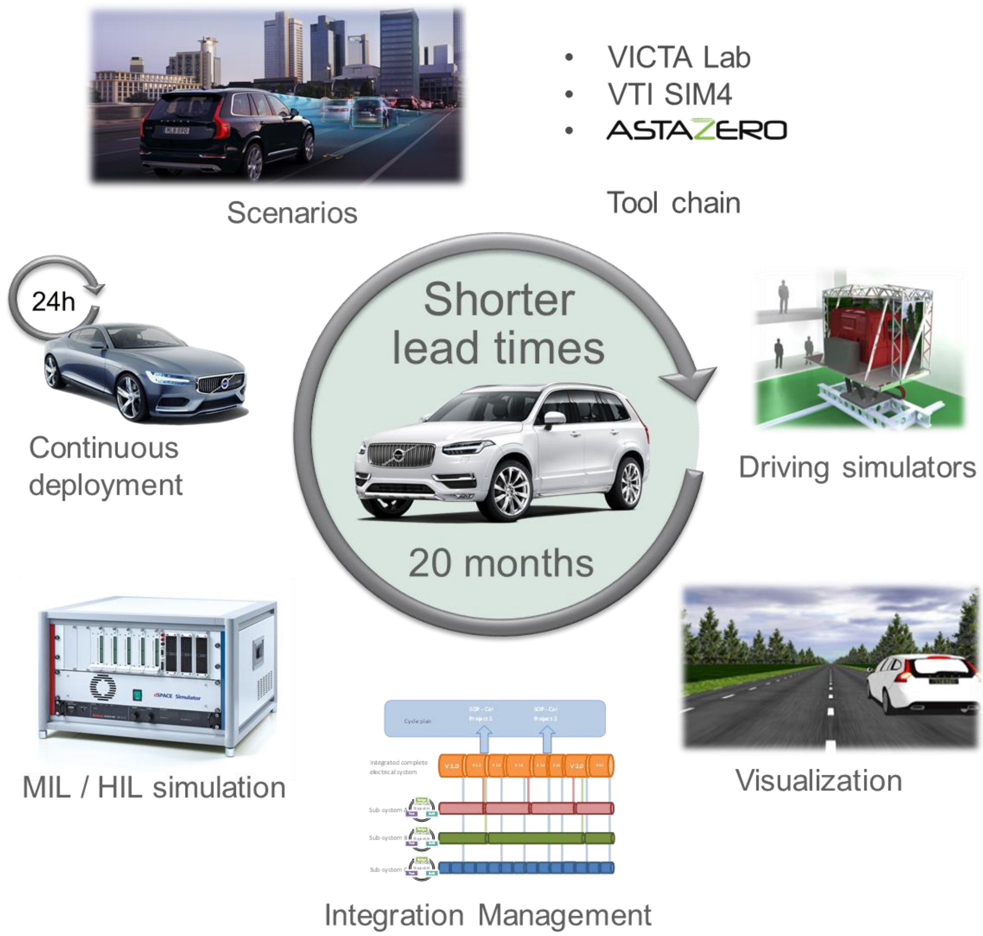
SECOND ROAD PHASE 2

Public report



Project within FFI/Fordonsutveckling

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FFI Fordonsstrategisk Forskning och Innovation

Content

1. Summary

The increased complexity driven by Green, Safe and Connected impact available processes, methods and tools (PMT) for development of automotive electronics and software.

This project, Second Road phase 2, address challenges within the areas of system and function integration, simulation supported verification and continuous roll out. The cornerstone is the creation of a model based infrastructure supporting parallel continuous activities for increased development speed and test coverage, despite reduction of test vehicles.

The project is divided into five sub projects:

SP1 One Virtual Car: Modelling and Simulation of the complete vehicle. Relevant integration tools have been evaluated. The VVA model architecture, the FMI standard and a multi-domain energy flow strategy have been basis for the proof of concept study where the complete tool chain have been exercised. A build server solution has been developed which is a critical contribution to a more efficient model development and integration process.

SP2 Continuous roll out: Possibilities of Continuous Deployment have been explored. A roll out loop has been designed and implemented in a prototype system. The WICE system has been extended with a software download feature, providing a channel for updating vehicle software and receive resulting data logs for further analysis.

SP3 Virtual auto-drive: Test automation and traffic scenarios. Volvo Cars and VTI has joined the OpenSCENARIO project to establish an industry-wide open standard file format for description of traffic scenarios. Methods and prototype tools for automatic road model generation in combination with GPS simulation makes it now possible to test key active safety features in a much more efficient way. Extensions to test automation including traffic scenarios has been established.

SP4 Integration management: Continuous Integration process and tools. An initial pre-study investigates how other large scale non-automotive companies applies agile approaches, and how to transfer ideas to automotive development. Frequent integration, key performance index monitoring and continuous improvement are important factors. Based on these findings a new process and tool requirements have been developed. A central continuous integration team and tool chain have been established as an effect.

SP5 Open Innovation Lab: 3rd party innovation and development support. A simulator has been developed and installed in the open VICTA lab located at Lindholmen, Gothenburg. The simulator architecture and functionality is based on three dimensioning use cases within the domains of active safety and infotainment. Source code of key modules have been published as open source. The lab is now officially open for 3rd party researchers and developers.

2. Sammanfattning på svenska

"Sammanfattning på svenska" shall be written in Swedish and shall be a compressed version of the report, not just a translation of the summary.

Effekterna av ständigt ökande komplexitet drivet av Green, Safe och Connected utmanar befintliga processer, metoder och verktyg (PMT). Detta projekt adresserar dessa utmaningar inom områdena system- och funktionsintegration, simuleringsbaserad verifiering och kontinuerlig utrullning av funktionalitet. I centrum står utveckling av en modellbaserad infrastruktur som stödjer parallella, kontinuerliga och täckande provningsaktiviteter för snabbare utveckling trots färre provbilar.

Projektet är uppdelat i fem delar:

SP1 One Virtual Car handlar om modellering och simulering av det kompletta fordonet. Relevanta integrationsplattformar har utvärderats. Modellarkitekturen VVA, FMI-standarden och ett nyutvecklat koncept för energiflöden mellan domäner har utgjort basen för en proof-of-concept där hela verktygskedjan har testats. Dessutom har en byggserverlösning etablerats vilket är ett kritiskt bidrag till en mer effektiv process för utveckling och integration av modeller.

SP2 Continuous roll out har utforskat möjligheterna med kontinuerlig utrullning. Konceptet innebär att varje liten mjukvaruuppdatering ska kunna följas genom olika faser: Nedladdning till bil, mätning av dess effekter – även subjektiva åsikter från bilanvändaren, analys av feedback och i slutändan input till nästa uppdatering eller justering. Processen, den s.k. roll-out loopen, har designats och delvis implementerats i ett prototypsystem som provkörts mot fysiskt provbil. Mycket återstår innan detta koncept kan tillämpas på kundbilar, men det är nu redo för provbilar.

SP3 Virtual auto-drive adresserar trafikscenarier och testautomation. Istället för att utveckla ett eget format har Volvo Cars och VTI valt att ansluta sig till OpenSCENARIO[1], ett öppet projekt med målet att etablera en branschstandard för beskrivning av trafikscenarier. Genom utveckling av GPS-simulering samt metoder och prototypverktyg för automatisk produktion av vägmodeller är det nu möjligt att testa nyckelfunktioner inom Active Safety på ett mycket mer effektivt sätt. Delprojektet har också bidragit till att etablera testautomation med stöd för trafikscenarier.

SP4 Integration Management fokuserar främst på processer och verktyg för kontinuerlig integration av fordonets elsystem och funktionalitet. Initialt utfördes en förstudie som undersökte hur stora företag i andra branscher lyckats tillämpa agila utvecklingsmetoder och hur idéer kan överföras till Automotive. Frekvent integration, bevakning av nyckelindikatorer och kontinuerlig förbättring är viktiga faktorer. Delprojektet har bidragit till etablerandet av ett centralt Continuous Integration-team samt ett nytt FIP-verktyg som redan används skarpt i nya mjukvaruprojekt på Volvo Cars.

[1] http://www.openscenario.org

SP5 Open Innovation Lab syftar till att involvera tredje part i utveckling och innovation av framtidens transportlösningar. Första steget har tagits genom att utveckla och installera en körsimulator i VICTA Lab[2]. Simulatorns arkitektur och funktionalitet är baserad på Volvo Cars nya SPA-plattform samt en rad use-cases inom Active Safety och Infotainment. Labbet är nu officiellt öppnat för forskare och utvecklare.

3. Background

The expectations on tomorrow's cars are sky high. Connectivity and self-driving capabilities require extreme measures in software and electronics development. The ways of work also need to be innovated. Software oriented companies provides inspiration in terms of agile methodologies and continuous deployment concepts. Combined with state of the art modelling and simulation based technologies we prepare to meet the challenges.
Through previous FFI-projects Mozart (2005-2009) and Second Road phase 1 (2011-2013) a Hardware- and Model-In-the-Loop (HIL/MIL) simulation infrastructure has been established that supports integration of the complete vehicle in a pure software or laboratory environment.

With this infrastructure in place the focus is now raised to the next level of PMT challenges: Methods to cope with complex models. And by involving virtual roads and simulated traffic scenarios we can test functionality on a complete system level. Another enabler is test automation that not only will increase rig utilization, but will be a critical component in a continuous integration tool chain that will be essential for fast growing software.

Looking even further ahead we should prepare for a continuous deployment loop, where user and vehicle data is made available real time for analysis on which continuous improvements are based. Last but not least, the connected car is becoming a system in a system. This opens up for functions and services of all kinds - sky is the limit. We need to establish platforms and arenas for 3rd party involvement to provide competitive products and experiences tomorrow.

4. Sub project 1: One Virtual Car

This chapter is a summary. For more information, please see the full subproject report [1].

Partners:

- Altran (project lead)
- Modelon
- Semcon

[2] https://vehicle.lindholmen.se/node/40273

- VCC (Complete Electrical Integration and Chassis/Active Safety teams)
- AB Volvo (Volvo Group Trucks Technology)
- VTI

Purpose, research questions and method

There is a constant need to increase ability to verify and validate vehicles virtually. In order to decrease the need of physical test cars and increase the ability to do more efficient verification and validation in all stages of the development process.

The purpose of this subproject is to provide a complete representation of the virtual vehicle for integration and verification of complex functions, in some cases spanning over several domains such as electronics, thermodynamics and vehicle dynamics.

Addressed problem areas are: How to integrate and execute models that has been developed in different incompatible tools? How physical properties affect each other across different domains? How to cope with complex models (delivery process, integration tool chain, Simulink-specific issues of large integrated source code models)? Can the emerging FMI-standard support our use cases? Can we adopt methods and tools from continuous integration frameworks used by the software development community?

The overall method is:

1. Define requirements in terms of a representative proof of concept
2. Systematic evaluation and comparison of currently available tools
3. Work on a set of specific problems (separate WPs)
4. Exercise and evaluate the complete tool chain in a final POC

Objective

Describe the objectives of the project as it was described in the application. If the objectives have been changed explain why and how they have changed.

The overall goal is to find ways to shorten the development time for new car models by using simulation based technologies and methods. There is a constant need to increase ability to verify and validate vehicles virtually in order to decrease the need of physical test cars and increase the ability to do more efficient verification and validation in all stages of the development process. The specific objectives of this subproject are:

Platform for multi-domain simulation

To be able to simulate vehicle functionality in a modern car multiple energy flows needs to be considered simultaneously (e.g vehicle dynamics, mechanical, thermodynamics, electrical), and how they affect each other across domains. These are normally studied in specialized teams using specific tools which now need to be re-used at an integrated level. A solution needs to be developed how to integrate these and make it usable for real-time simulations in a HIL environment.

Support for large integrated Simulink models

Several MIL and HIL simulator subsystem environments based on Simulink have been established and are currently in use for development and verification of vehicle functions. Today models need to be modified by hand in order to be integrated and used simultaneously on the complete vehicle level. Such modifications are not only tedious but are also unwanted from a quality assurance perspective. The objective is to enable efficient reuse of models and test cases between the simulation environments. A common architecture is needed that supports model components. One possible way to componentize Simulink models is by utilizing the FMI (Functional Mock-up Interface) standard. An additional approach to get separation is by means of an AUTOSAR aware integration platform where separate controller models are integrated in AUTOSAR SWC's.

Automated integration of model deliveries for MIL/HIL

Teams that deliver models need support for testing deliveries without access all licenses and tools needed for the integrated super-model. A build server will provide a central platform for acceptance testing of models. The build server shall give automatic and detailed feedback to the one delivering the models. This will shorten the lead time from model delivery to up and running in the integrated environment, and also shorten the feedback loop to the delivering department. Guidelines for the model deliveries need to be established.

Results and deliverables

Describe the results and deliverables of the project and how they have contributed to the objectives of the FFI-program both for the program in general and for the specific sub program in particular.

How have the goals been reached? Comment on deviations, both positive and negative

The selected use case, that drives the proof of concept, is a hybrid high voltage battery that is part of the energy balance of the vehicle, both in general electrical way and that the electrical energy is converted to propulsion of the vehicle and included in the thermal handling of the vehicle. The battery can require climatization to keep better performance. The propulsion and stability of the vehicle is involving many actors.

The POC setup consists of controllers and plants based on available software models from VCC in-house development teams. Additional software models are included in the full setup to fill out the behaviour of additional ECUs to varying degree. In some cases simple logic describing controller behaviour or dummy signals are enough. With models coming from a VVA structured MIL simulation one benefit from that the base models are already integrated in one environment, assuring logically connections and thus avoiding related issues. This is thoroughly described in [1].

Three commercial integration platform tools have been evaluated: Silver (QTronic), CANoe (Vector) and VEOS (dSPACE). All three of the evaluated toolchains have very similar functionality for our simulations purposes but since CANoe utilizes information from the database in an easy and straightforward way to set up the network communication into a working bus simulation it became the recommendation from the evaluation to be used for the POC. In addition the Volvo GTT in-house developed tool Adapt has been tested and successfully validated by comparison to Vector CANoe simulation results.

In summary all goals have been reached. Relevant integration tools have been evaluated. The VVA model architecture, the FMI standard and a multi-domain energy flow strategy have been basis for the proof of concept study where the complete tool chain have been exercised successfully with a representative sub system including both plant and controller models. A build server solution has been developed which is a critical contribution to a more efficient model development and integration process.

5. Sub project 2: Continuous roll out

This chapter is a summary. For more information, please see the full subproject report [2].

Partners:

- Semcon (project lead)
- VCC (Complete Electrical Integration and Climate Control teams)
- Alkit.

Purpose, research questions and method

The long term purpose of the subproject is to allow vehicle manufacturers to deliver adapted software functionality with extremely short lead times over the air. The goal is to achieve a faster feedback loop during development than is currently feasible to increase quality of the software system.

There are a lot of questions to explore in this area, both legal and technical. This project focus on a set of technical ones: Which use cases, from a test perspective, will be possible once a continuous deployment loop is established? How can Big Data approaches contribute to the analysis phase? What are the bottlenecks in the current development and test process?

The overall method has been to explore ideas, test concepts and learn by developing a proof of concept system. The major activities have been:

- Identify a set of use cases based on VCC Climate Control team input
- Define the overall roll out process
- Design the loop framework software architecture
- Implement and demonstrate a proof of concept

In addition, a pre study on Big Data and Machine Learning was performed to explore how Big Data and Machine Learning can be used in the context of connected cars and continuous integration.

Objective

Describe the objectives of the project as it was described in the application. If the objectives have been changed explain why and how they have changed.

Given an over-the-air (OTA) communication link between a backend and the vehicle, a collect-update-deploy loop can be established delivering improved functions to the user based on automatic usage reports. The objective of this subproject is to establish a proof of concept framework on which ideas can be tested and demonstrated. This is an important step towards adopting continuous deployment.

The initial ambition was to have a fleet of ten test vehicles involved in the proof of concept. However, due to limited access to test vehicles we had to adjust the strategy. Physical vehicles could be replaced by simulated ones accessible via the backend, so from the framework point of view physical and simulated vehicles are identical. One physical test vehicle was available for a set of tests which were valuable for full system validation and demonstration purposes.

A key component of a super-fast roll out loop is test automation. Driven by complexity and continuous integration test automation has gained a lot of focus the last couple of years. A dedicated in house team at VCC has been established developing a test automation framework, fairly named Awesome Framework. This framework provides a key component to the roll out loop concept, however it was not possible to integrate it in the POC during the time frame of this project.

Results and deliverables

Describe the results and deliverables of the project and how they have contributed to the objectives of the FFI-program both for the program in general and for the specific sub program in particular.

How have the goals been reached? Comment on deviations, both positive and negative

Use cases
To establish common ground for all project partners and to get a picture of potential application scenarios for a wireless roll-out technology all project partners were involved in developing a set of use cases briefly described below.

Parallel Roll-out covers two basic cases: 1. Test identical SW in many cars at different geographic locations, for example to test climate control under different conditions. 2. Test multiple SW candidates in similar environment, typically at the same geographic location, to get comparable test results.

Stepwise Roll out is the concept where new software are pushed to vehicles in number of steps, gradually targeting more and more vehicles. The idea is simply that the expected behaviour of the software can be verified gradually and potential errors can be detected before all vehicles are updated.

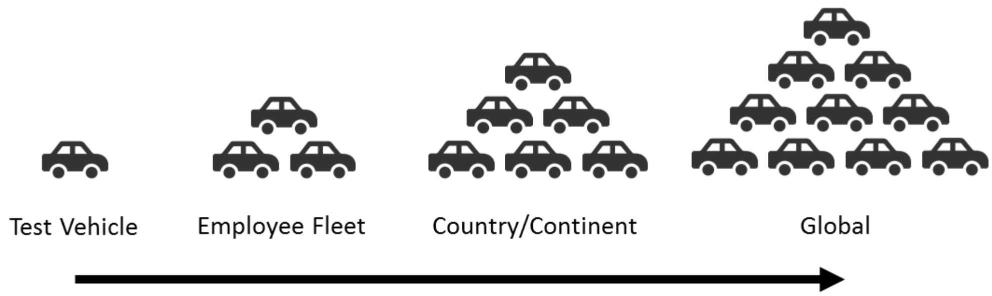

Figure 1: Stepwise roll-out

Subjective Feedback is a use case to get feedback by actually asking a question and receiving an answer - as simple as that. How a customer experiences a specific modification or new function can to some degree be observed by monitoring user behaviour and analysing data from the vehicle. However, sometimes you want to get subjective feedback from a simple question. This can be done either directly in the car HMI or offline via a mobile phone app. A potential opportunity is to generate questions based on very specific observations, for example if the user operates the climate controls in a totally unexpected way. The willingness to answer such questions can also be monitored and affect the probability of the same customer getting another question.

Process and software architecture

The overall process can be described as a loop illustrated below. A Task manager framework coordinate software updates to and measurements from vehicles. Analysis and evaluation of the results are performed outside the vehicle in a backend system. If the task is a bug-fix which is approved the task is closed. In the general case the developing team will receive the analysis results and continue to improve the software. Once a new version is ready it will undergo integration and test activities before handed over to the Task manager framework for the next loop.

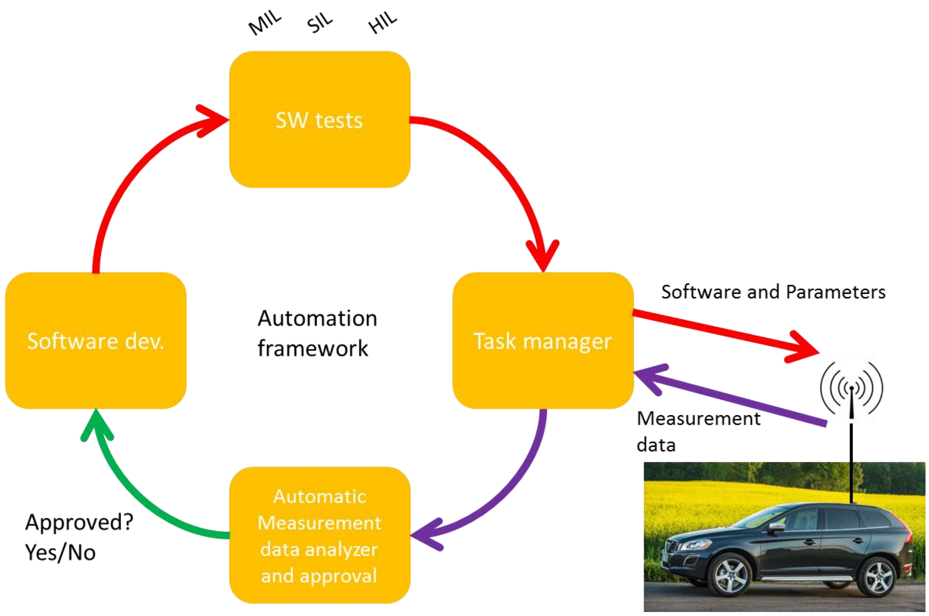

Figure 2: The overall continuous roll out loop

The Automation Framework (implementation of the architectural component Task Manager) developed in this project has a modular design which is achieved by dividing the software components into connectors and modules. Components are connected to each other using a common messaging protocol, MQTT. Replacing modules is thus possible as long as the interface is kept intact.

Wireless vehicle communication

The system used within this project for downloading software, performing measurements and uploading resulting data logs and reports is WICE. It is a product developed by Alkit primarily targeting test vehicle fleets. It consists of in-vehicle hardware units hooked up to the vehicle communication buses and in the other end connectivity and telematics services communicating to a backend platform.

The main result and contribution to this project is a remote SWDL function implemented in the WICE telematics system and a corresponding API which enables the automation framework to schedule and perform software upgrades on test vehicles equipped with WICE telematics units.

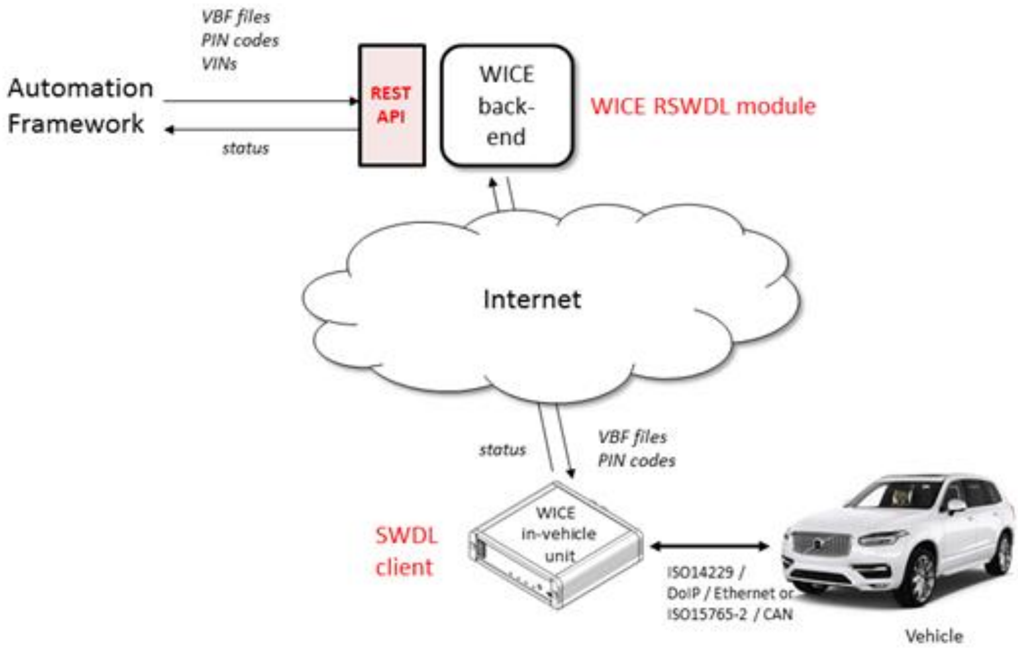

Figure 3: WICE system overview

Summary

The technical goals have been fulfilled. A roll out loop has been designed and implemented in a prototype system, Automation Framework. The WICE system has been extended with the critical software download feature, providing a channel for the Automation Framework to update vehicle software and receive resulting data logs for further analysis.

Test strategy use cases have been discussed and provided inspiration for the project. Big Data opportunities have been explored both in a brief pre-study and in collaboration with the BAUD project [3].

Pilot tests were downscaled from the planned 20 cars to a single physical car due to limited test vehicle availability. However this has not significantly affected the scope or result of the project.

6. Sub project 3: Virtual auto-drive

This chapter is a summary. For more information, please see the full subproject report [4].

Partners:

- VCC Chassis/Active Safety CAE (project lead)
- VCC Complete Electrical Integration

Purpose, research questions and method

Verifying that a vehicle is safe and reliable requires more testing than possible using physical test cars only. Virtual test environments makes it possible to perform controlled tests of vehicle functionality on all levels, from single components up to the complete integrated vehicle. The ever increasing complexity of the vehicle functionality, primarily driven by connectivity and active safety now also puts our virtual test environments on the critical line. We need to share test cases, including road models and traffic scenarios. We need to increase automatic testing not only to support continuous integration and increase utilization, but also to produce reliable comparable test results.

In this sub project two groups at Volvo Cars, both operating HIL and MIL simulators, have collaborated to establishing a common traffic scenario format and to integrate traffic scenario simulation with a common test automation framework, Awesome Framework, being developed in parallel. Basically, Awesome Framework defines the actions of the Ego vehicle under test while the Scenario covers everything outside that vehicle, i.e. road, environment and traffic.

At the start of the project no common traffic scenario format existed. Each simulator tool used native formats making it impossible to run a scenario produced in one tool in any other tool. The central question is: Is it really not possible to define a generic enough traffic scenario format. Are tools to divergent? Are use cases to divergent?

The overall work process and method applied:

- Collect needs
- Define the format
- Adapt the selected simulators to support the format
- Implement and run a pilot scenario

Objective

Describe the objectives of the project as it was described in the application. If the objectives have been changed explain why and how they have changed.

The overall goal is the ability to share and perform automatic virtual tests including traffic scenarios to maximize simulator utilization, reduce MIL/HIL lead times and improve function verification coverage. A critical enabler is a common scenario description format, which was the primary objective of the sub project. Another objective was to adapt a selection of four HIL and MIL simulators at VCC to the new, common scenario format.

The initial plan was to define a native VCC-specific format and the ambition was to adapt four specific simulator environments to understand the new format. However, early on we found out about the OpenSCENARIO[3] project aiming to establish an open, industry-wide scenario description format. After an initial review we found the objectives aligned with

[3] http://www.openscenario.org/

ours, why we decided to put ideas of a VCC-internal format aside and instead join the OpenSCENARIO project. For the definition of the format we can take a more supportive and controlling role, allowing us to reallocate efforts into other critical parts of the scenario tool chain, for example road modelling and GPS simulation.

By integrating with Awesome Framework we could let go of the objective to produce one pilot benchmark scenario since hundreds of relevant test cases already have been produced with Awesome Framework. Instead, a set of common roads and a couple of traffic scenarios have been developed and tested in the target HIL and MIL environments. Necessary adaptations of the simulator environments have been done in order to run the same scenarios.

Since OpenSCENARIO is under development, VIRES native XML-based scenario format has been used for pilot tests during this project.

Results and deliverables

Describe the results and deliverables of the project and how they have contributed to the objectives of the FFI-program both for the program in general and for the specific sub program in particular.

How have the goals been reached? Comment on deviations, both positive and negative

The OpenSCENARIO project

The OpenSCENARIO project started in 2014 between VIRES Simulationstechnologie GmbH[4] and the Automotive Simulation Center Stuttgart[5], supported by a collection of OEMs, among others Daimler and Porsche. The observation is that static content of driving simulation environments can be described in the established tool-independent open OpenDRIVE[6] format. The missing part, the challenge for OpenSCENARIO is to establish a common format adding dynamic elements, typically traffic scenarios and whether conditions, on top of the static content.

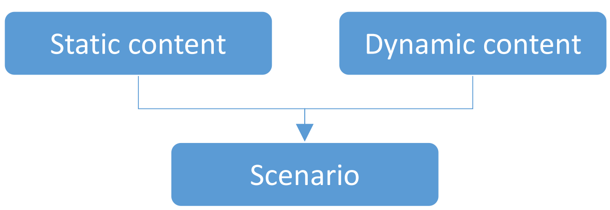

Figure 4: A scenario, in this context, is the combination of static and dynamic content.

The hypothesis is that relevant tools share a considerable fraction of common functionality to motivate a common file format.

[4] https://vires.com/
[5] https://www.asc-s.de/en/
[6] http://opendrive.org/

As of March 2017 the core team, which represents the main stakeholders and contributors, has 24 member partners, among others Opel, BMW, Daimler, Porsche, Volkswagen, Audi, dSPACE and VIRES. Swedish partners are VTI and Volvo Cars. The complete list is found on the OpenSCENARIO project web page.

The OpenSCENARIO format

The file format is based on XML. In addition to a detailed XML-schema a high level description is available in a mind-map format. On the highest level a scenario consists of a road network (reference to OpenDRIVE) and a storyboard of dynamic events. The scenario also identifies participating entities, i.e. road users and objects. So far OpenSCENARIO supports vehicles, pedestrians and static objects.

The storyboard contains a collection of maneuvers types, for example lane change, weather conditions and traffic signals. Maneuvers are triggered by start conditions, for example a vehicle reaching a specific position along the road. A typical scenario is a compound set of maneuvers. For example overtaking can be defined as three sub events: First a lane change left, then passing the vehicle and finally a lane change right.

More information and some examples are available at the OpenSCENARIO download webpage[7].

Road generator tool

Vehicle functions are increasingly dependent on map and cloud data. ADASIS based Electronic Horizon is one example where map data provides information about upcoming road properties not yet visible for the driver or car sensors. Hence, simulator roads need to represent real roads available in the map data.

Manual road modeling using existing tools is too time consuming, not only from an economic perspective. The ability to prepare the simulator for specific test scenarios on short notice is important in an agile development process.

A prototype tool chain has been developed to produce road models for simulator use. Basically, given points A and B on a map it automatically generates a virtual representation of the road segment between A and B. The road data is processed in several steps, e.g. conversion of geographic coordinates, filtering and spline fitting. The result is an OpenDRIVE road description and a 3D model.

[7] http://www.openscenario.org/download.html

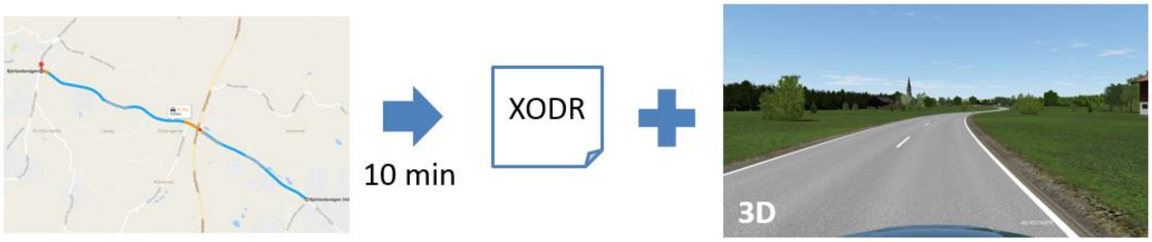

Figure 5: Road generator tool overview.

The process is less than 10 minutes and the files are ready to use in the four target VCC simulators. Most notable limitations are lack of city environments and lacking support for crossings. More information is found in a separate report [5].

GPS simulation

The geographic position of the car is needed for several function areas: Active safety, Autonomous Drive and Infotainment. By predicting the route ahead and consider known properties along that way, for example speed changes, curves, hills and traffic signs, the active safety system can make decisions optimizing the driving w.r.t. safety and economy. This ability of the vehicle to "see" beyond what the driver is capable of, known as the Electronic Horizon (EH), is one example of how active safety makes use of the positioning system. In the Infotainment domain, navigation is the obvious function area.
To support simulation based testing we need to provide GPS input as if the vehicle actually where moving along a route. By simulating the positioning system it is possible to verify related functions in virtual environments.

A pre-study and initial implementation of a prototype GPS simulation concept was developed as part of the Second Road phase 1 project. During Second Road phase 2 the GPS simulator has been further developed into an application that operates in several rigs and test environments, even in real test vehicles (virtually transforming the vehicle to any place on earth)!

The combination of map based roads and GPS simulation makes it possible to verify key Active Safety functions earlier and much more efficient. It has been used to verify EH for Europe and North America. Specific EH properties have been tested and validated on more than 2000 km, namely

- Stable operation of Infotainment ECU, producing the EH signal
- Correctness and availability of road properties in map database on different markets
- Accurate and stable map-matching
- Correct format and content of the output of EH to Active Safety functions

More information regarding the GPS simulator and use cases is available in [6].

Test automation

In parallel and partly supported by Second Road phase 2 a test automation framework, named Awesome Framework, has been developed. It aims to be shared widely between domains and test environments within VCC. The major drivers for Awesome Framework are:

- Test efficiency - more coverage in less time
- For non-programmers - many test designers lack programming skills
- Shorter loops - enabler for continuous integration
- Common test case repository - exploit synergies, share knowledge

There are already hundreds of driving cycle tests defined in Awesome Framework, many of which are executed each night as part of a continuous integration framework. SP3 has contributed with integration of VIRES traffic scenario handling in Awesome Framework by means of the Scenario Control Protocol (SCP). For example, it is now possible for a test case author to specify which scenario (road, environment and traffic events) to use.

7. Sub project 4: Integration management

This chapter is a summary. For more information, please see the full subproject report [7].

Partners:

- Volvo Cars, Electrical Integration (project lead)
- Knowit
- Sellegi

Purpose, research questions and method

Developing a vehicle is a major integration challenge. SP4 focus is to improve integration methods and tools targeting a 20 months automotive development plan. VCC has been the main target company during the project, but recommendations and findings should be applicable for the automotive industry in general.

SP4 contains two work packages: WP1 - Process/Methods and WP2 - Tools. The overall approach has been:

1. Capture the current state and potentials in a pre-study
2. Develop ideas for methods, processes and tools
3. Anchoring the ideas and receive feedback from within VCC, e.g. by interviews
4. Define a new process and tool requirements
5. Extend and adapt the Sellegi ACT tool

The central research question is: Apparently it is possible to adopt agile development processes in large scale companies in successful ways. Would it be possible to apply some concepts also in the challenging automotive industry? And in that case, what is the first plausible steps to be taken?

Objective

Describe the objectives of the project as it was described in the application. If the objectives have been changed explain why and how they have changed.

The ultimate goal is to reduce time to market for vehicle functionality while increasing quality. This can only be done by adopting continuous integration and deployment ideas which is central in agile development frameworks.

This project contributes with a couple of first necessary steps. The first objective is to investigate how other large scale non-automotive organizations have applied agile approaches, and how to transfer successful ideas to the automotive development process.

Next objective is to define, document and communicate a new or improved development process, including key performance indicators. This should be done iterative in order to continuously improve the process based on feedback.

The final objective is to define requirements on a tool to support an agile development process where requirements and time plan are dynamic elements. The Sellegi ACT tool will be further developed into a prototype that can be used for a pilot study within Volvo Cars.

Results and deliverables

Describe the results and deliverables of the project and how they have contributed to the objectives of the FFI-program both for the program in general and for the specific sub program in particular.

How have the goals been reached? Comment on deviations, both positive and negative

The overall finding from the pre-study was convincing arguments supporting that agile methods and processes might fit also VCC/Automotive. The pre-study is documented in the separate report [8].

Findings highlights:

- Frequent integration and agile/lean problem solving seems to be a success-factor independent of company type.
- It is important to identify key performance indicators and monitor these while continuously improving your process.

The problem is basically going from a rigid integration process with few distant release points to a process that supports frequent integration, test and potential shipping of software.

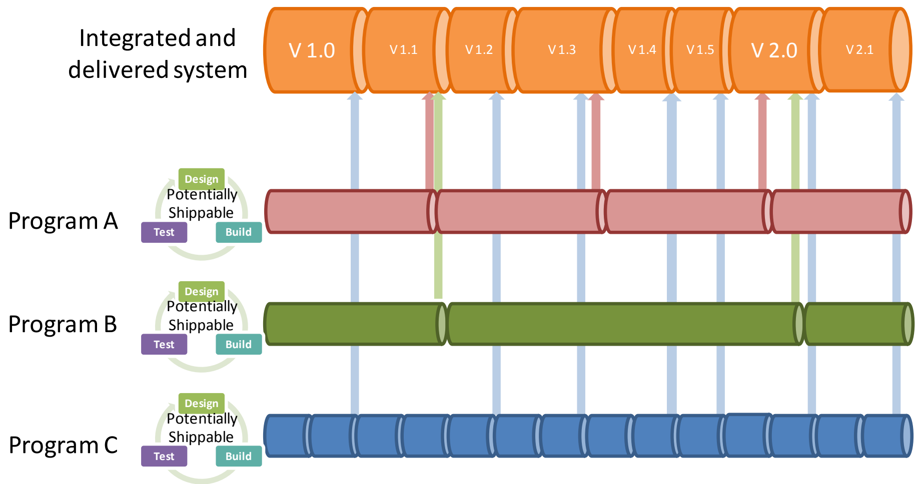

Figure 6: Process supporting frequent integrations and deliveries.

One important strategy to enable this is increased use of Model-In-the-Loop (MIL), Software-In-the-Loop (SIL) and Hardware-In-the-Loop (HIL) technology. Besides enabling early validation, for example testing ideas and concepts by using a software model before the hardware is available, this also reduces development cost compared with verification in physical vehicles.

Key elements of the new process

- Planning includes breaking down the development into functional increments which continuously adds value to the product.
- A functional implementation plan (FIP) built on planning and follow up on functional increments is set up in a tool which allows the coordination between many projects. It should help synchronizing projects to maximize testable scope over time.
- A main track is set up with a repository for all common software which is shared between top hat projects
- Continuous integration is seen as a key enabler for rapid, high quality software integration. This includes an automated integration machine that provides immediate feedback to the organization and the individual developer.
- The following KPI's are introduced:
    - A Cumulative Flow Diagram (CFD) to monitor current status. How far have we come? How much work is left? Will we succeed?
    - A traceability check to follow up on requirements, needs and functions to indicate any functional changes (requirements) that have no planned technical work connected to them?
    - A graph plotted over time that shows the number of issues identified per number of executed test cases and the number of new issues identified per week or functional increment.

Tool requirements

The new FIP tool should address the following needs: Information, operations and views should be designed from different roles perspectives. E.g. as an integration leader I want to see what deliveries require new hardware for the next integration event. It should allow for simultaneous use by many, at least 500, users. FIP data should be version handled automatically (and backed up of course).

Effects

The SP4 sub project was finished 2015, one year ahead of the others. At the time this report is written a new FIP tool (FIP2) has been developed and pilot tested. It is currently being rolled out within selected parts of VCC working with all new software projects, targeting car models reaching the market from year 2019 and forward, where it is a critical tool for monitoring and controlling software integration.

Mid 2016 a dedicated Continuous Integration team was set up at Electrical Integration department. Their mission is to establish a process and tool chain for software integration and test on all levels, from sub system to the complete vehicle. As of today (2017-05-30) this “Integration Machine” are running hundreds of tests each night, on different system levels and using different test environments, including box cars and HIL rigs.

Needless to say, these are major steps forward, directly building on contributions from SRF2.

8. Sub project 5: Open Innovation Lab

This chapter is a summary. For more information, please see the full subproject report [9].

Partners:

- RISE Viktoria, former Viktoria Swedish ICT (project lead)
- HiQ
- Semcon
- Volvo Cars (integration environments)
- VTI

Purpose, research questions and method

The goal of SP5 was to establish a driver-in-the-loop simulator for the testing of advanced user visible functions; e.g. infotainment, HMI, and active safety. The simulator shall be representative for the SPA platform developed by VCC, and compatible with the Sim4 simulator developed by VTI. The simulator will be a central part of VICTA Lab (lead by

Vehicle ICT Arena)[8], which aims to offer a development and test facility to support third party involvement adding content and functions to future vehicles, securing innovation and competence supply for the vehicle industry in Sweden.

A central question for the project has been: What kind of use cases are most relevant for 3rd party involvement and how should this affect the architecture of the simulator?

SP5 have followed an iterative approach with short sprints, a common backlog of issues and work topics, and internal as well as external demos for feedback and learning. Demo cases was defined in the beginning of the project based on stakeholder interviews. The demo cases were used as requirements on the simulator during development, and finally implemented for Proof-of-Concept.

Objective

Describe the objectives of the project as it was described in the application. If the objectives have been changed explain why and how they have changed.

The first objective was to capture the need and requirements on the simulator in a use case specification (milestone 1). The next objective was to establish and document an architecture that serves the use cases and other important aspects such as maintainability and easy integration of 3rd party applications (milestone 2).

To support interactive testing and demonstration of vehicle features a physical driving interface is needed for the simulator (milestone 3).

The central objective, represented by Milestone 4, was the complete driver-in-the-loop simulator, integrating a model representation of a Volvo XC90 functions and a separate HMI lab platform. Milestone 4 also include documentation of the simulator to support usage and maintainability.

The final milestone 5 includes implementation and demonstration of a set of demo cases in the simulator. An additional objective was to investigate how to make the high fidelity simulator VTI SIM4 compatible with Open Innovation Lab and the current SPA electrical platform.

Results and deliverables

Describe the results and deliverables of the project and how they have contributed to the objectives of the FFI-program both for the program in general and for the specific sub program in particular.

How have the goals been reached? Comment on deviations, both positive and negative

[8] http://vehicle.lindholmen.se/en

All objectives as described in the previous chapter have been reached. Stakeholder drivers, use cases, architecture, simulator specification, and developer APIs have all been thoroughly documented in separate reports [10] [11] [12] [13] [14].

In addition, a software architecture of a future generic simulator platform has been proposed [15], based on experiences from other industrial domains such as aeronautics. A proof of concept implementation was demonstrated at the SRF2 bazaar 27/8 2015.

Three selected use cases has been implemented and demonstrated at SRF2 project meetings and bazaars:

1. TrustMe providing a visualization of what the vehicle is aware of and plans to do - a window into the mind of the vehicle.
2. Electronic Horizon based Curve Advisor informing about the maximum recommended speed in upcoming curves. It will also warn and brake, if necessary.
3. Driving Style Assistant motivating the driver to improve with regard to safety and fuel economy.

The source code of the demo cases are available at the VICTA lab web page[9].

The source code for the Semcon Secure Gateway, used as a broker between automotive and infotainment domains, has been published as open source at GitHub[10].

9. Dissemination and publications

The Second Road phase 2 project have in effect worked as a regional arena or umbrella for activities connected to virtual verification. Formal associations with consortium ViP and the FFI project Heavy Road opened up for even closer collaborations, for example sharing vehicle and environment models.

More than 50 persons have actively taken part in SRF2. All have been invited to regular quarterly project meetings. Every second project meeting was extended with a bazaar session where results was demonstrated and discussed in more detail. These extended project meetings have been open for selected external participants.

A series of seminars on specific topics have been arranged, primarily for SRF2 and associated partners, but open also for selected external participants:

- 2015-03-11 FMI Technology Day – a full day event combining presentations and workshops on the FMI standard for model exchange and co-simulation.
- 2014-10-23 SAFe, Scaling Agile and Lean to the Enterprise – a half day course on the foundations and ideas based on the Scaled Agile Framework (SAFe)

[9] http://vehicle.lindholmen.se/en/
[10] https://github.com/caran/SecureGateway

Additional public presence:

- SRF2 was presented at the VICTA Innovation Bazaars 2014-09-11 and 2016-02-04.
- SRF2 was presented at Elektronik I Fordon 2016[11]
- SRF2 and Heavy Road joint Final Seminar[12] 2017-05-24, a full day open event mixing presentations and demos to spread insights and results from both projects.
- AstaZero Researchers Day[13] 2015-10-14
- Lindholmen Software Development Day[14] 2015-10-22
- ViP[15] conference 2016-04-26
- VICTA innovation bazaar[16] 2017-03-22

In addition, SRF2 have contributed to the following publications:

- Erik Durling, Elias Palmkvist and Maria Henningsson, “FMI and IP protection of models: A survey of use cases and support in the standard”, The 12th International Modelica Conference 2017, 2017[17]
- M. Johanson, S. Belenki, J. Jalminger, M. Fant, M. Gjertz, "Big Automotive Data - Leveraging large volumes of data for knowledge-driven product development," The IEEE International Conference on Big Data, Washington DC, October 27-30, 2014.[18]

In submission:

- Burden, H, Lind, K, Magazinius, A, and Mellegård, N, ”Drivers and Barriers for New Stakeholder Involvement in an Open Innovation Lab”, 2017

Theses:

- Sundgren, E, ”A structured approach to review and refine architecture documentation”, Bachelor Thesis, University of Gothenburg, 2016
- Theodoridou, P, ”Open Digital Innovation: Emerging Designs in AgileEnvironments”, Bachelor Thesis, University of Gothenburg, 2016
- Andersson, E, Johansson, D, “Model abstraction and connectivity for portable system design”, Chalmers University of Technology, 2017

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12 http://sites.google.com/site/srf2hrseminar
13 http://www.astazero.com/research-and-development/astazero-researchers-days/
14 http://softwareday.lindholmen.se/
15 http://www.vipsimulation.se/
16 http://vehicle.lindholmen.se/evenemang/
17 http://modelica.org/events/modelica2017/proceedings/html/submissions/ecp17132329_DurlingPalmkvistHenningsson.pdf
18 http://ieeexplore.ieee.org/document/7004298

Dissemination summary

How are the project results planned to be used and disseminated?	Mark with X	Comment
Increase knowledge in the field	X	By broad collaborations and regular bazaars
Be passed on to other advanced technological development projects	X	The two FFI projects "Simulation Scenarios" and "Open Innovation Lab" are continuations focusing on common traffic scenarios and 3rd party development.
Be passed on to product development projects	X	SRF2 contributed to: The establishment of a central Continuous Integration team at VCC. A new integration planning tool, FIP2, supporting an agile development process, are currently being rolled out at VCC step by step.
Introduced on the market		
Used in investigations / regulatory / licensing / political decisions	X	In the context of SRF2 VCC and VTI joined the OpenSCENARIO project, potentially contributing to a future certification of autonomous vehicles behaviour in traffic situations. The FFI project "Simulation Scenarios" will maintain a regional link to the OpenSCENARIO project.

Are there links to other internal / external projects that can accelerate the introduction or give greater impact?

10. Conclusions and future research

Summarizing the five sub projects we have contributed to a synchronized great step forward in several strategic areas. Environments and methods for integrating and testing functions on complete vehicle level have evolved from partly virtual (HIL) to pure virtual using models (MIL) and software (SIL) integration. Combined with simulated GPS simulation and map based virtual roads the potential test coverage has greatly improved. Process and tools for continuous integration and automated testing utilizing these HIL and MIL environments has been established.

All in all we have contributed to an automatic integration machine that prepares, integrates and execute functionality on a virtual, representative complete vehicle. There is already hundreds of test cases, many used for regression tests each night. Some of them utilizing the virtual map based roads necessary for many active safety functions. Some technical issues still remain to be solved before scaling up.

Continuous integration and HIL/MIL/SIL are now mature areas. Since winter 2016/2017 a complete team is operating the continuous integration framework. Two teams of in total 30 persons are operating the HIL, MIL environments and a SIL environment is under development.

Continuous roll-out is not yet mature for customer cars, but are now ready to be used for test vehicles, which will contribute to a more efficient analysis of vehicle behaviour and errors. It's too early to make any further conclusions.

Open Innovation Lab is emerging. The VICTA Lab is now officially opened offering a driving simulator very well representing a Volvo Cars SPA based modern car. Even though Volvo Cars not yet provides official APIs for Infotainment and Active Safety domains functionality it is a perfect platform for researchers and students to innovate and learn. This field needs more continuous collaboration between institutes, academia and OEMs. The recently started Open Innovation Lab[19] project will ensure further development.

Another area in need of further development is the standardisation of how to describe traffic scenarios for test track and simulator applications. During SRF2 we joined OpenSCENARIO aiming for an international open standard file format. This work needs to continue in order to establish the format. Additionally we need to improve production of environments in which the dynamic traffic events is to take place. These aspects are addressed by the Simulation Scenarios[20] project.

11. Participating parties and contact persons

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[10] H. Burden, K. Lind, A. Magazinius och N. Mellegård, *Drivers and Barriers for New Stakeholder.*

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