Signal Flow Analysis for CARB Reporting – Third Introductory Meeting: Aug 16, 2022

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AGENDA - AUGUST 16, 2022

- Introductions
- Summary of Problem Statement & General Approach (Tim)
- Alignment with other HRCS Initiatives (Tim)
- Example Project Description, Success Story and Open Issues (Stephan)
- Plans & Next Steps
- HRCS Membership (Peter)
- Open Issues / Discussion

Summary of Problem Statement & General Approach

Tim Felke

PROBLEM STATEMENT - FOCUSED

There are several use cases related to automotive emissions compliance that require an understanding of the propagation of signals within and between the vehicle's Electronic Control Units (ECUs)

Specifically -

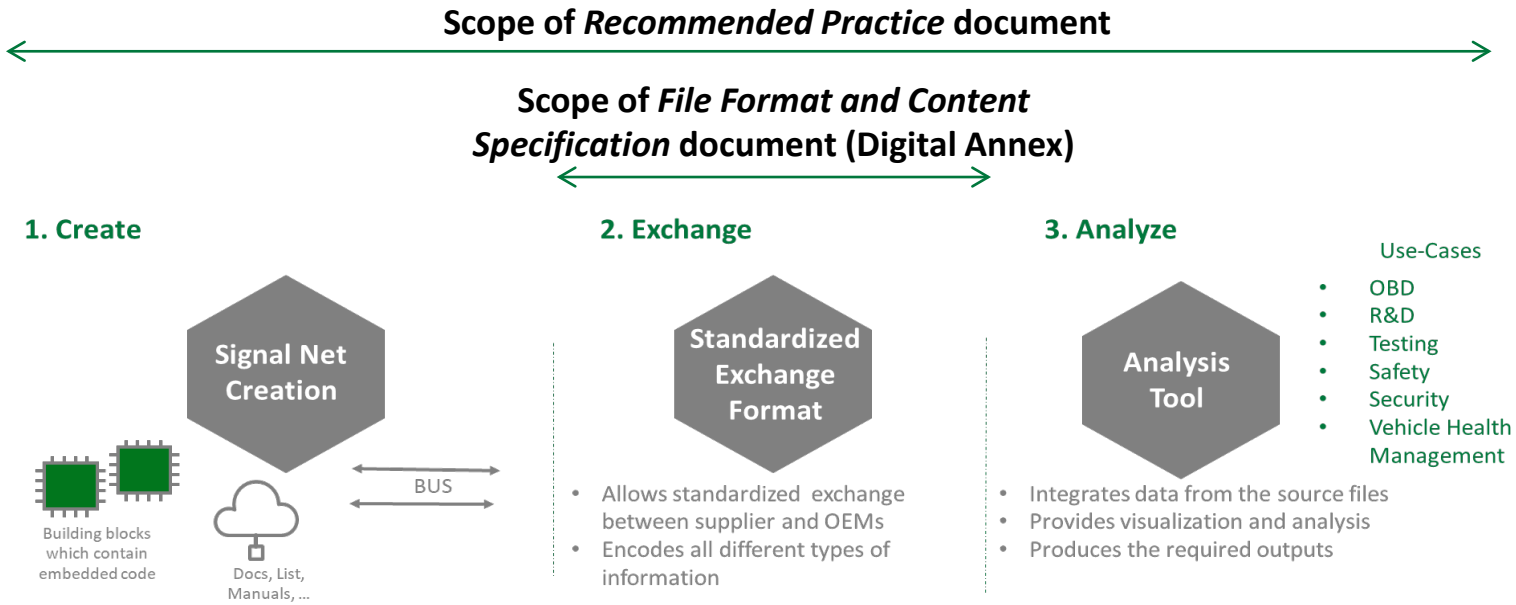
> CARB request to all OEMs in 2019 …
>
> (1) Certification Documentation ….
>
> (2) The following information shall be submitted as “Part 1” of the certification application. … The information must include: …
>
> **(2.8) A listing of all electronic powertrain input and output signals (including those not monitored by the OBD II system) that identifies which signals are monitored by the OBD II system. Note: Traditionally, the compliance report focused only on sensors and actuators, now if must include serial bus signals.**

The focus of this Working Group is to develop methods allowing OEMs to identify the source for all signals related to emissions as well as those whose failure results in operating mode that effect compliance.

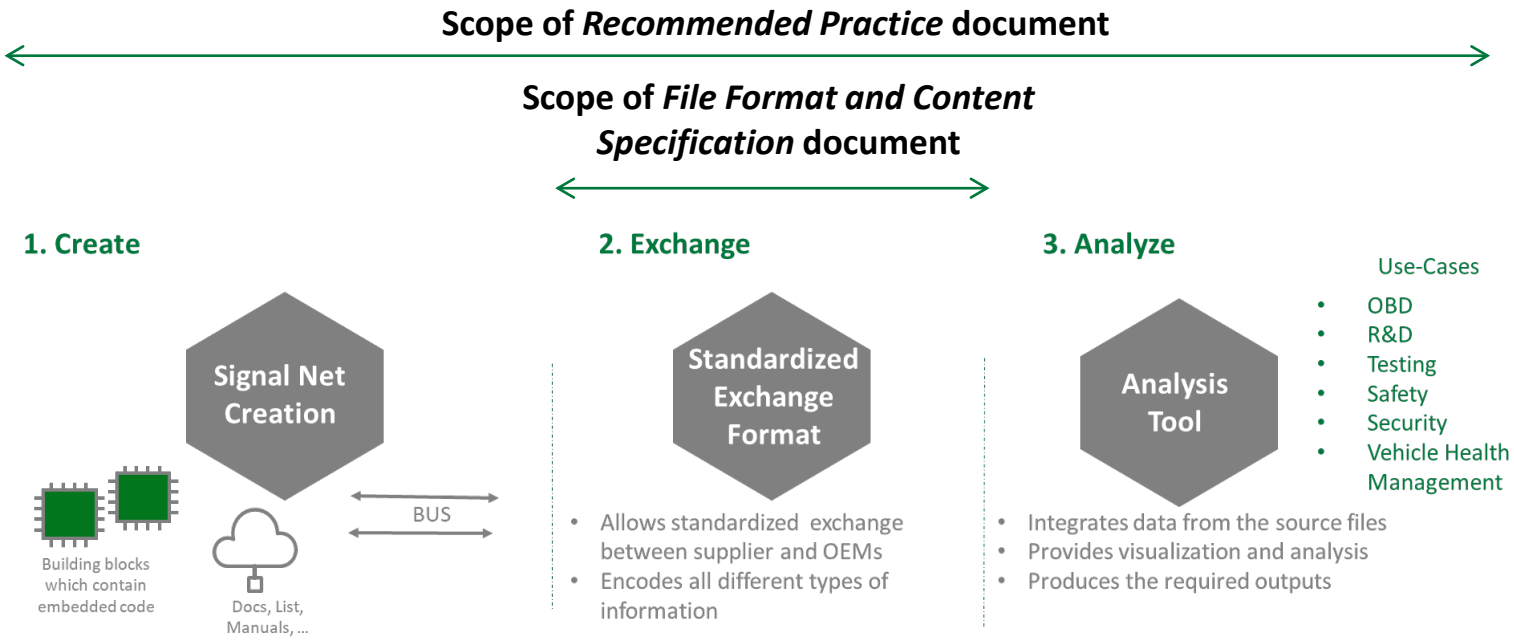
PROPOSED APPROACH - METHOD

The project will focus initially on producing documents related to use of signal flow analysis to support the CARB OBD Summary Reports for a vehicle.

- A *Recommended Practice* document that describes the overall process, required inputs, processing and outputs.
- A *File Format and Content Specification* document that will be a digital annex that provides a detailed schema and ruleset for the creation and use of exchange files.



PROPOSED APPROACH – OUTCOMES



1. HRCS + Industry Group Documents will include mechanisms by which **tool providers** can validate their functionality and results.
2. **OEMs** can use validated tool chain from any mix of supplier and/or create their own compliant solutions.
3. **CARB** will receive standardized, validated data sets by which they can assess compliance.

PROJECT PLAN – NOTIONAL SCHEDULE

Today

	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23
Coordination Activities	Introductory Meeting #1	Introductory Meeting #2	Introductory Meeting #3	Project Kick-Off	Stakeholders Meeting #1	Stakeholders Meeting #2	Stakeholders Meeting #3	Stakeholders Meeting #4	Stakeholders Meeting #5	Stakeholders Meeting #6
Recommended Practice Document Working Group				RP Team Kick-Off	Document Rationale, Scope and Definitions	Working Sessions and Report-Out	Working Sessions and Report-Out	Working Sessions and Report-Out	Initial Document Submitted for Review	Final Document Released
File Format Document Working Group				FF Team Kick-Off	Document Rationale, Scope and Definitions	Working Sessions and Report-Out	Working Sessions and Report-Out	Working Sessions and Report-Out	Initial Document Submitted for Review	Final Document Released

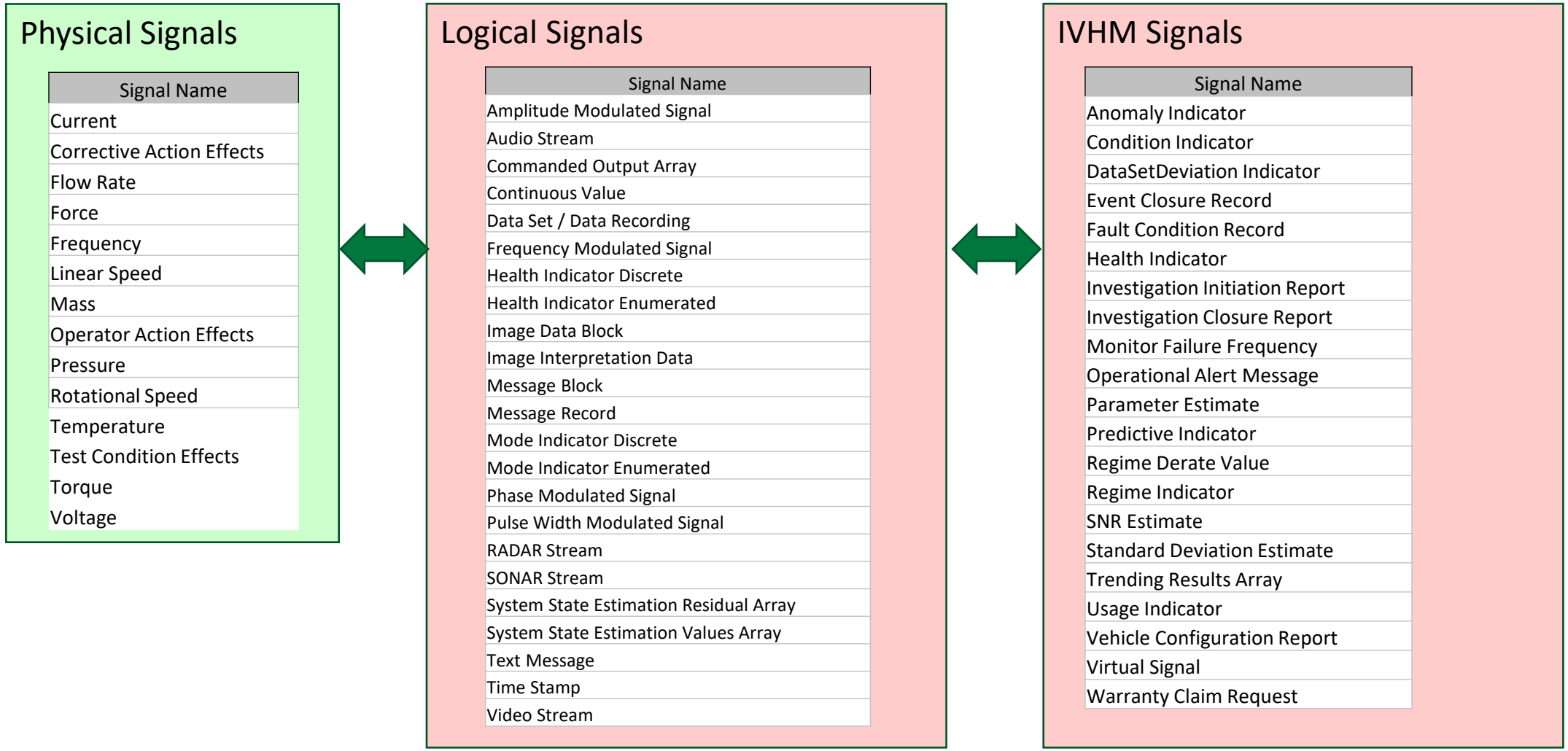
Note - Project Kick-Off date is TBD to accommodate feedback from industry and stakeholders.

Related HRCS Initiatives

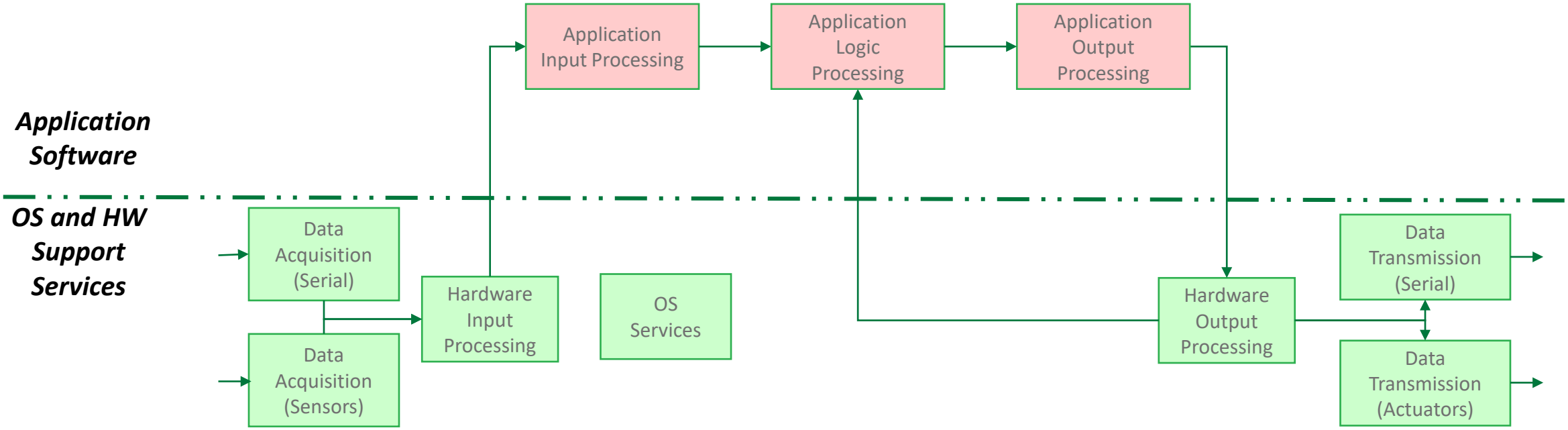
HRCS-GUCN001-2208
JA6268™ Reporting and Processing Guidelines for Master Signal Types

Tim Felke

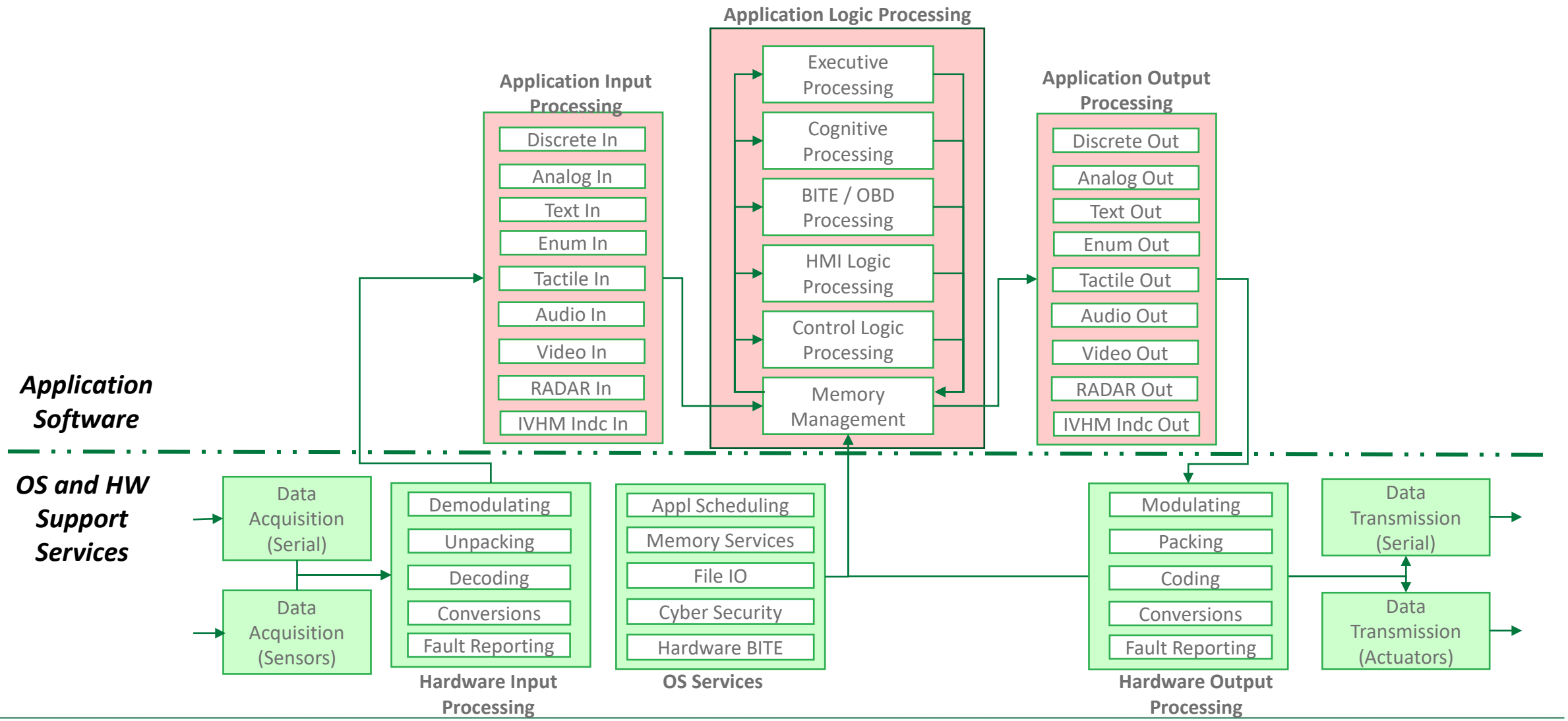
JA6268 Domains and Master Signal Types



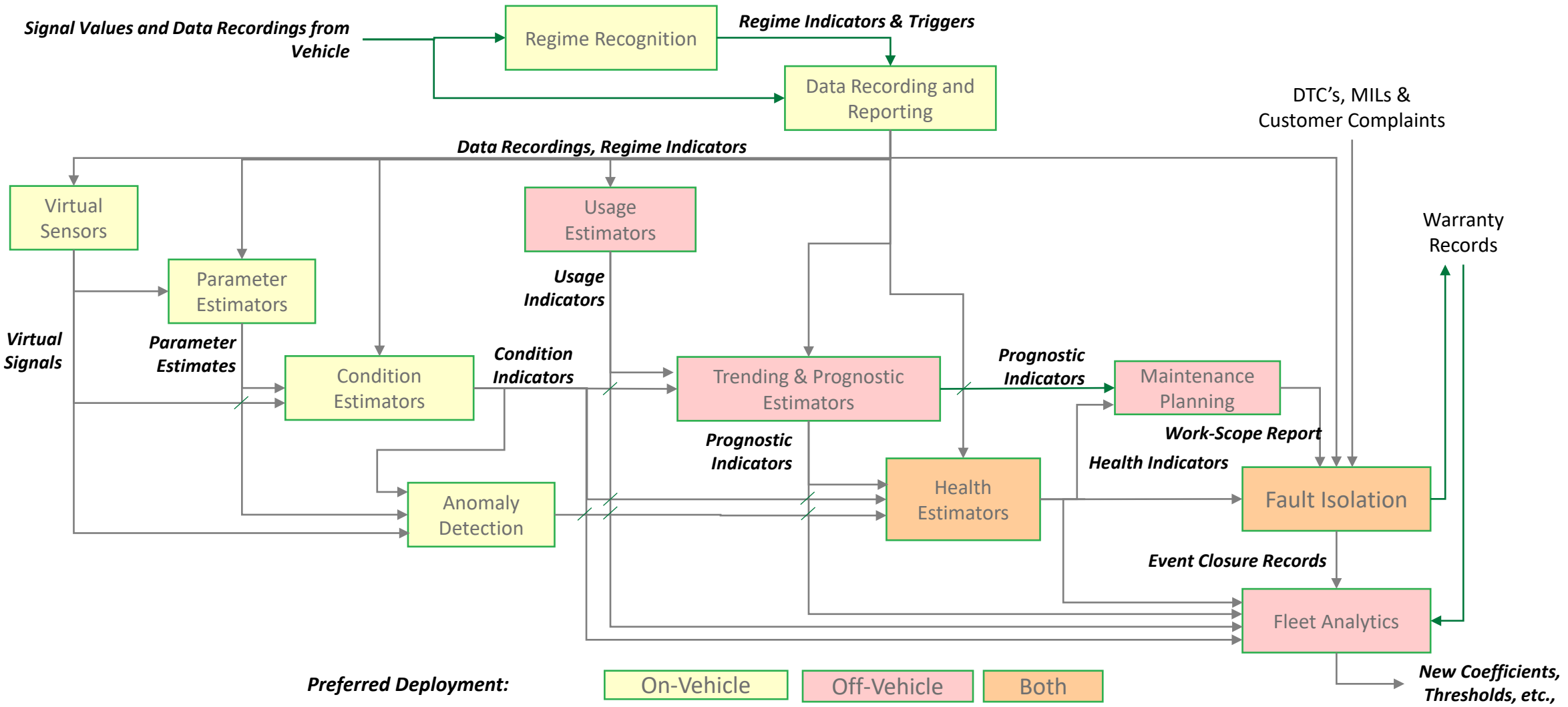
On-Vehicle Processing Steps



On-Vehicle Software Package Types



IVHM Algorithms and Indicators (On-Vehicle &Off-Vehicle)



SUMMARY

- HRCS is already working with industry to standardize signal type definitions, function type definitions, and generic signal flow.
- These definitions will help to improve the completeness and accuracy of the model and to help with corrections to errors / problems that are encountered.
- Findings from Signal Flow Analysis can be fed-back to the HRCS standards documents to improve their accuracy.
- This methodology can be applied to ADAS and Autonomy.

Example Project Description, Success Story and Open Issues

Stephan Mauk

AGENDA

- Introduction and current / historic approach to create signal net analysis
- New / automated approach based on code analysis
- Results & figures
- General approach to create the I/O list for CARB
- Insights to validation & consistency checks
- Overview of already covered / touched challenges (shown in meeting 2)
- Summary
- Questions / Discussion

INTRODUCTION

Being involved in Signal Net Analysis for several use cases we have faced different approaches to tackle this complex challenge:

- Walls full of printed functional descriptions (not only in automotive)
- Huge Mind Maps
- Excel Matrixes
- ….

Signal chains are mainly created manually.

These approaches are legitimate for their specific tasks / use cases.

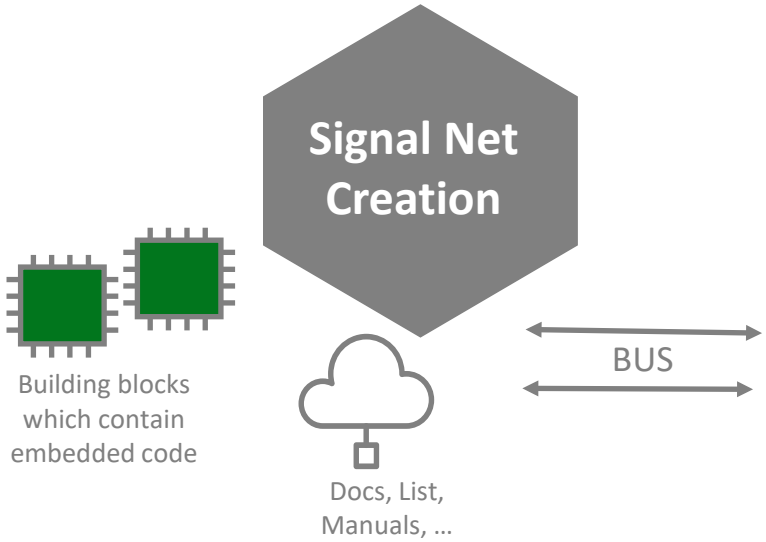
But when we are asked to apply one of these processes to an engine control unit, we quickly reach our natural limits, simply because of the complexity and large amounts of data.

The SW development cycle is much faster as it would need to manually create the Signal Net of one ECU version, therefore even before we would have finished our analysis, the data would outdated.

→ Need for faster / automated Signal Net creation

NEW / AUTOMATED APPROACH

Best practice following the approach: Create / Exchange / Analyze



Automated generation of Signal Net Artefacts based on source code from each ECU.
BUS Converter to link several control units.

Specified Exchange format.
Enable Tiers to deliver their own inputs.

Analysis Tool
- Import / merge
- Queries
- Export

RESULTS & FIGURES

Successful operation of different levels – ECU and Vehicle

- ECU (2 stakeholders; OEM & Supplier)
- Vehicle (Engine, Gearbox and Brake) including vehicle specific application

Some figures of the Engine Control Unit

- More than 10,000 function-modules converted from C-Code to signal net artefacts
- More than 150,000 signal-nodes created
- More than 3 Million connections between the nodes imported and merged in the analysis tool
- Connection matrix between InBus & DTCs:
  - > 90,000 connections (E2E)
  - > 1.8 Million steps
  - < 1 hour calculation time including export

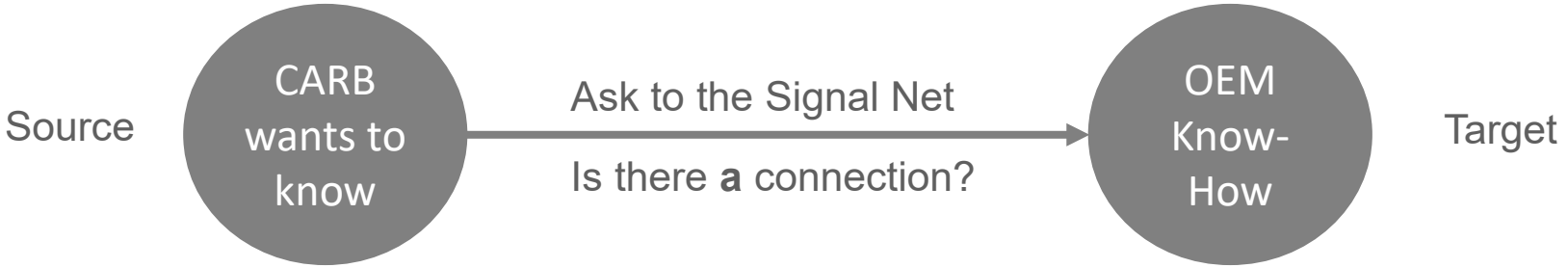
HOW TO CREATE THE I/O LIST FOR CARB

Once the signal net was available, a general approach was used to identify the requested I/O list for CARB (ECU level).

Signals are **OBD relevant** IF they:

- have significant impact on tail pipe emissions (historic Know-How of OEM) OR
- feed SW blocks that are known to be OBD relevant (e.g. OBD functions & OBD DTC, OBD Actuators, …)

→ **OBD relevant** signals (i.e. Incoming Bus) can be derived from known **Targets**



OBD relevant I/O:
- i.e. Incoming Bus Msgs

OBD relevant Target:
- i.e. OBD DTC
- OBD actuator
- OBD function (Engine stop)
- …

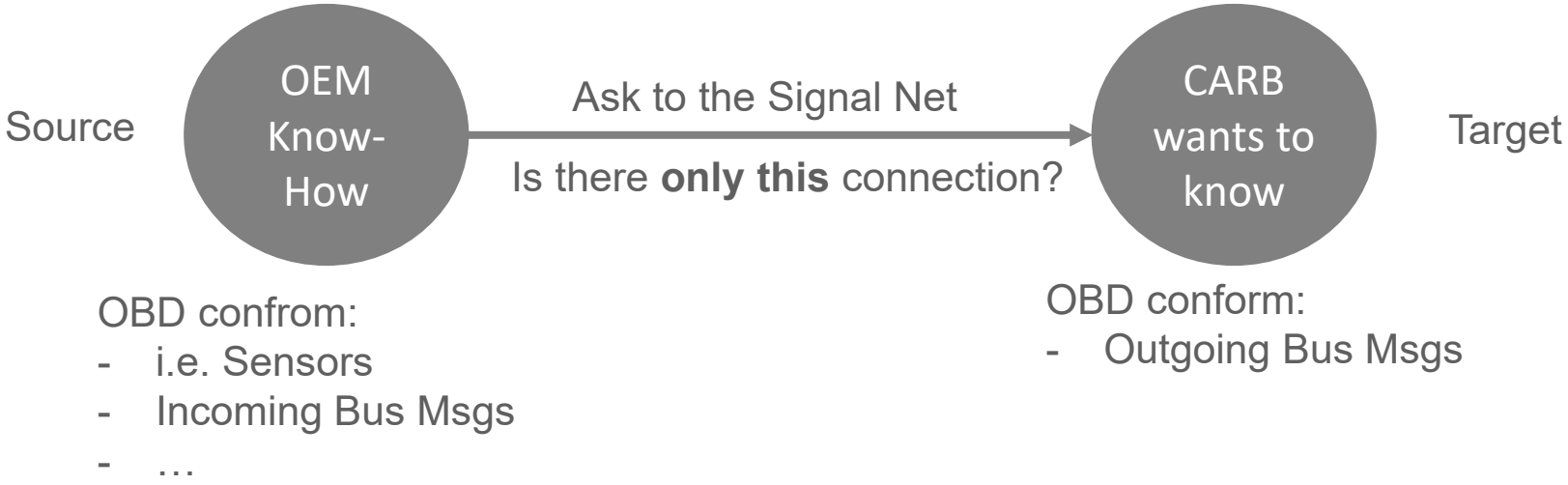
Note: very simplified approach to OBD laws

HOW TO CREATE THE I/O LIST FOR CARB

Signals are **OBD conform** IF they:

- are monitored according to the OBD laws (historic OEM Know-How) OR
- are ONLY fed by OBD conform inputs

→ **OBD conform** signals (i.e. Outgoing Bus) can be derived from known **Sources**



Note: very simplified approach to OBD laws

INSIGHTS TO VALIDATION & CONSISTENCY CHECKS

How to validate these new / big amount of data?

- Validation guideline and templates
  - Established
  - Harmonization between OEM & Tiers
  - Used to pass defined milestones in the process
- Tool based / automated validation
  - Completeness
  - Comparison
  - Detailed validation (i.e. signal paths)
- Extensive statistic reports
  - Compare SW versions
  - Compare ECUs
  - …

→ Good control and overview of maturity of results

→ Based on mature results on ECU level, consistency checks could be done between several control units to provide consistent I/O List for the different ECUs

OVERVIEW OF ALREADY COVERED / TOUCHED CHALLENGES

green = achieved on project level

Wide Range of Input Data

- OEM needs to integrate data from many suppliers & departments
- Many languages and bus protocols (CAN, LIN, Ethernet, …)
- Different AutoSAR implementations
- Many SW layers & interfaces (application SW, basic SW, IO, HW, …)
- Affects through DTC State Managers, MIL State Managers and overall DTC Reporting and Consolidation Services (DSM)
- Need to consider Calibration Files and System Constants
- How to handle obsolete path / "dead" code
- Existing Know-How needs to be included
- Already agreed "engineering judgements" / agreements

Definitions / Common understanding

- Definition of OBD relevant, OBD conform, …
- How to identify which functions and signals are OBD relevant / conform
- Which information shall be included, prioritization, … (i.e. engineering judgement vs signal net analysis)
- Signal net artefact: content, simplification, naming, annotations, …

Complexity

- Static, dynamic, thermal, … effects
- Location specific and optional functions, or dependent on the conditions of the vehicle
- Need to filter large connection networks to the relevant subsets (size & complexity)
- Requirements from different stakeholder (CARB, Europe, China, RoW, …)

Validation

- Automated generated signal flow files can be large and difficult to validate
- Mechanism needed that enables validation on different levels (software, functional, HiL, on vehicle, …)
- Mechanism to incorporate expert expectations
- Compatibility to use already existing data from i.e.: Functional Safety, Test Plans,, Service Records and Service Procedures, Service Bulletins, …) OBD Summary Tables
- Solution must produce intermediate results that build confidence in the overall solution

General

- Solution must protect IP of application SW suppliers, integrators and tool suppliers
- Solution must enable affordable / pragmatic approaches especially for less complex functions / components

SUMMARY

- Important contribution for successful first delivery of results to CARB
- General approach “Create / Exchange / Analyze” works
- Automated generation of Signal Net Artefacts helps to handle big ECUs
  → “From Code to CARB”
- Standardized exchange format to replace individual exchange format used needed for scalability
- Method considered as a feasible way to:
  - Cover the CARB requirements
  - Having the Signal Net available is a clear enabler for many additional Use-Cases

HRCS Membership

Peter Grau

HRCS ROLE IN THE OBD SIGNAL FLOW ANALYSIS

- Provides neutral, precompetitive, non-proprietary environment
- Increased bandwidth and shortened response time
- Will produce a common and coordinated approach to this challenge
- Differing perspectives of participants will produce a better final solution
- HRCS will produce, file, maintain, and market needed templates for this effort

HRCS ROLE IN THE OBD SIGNAL FLOW ANALYSIS

Focus of HRCS:

- Define needs/use cases with industry and regulators (focus on OBD)
- Identify and propose solutions for technical challenges that fulfill these needs
- Develop a standard to exchange and document signal net artifacts
- Author “Best Practices/Cookbook” for signal net analysis (entire process based on “create/exchange/analyze” approach).

Out of Scope for HRCS:

- Tool/standard defining how to create signal net artifacts
- Tool/standard describing how to analyze signal net artifacts

Why:

- The goal of the standardized exchange format and best practice guidelines should be an open solution approach that helps/enables all stakeholders to find their best cost-effective approach for the signal net analysis

HRCS MEMBERSHIP

- HRCS Membership Benefits to Members
  - Common channel with CARB (and other regulators)
  - Simplified communications between OEMs, Suppliers, and Operators
  - Reduced effort to respond to CARB mandate vs. individual company approaches
  - Differing perspectives, increased bandwidth, division of labor
  - Methodology can be applied to other developing areas (ie: autonomy, safety, cybersecurity etc.)
- IP and Antitrust Protection
  - Consortium is structured as a 501(c6) organization
  - Membership at the ***Corporate Level*** confers antitrust protection to the corporation
  - ***Corporate membership*** covers the entire company; unlimited participation
  - Discussions will be pre-competitive, non-proprietary
  - Proprietary information can be protected and will not require disclosure
  - Work Session summaries to contributors for reporting to their organizations
- Common approach and unified coordination with CARB
- Engagement with other HRCS initiatives

HRCS CONSORTIUM

- Overall Objective: Facilitate introduction of Integrated Vehicle Health Management (IVHM) across mobility sectors
  - Critical and enabling technology for autonomous vehicles; safety critical components must be health ready

- Enhance performance, availability, and safety of mobility assets through use of IVHM incorporating:
  - Uniform information sharing techniques
  - Predictive analytics and prognostics
  - Interoperability instead of costly proprietary approaches
  - Design and run-time information exchange

- Targets seven mobility sectors:
  - Aerospace
  - Automotive
  - Off-Highway Vehicles (agriculture, construction, mining)
  - Rail
  - Defense
  - Marine
  - Commercial Vehicles

Why now? – Drive use of a common standard before the market fragments into costly proprietary solutions

HRCS MEMBERSHIP STRUCTURE

- **Executive Committee:** (July 1 – June 30 one-year positions)
  - Chairman Steve Holland (VHM Innovations/retired GM)
  - Vice Chairman Brian Tucker (Bell)
  - Secretary Joe Klesing (Nexteer Automotive)
  - Treasurer Peter Grau (SAE ITC)
- **Membership Levels:**
  - **Member** (full voting privileges, eligible for Executive Committee, full participation in other HRCS technical activities, early access to program results and output, ability to provide input to Executive Committee) Annual membership dues: $9,000, prorated for partial year membership
  - **Associate Member** (full participation in other HRCS technical activities, early access to program results and output, ability to provide input to Executive Committee) $5,000, prorated for partial year membership
  - **Strategic Partner** (by invitation of the Executive Committee, (full voting privileges, eligible for Executive Committee, full participation in other HRCS technical activities, early access to program results and output, ability to provide input to Executive Committee) Payment in-kind

Next Steps

Peter Grau

PLANS AND NEXT STEPS

- OBD Americas September 13-15
- Committee launch artifacts and general approach (contact us if interested)
  - Document rationale & abstract
  - Scope
  - Timeline
  - Resources committed
  - Anticipate launch in early October
- CARB discussions prior to formal launch

Discussion

All

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