scala, IBEO, Quanergy, Velodyne, Hesai ...)
- Context/Reference Cameras
- Vehicle Cameras (MobilEye-TAPI, RAW Data ...)
- Fusion-ECU / XCP-based Systems
- Analog sensors (pressure, accelerometer ...)
- GPS / IMU (GeneSys ADMA ...)
- Vehicle Networks
- Other sensors (Brightness, Humidity, Audio)
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More Information about Vector ADAS Products
Vector offers different solutions to the topic of ADAS development and verification

Please have a look on our Webpage for products, articles, know-how, webinars and more:

For more information about Vector and our products please visit

www.vector.com

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