

PhD student: Mario Noioso

Advancing Safe Autonomous Systems: A
SOTIF-Oriented Simulation Framework
Integrating V2X and Environmental Factors

Tutor: Stefania Santini

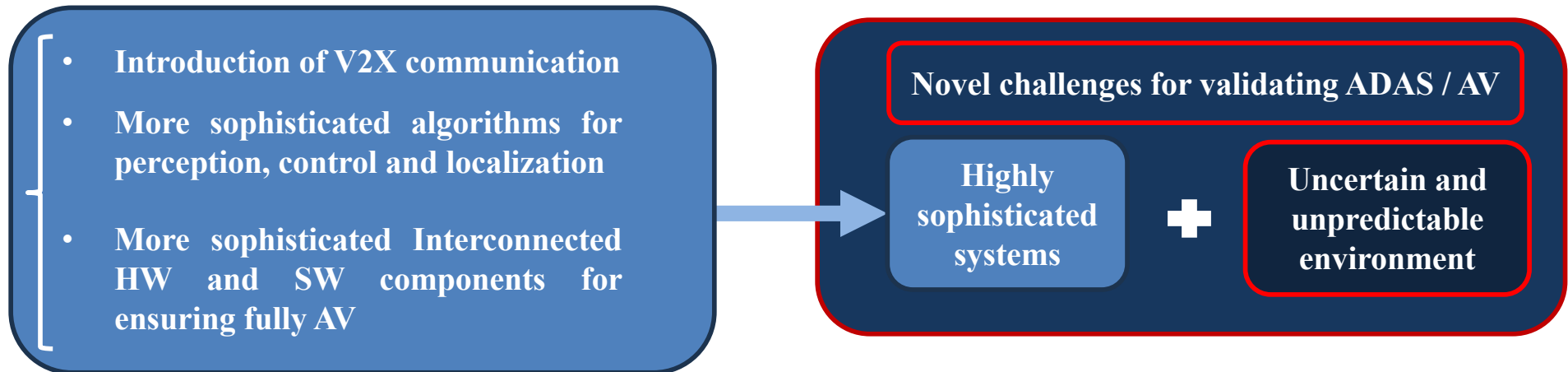
Cycle: XXXIX

Year: Second

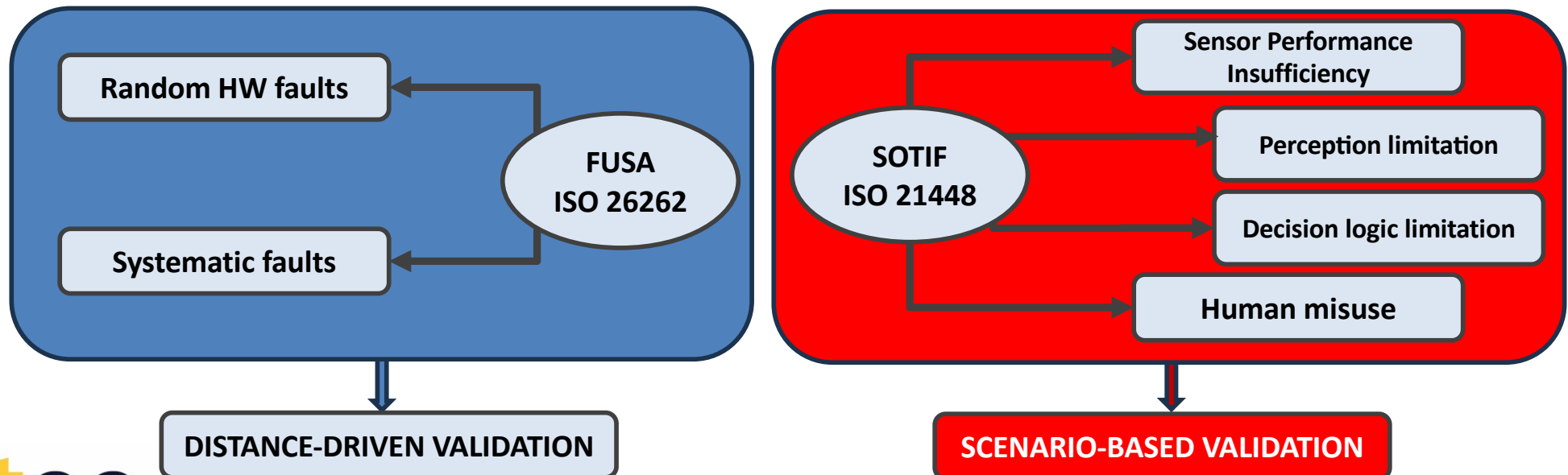
Candidate's information

- **Master Degree:** “Automation Engineering” obtained from University of Naples – Federico II
- **Master Thesis:** “Intermittent nonlinear control strategies for COVID-19 epidemic models”
- **Research Group:** DAiSY Lab
- **PhD start date:** November 2023 **PhD end date:** November 2026
- **Scholarship type:** No scholarship (working in Automotive field since 2021. Currently employee in “Kineton”)

Research field of interest: CCAM (Cooperative Connected and Automated Mobility)

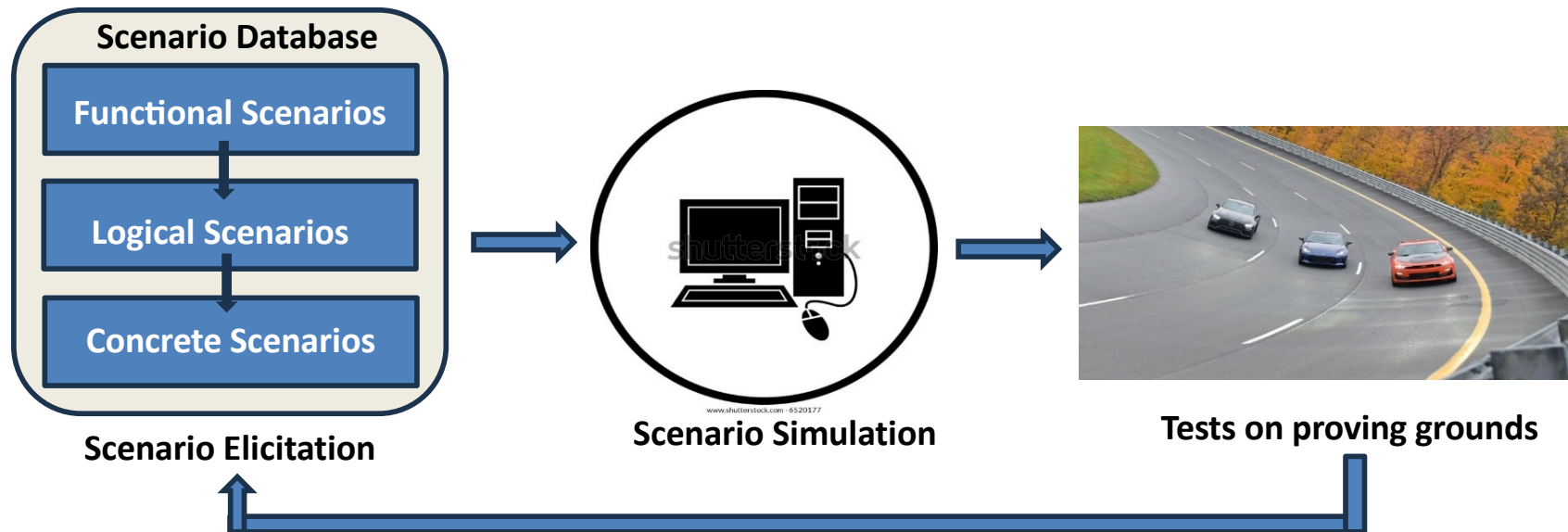


- **New challenges** may go beyond the scope of ISO 26262, leading to **non-functional faults**, **performance limitations** and **unreasonable risks**. **SOTIF** is introduced (ISO 21448)

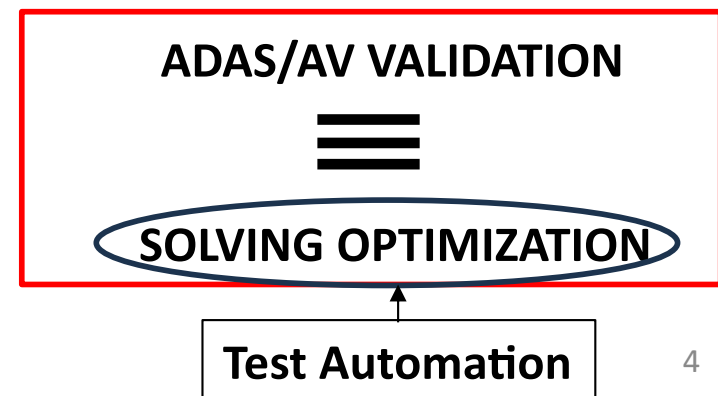
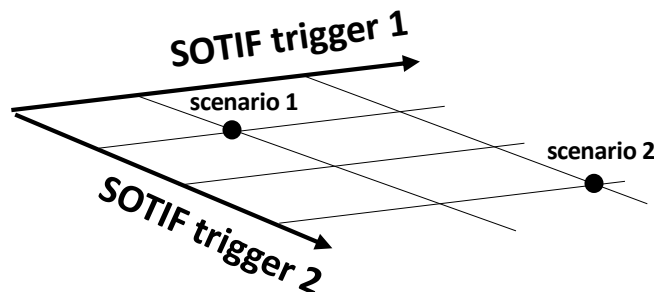


Research field of interest: CCAM (Cooperative Connected and Automated Mobility)

- To **tackle the complexity** arising from considering the effect of all the influencing factors (**SOTIF triggers**) in all the relevant driving situations, an **iterative scenario-based validation process** of the ADAS/AV has been introduced:



- Logical Scenarios**, that takes all the modelling effort, assimilable to a **decisional space** of an **optimization problem**



Summary of study activities

To approach the chosen topic in its manifold facets, while also enhancing my soft skills, I have attended various seminars and courses. The most significant of these are listed below:

- **PhD/MSc Courses:**

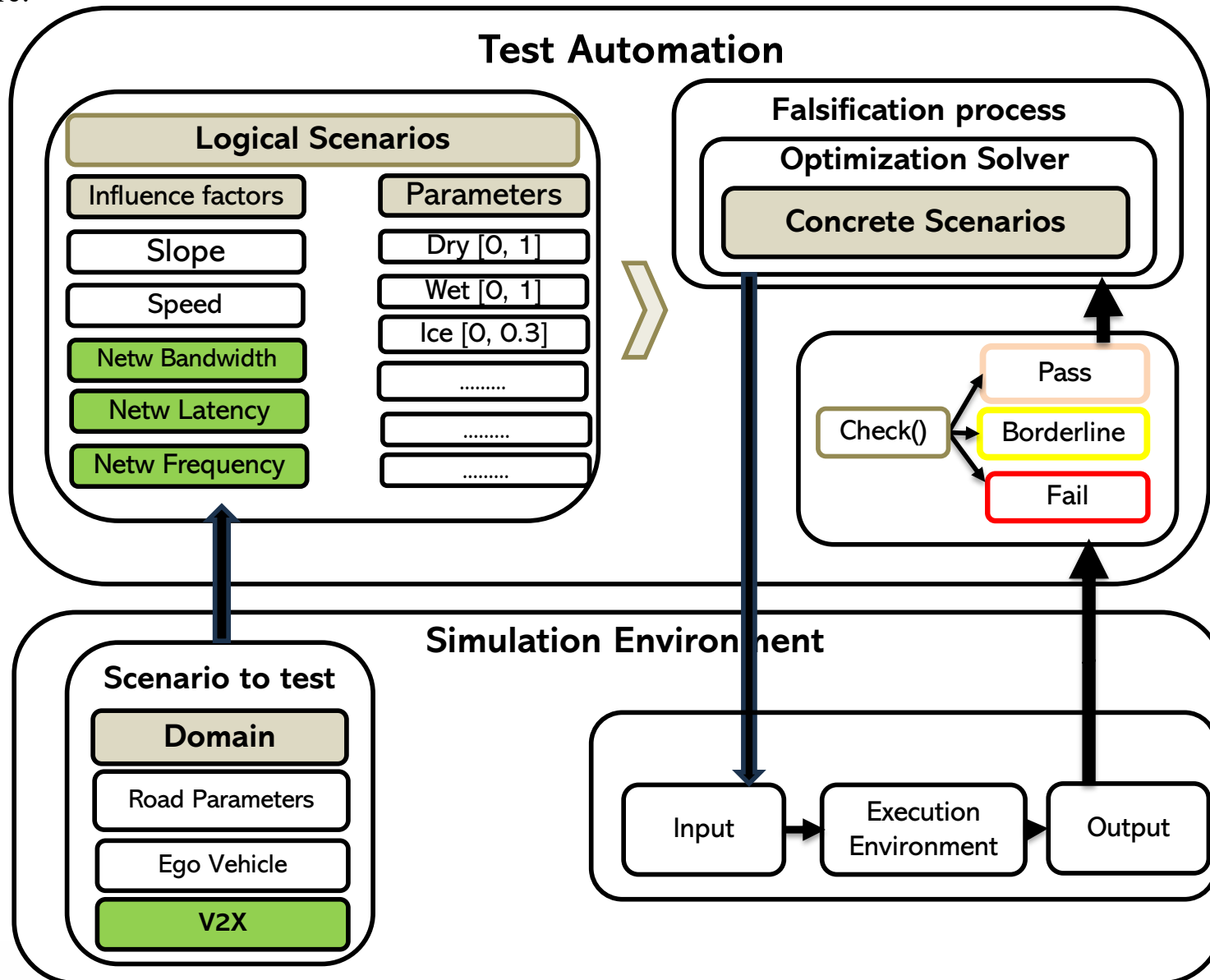
- *Testing and Validation of Automated Road Vehicles* – Prof. Angelo Coppola
- *Machine Learning for Science and Engineering Research* – Prof. Anna Corazza

- **Seminars:**

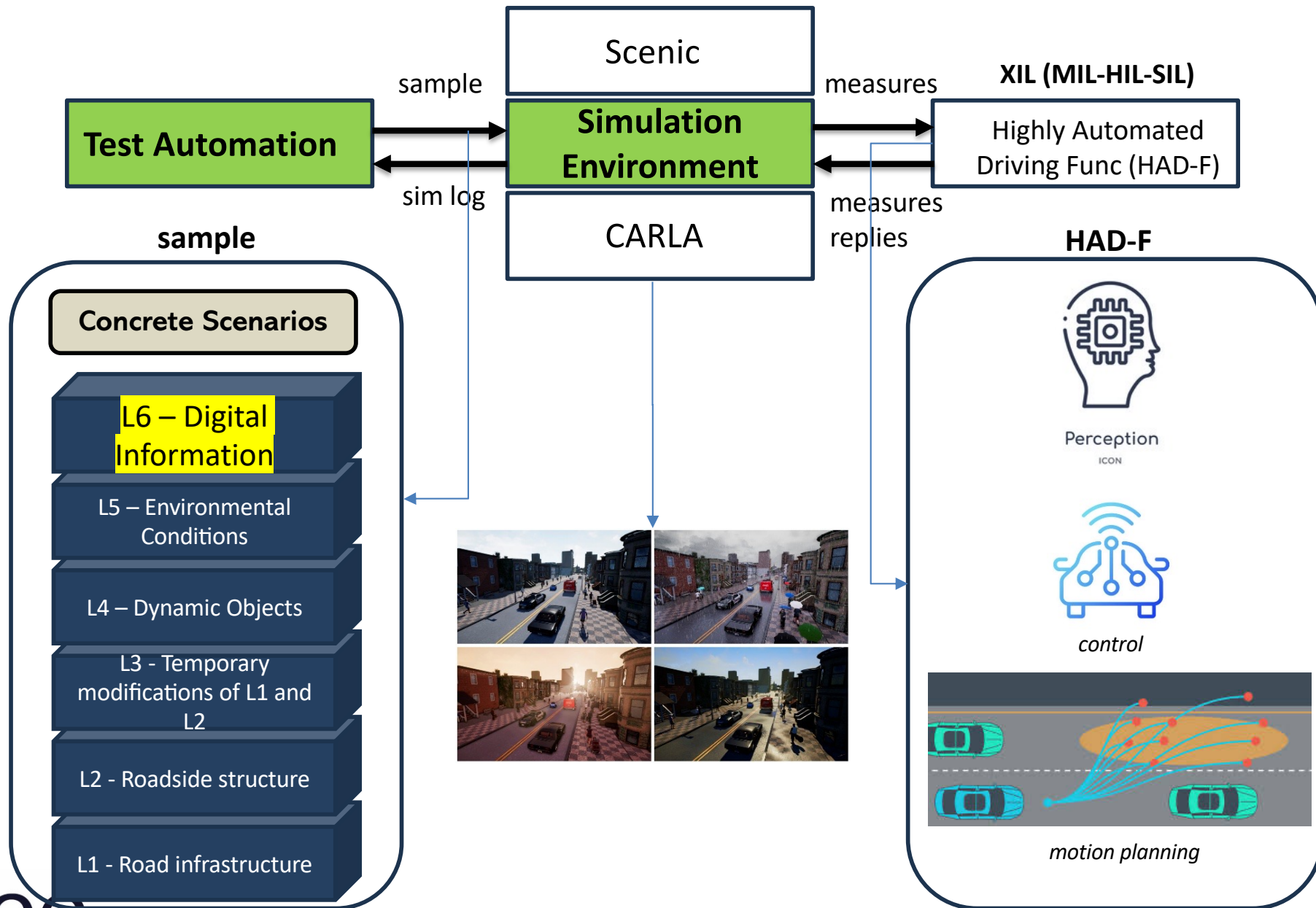
- *Emergent behaviors and collective decisions in cyber-physical-human systems* – Karl. H. Johansson (SSM Scientific Colloquium)
- *Safety Assessment of Autonomous Vehicles: Approaches and Challenges* – Prof. Peter Popov (Prof. Stefano Russo)
- *Control of multi-agent systems with time delays: theory and applications* – Prof. Stefania Santini (Prof. Gabor Orosz)
- *IEEE ITSS Italian Chapter Annual Meeting and PhD Award 2025* – IEEE ITS

Research activity: Simulation Framework Architecture

- The **Scenario-based Elicitation and Simulation framework** that has been developed has the following architecture:

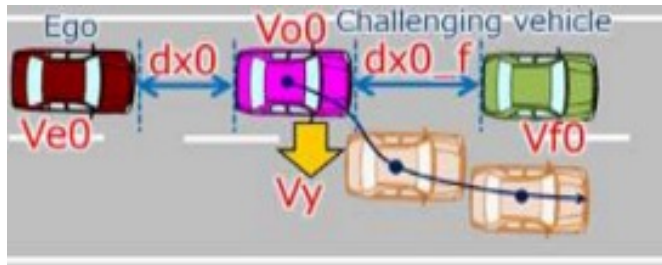


Research activity: Falsification procedure



Research activity: Case Study: “Cut-out” Scenario Falsification

- Identifying the **Operational Design Domain (ODD) boundaries** of a **Cooperative Adaptive Cruise Control (CACC)** system through a **falsification procedure**. The procedure is executed using the **Genetic Algorithm (GA)** component of the MATLAB Global Optimization Toolbox, specifically targeting the 'cut-out' driving scenario



Cut-out scenario

$$\text{fitness Func} = \text{TTC}^2 + v_{\text{coll}_{\text{rel}}}^2$$

SOTIF triggers:

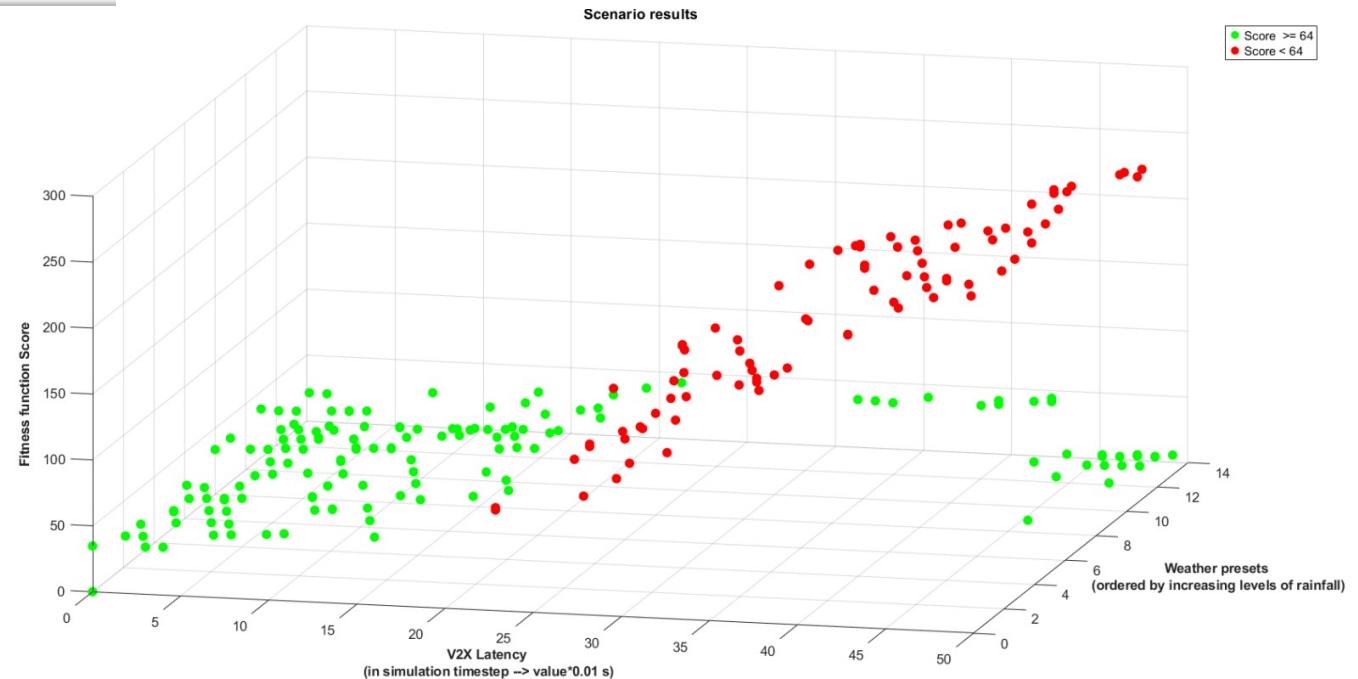
- V2X Latency** → discrete values in $[0 - 0.5]$, step = 0.01
 - weather conditions** →
 - wind intensity and orientation
 - precipitation intensity
- 14 combinations**

- Scenario details (constant)**

- $\text{Ve0}, \text{Vo0}, \text{Vf0} = 27.78 \text{ m/s (100 km/h)}$
- $\text{dx0} = 10 \text{ m}$
- $\text{dx0}_f = 7 \text{ m}$

- threshold value = 64**

$\max v_{\text{coll_rel}}^* = 8 \text{ km/h}$



*Krafft, Maria & Kullgren, Anders & Malm, Sigrun & Ydenius, Anders. (2005). Influence of crash severity on various whiplash injury symptoms: A study based on real-life rear-end crashes with recorded crash pulses.

Study and Training Activities – Credits earned

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1	0	1.1	8.9	0	10
Bimonth 2	5	1	4	0	10
Bimonth 3	0	1.1	8.9	0	10
Bimonth 4	9	1.1	0	0	10.6
Bimonth 5	0	1	9	0	9.4
Bimonth 6	0	1.1	8.8	0	10
Total	14	6.4	39.6	0	60
Expected	10 - 20	5 - 10	30 - 45	0 – 1.6	

Next Year

- **Analyzing the “cut-out” scenario already considered within an augmented configuration space.** This space will include new V2X and additional scenario-influencing factors enabling the analysis of the coupled effects of more than two factors
- **Employing different optimization algorithms (surrogate models, PSO, etc)** specifically designed to handle the complexity that arises from considering continuous stochastic variables.
- **Replacing the CARLA simulator's built-in physics (from UE4) with a fully controllable, custom white-box model.** This customization will ensure greater transparency and manipulability of the underlying dynamics