

Automated Generation of Diversified Tests for Self-driving Cars from Existing Maps with SALVO

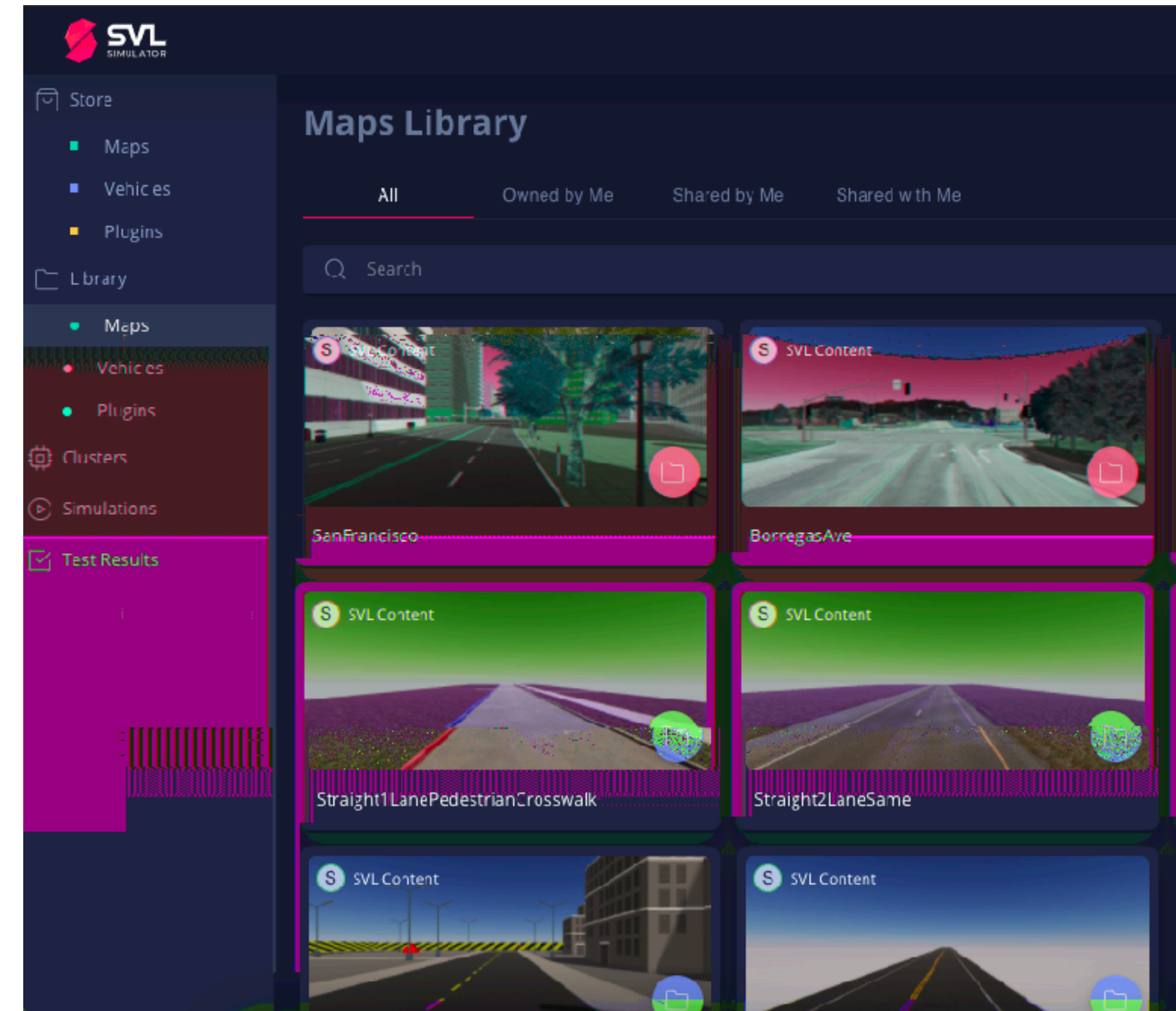
Stefan Huber, **A**lessio Gambi, **VuO**ng Nguyen

University of Passau

Intro and Motivation

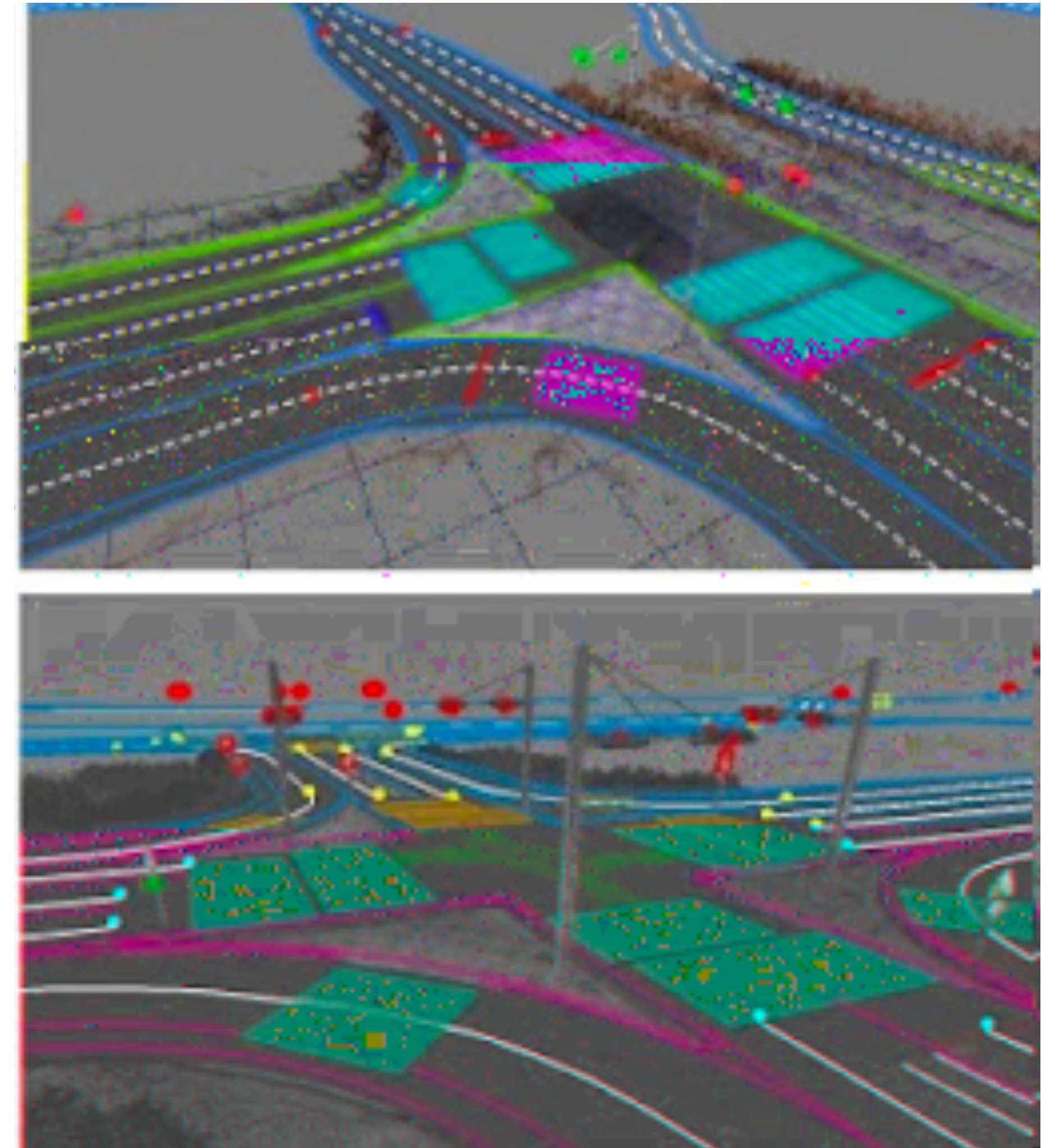
The Importance and Value of HD Maps

- Using simulations to test Autonomous Vehicles (AV) is one of the standard approaches to Quality Assurance
- Simulation-based testing of AV needs: detailed maps & relevant scenarios
- Generating **HD Maps** is mostly a manual activity.
- HD Maps are **expensive** and **valuable**, we **maximize** their use and reuse



Relevant Driving Scenarios at Intersections

- **Relevant scenarios** should stress the ego-car in critical conditions or risky situations
- Driving scenarios that take place at **intersections** are one of the most complex driving scenarios
- We generate driving scenarios that force the ego-car to cross intersections as **relevant**



Automated Generation and Diversity

- Thorough testing requires the generation of many **diverse** (concrete) driving scenarios
- **Automated test generation** is a must to achieve cost-effectiveness (fixed budget for testing, pressure/time-to-market, many possible driving scenarios, etc.)

The SALVO Approach

The SALVO Approach

"Safe" *in Italian*

- SALVO **automatically** generates **many, diversified, relevant** tests from **existing** maps
- SALVO aims to **maximize** cost-effectiveness, diversity of tests, and maps reuse

The SALVO Approach

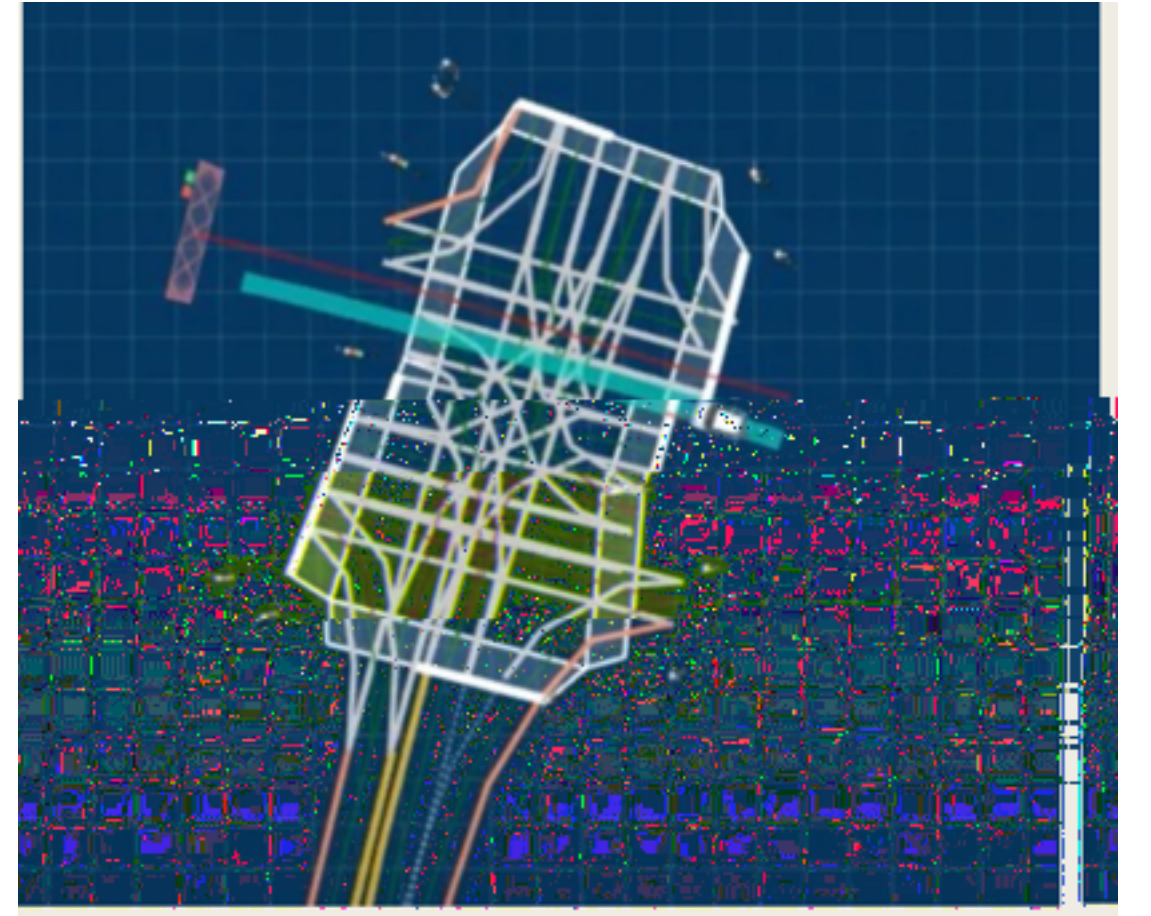
"Safe" in Italian

- SALVO has 5 steps:
 1. Analyzing input maps to identify the intersections and possible ways to **legally** cross them
 2. Generating concrete driving scenarios that implement them
 3. Selecting a diversified set of driving scenarios by systematically filtering similar driving scenarios
 4. Increasing diversity by introducing NPC in various positions
 5. Automatically generating and executing test cases in the SVL simulator

Selected Scenarios

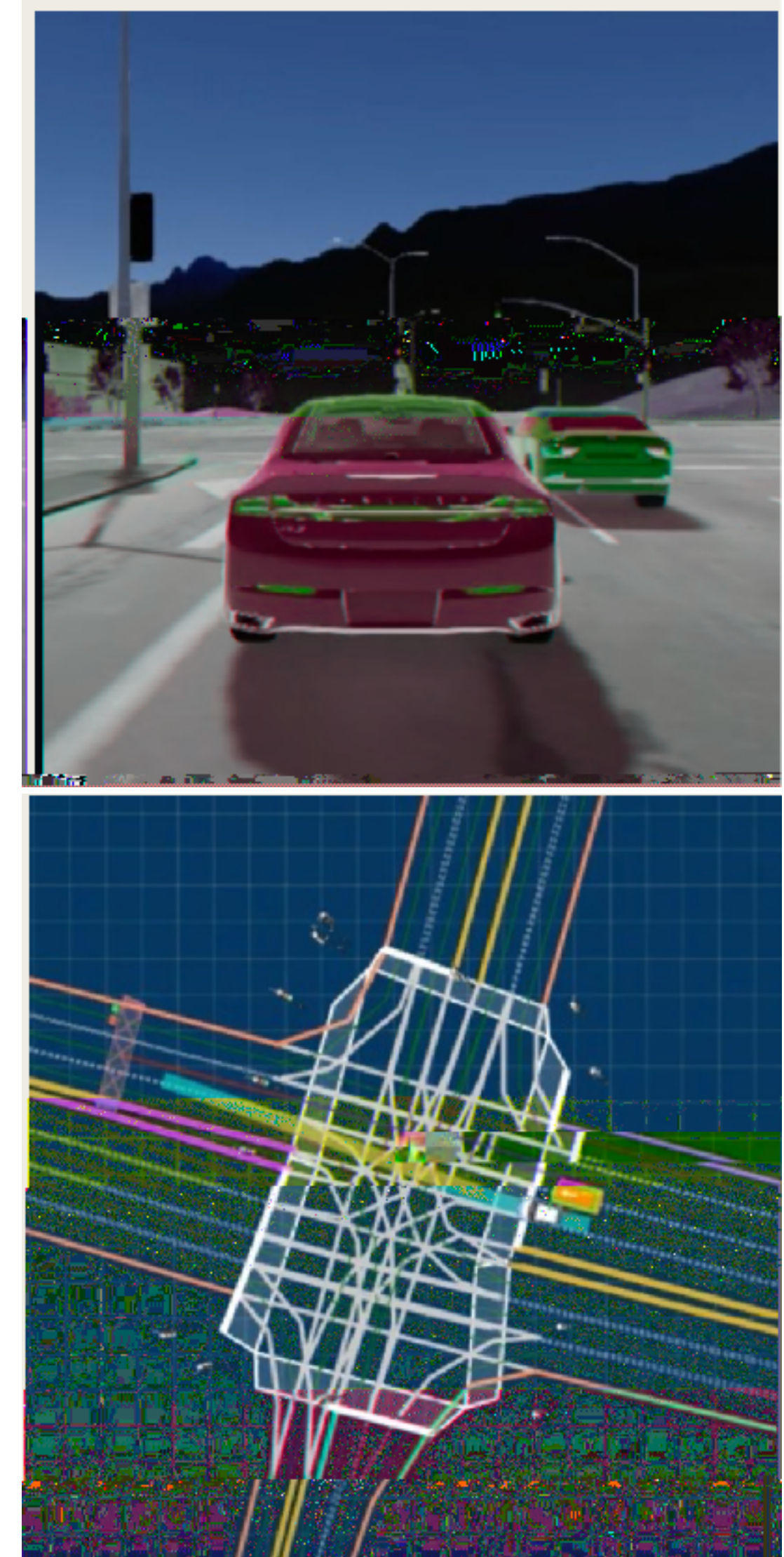
Scenario 01: Simple Tests in Borregas Avenue

- Map: Borregas Avenue
- Video: <https://www.youtube.com/watch?v=IseDL4R2AIE>
- Description:
 - SALVO generates all the possible driving scenarios across the intersections in the map **without** filtering
 - SALVO executes the test cases without involving any NPC



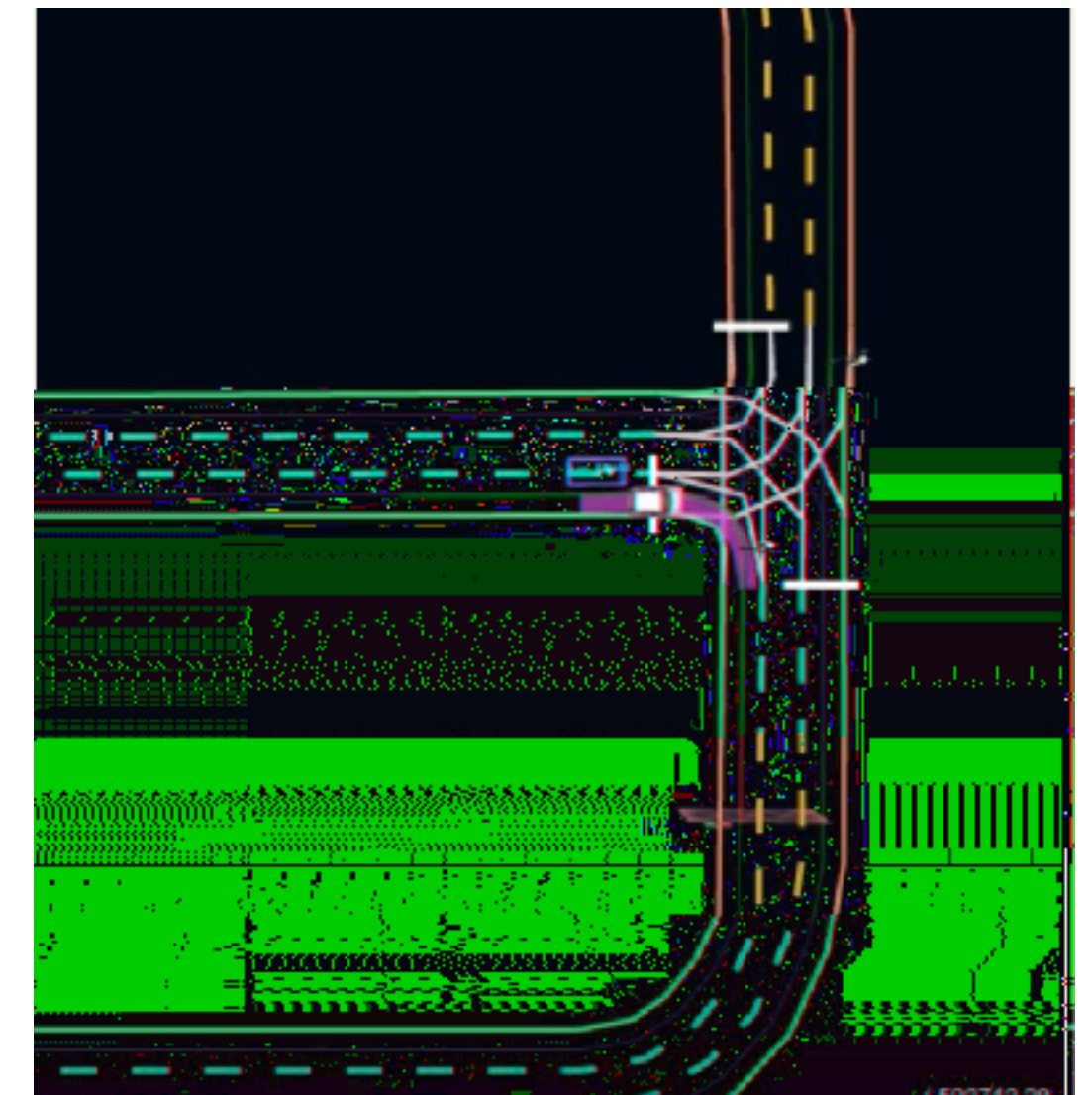
Scenario 02: Obstacles in Borregas Avenue

- Map: Borregas Avenue
- Video: <https://www.youtube.com/watch?v=2Im8xnfY3lc>
- Description:
 - SALVO generates all the possible driving scenarios across the intersections in the map **without** filtering
 - SALVO place a NPC on the **right** side of the lane in front of the ego-car, just before it enters the intersection
 - SALVO executes the test cases



Scenario 03: Obstacles in CubeTown

- Map: Cube Town
- Video: <https://youtu.be/ubiUYdo4ZUc>
- Description:
 - SALVO generates all the possible driving scenarios across the intersections in the map **without** filtering
 - SALVO place a NPC on the **left** side of the lane in front of the ego-car, just before it enters the intersection
 - SALVO executes the test cases



Scenario 04: More Obstacles in CubeTown

- Map: Cube Town
- Video: <https://youtu.be/WLIh9Pv8FcI>
- Description:
 - SALVO generates all the possible combinations of obstacle placement for one intersection in the map
 - SALVO executes the test cases