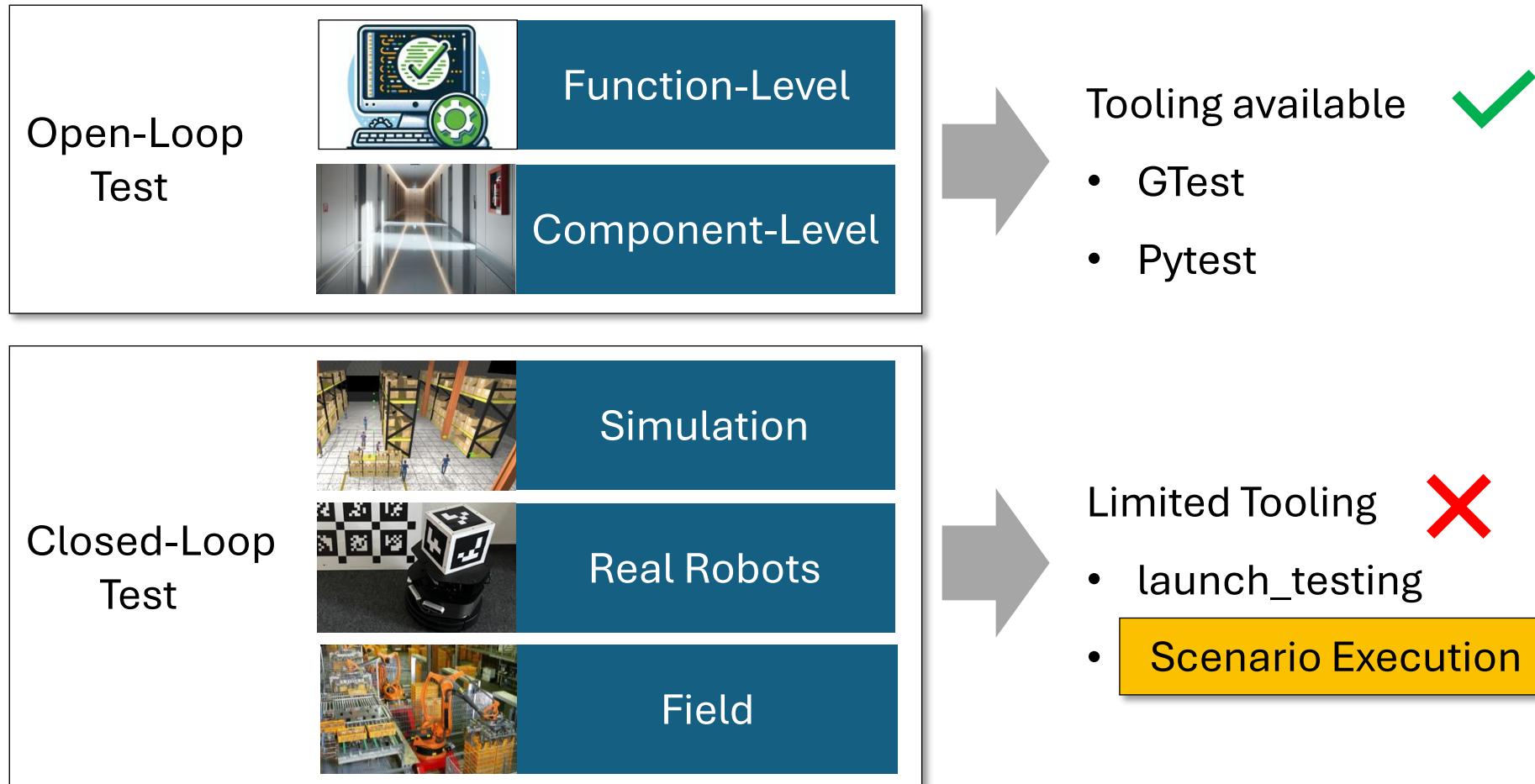


Scenario-Execution

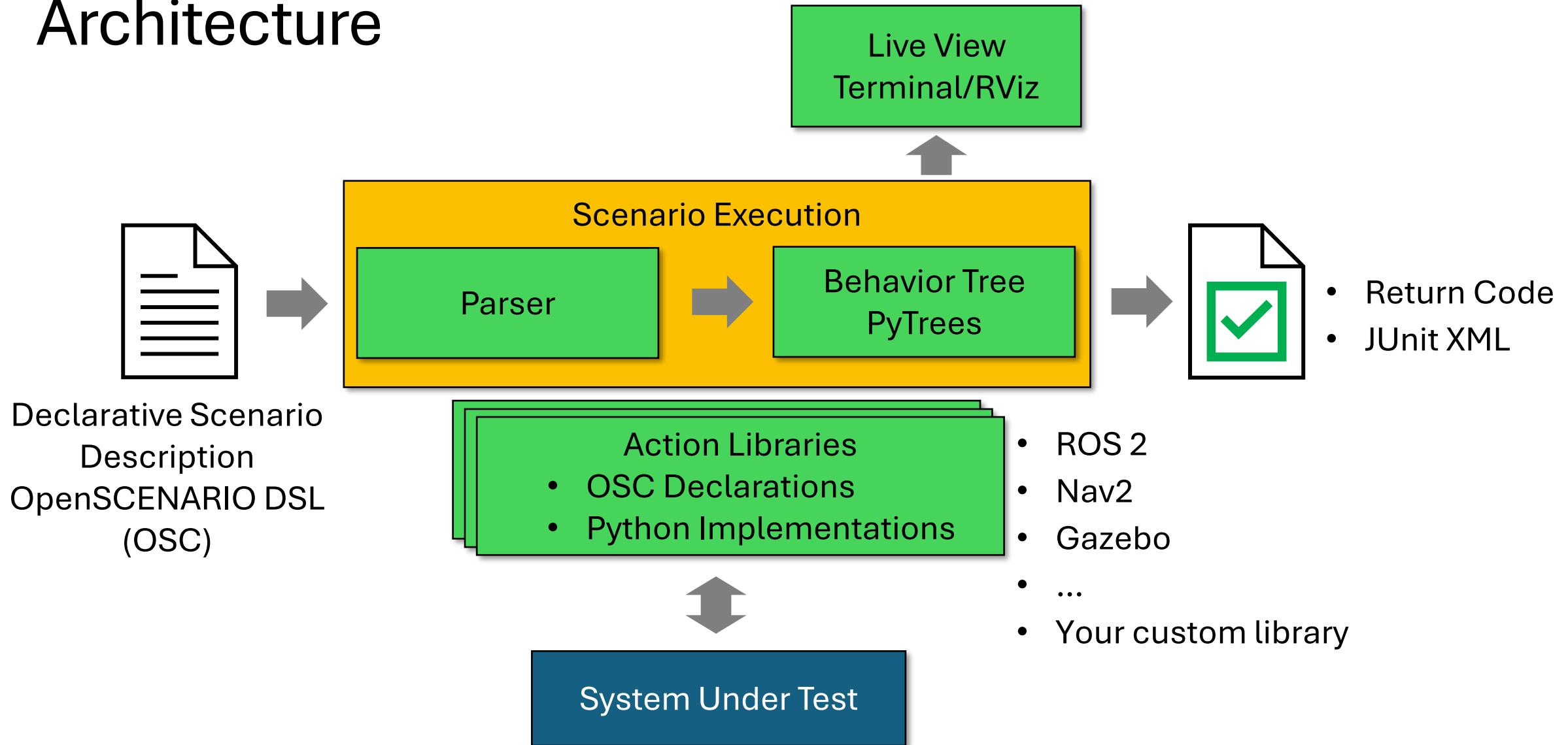
**eine Bibliothek für die Beschreibung und reproduzierbare
Ausführung von Roboter-Experimenten**

Florian Mirus*, Frederik Pasch

Testing Approaches for Robotic Systems



Architecture



OpenSCENARIO DSL

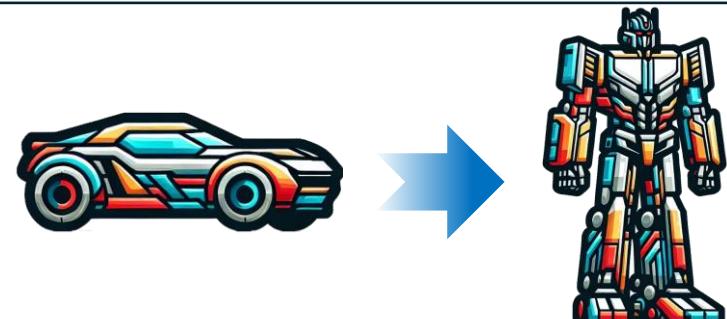
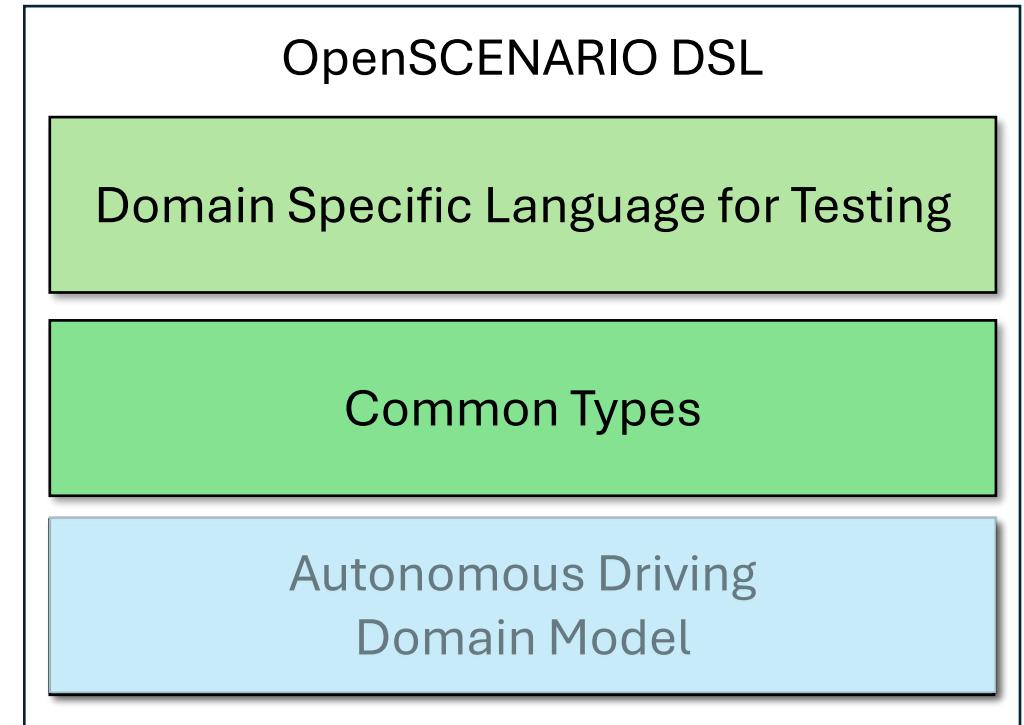
“... designed for verification and validation purposes to test safety and functionality of autonomous vehicles **any robotic system...**”



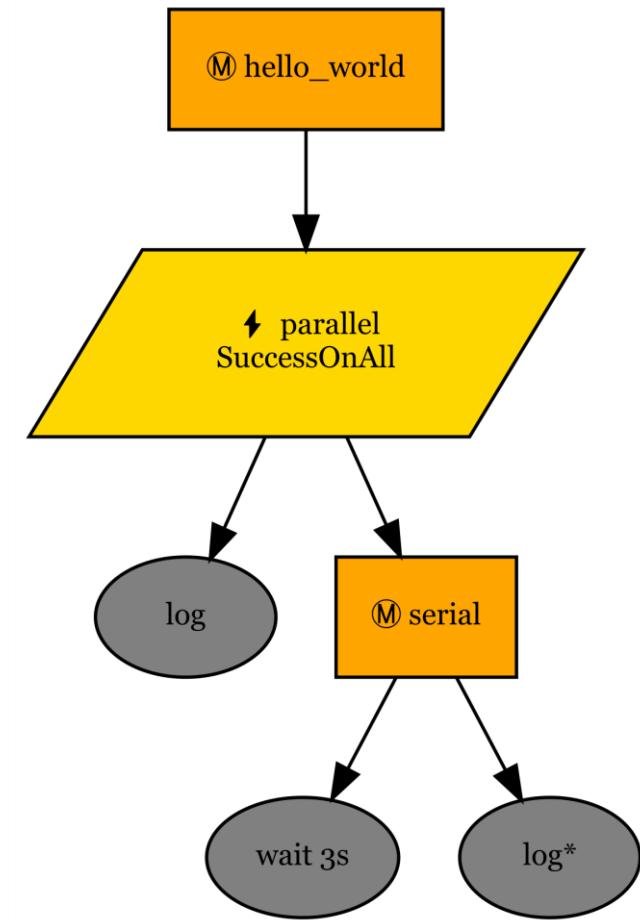
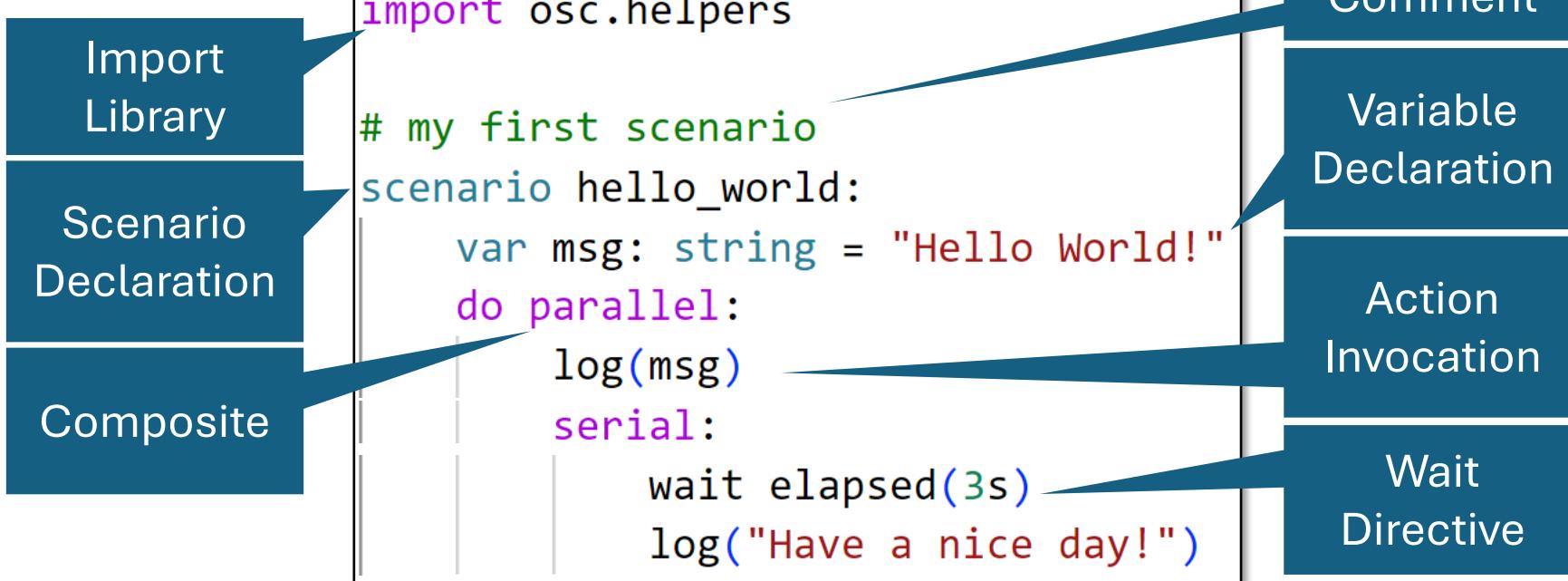
Association for Standardization
of Automation and Measuring Systems

Key Facts

- Human-readable/writable
- Supports Variation
- Widely Used
- Applicable to any robotics system



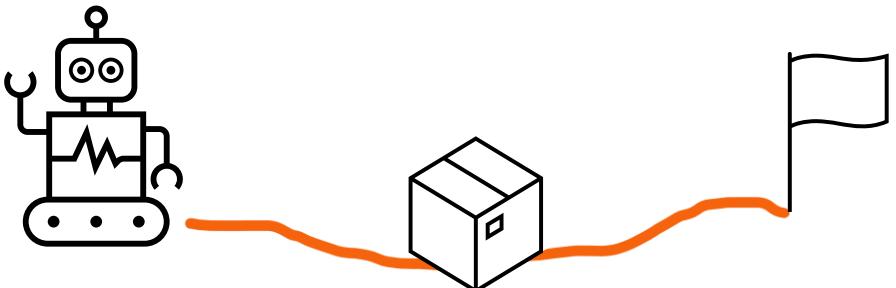
Hello World Scenario



```
$ █
```

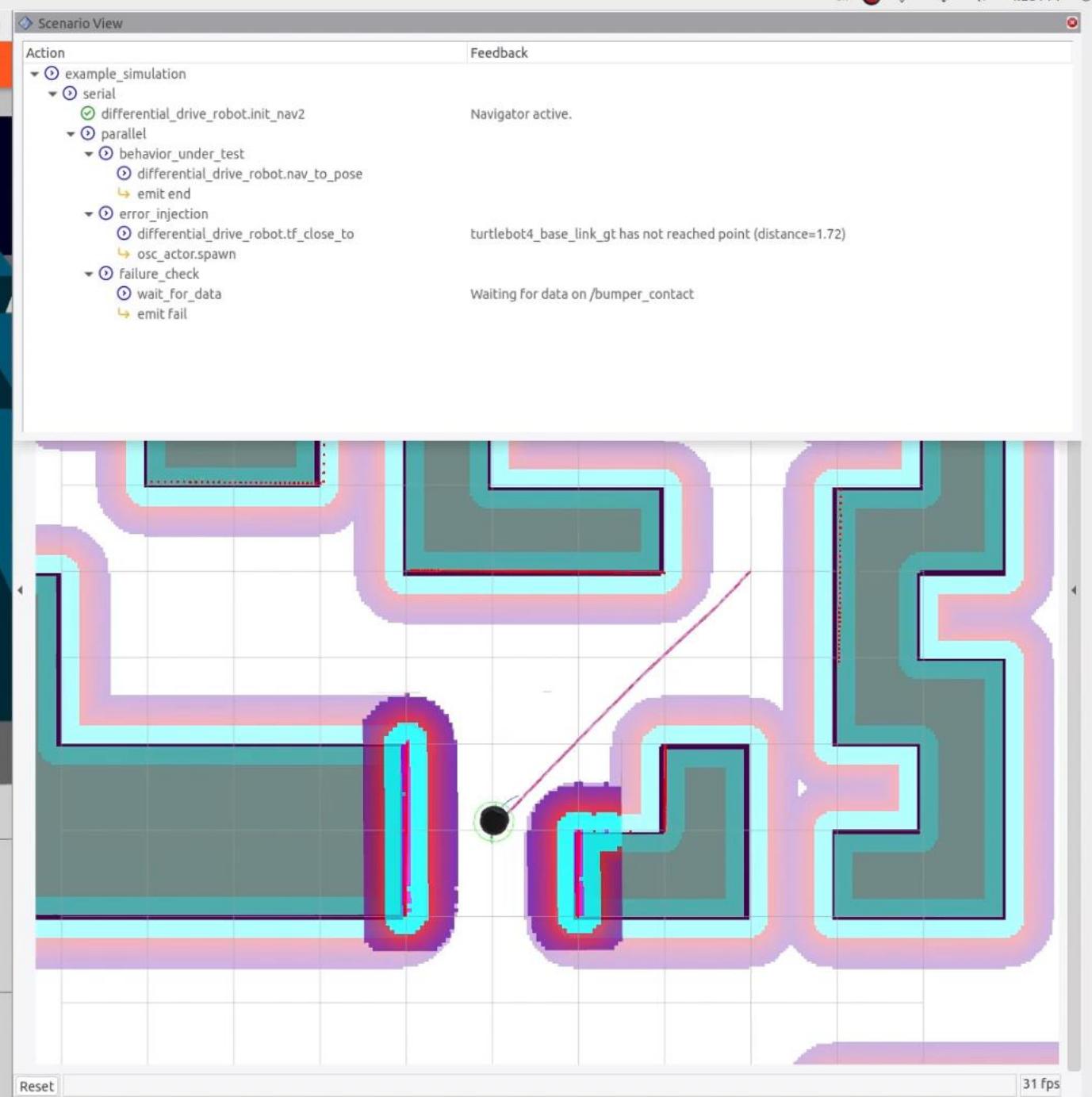
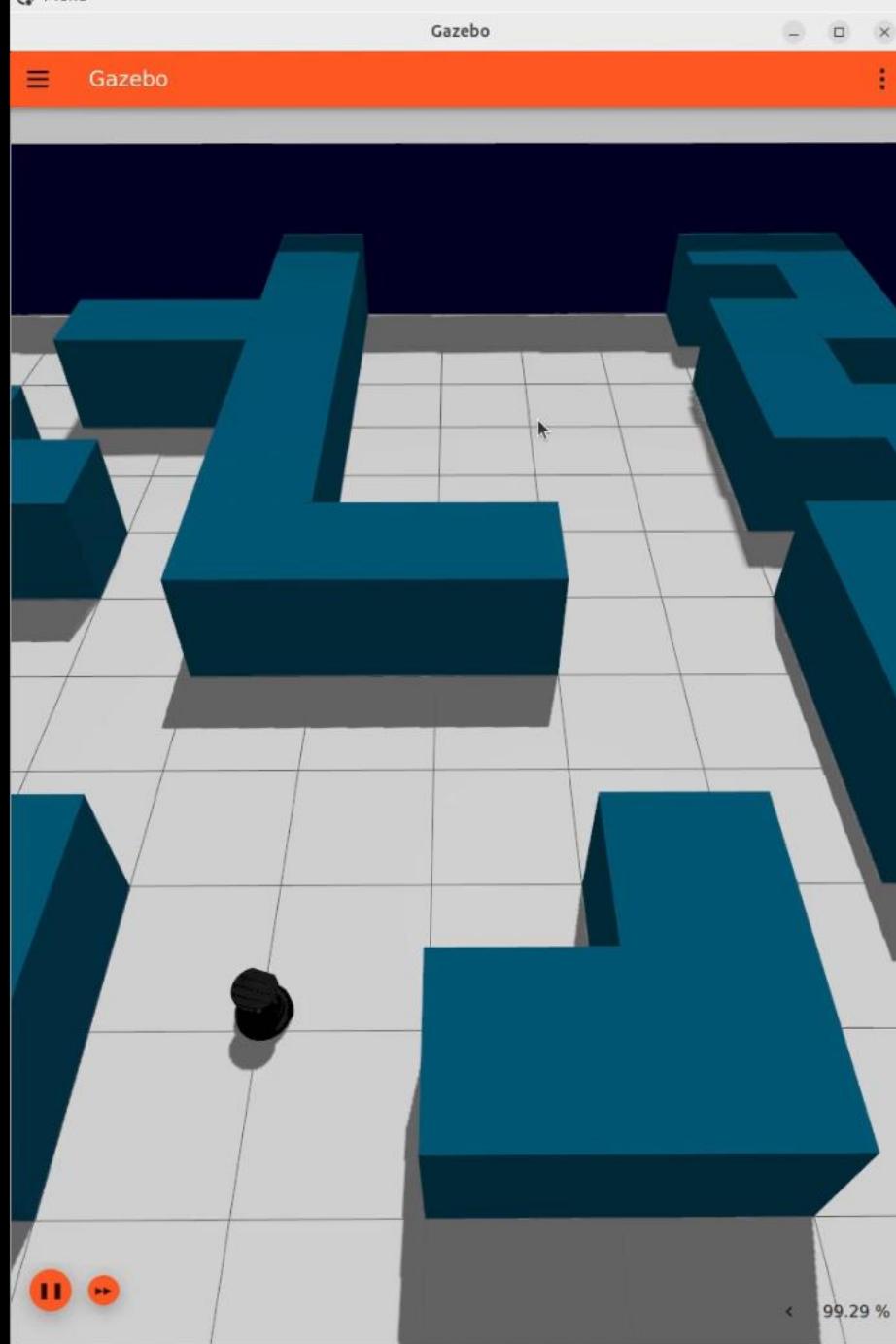
Navigation Scenario

- Start Simulation/Nav2
- Initialize Nav2
- Request to navigate to goal
- If robot reaches position:
 - Spawn Obstacle into Path
- Success Criteria:
 - Robot does not collide with obstacle
 - Goal is reached



```
import osc.helpers
import osc.ros
import osc.gazebo
import osc.nav2

scenario example_simulation:
    robot: differential_drive_robot
    box: osc_actor
    do serial:
        ros_launch('tb4_sim_scenario', 'sim_nav_scenario_launch.py') with:
            running_is_success()
        robot.init_nav2(pose_3d(position_3d(x: 0.0m, y: 0.0m)))
    parallel:
        behavior_under_test: serial:
            robot.nav_to_pose(pose_3d(position_3d(x: 3.0m, y: -3.0m)))
            emit end
        error_injection: serial:
            robot.tf_close_to(
                reference_point: position_3d(x: 1.5m, y: -1.5m),
                threshold: 0.4m,
                robot_frame_id: 'turtlebot4_base_link_gt')
    box.spawn(
        spawn_pose: pose_3d(
            position: position_3d(x: 2.0m, y: -2.0m, z: 0.1m),
            orientation: orientation_3d(yaw: 0.0rad)),
        model: 'example_simulation://models/box.sdf')
    failure_check: serial:
        wait_for_data("/bumper_contact", "ros_gz_interfaces.msg.Contacts")
        emit fail
```



Scenario Parameter Variation

Abstract Scenario

A navigating robot is able to localize itself using erroneous lidar data

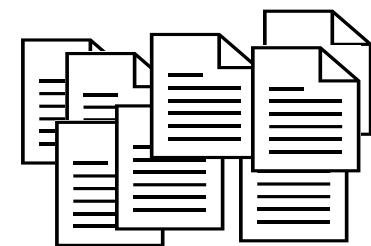
Potential Scenario Count

∞

Logical Scenario

Lidar Data Errors:

- Noise Std. Dev.: 0 to 0.7
- Data Loss: 0 to 70%



Concrete Scenario

Lidar Data Errors:

- Noise Std. Dev.: 0.4
- Data Loss: 10%

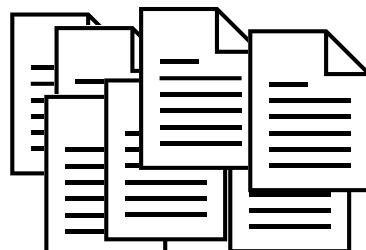


Scenario Parameter Variation Example

```
scenario laserscan_fault_injection:  
    robot: differential_drive_robot  
    do serial:  
        robot.init_nav2(pose_3d(position_3d(x: 0.0m, y: 0.0m)))  
        bag_record(['/tf', '/tf_static'], use_sim_time: true)  
        set_node_parameter('laserscan_modification', 'gaussian_noise_std_deviation') with:  
            | keep(it.parameter_value in ['0.0', '0.1', '0.2', '0.3', '0.4', '0.5', '0.6', '0.7'])  
        set_node_parameter('laserscan_modification', 'random_drop_rate') with:  
            | keep(it.parameter_value in ['0.0', '0.1', '0.2', '0.3', '0.4', '0.5', '0.6', '0.7'])  
        robot.nav_to_pose(pose_3d(position_3d(x: 3.0m, y: -3.0m)))  
        robot.nav_to_pose(pose_3d(position_3d(x: 0.0m, y: -0.0m)))
```



Scenario Variation



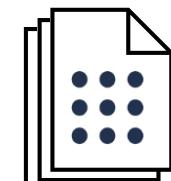
8x8 Concrete Scenarios



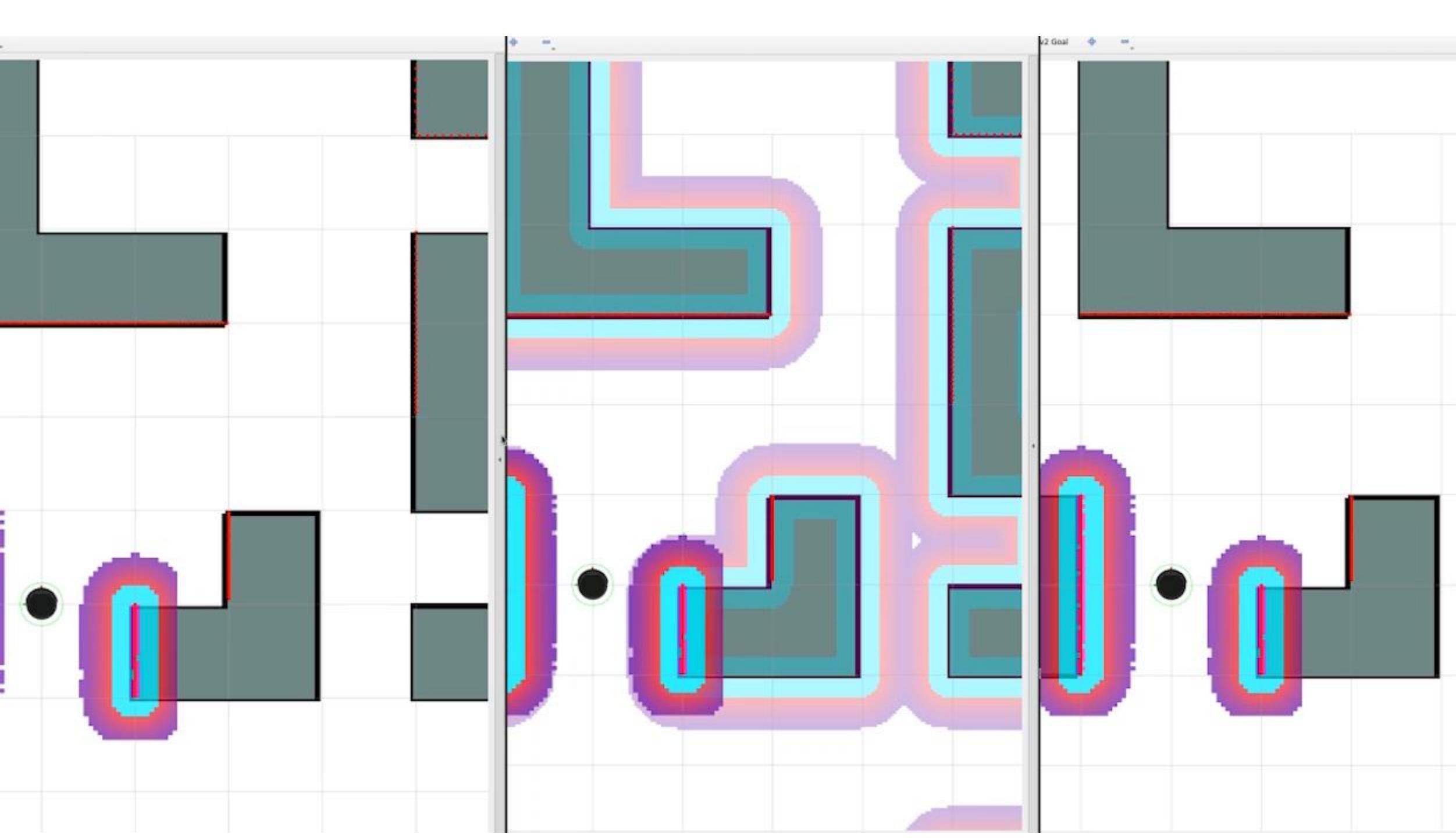
Scenario Batch Execution



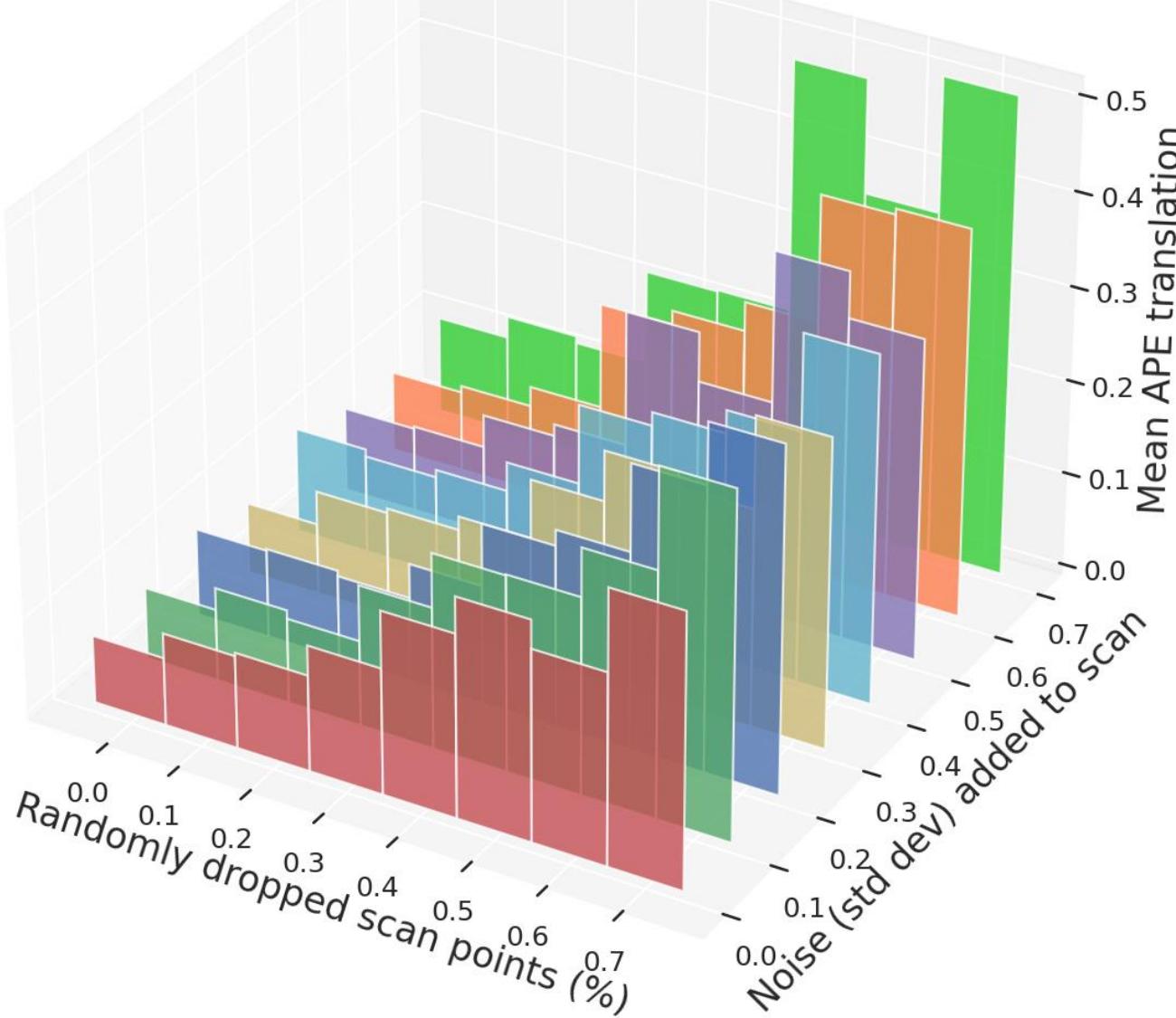
Overall Test Result



64 ROS bags

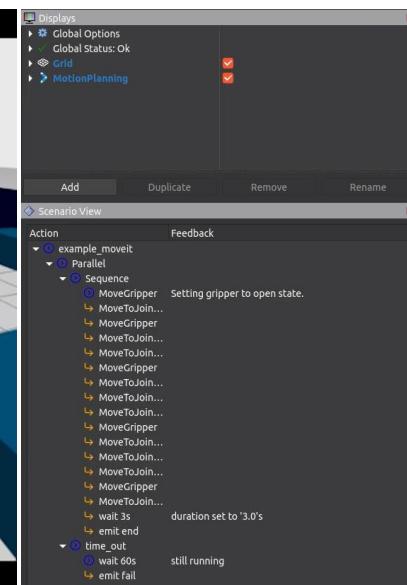
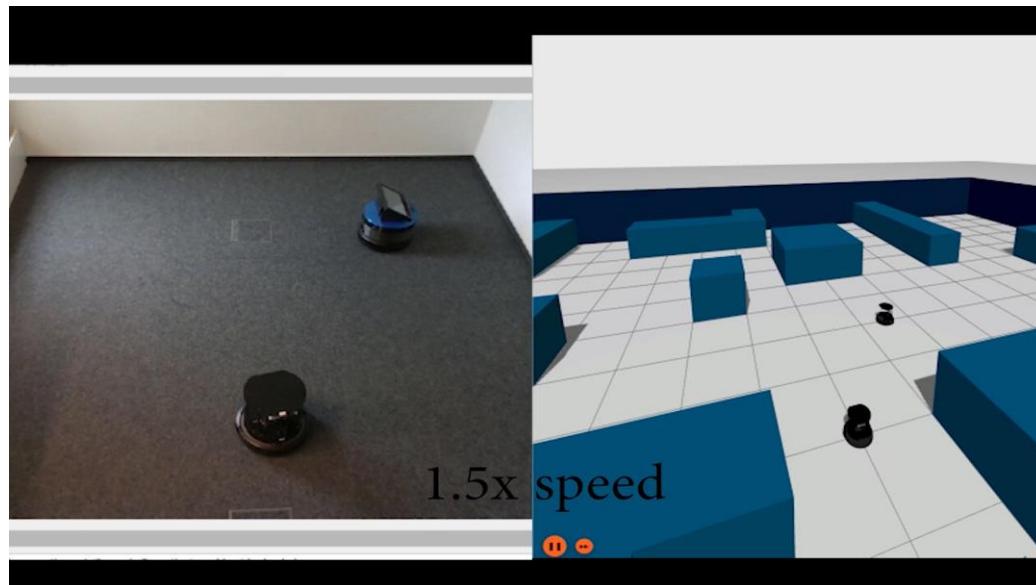


Scenario Variation – Localization analysis

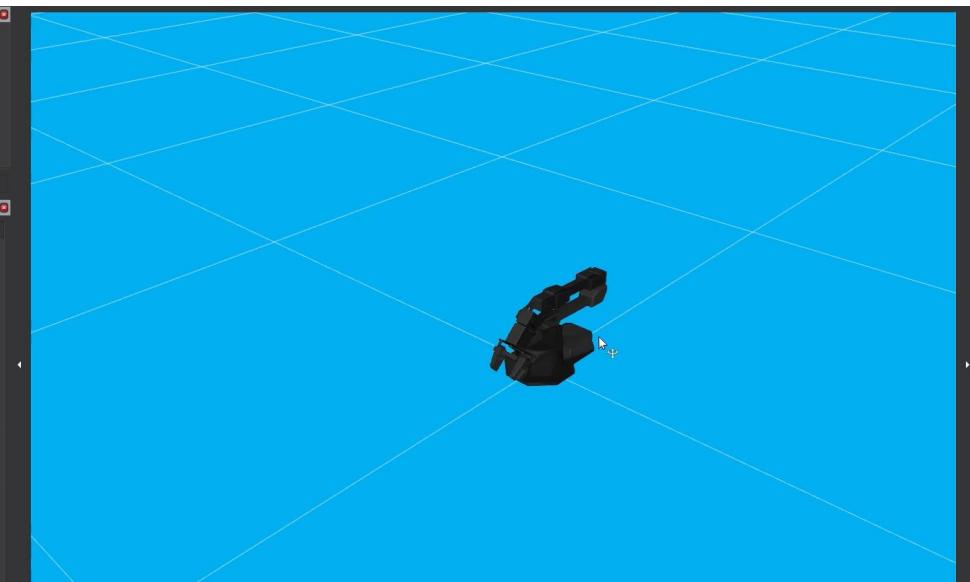


Some more examples

Nav2 Sim2Real



Movelt2 Action library



Scenario Execution for Robotics

OpenSCENARIO DSL

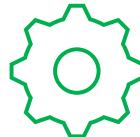
Action Libraries



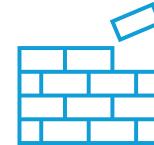
Behavior Tree



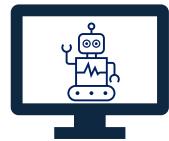
ROS2
realization



Easy CI
integration



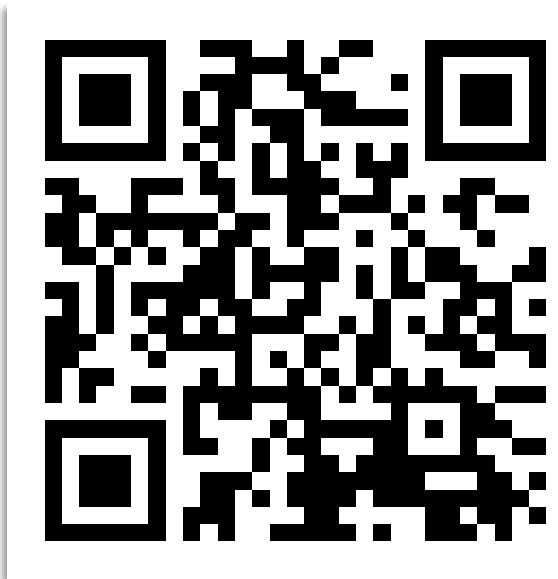
Modular
implementation,
easy to extend



Compatible with
simulations and
physical robots

Try it out!

```
sudo apt install -y ros-jazzy-scenario_execution*
```



GitHub

[https://github.com/IntelLabs/
scenario_execution](https://github.com/IntelLabs/scenario_execution)



Documentation

[https://intellabs.github.io/
scenario_execution/](https://intellabs.github.io/scenario_execution/)



Paper

[http://www.arxiv.org/
abs/2409.07080](http://www.arxiv.org/abs/2409.07080)

Questions?

LinkedIn Profiles



Florian Mirus



Frederik Pasch