ENABLE-S3
European Initiative to Enable Validation for Highly Automated Safe and Secure Systems

http://www.enable-s3.eu/

Sergio Sáez, Instituto Tecnológico de Informática, Spain

Workshop on Challenges and new Approaches for Dependable and Cyber-Physical Systems Engineering
Warsaw, Poland, 14th June 2019

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Project motivation

How can we make sure that an autonomous system behaves correctly in every situation?

Project consortium

68 Partners / 16 Countries

70 M€ budget

6 Domains (Automotive, Farming, Rail, Maritime, Aerospace, Health)

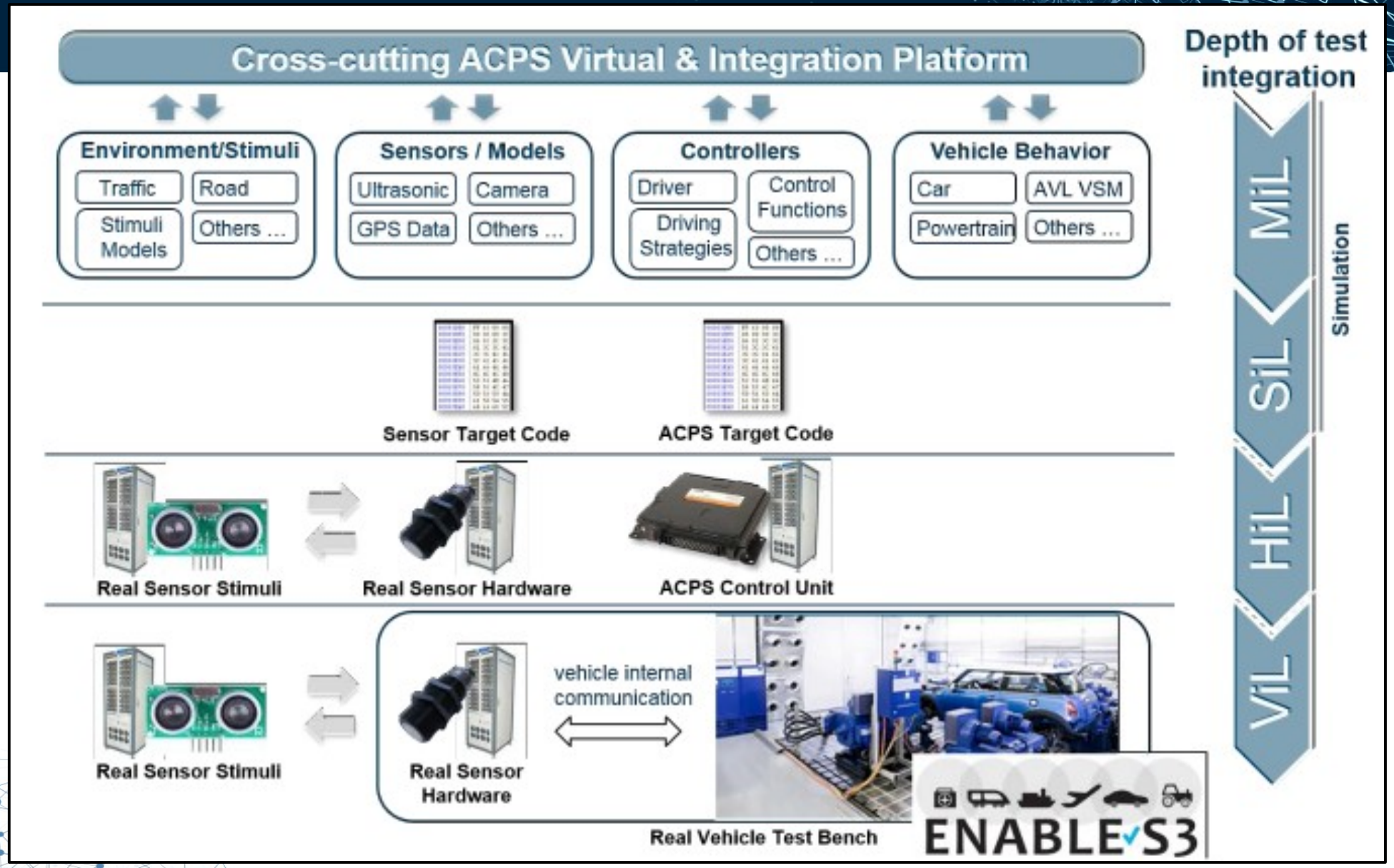
Full Value Chain for automated systems

- 7 OEMs as producer of end-customer products
- 12 Component supplier / tiers
- 5 Academia (highly automated systems)
- **20 Tool suppliers**
- **23 Academia (V&V Methodology)**

Project Goals

- Scenario-based V&V in virtual, semi-virtual and real testing environments
- The collection and/or development of environment and sensor models as well as adequate sensor stimuli for seamless Model / Software / Hardware / Powertrain / Vehicle-in-the-loop testing (MiL, SiL, HiL, PiL, ViL)
- The extraction of test scenarios from recorded operation data by using big data technology
- Risk- and coverage-oriented methods to reduce the number of required tests in highly varying environmental conditions
- Integrated safety and security analysis as well as runtime verification approaches
- Simulation-based approaches for homologation, certification and type approval of ACPS components and systems

Project Goals



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Use Case Work Packages

DOMAINS & USE CASES

RAIL

UC 9
Automated RailwayCommand and Control Systems

AUTOMOTIVE

UC 1
Highway Pilot

UC 2
Intersection Crossing using Autonomous Vehicles

UC 3
Context-Aware In-Car Reasoning System

UC 4
Traffic Jam Pilot with V2X

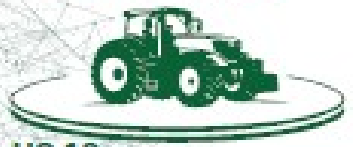
UC 6
Valet Parking

AEROSPACE

UC 7
Touch and Go Assistant

UC 8
Reconfigurable Video Processor for Space

FARMING



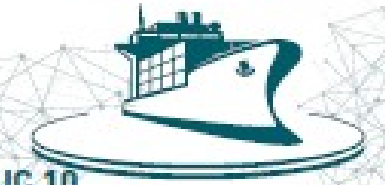
UC 13
Autonomous Control Platform

HEALTH

UC 11
Autonomous Robotic Movements

UC 12
X-ray Imaging Automation

MARITIME



UC 10
Shore Based Bridge/Navigation Centre including Secure Data Exchange

ENABLE-S3 is following an use-case driven approach. This means that the requirements for the project are coming from industrial use cases within the 6 industrial domains and that each technical solution is required by a specific use case.

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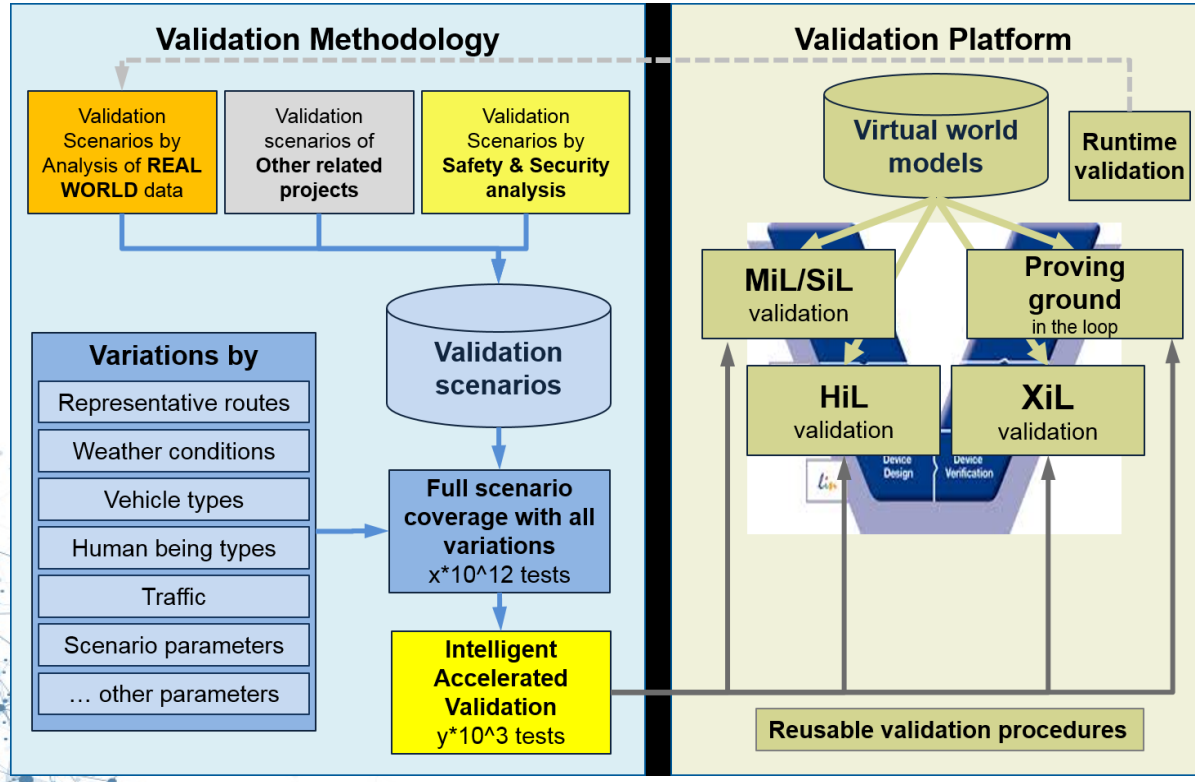
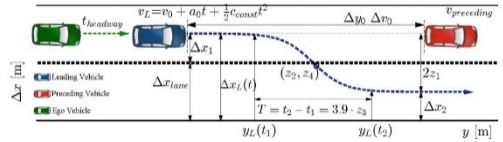
Overview Essential Results



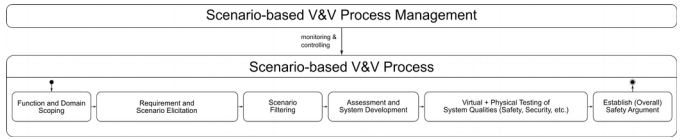
Cross-domain R&D

Best practice sharing

Scenarios and Scenario Classes



Scenario-based V&V methodology



Generic reference architecture

Reusable technology bricks

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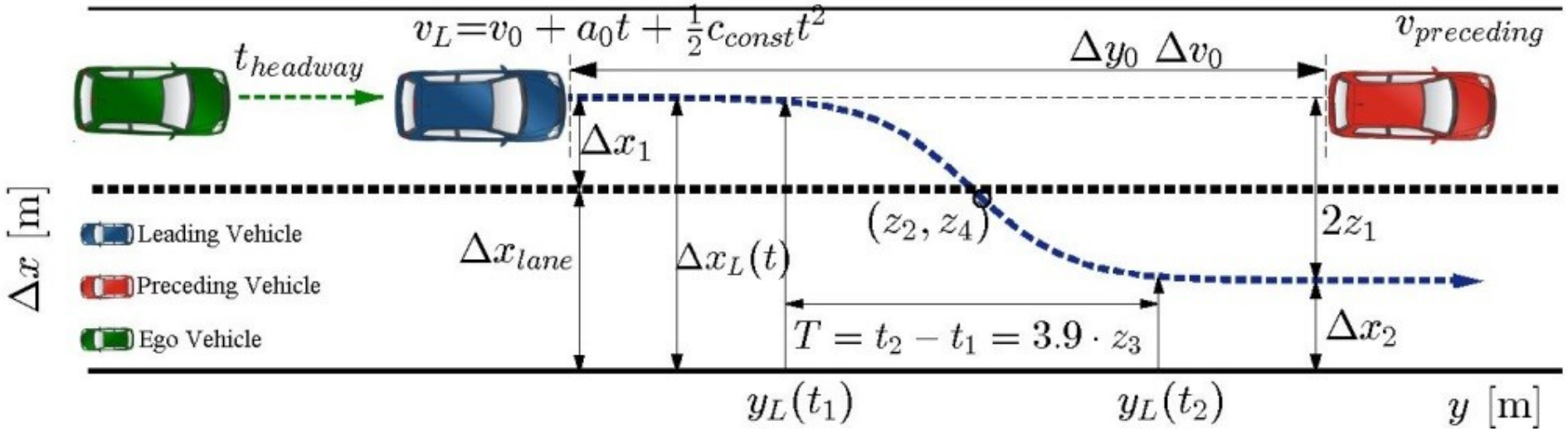
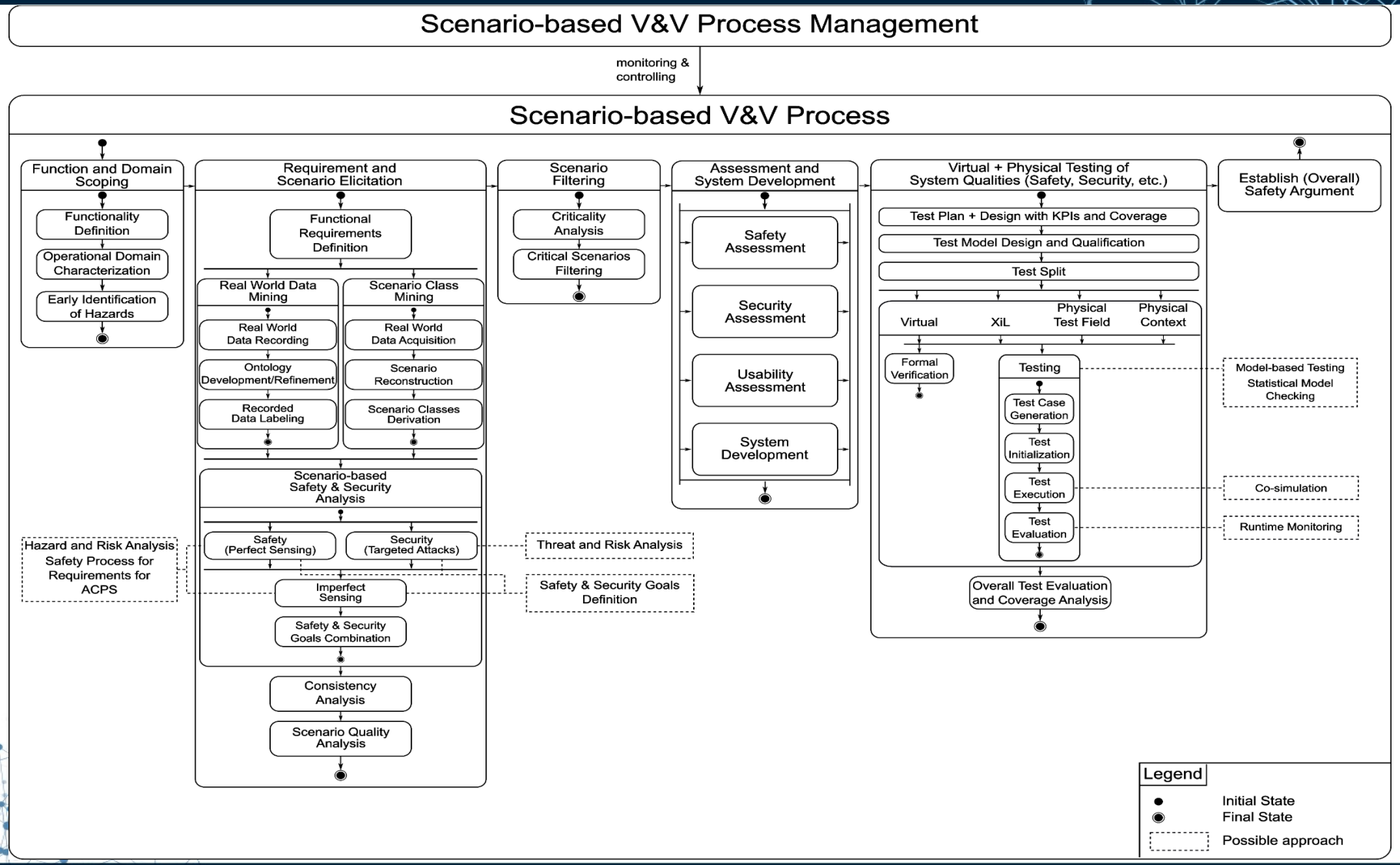
Scenarios and Scenario Classes

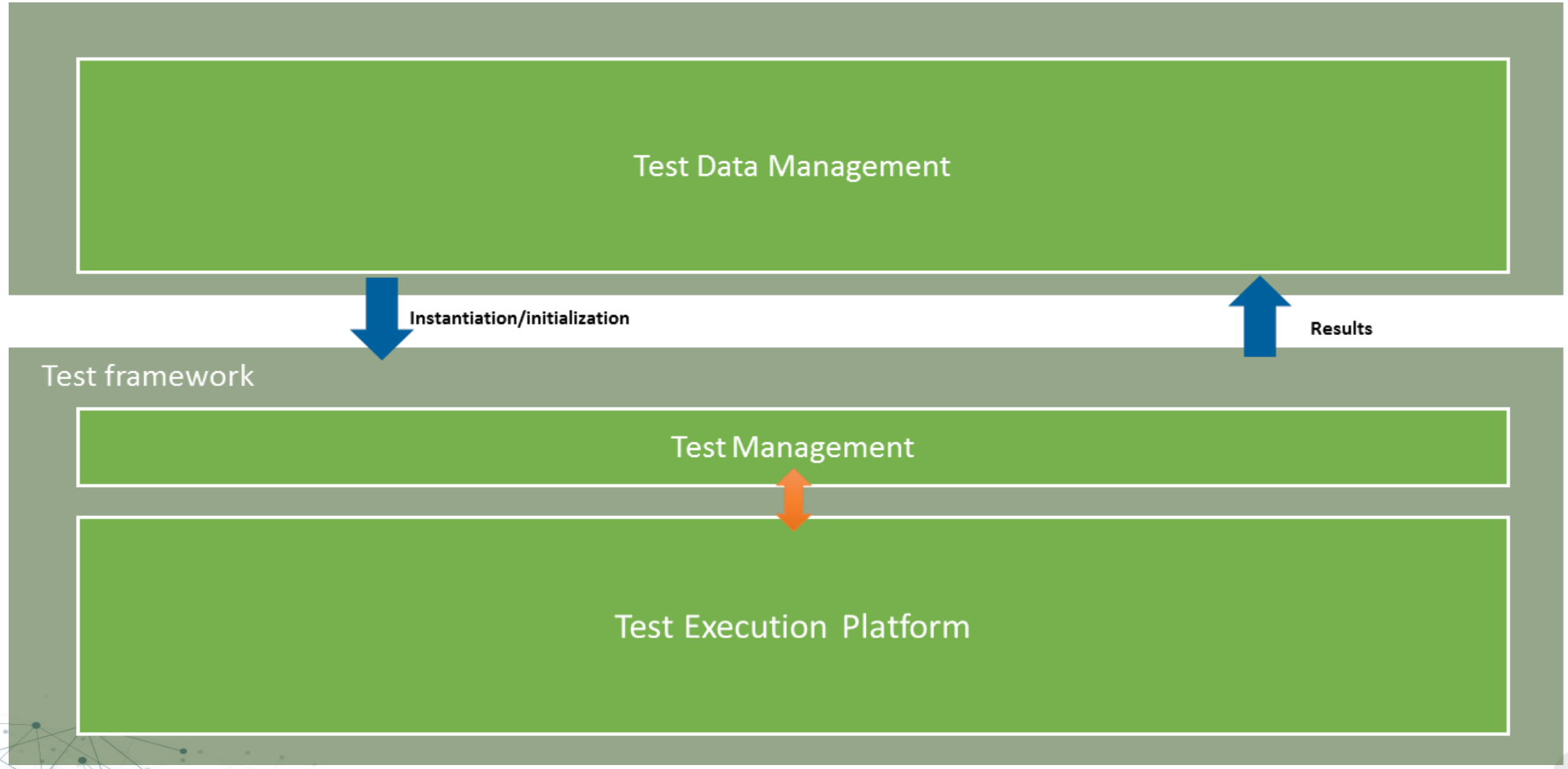


Scenario: all parameters instantiated – e.g specific velocities and distances
Scenario class: parameter ranges – e.g. velocity and distance ranges

Scenario-based V&V Methodology



Generic Test Architecture



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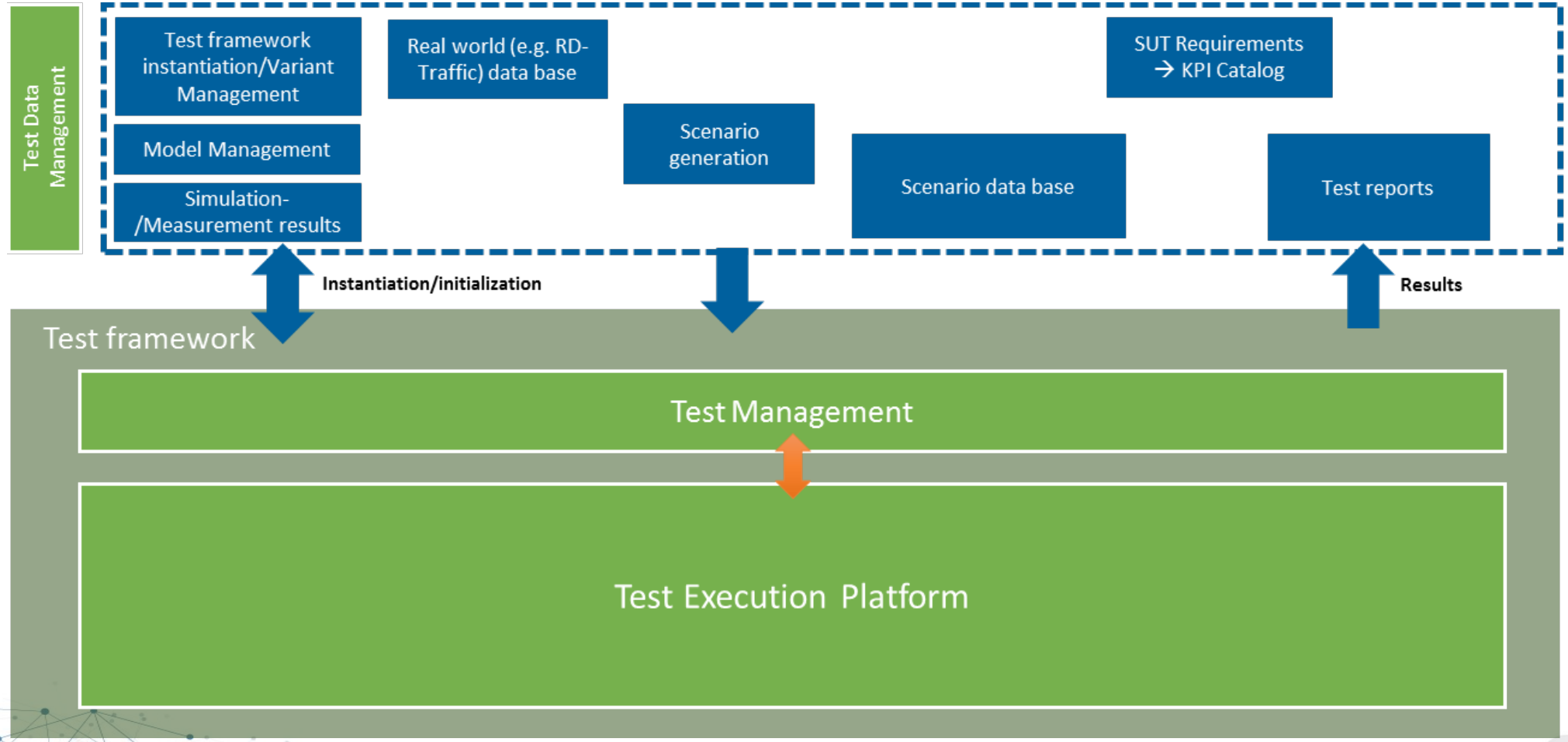

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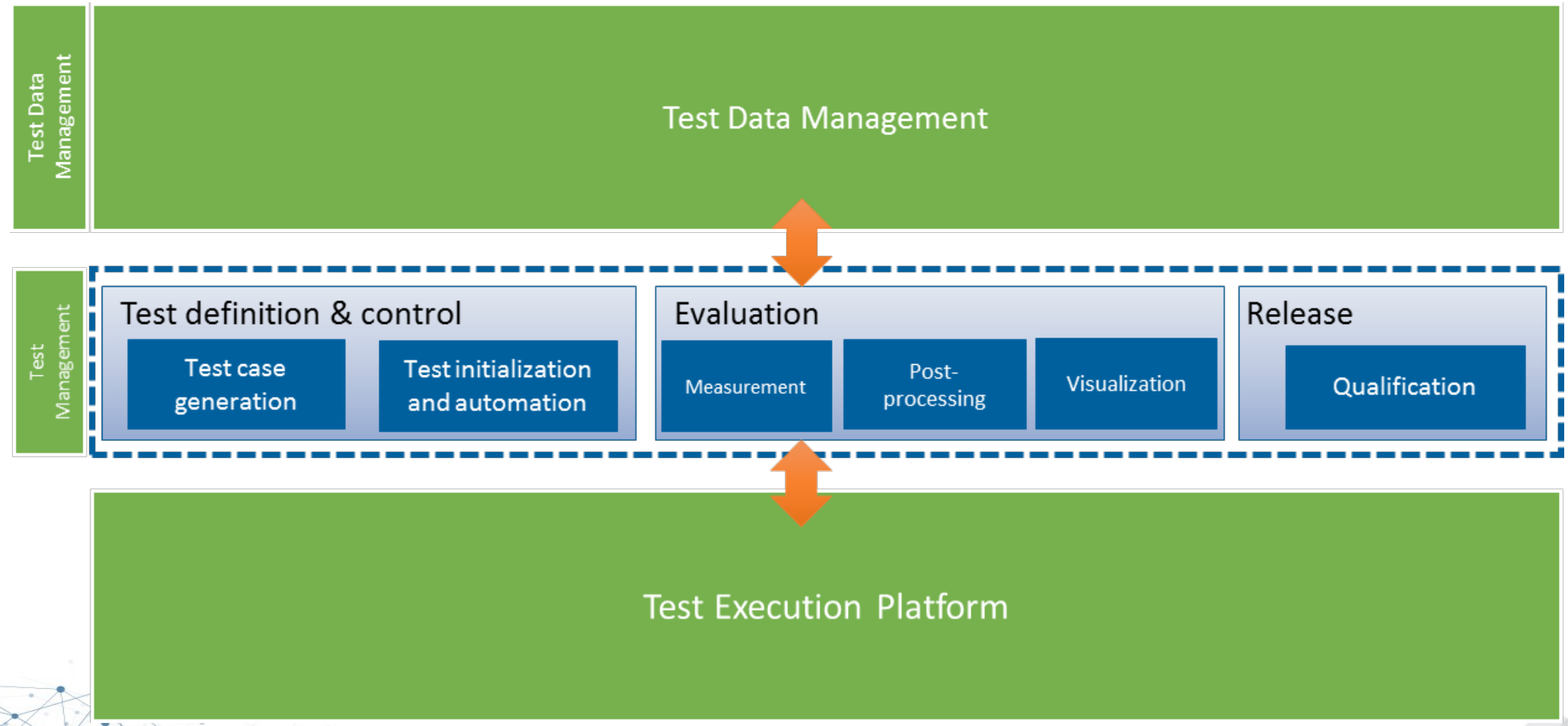
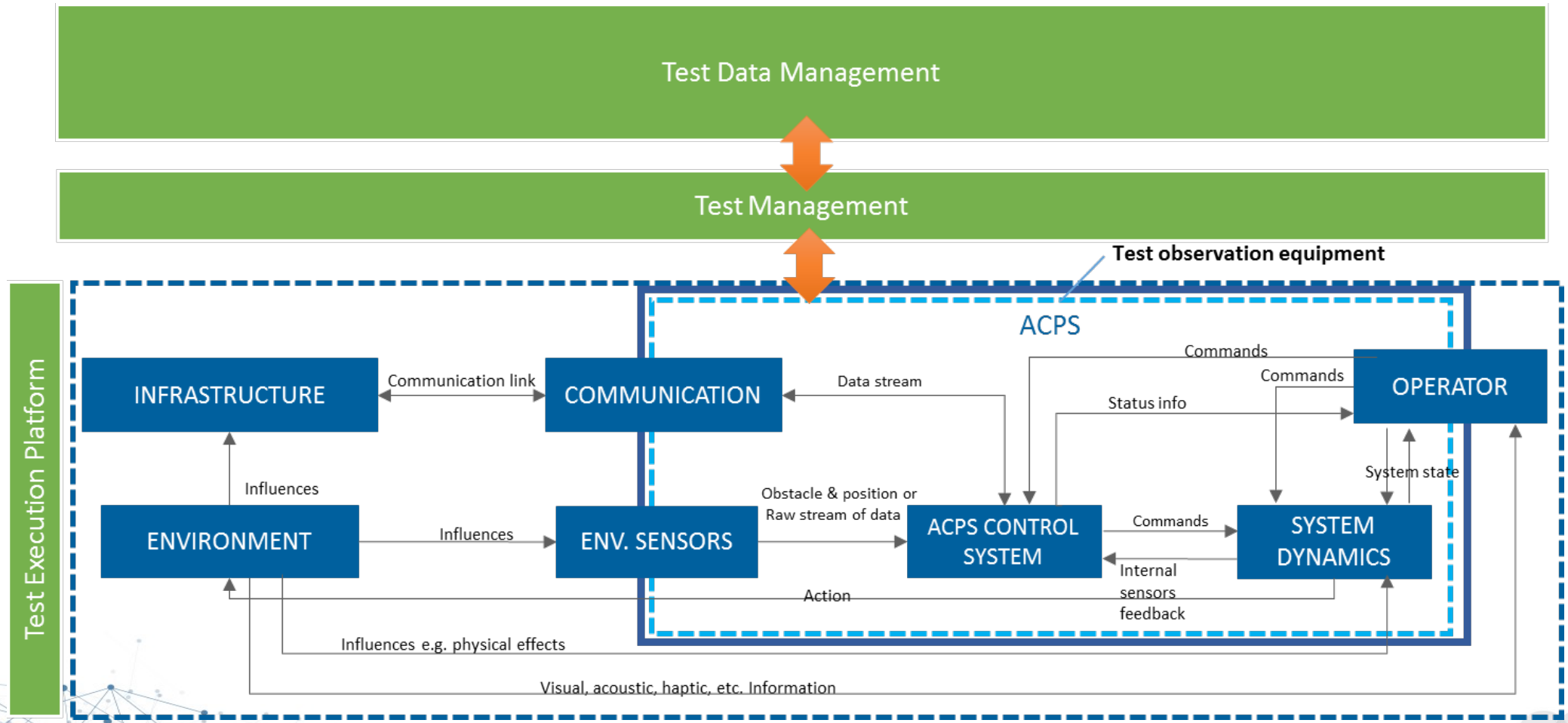
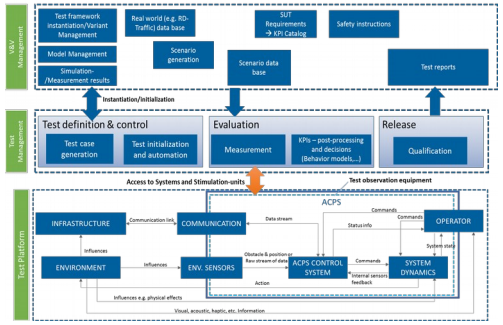


Generic Test Architecture

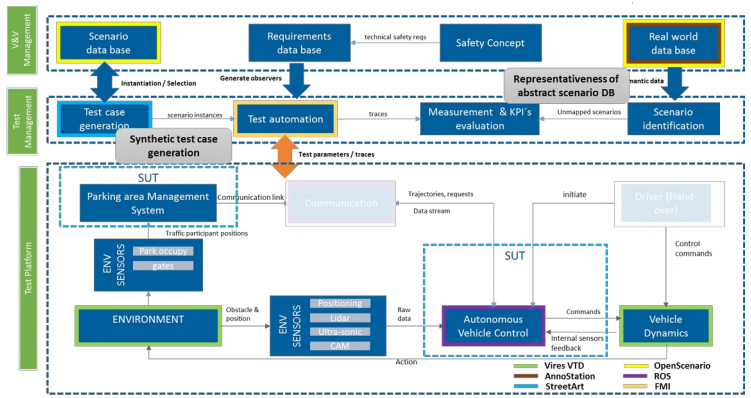


Technology bricks & GA



Reference test architecture for scenario based virtual/real validation of highly automated systems

Set of reusable technology bricks



Use Case specific Validation tool chains

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Technology bricks: Tools

Main areas

- Automated test design
- Simulation based testing
- Automated validation and verification

Adaptations for use cases

- Domain specific enhancements
- Cross-domain tools

Support re-usability

- Common interfaces
- Integration into V&V environments

Technology bricks: Tools

- Finalization of tools, tool integration to use cases, and evaluations in use cases
  - 57 tools
  - 17 tools used in two use cases
  - 4 tools used in three use cases
  - 9 tools used in several domains
- Four categories of tools
  - Open source
  - Commercial
  - Proprietary
  - Research
- Related objectives:
  - Obj_01 Reduce at least 50% of test execution effort compared to conventional testing.
  - Obj_04 Reduction of re-qualification efforts by at least 30% compared to effort prior to the project.

Technology results

- Know-How and Technology developed
  - generic test architecture
  - generic methodology for scenario-based V&V of ACPS
  - 50+ tools and tool-extensions
  - new scenario data-sets including analysis
  - virtual sensor models
  - methods for sensor stimulation
  - improved co-simulation techniques (real-time, distributed)
- Contributions to standards
  - OpenSCENARIO, OpenDRIVE, OpenCRG
  - SoTIF
  - FMI, DCP
  - OSI
- Commercial exploitation

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DOMAIN
AEROSPACE

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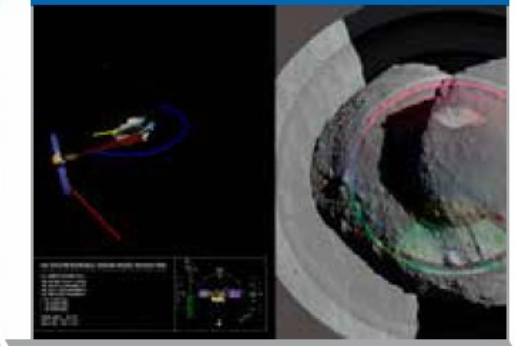
- UC8 – Reconfigurable Video Processor

New Space Challenges

Step 1: Today vs. traditional approaches

New solutions are being explored for the space environment, such as Reconfigurable FPGAs used in industrial applications.

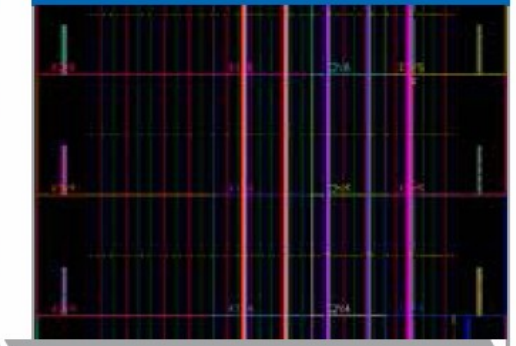
SuT & Scenarios



Step 2: Test of SuT architectures

Earth Observation and Vision-based Navigation are two traditional applications, implemented in the UC8 running common platform. Earth Observation, incl the compression of a hyperspectral image, is 1st shown in a fault free, then in a faulty environment.

FPGA in the Loop



Step 3: Fault injection tool

Rad-Hard are used traditionally to avoid radiation faults due to space environment. Reconfigurable FPGAS are not Rad-Hard, so the self-healing mechanism provided by Artico3 is used to cope with radiation simulated by a fault Injection tool.

Scheduling Simulation

Step 4: SuT model-based simulation

The satellite platform and the applications were modelled with the tool suite. Model-based simulation allows the engineer to identify unfeasible scenarios that do not comply with timing constraints due to the fault recovery processes.

Test Campaign

Step 5: Validation & Monitoring

The autonomous vision-based navigation demo with reconfigurable HW capabilities is validated and verified in this step. The art2kitekt© tool suite coordinates the test system tools, while monitoring the temporal behavior of the SuT in runtime.

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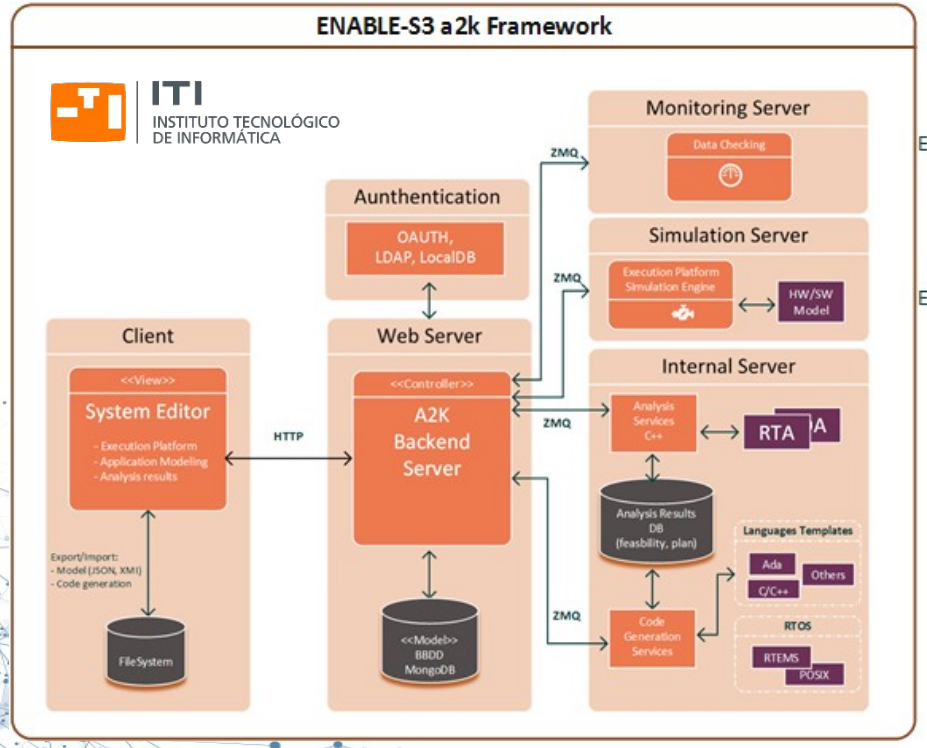
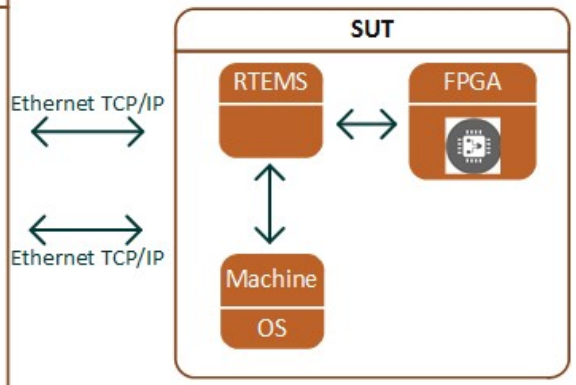
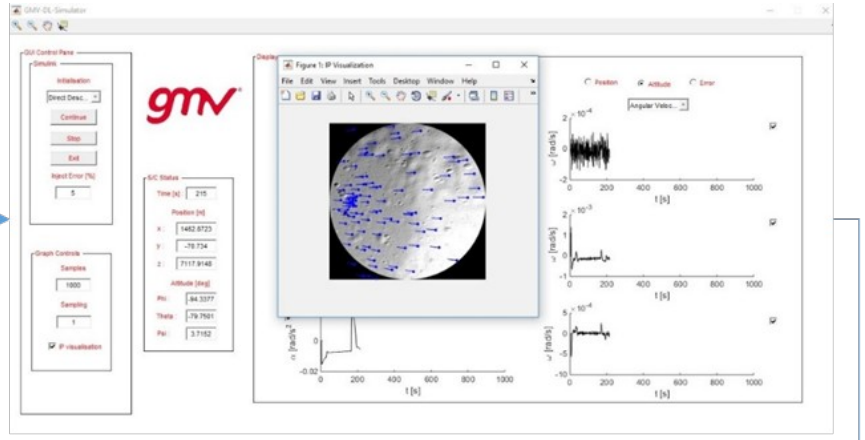
- UC8 – Reconfigurable Video Processor








Xilinx Zynq UltraScale+ MPSoC ZCU102 Evaluation Kit

gmv INNOVATING SOLUTIONS

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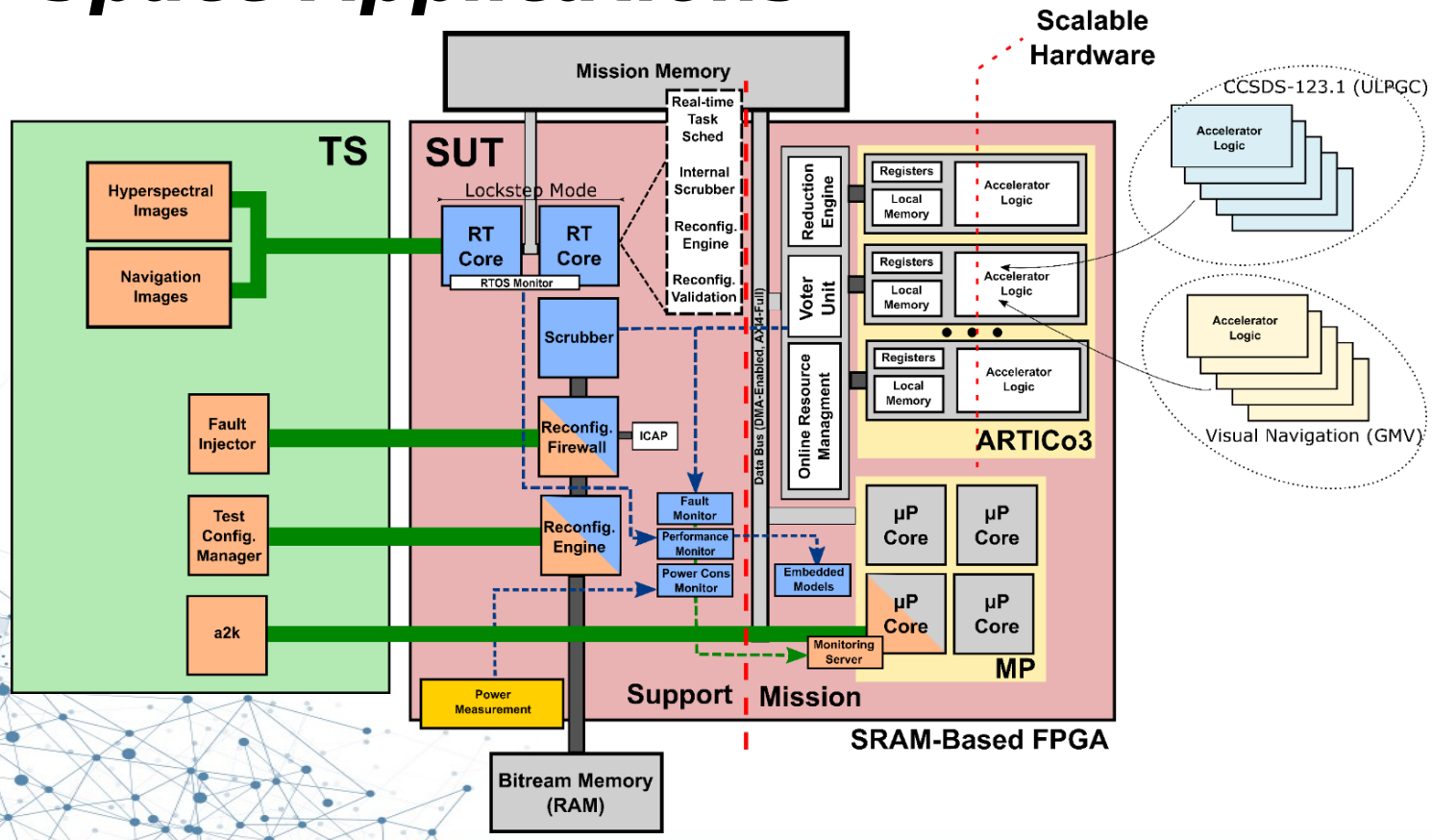
Reconfigurable Platform to test Video Processors Space Applications



An **integrated platform** has been developed based on Enable S3 architecture to deeply **test 2 Reconfigurable Video Processors applications** for Space:

- 3 demos over the same platform to show the behavior under test of these 2 applications
- The technology bricks developed to:
  - insert real failures
  - reduce test scenarios
  - automate the test campaign

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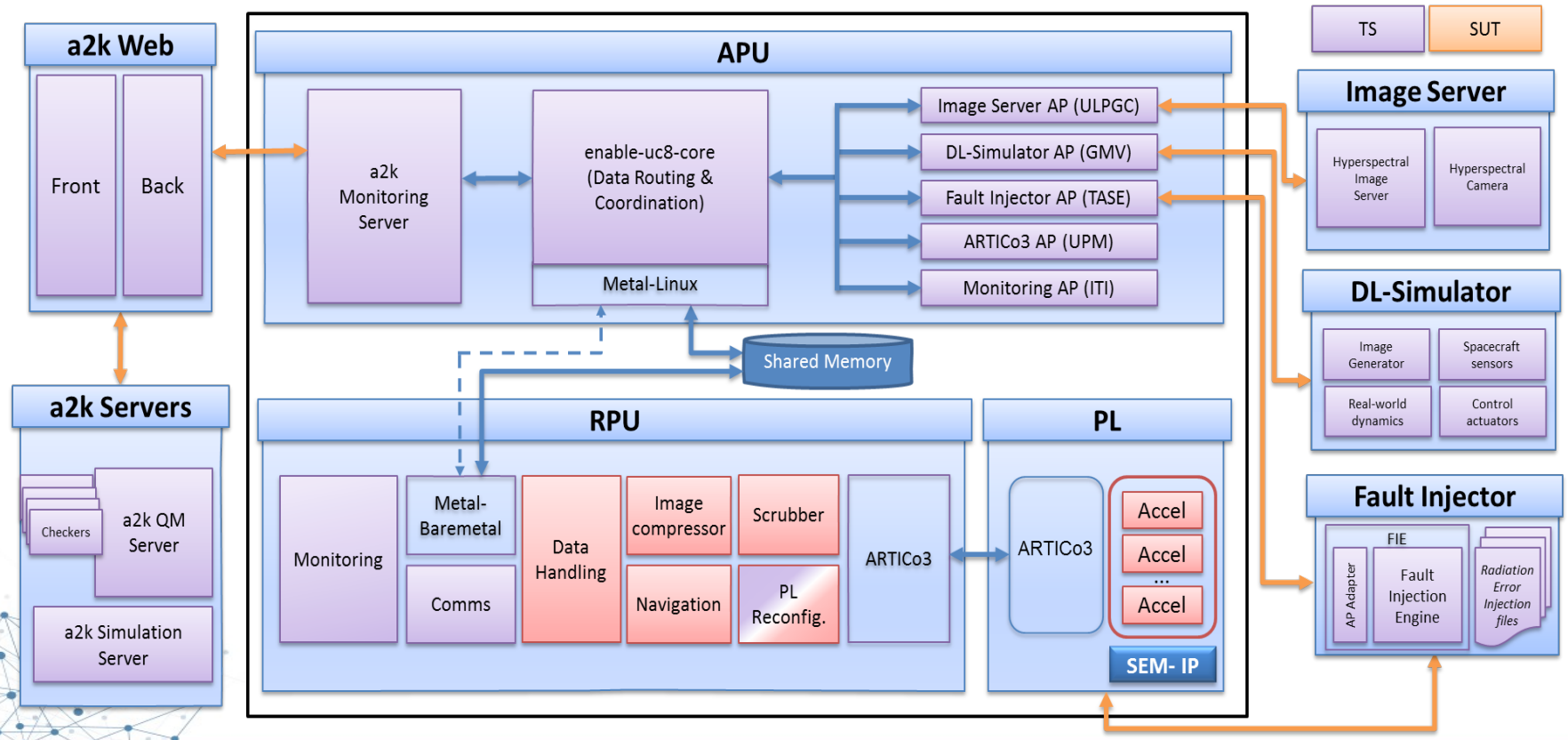
Reconfigurable Platform to test Video Processors Space Applications



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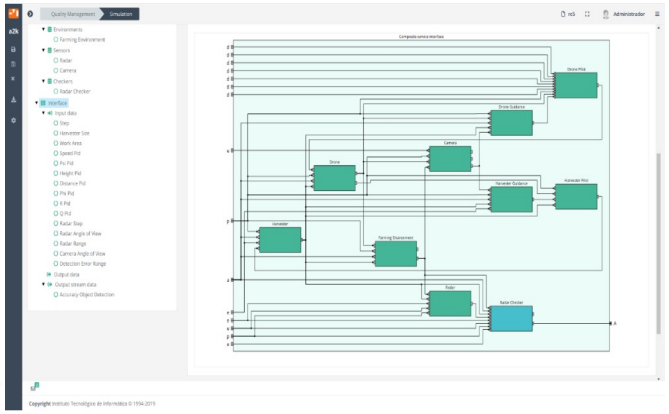
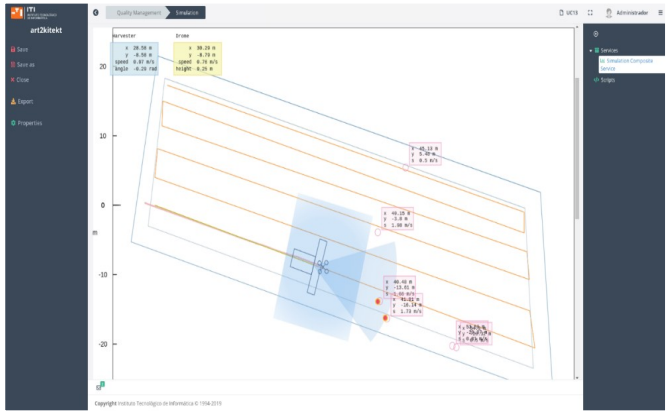
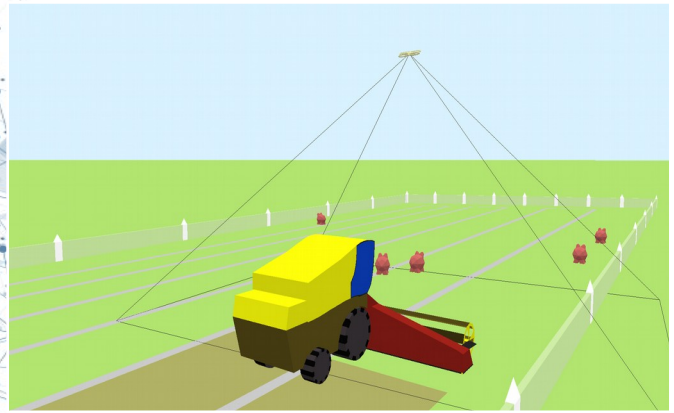
Main impacts due to UC8 Reconfigurable Video Processor:

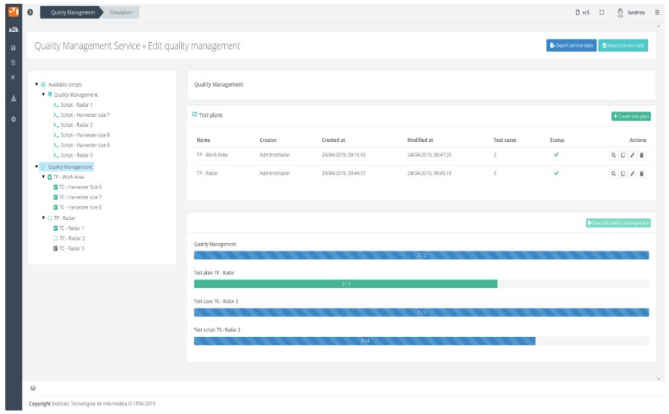
- **Enables the Use of COTS** (SRAM FPGAS in place of Rad-hardened FPGAS) thanks to self-healing and reconfiguration techniques
- **Speed-up of adaptation and its corresponding validation phase** of space Vision-Based Navigation (VBN) strategy and algorithms implementation
- Hyperspectral EO and Navigation **APPs can be tested against radiation using a fault-injection engine**, alternative to go BEAM campaigns
- Use the **same platform for develop and test new applications**
- Develop application using **QEMU (virtual simulator)** before to introduce in the real board
- **Reinforce the critical parts of the design in early stages** of the development by real and unlimited fault injection on the laboratory
- *art2kitekt*© allows the engineer to **monitor system real-time behavior** and **automatize full test campaigns**, measuring real-time performances
- **Model and simulate the applications** to perform test off-line to evaluate the match of the APPs to the mission requirements

- UC 13 – Automated Control Platform

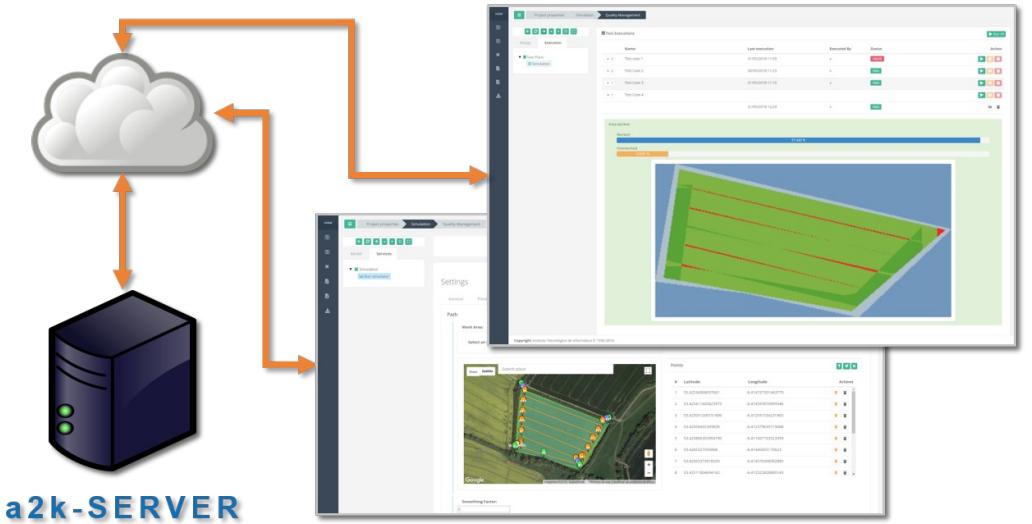








a2k-QUALITY MANAGEMENT



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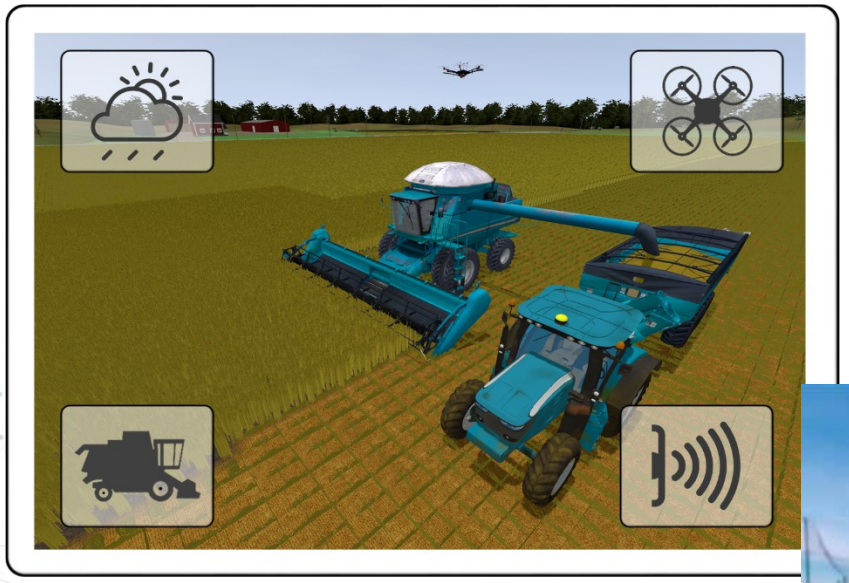
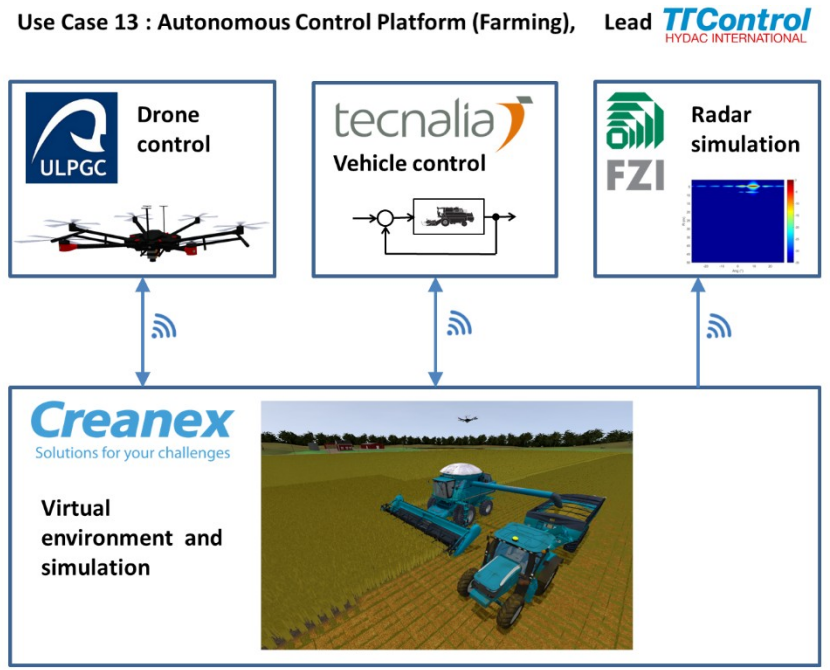
- UC 13 – Automated Control Platform





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THANK YOU

ECSEL JU

The research leading to these results has received funding from the H2020-ECSEL-2015-2-IA-two-stage for ENABLE-S3 – European Initiative to Enable Validation for Highly Automated Safe and Secure Systems Joint Undertaking under grant agreement n° 692455 and from specific national programs and / or funding authorities.