

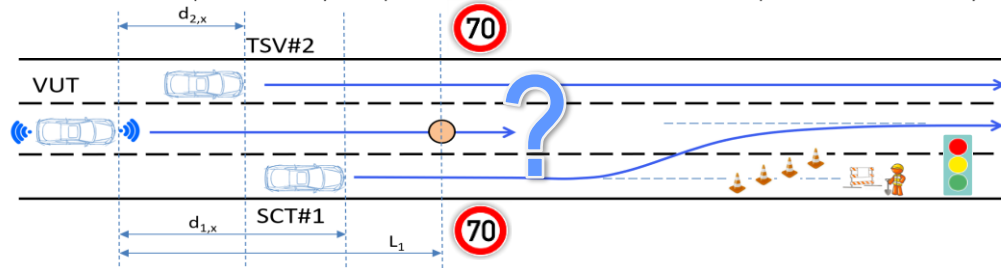
Holistic Proving Ground Instrumentation & Automation

for Vehicle-in-the-Loop Testing & Homologation of Automated Driving Vehicles

Efficient Scenario-Based Testing of PAD, HAD and FAD Vehicles on Proving Grounds

Complex Conditional Lane Change Scenario (PEGASUS):

SCT#1 and TSV#2 adapt their velocity in respect to VUT's behavior to force the VUT to perform a certain activity.

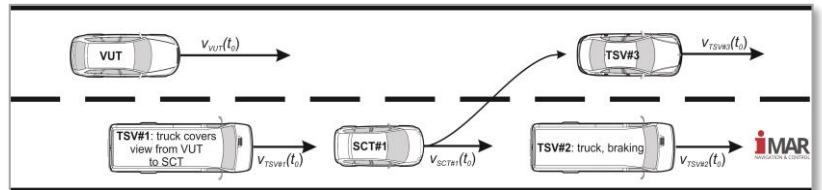


iSWACO-ARGUS is the holistic “Vehicle-in-the-Loop” solution for development, verification, validation and homologation also of safety relevant dynamic driving task (DDT) features of partially, highly and fully automated driving systems (ADS), like object detection and response systems (OEDR). It covers all SAE levels, i.e. from level 1 “hands on” up to level 4 “hands off, mind off - sometimes” and level 5 “hands off, no driver”, with a single test infrastructure. **iSWACO-ARGUS** stays for “**Swarm Control & Continuous Surveillance with the reliability of the legendary Argus’ Eyes**” and controls and monitors the motion behaviour of all real and virtual objects on the proving ground. It provides the unmatched flexibility to generate and execute precise repeatable tests within real emulated complex traffic scenarios on the proving ground or to monitor vehicle behavior even on public roads.

The iSWACO-ARGUS infrastructure can be installed quickly, simply and safely on arbitrary proving grounds and test vehicles. Thus, it is the testing and automation solution for both, OEMs and testing / homologation organizations.

SCENARIO AND TRAJECTORY BASED TESTING: KEY FEATURES & ADVANTAGES OF iSWACO-ARGUS

- Flexible Architecture – **easily applicable** on all proving grounds regarding infrastructure and topology, worldwide.
- **Cost saving** due to the capability to execute individual & fully repeatable test scenarios with minimum personnel effort.
- No steering or driving robots required. Control of Traffic Simulation Vehicle’s (TSV) steering / throttle / braking via vehicle’s internal actuators or control loops. Therefore iSWACO-ARGUS **saves pretty much setting-up time**, compared to competing systems. Beside of **TSVs** and **SCTs** (Soft Crash Targets) also so-called **Virtual Elements (VE)** can be managed.
- Support of components like steering, brake or diving robots of other manufacturers on demand (Stähle, ABD, Vehico etc.).
- The iSWACO-ARGUS **package includes all you need on the proving ground** for PAD / HAD / FAD testing, i.e.:
 - ✦ iMAR’s unique **toolchain for a seamless workflow** from the traffic scenario import from simulation ([OpenSCENARIO](#); other like CarMaker etc. on demand) to the real-world test execution on the proving ground, compliant with the **PEGASUS** approach.
 - ✦ iMAR’s iARGUS-CC **Control Center** with software iARGUS-CMD for **trajectory import, adaptation to proving ground, validation and test execution, safety supervision, test visualization** in real-time as well as in playback mode, data storage and data export.
 - ✦ iMAR’s **Vehicle Localization and Guidance & Control** hardware for **10++ moving objects**, i.e. to manage Traffic Simulation Vehicles (**TSV**), Soft Crash Targets (**SCT**) and Vehicles under Test (**VUT**), based on INS/GNSS/ODO technology and cognitive vision, i.e. also operable in GNSS denied areas of a proving ground (allows also testing the VUT under real GNSS outage conditions) on centimeter level accuracy. Also support of Virtual Elements (**VE**) with standardized interface.
 - ✦ iMAR’s Traffic Simulation Vehicle **iTSV-KIA-NIRO** as **turnkey solution for driverless** operation in traffic scenarios (other customized).
 - ✦ iMAR’s **Collision warning and avoidance** system iARGUS-RCS, based on INS/GNSS and optional iARGUS-MV machine vision.
 - ✦ iMAR’s mobile **iDMN Dynamic Mesh Network communication** with lowest latency for data, video and voice. **5G** is also supported.
- The implementation covers the recommendations of the future **ISO 22133-1** “Road Vehicles - Test Object Monitoring and Control for Active Safety and Automated/Autonomous Vehicle Testing” standard. iMAR is part of ISO Working Group.
- iSWACO-ARGUS development has been supported within PEGASUS by one of the largest German testing organizations, intending to be the base of future **homologation** of automated & autonomous Vehicles under Test up to SAE level 5, and by a large German automobile manufacturer.



easy to install – provides scenario based testing up to SAE level 5 – easy to operate

Technical Data iTraceRT-MVT

- all data are RMS values, if not otherwise stated -

Localization Performance (on each vehicle): iTraceRT-MVT-510 or iTraceRT-MVT-200/SLN

Position Accuracy:	2 cm [CEP] < 0.1 % of distance travelled	INS/GNSS/ODO, RTK during GNSS outages
Velocity Accuracy:	0.02 m/s	INS/GNSS/ODO
Roll / Pitch / Heading Accuracy:	< 0.05° / 0.05° / 0.05°	INS/GNSS/ODO, RTK
Gyro / accel Performance iTraceRT-MVT-510:	* < 0.1 °/h / 0.2 mg day2day < 0.01 °/h / 0.04 mg AV	
Gyro / accel Performance iTraceRT-MVT-200:	< 3 °/h / 1 mg in motion < 0.5 °/h / 0.06 mg AV	
Heading / Roll / Pitch Range:	0...360° / ±180° / ±90°	(no limitations)
Angular Rate Range:	±400 °/s	
Acceleration Range:	±10 g	(others as option)
Data Output Rate / Bandwidth; data latency:	1...500 Hz / 200 Hz; < 2 ms latency, 1 ms jitter	



Interfaces:

Serial Data:	3 x UART RS422 or RS232 (iXCOM, NMEA 0183)
Ethernet:	1 x TCP/IP or UDP (data and status via iXCOM/NMEA)
CAN Bus:	standard protocol (data, status)
GNSS correction data input:	RTCM (from iREF-GNSS, iREF-LITE via NTRIP or GSM)
GNSS (GPS/GLONASS/BEIDOU/GALILEO):	integrated multi-constellation, all frequencies capable GNSS engine (500 channels); single & dual ant.
Odometer input:	RS422 level (A/B) quadrature signal or pulses fw./bw./dir.



Physical / Operating / Environmental Parameters:

Power Supply Voltage:	12 V DC (10...35 V DC)
Power Consumption:	25 W (iTraceRT-MVT-510) resp. 10 W (iTraceRT-MVT-200)
Dimensions:	187 x 128 x 196 mm (-510) resp. 102 x 62 x 138 mm (-200)
Weight:	< 5.7 kg (-510) resp. < 900 grams (-200)
Operating / Storage Temperature; Humidity:	-40...+65 °C / -45...+75 °C; 8...100 % rel.
Housing / Protection Category:	fully sealed aluminum enclosure / IP 67

Accessories for iSWACO-ARGUS:

- Included:
- Graphical User Interface iARGUS-CMD (Control Center) and iXCOM-CMD (each vehicle) [Windows / Linux]
 - Operator handbook (usage & maintenance) for iSWACO-ARGUS, iARGUS-CMD and iTraceRT-MVT
 - internal data logger (up to 128 GByte), also for the vehicle's diagnosis interface (CAN / ETH)
- Optional:
- several cable sets, GNSS and RF antenna fixtures, uninterrupted power supply on test vehicles etc., support of local positioning systems (e.g. LOCATA), airborne real-time video supervision of proving ground
 - PTP or NTP time server capability
 - iDMN Dynamic Mesh Network, iARGUS-RCS (roof mounted communication & sensor head)

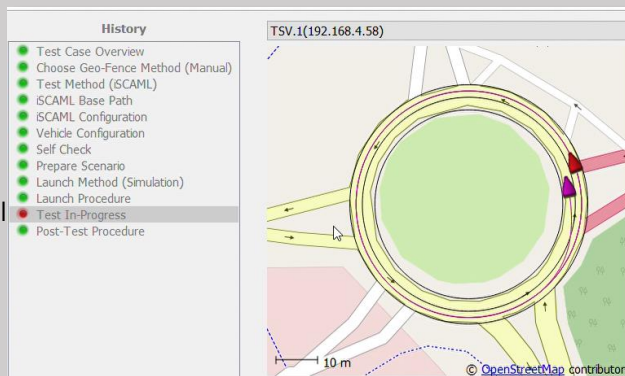
Standards:

future ISO 22133 (not yet approved by ISO – iMAR is member of the standardization working group)

* The better the inertial sensor performance (bias, noise, scale factor accuracy, bandwidth etc.), the better the system performance can be kept also during certain GNSS outages or in urban canyons (i.e. to achieve a lower standard deviation of the measurements). See dedicated datasheet for details. The automotive systems of family iTraceRT-MVT-60x, -510, -500 and -200 are fully compatible by interfaces and hardware with our common systems iNAT-RQT, -FSLG, -FSSG, -M200 etc.

iARGUS-CMD:

Control your workflow from OpenScenario test description to real world test execution and result protocol generation - on every proving ground, whatever the lane shape will be.



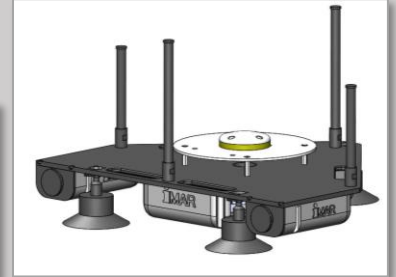
Stereo vision based automatic environment perception for localization and collision avoidance:



iSWACO-ARGUS

All automation components (hardware and software) for the proving ground are designed and provided by iMAR:

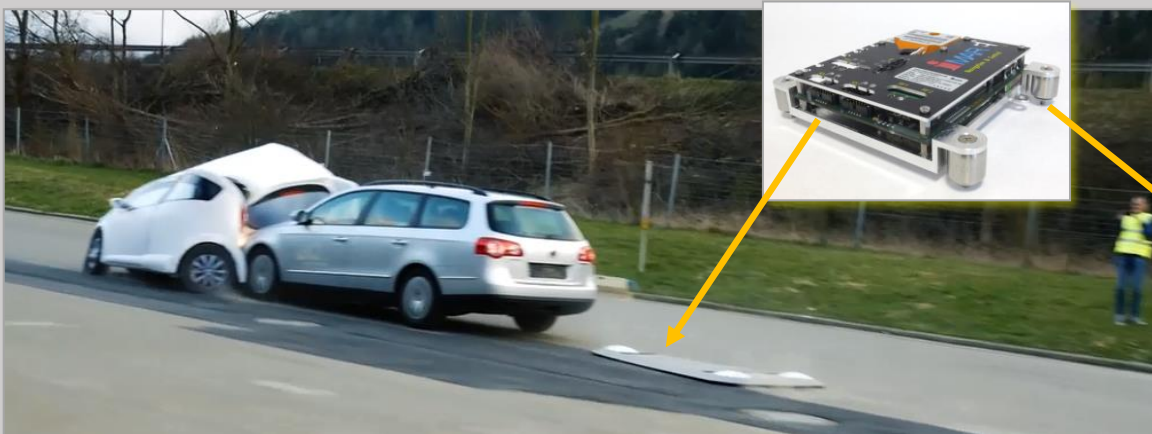
- iMAR's INS/GNSS localization systems on each vehicle, i.e. iTraceRT-MVT-510, iTraceRT-MVT-500 or iTraceRT-MVT-M200 with optional vehicle control system (iARGUS-VCS) and uninterrupted power supply iARGUS-UPS. The [iTraceRT-MVT](#) series is specifically designed for automated and autonomous driving vehicles with lowest data latency. Cognitive vision based stereo camera system iARGUS-MV available for AI based environment perception. Onboard real-time sensor data monitoring and recording (inside and outside cameras, microphones, OBD via CAN etc.) with precise timestamping available.
- iMAR's [iREF-GNSS](#) RTK correction data acquisition and distribution system for cm accuracy.



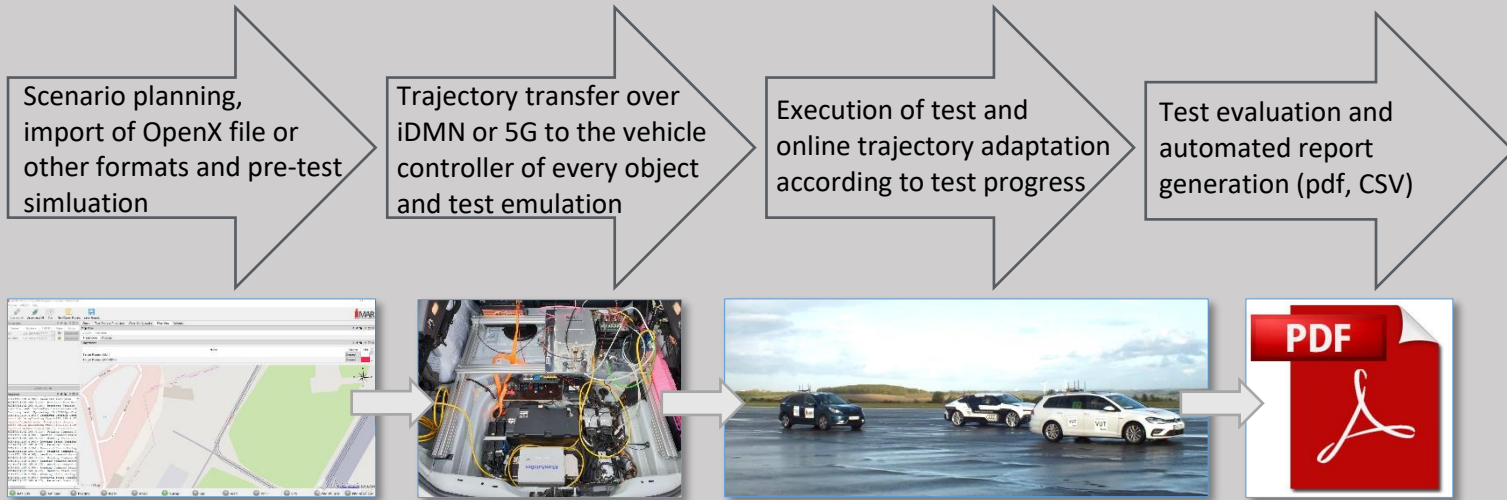
- iMAR's Dynamic Mesh Based Communication Network ([iDMN](#)) with optional encrypted Multi-Car-to-Car and Car-to-ControlCenter communication. Minimum data latency, Fresnel zone mitigation, fast reacquisition and self-configuration setup. Installation can include a 15 m antenna mast, mobile hotspots or UAV based data distribution (flying hotspot) with integrated stabilized HD camera for proving ground test scenario observation (supports fully automatic take-off, flying and landing; uninterrupted operational time for 12+ hrs as option).



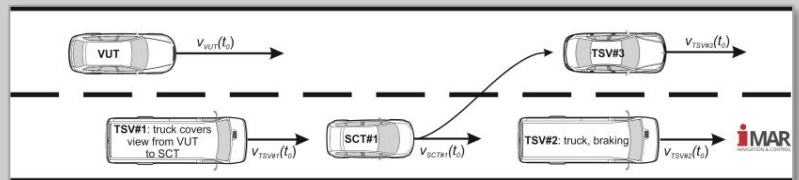
- iMAR's iARGUS-CC Control Center with [iARGUS-CMD](#) software for test setup, scenario import from [OpenSCENARIO](#) (option), trajectory planning for each vehicle, simulation, test execution, data storage, equipment supervision; incl. visualization console, [iDMN](#) communication, opt. uninterrupted power supply and [iREF-GNSS](#) for RTK corrections.
- iMAR's Traffic Simulation Vehicles of type [iTSV-KIA-NIRO](#) or similar with integrated actuator interfaces, as turnkey solution with trajectory control via iARGUS-VCS / iARGUS-LTG, [iTraceRT-MVT](#) based INS/GNSS/ODO localization and [iDMN-OHS](#) Dynamic Mesh Communication Network. Support of driving robots (e.g. [Stähle Robots](#)). Support of customer vehicles as TSV on request.
- Soft Crash Target ([SCT](#)) integration into the test setup: Targets from 4a Systems, as 4activeFB, including integrated [iTraceRT-MVT](#) for high precision localization, navigation and control, or others from DSD / Humanetics, ABD or DRI on demand.



Test Preparation, Simulation, Emulation, Execution and Documentation: Workflow within iARGUS-CMD



The trajectories to be executed by all swarm vehicles during the Traffic Scenario (up to 10++ VUT, TSVs, SCTs, VEs operable simultaneously on demand) and the timing of the active infrastructure elements ISE (when to change traffic lights, speed limit information etc.) are generated by the iARGUS-CC Control Center software [iARGUS-CMD](#) or are automatically imported from datasets generated by [OpenSCENARIO](#) (others like CarMaker on demand) and adapted to the PG.



iMAR's Trajectory Import, Planning, Simulation, Test Execution, Visualization and Data Export Tool iARGUS-CMD:

Example: Lane change (3.75 m lateral) at 100 km/h with 0.5 g (!) lateral acceleration, driven in fully autonomous mode (factory expanded) OEM vehicle (by iMAR's iTraceRT-MVT-200 with iARGUS-VCS incl. actuator interface) on proving ground at Zweibrücken.

iMAR Navigation is known for more than 25 years as the worldwide expert for most reliable localization, navigation, surveying and control solutions in automotive testing & verification, avionics, defence and industrial applications. For details, consultancy or support, please feel free to contact our sales or support department.



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 Rev. 1.20 / 17.01.2021 • DocNo. DOC170531001