



Data Acquisition beyond VSS

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Aspects of Data Collection

Architecture

- Data Model—VSS
- Data Transport—VISS
- Data Preprocessing
- Data Collection

Software Defined Vehicle Concerns

- Combining Robustness and Dynamic Update
- Complete Data Types: Quantities vs. Raw Numbers
- Software Selfawareness
- Dynamic Test and Deployment

Data Transport between Vehicle and Cloud

Requirements

- Efficient Transport
- Topic and Message Structure Based on VSS
- Multiple Devices in Vehicle
- Fast Fail-Over
- Interoperability



Candidate: Sparkplug B

- Explicit, fast fail-over using multiple (hundreds) of redundant message brokers
- Fast life-cycle updates, with inherent invalidation of stale signals
- Unlimited metadata, only transmitted on connection start (same goes for immutable properties)
- Very efficient transmission scheme based on protobuf
- Topic structure supports edge-of-network (gateway) + one layer deep devices behind gateway
- Message structure supports unlimited depth of signal (metric) organization
- Support for historical (non-realtime) signal data

Data Acquisition Plan

REQUIRE

Data Acquisition Plan

- Dynamically Select Data
- Triggers and Synthetic Data
- Customizable Data Preprocessing

SIMULATE

Rapid Turnaround

- Off-board testing
- Same tools for data generation
- Generate VSS defined signals

Evolution of Data Collection

Static Acquisition

- Predefined Signals
- Limited control

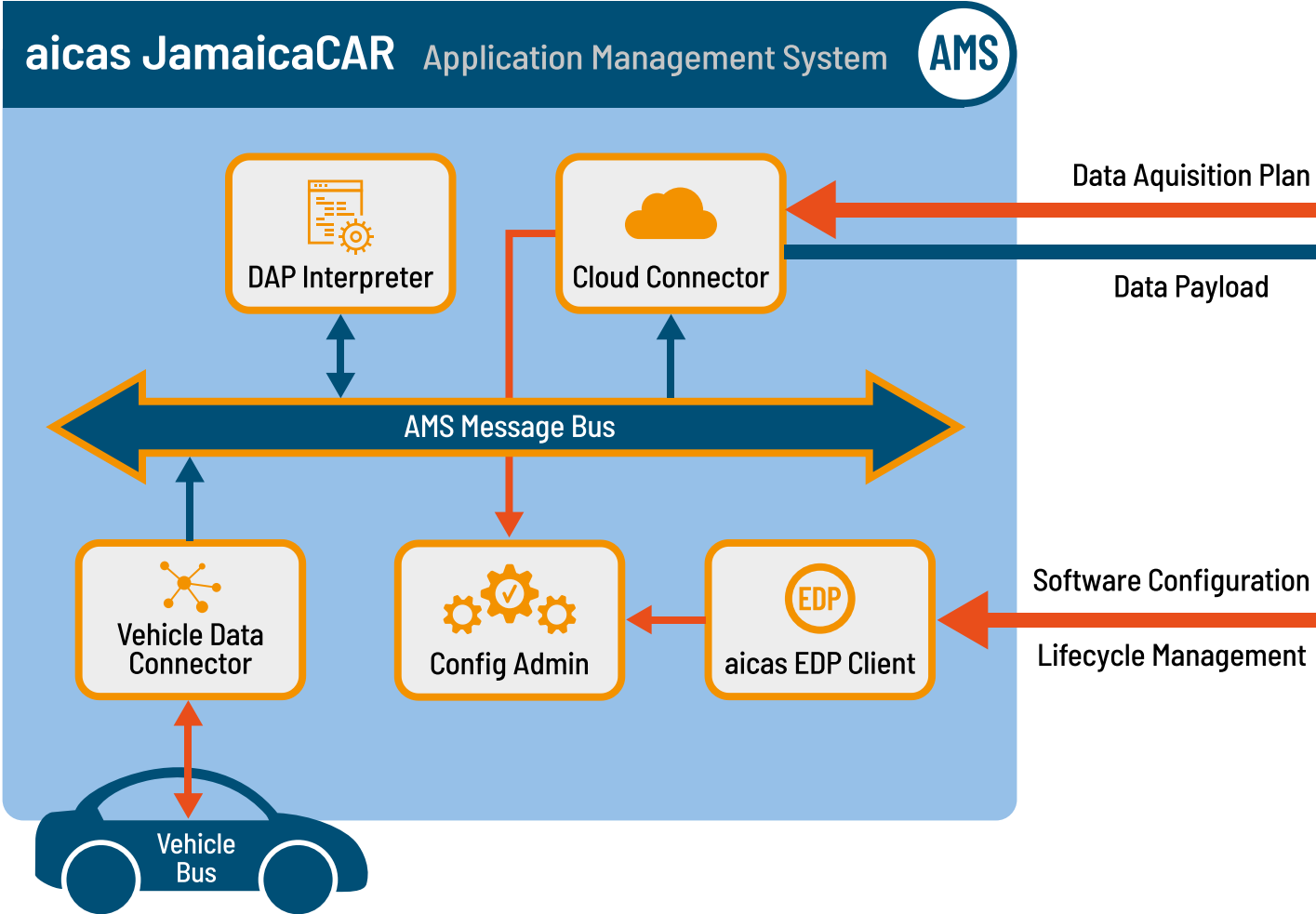
Rules w/ Fixed Operations

- Downloadable Rules
- Predefined Signals
- Predefined Operations
- Frequency Control
- Event Triggers

Dynamic Network & Nodes

- Network of Nodes
- Dynamically Updatable
- Dynamically Defined Nodes
- Based on Application Framework
- Eases Merging Multiple Data Acquisition Plans
- VSS selfawareness

Data Collection Architecture in Vehicle



Data Acquisition Plan Examples

1. Conditional

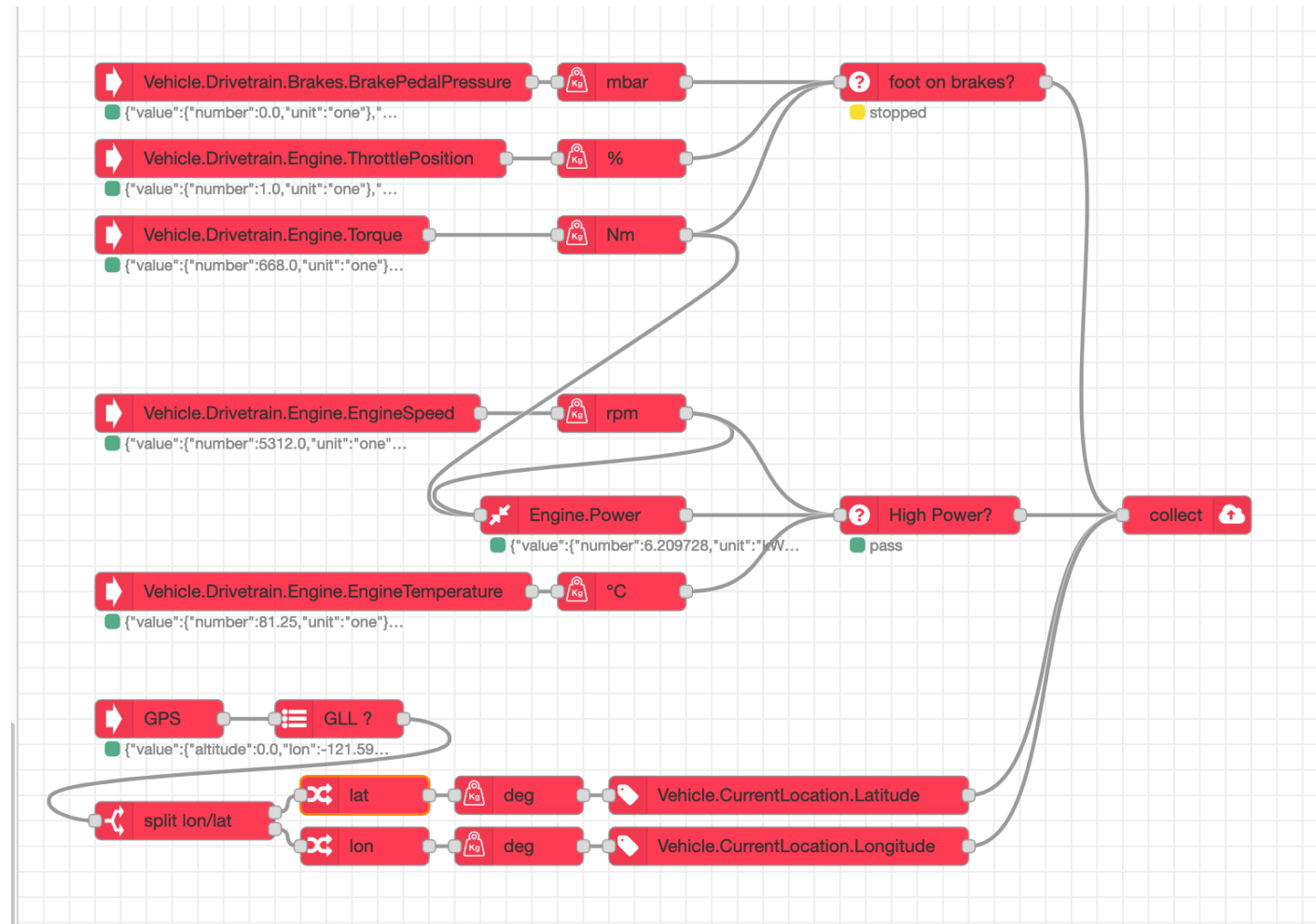
Pressure on Brake & Throttle

2. Synthesis

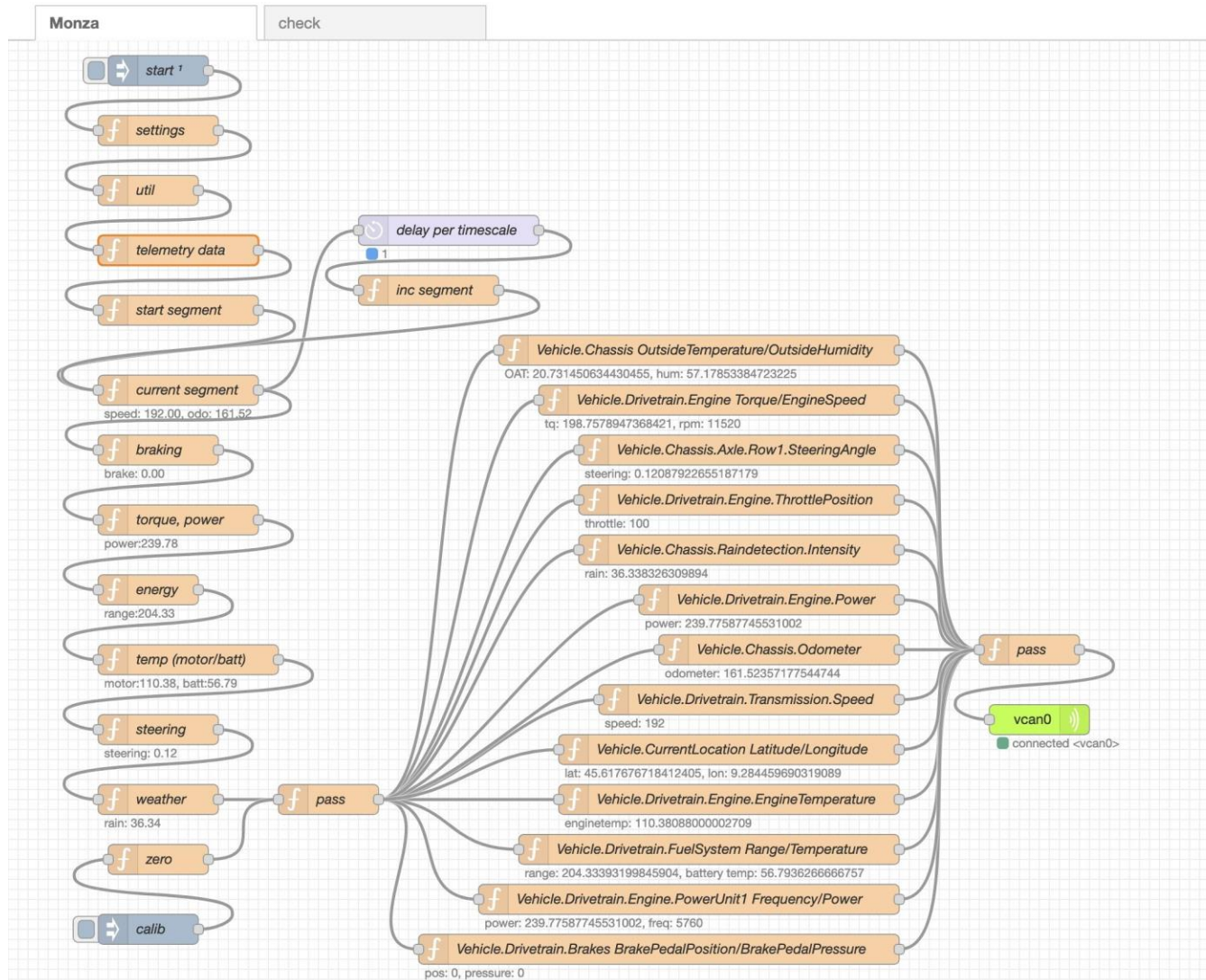
Power from RPMs & Torque

3. Conversion

Device binary or text data stream to VSS signal



Track Data for Simulation



Software Selfawareness: Tracing Software Providence



UN

Global Regulations

Cyber Security and Software Updating

- UNECE r155—vehicle cybersecurity and cybersecurity management systems
- UNECE r156—vehicle software updates and software update management systems

ISO

Guidance and Best Practice

Road Vehicles

- ISO/SAE 21434:2021
Cybersecurity engineering
- ISO 24089:2023
Software update engineering

US Government: EO 14028—SECURING THE SOFTWARE SUPPLY CHAIN

Memory Safety

Why is it important?

- ~70% of Security vulnerabilities are due to lack of memory safety.
- Found in iOS, Android, and Microsoft Products

What does it mean?

- Buffer overrun or out of bounds array reference
- Reference object with wrong type
- Use number as pointer
- Reference object that has been freed

References

- <https://www.memorysafety.org/docs/memorysafety/>
- https://media.defense.gov/2022/Nov/10/2003112742/-1/-1/0/CSI_SOFTWARE_MEMORY_SAFETY.PDF
- <https://www.whitehouse.gov/wp-content/uploads/2024/02/Final-ONCD-Technical-Report.pdf>

DO-332 Memory Safety



Objectives							
Technique	Unambiguous Reference	Fragment Avoidance	Timely Deallocation	Reference Consistency	Deterministic Allocation	Atomic Move	Sufficient Memory
Object Pooling	AC	AC	AC	AC	MMI	N/A	AC
Stack Allocation	AC	MMI	MMI	AC	MMI	N/A	AC
Scope Allocation	MMI	MMI	MMI	AC	MMI	N/A	AC
Manual Heap Allocation	AC	?	AC	AC	MMI	MMI	AC
Garbage Collection	MMI	MMI	MMI	MMI	MMI	MMI	AC

AC = application code, MMI = memory management infrastructure, N/A = not applicable, and ? = difficult to ensure by either AC or MMI.

Signal Data Safety

Why is it important?

- Prevents false interpretation of data
- Provided additional type checking on data transformations
- Ensures robust software defined systems
- Can prevent catastrophic failure when data is used for control

What does it mean?

- Every value is accompanied by its unit of measurement
- This includes boolean values, which should be tristate: on, off, or unknow

Reference

- <https://jcp.org/aboutJava/communityprocess/mrel/jsr385/index2.html>

Framework Requirements

SOA

Flexibly Combine Capabilities

Memory
Safety

Exact Garbage Collection

Realtime
Scheduling

Properly Prioritize Tasks

Life Cycle
Management

Full Control of Software

Software
Signature
Verification

Only Run Validated Software

Versioned
Service
Resolution

Prevent Service Mismatching

Low
Latency

Minimize Context Switch and Serialization

When is Java not Java?

Fairness

Conventional Java

- Base Language
- Undefined Scheduling: assumes fair scheduling
- Relies on JiT for performance
- Little support for interacting w/ hardware

Priority

Realtime Java

- Refined semantics & additional APIs (RTSJ)
- Defined Scheduling: preemptive priority & time-sharing(fair)
- Uses AoT for performance
- Support for events, device access, & interrupts

Advantages of OSGi



Nanoservices

➤ Very small Modules (< Containers)



Service-Oriented Architecture

➤ Remote controlled deployment and update



Message Based

➤ Life-cycle management w/ version tracking

➤ Service Registry

➤ Standard Typed Data Bus

OSGi Challenge: Robustness and Realtime Scheduling



Problem

System Lockup

- CPU Exhaustion
- Memory Exhaustion
- RT Scheduling makes this worst
 - Priority Preemption

A high priority thread can block all lower priority threads

Solution

Resource Enforcement

- Resource Enforcement (limits)
 - CPU Use
 - Memory Use
 - Thread Creation
- Safe bundle force termination
 - Thread.stop is unsafe
 - Ensure that finally clauses can run
 - RTSJ: Asynchronous Task Termination
- RTSJ 2.0 provides infrastructure
 - `javax.realtime.control`
 - `javax.realtime.enforce`

Framework Comparison



	Memory Safety	Realtime Scheduling	Software Validation	Service Oriented Architecture	Life Cycle Management	Versioned Service Resolution	Low Latency
AUTOSAR Adaptive	Red	Green	Red	Green	Green	Red	Green
Macchina.io	Red	Green	Red	Green	Green	Red	Green
Container	Red	Light Green	Light Green	Yellow	Light Green	Light Green	Red
Conventional OSGi	Green	Red	Green	Green	Green	Green	Green
Realtime OSGi	Green	Green	Green	Green	Green	Green	Green

Data Acquisition Plan Deployment Process



Initial Development

- Select signals
- Design Preprocessing
- Test functionality with simulated data

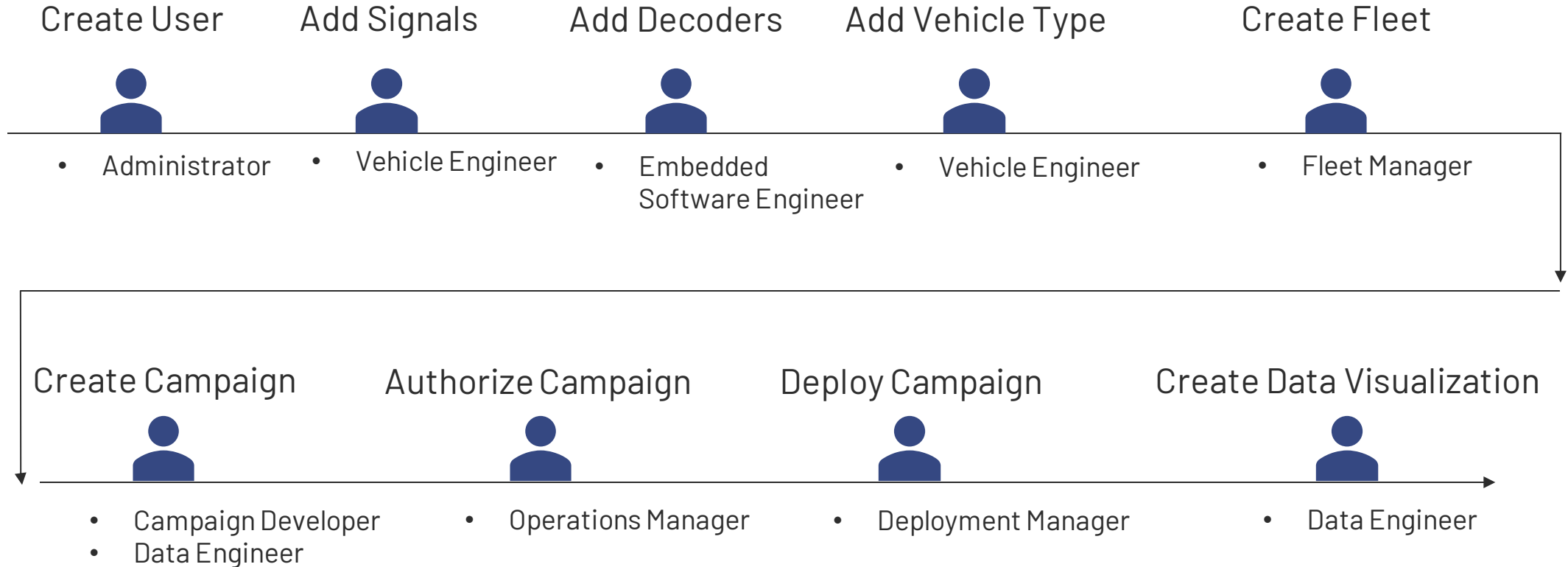
Integration Test

- Test with simulated data
- Integrate with other data collection plans
- Check performance

Deployment Test

- Test with real-world data
- Check performance
- Test usefulness

Role-Based Access UI



Who needs Data Collection? Example Roles and Permissions



Acquisition Element	Create	Read	Use	Authorize	Update	Delete
Vehicle connector	ESW Eng	ESW Eng SW Eng	ESW Eng SW Eng	QA	ESW Eng	ESW Eng Ops Mgr
Enterprise VSS catalog	Vehicle Mgr	Vehicle Mgr SW Eng	Vehicle Mgr SW Eng	QA	Vehicle Mgr	Ops Mgr
DB Schema	IT Eng	IT Eng SW Eng	IT Eng SW Eng	QA	IT Eng	Ops Mgr
Vehicle Data	Vehicle Eng	Vehicle Eng Data User	Vehicle Eng Data User	Vehicle Mgr	Vehicle Eng	Vehicle Mgr Ops Mgr
Vehicle Definition (VSS)	Vehicle Eng	Vehicle Eng Data User	Vehicle Eng Data User	Vehicle Mgr	Vehicle Eng	Vehicle Mgr
Fleet	Fleet Mgr	Fleet Mgr Data User	Fleet Mgr	Deploy Mgr	Fleet Mgr	Fleet Mgr
Data Acquisition Plan	Data User	Data User	Data User	Deploy Mgr	Data User	Data User
Campaign	Data User	Data User	Data User	Ops Mgr	Data User	Data User
Visualization Template	UI Design	UI Design Data User	UI Design Data User	Data Mgr	UI Design	UI Design

Summary

1. VSS is a great contribution to interoperability for automotive data collection
2. Use industrial standard data transmission protocols: Sparkplug
3. Vehicles should be self-aware (maintain their own VSS description)
4. A flexible means of selecting, preprocessing, and sending data is needed
5. Signal data should always carry its unit of measurement
6. Secure software defined data collection requires a memory safe framework
7. Processes, rolls, and responsibilities are necessary for dynamic data collection



Simplify Edge-to-Cloud

aicas. embedded. connected.

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AUTOSAR SWOT Analysis



Strengths

- Standard
- Automotive Focus
- Model Based (XML)
- Modular

Weaknesses

- Poor interoperability
- Reinvents the wheel
- Overly static
- No open reference implementation

Opportunities

- Could become more open
- Could improve binary compatibility
- Could align with other standards

Threats

- Inadequate for the Software Defined Vehicle
- Not well aligned with other standards
- High Cost of use.

Data Acquisition Plan Examples

**W/O
CODING**

Tailored Data Acquisition Plans

- Collect all required data; no more, no less.
- Graphically editable.
- Safe and secure update.

SIMULATE

Rapid Turnaround

- Off-board testing.
- Same tools for data generation.
- Generate VSS defined signals.

Vehicle Signal Specification SWOT Analysis

Strengths

- Single language for sensors & actuators
- Open Standard
- Logically structured
- Extendable

Weaknesses

- Lacks rigorous definition (DDT)
- No distinction between definition and use
- Overlay concept lacks structure
- Units of measurement not well handled

Opportunities

- Open standard for defining signals & actuators
- Promotes interoperability of tools & services
- VISS for enterprise communication

Threats

- Overreach: "have hammer, everything is a nail"
- Reduce Data collection to retrieving signal values
- Forcing data communication into a single form