Target-Independent Component-Based Design for Automated Driving Systems

Siddharth D’Silva & Eugene Kagan
MathWorks Automotive Conference
May 12, 2016
Autoliv – An Industry Pioneer for 60+ Years in Automotive Safety
Autoliv – A Complete System Safety Supplier

- Vision system
- Inflatable curtain airbag
- Passenger airbag
- Pedestrian protection
- Night driving assist
- Satellite sensor
- Far-side airbag
- Blind spot radar
- Rear-side airbag
- Integrated child seat
- Side airbag
- Anti-whiplash system
- Seatbelt systems
- Side impact sensor
- Driver airbag
- Steering wheel
- Pelvis restraint cushion
- Knee airbag
- Battery disconnect switch
- Extra safety belt
- Bag-in-belt
- Electronic control unit and Brake control/ESC
- Bag-in-belt
- Blind spot radar
- Rear-side airbag
- Integrated child seat
- Side airbag
- Anti-whiplash system
- Seatbelt systems
- Side impact sensor
- Passenger airbag
- Pedestrian protection
- Satellite sensor
- Night driving assist
- Driver assist radar
- Dynamic spot light
- Extra safety belt
- Extra safety belt
- Bag-in-belt
- Blind spot radar
- Rear-side airbag
- Integrated child seat
- Side airbag
- Anti-whiplash system
- Seatbelt systems
- Side impact sensor
- Passenger airbag
- Pedestrian protection
- Satellite sensor
- Night driving assist
- Driver assist radar
- Dynamic spot light
The Automated Driving System Team Roadmap

- Feet off: 2000
- Hands off: 2015
- Eyes off: ~2020
- Mind off: >2025

2000 ~2025
The Road to Autonomous Driving

Adaptive Cruise Control

Lane Centering

Automated Highway Driving

Autonomous Driving

Automated City Driving

Automated City Parking
Autoliv’s Current Footprint Within the Automated Driving Pyramid

- Autonomous Driving
  - Automated Route (Trained)
    - Automated Highway Driving
  - Automated Route (Destination)
    - Automated City Driving
    - Automated Valet Parking
    - Evasive Maneuvers
  - AEB – City
  - AEB – Urban
  - AEB – Ped/Cyclist
  - Intersection Assist
  - Overtaking Assist

- In house
- Partners
- Recent JVs and M&A

- Volvo
- Autoliv-Nissin
- Brake Systems
- Electric Power Steering
- Blind Spot Monitoring
- Ped/Cyclist Detection
- Parking Aid
- Traffic Sign Recognition
- Lane Departure Warning
- Forward Collision Warning
- Surround / Rear View

- HMI
- Antilock Brakes
- Stability Control

- Radar
- Cameras
- Driver Monitoring
- LIDAR
- Ultrasound Sensors
- Inertia Sensors
- GPS
- MAPS
- V2X
How does an OEM view us in the Domain of Automated Driving?

- Are we a radar sensor supplier?
- Are we a camera sensor supplier?
- Are we an ECU supplier?
- Are we an active safety feature supplier?
- Are we a system software supplier?
- Are we software integrators?
- Are we a full active safety system supplier?
- Are we collaborators on future system designs?

The answer is Yes to all
Example Real-Life Customer Pursuits

**OEM A**
- Camera: Supplier A
- Feature Set: Supplier A/OEM
- Integration ECU: Camera
- Feature Integrator: Supplier A

**OEM B**
- Camera: Supplier A
- Radar: Supplier B
- Fusion: Supplier B
- Feature Set: OEM
- Integration ECU: Radar
- Feature Integrator: Supplier B

**OEM C**
- Camera: Supplier A
- Radar: Supplier B
- Fusion: Supplier C
- Feature Set: OEM/Supplier C
- Integration ECU: ADAS ECU
- Feature Integrator: Supplier C

D'Silva-Kagan 05/12/2016
The Autoliv Software Integration Workflow

Target System Content

Architecture

SWC1  SWC2  SWC3

Architectural Contract

Vehicle (Integration context)

Input Interface

Feature Content

Vehicle Configuration

Output Interface

Target Platform Blocks or BSW

Vehicle Interface

Project Algorithm

Integration Platforms

Target Configuration and transformation rules

Custom Tools

Target Executable(s)
Model Based Design and Software Integration
Challenges of Model Based Design and Software Integration

- Multiple internal development sites across the world
  - Local constraints on access to tools

- Autoliv is participating in several co-development activities involving multiple external parties
  - Bi-directional exchange of models
  - Incompatible development environments

- A single project may see multiple integration platforms
  - E.g. PC Simulation and replay, 3rd party simulation environments
  - E.g. Real-time platforms: RCP, production target ECU

- Variety of Component formats for integration
  - Simulink Models: white box and IP protected
  - C source files
  - Object files

- Subject matter expert challenge
  - Subject matter expertise versus “know it all”
Autoliv’s Approach using the MathWorks Suite

- **Packaging Internal Software Components for re-use in multiple projects**
  - Explicit boundary and external dependency
  - Clear separation between the function and the data

- **Establishing a framework for multi-site development of feature content**
  - Uniform MBD project setup with a foundation in common and portable project configuration/build system
  - Scalability: Not every development site will need a full project toolset

- **Supporting multiple integration platforms**
  - Target independence in defining a component functionality and data
  - Custom toolset for mapping component functionality and data onto a target platform

- **Collaborating with external companies**
  - Flexibility in accepting model formats and content packages from external collaborators
  - Provisioning for mapping external deliveries to the selected targets

- **Encouraging subject matter expertise**
  - Let the experts concentrate on what they know and do the best
Software Component Packaging

- **Core Functionality**
  - Global Parameters
  - Constants
  - Block types for fixed-point models
  - Instance memory

- **External Interface**
  - Root IO interfaces

- **Configuration**
  - In-vehicle tuning parameters
  - One time adaptation to the vehicle
  - Variant subsystems

- **Internal Data Dictionary**
  - Constants
  - Block types for fixed-point models
  - Instance memory
Software Component Packaging

- In-vehicle tuning parameters
- Constants
- Block types for fixed-point models
- Instance memory

- One time adaptation to the vehicle
- Variant subsystems
What is Target Independence?

- The component owner should primarily care about its design & functionality
  - Proper representation of the execution model: E.g. floating point versus fixed point designs
  - Simulink-based component is delivered without the assumption of an integration environment

- Enforcing adherence to internal modeling standards

- All component relevant data sets are defined in the generic form
  - E.g. generic Matlab variables (discouraged)
  - E.g. Simulink.Parameter objects without specification of Custom Storage Classes

- Existence of well established transformation rules
  - E.g. Mapping the data and functions onto the various targets
  - E.g. Custom code generation with standardized build toolset
Software Integration of Target Independent Models

- Standardized code-generation toolset should support:
  - Adaptation to incompatible external interfaces
    - Model reference is a good integration unit but....
    - Is it a good re-use unit?
  - Flexible target memory allocation
    - E.g. End-Of-Line calibration
    - E.g. Inline or non-inline constant section
    - E.g. Non-volatile memory
  - Ability to transform models into target platform compatible code
    - E.g. Real-time RCP targets vs. target ECU
    - E.g. AUTOSAR vs. non-AUTOSAR targets
Example Success Stories

- The presented methodology has been successfully applied to the following Autoliv products:
  - Passive Restraint System
  - Variants of ESC/ESB systems
  - Automated Driving applications
    - Mono-Vision AEB System with internal SW components
    - Forward Looking Radar based ACC with external SW components
    - Best in-class ADAS system with Mono-Vision Camera, Forward Looking Radar and a combination of mixed internal and external SW components
Thank You!

Every year, Autoliv’s products save over 30,000 lives and prevent ten times as many severe injuries.