Evaluate Path Planner and Controller for Automated Parking

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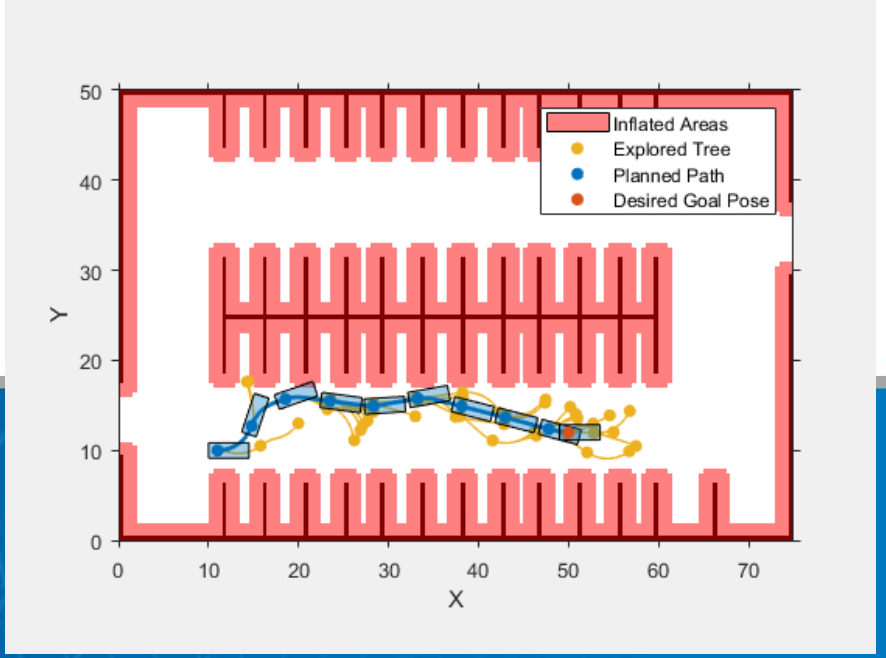
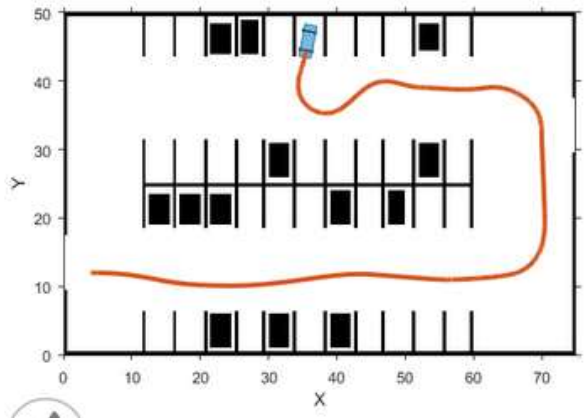
Application Engineering, MathWorks



Learn about path planning with these examples

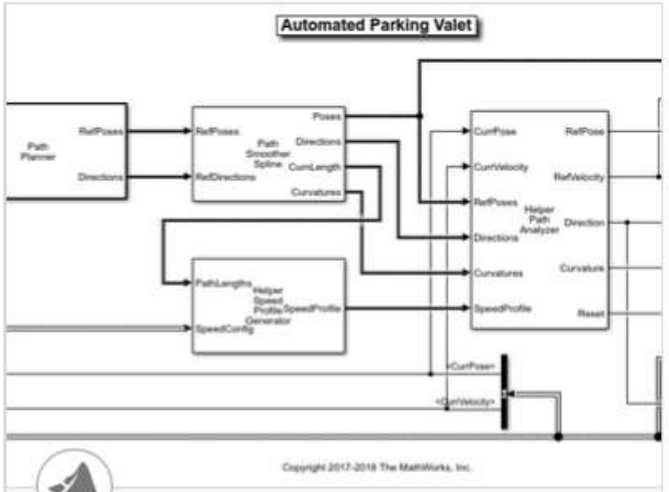
MATLAB example



Automated Parking Valet

Construct an automated parking valet system using path planning, trajectory generation, and vehicle control techniques.

Open Script



Automated Parking Valet in Simulink

Construct an automated parking valet system in Simulink with Automated Driving Toolbox.

Open Model

Simulink test bench

Learn about path planning with these examples

How robust is the algorithm?

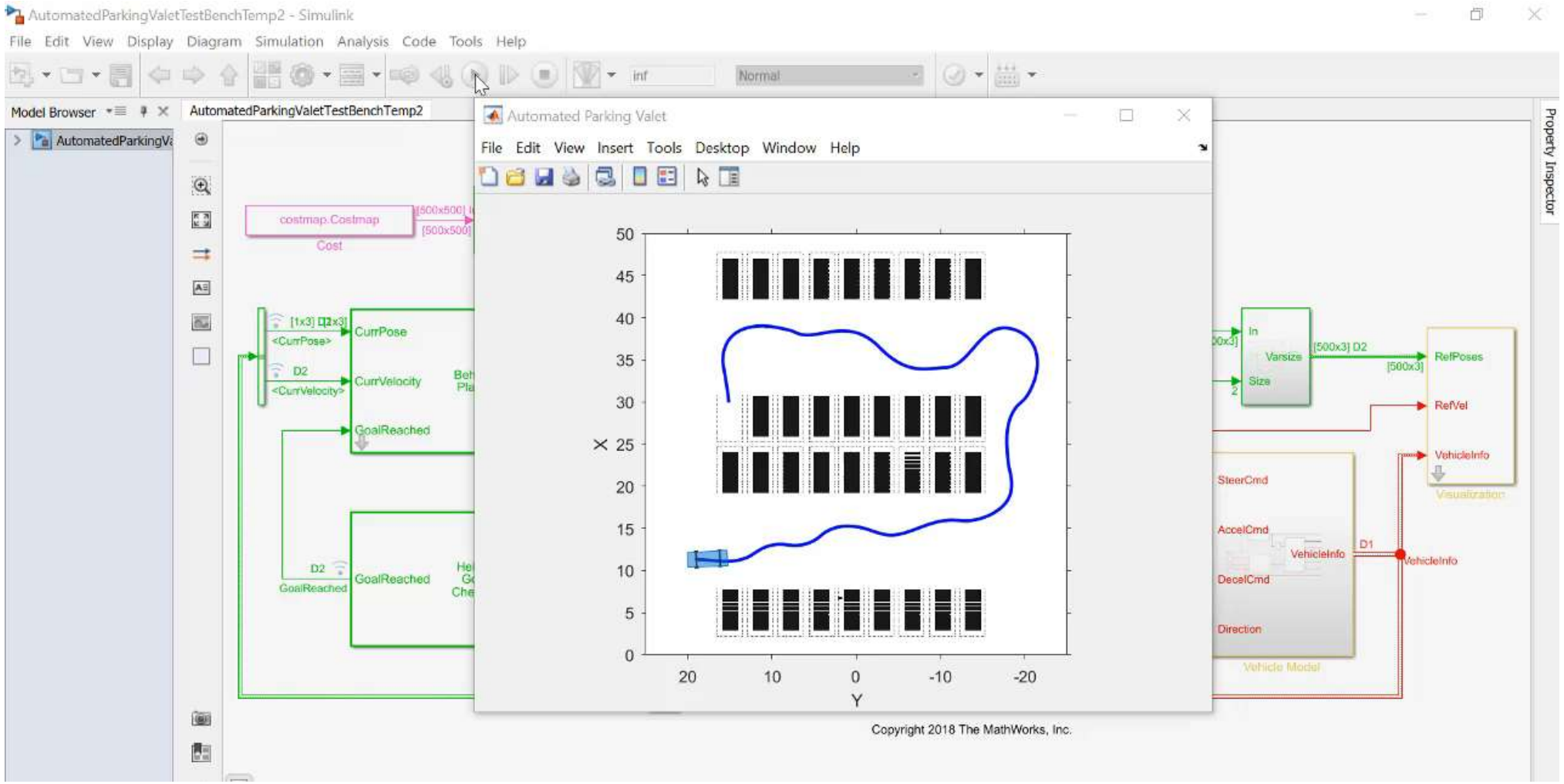
How can I handle moving pedestrian

How can I automate the tests?

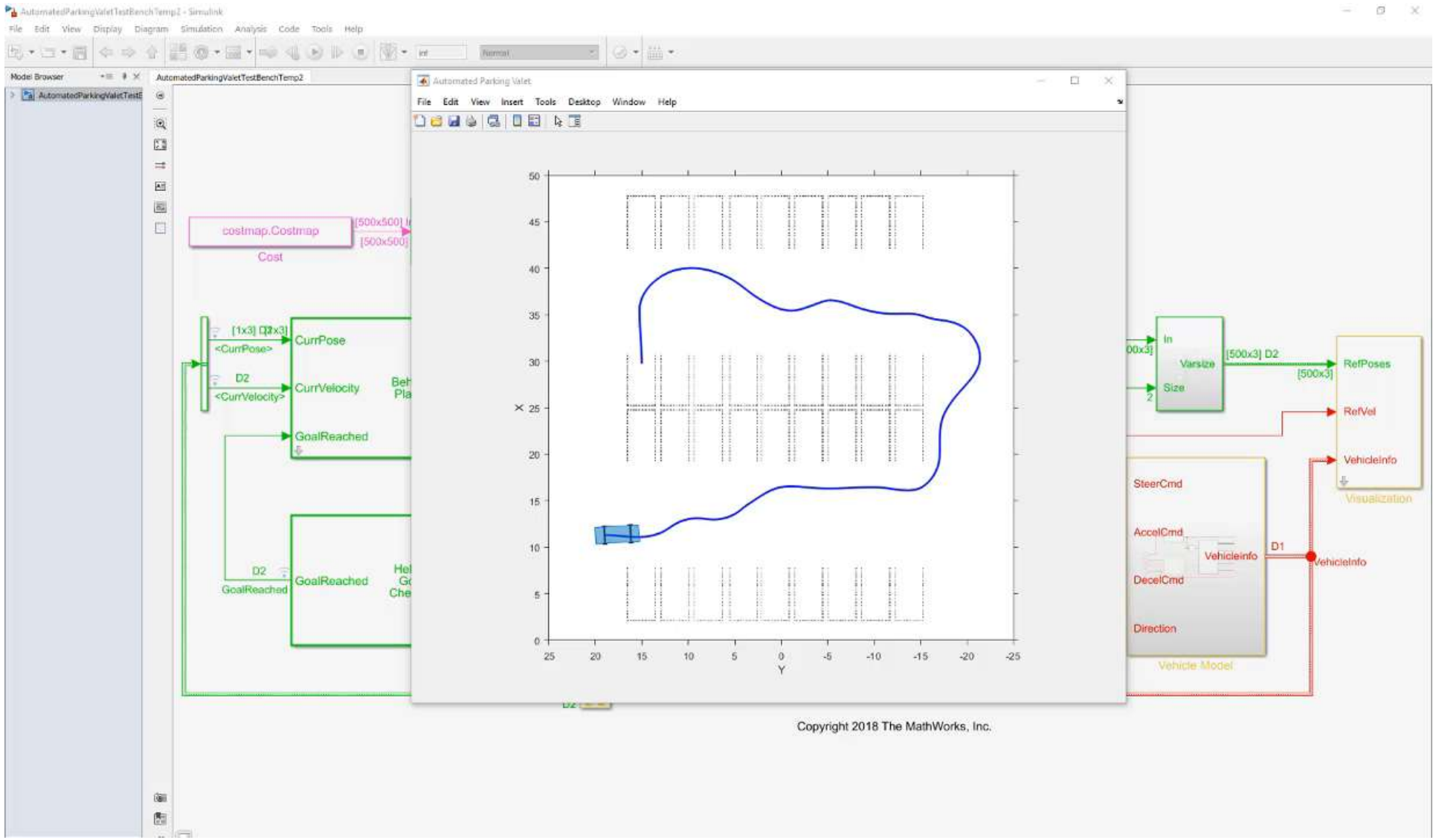
Evaluate Path Planner and Controller for Automated Parking

- Explore system robustness with simulation
- Improve design to handle moving pedestrian
- Test automation for regression tests

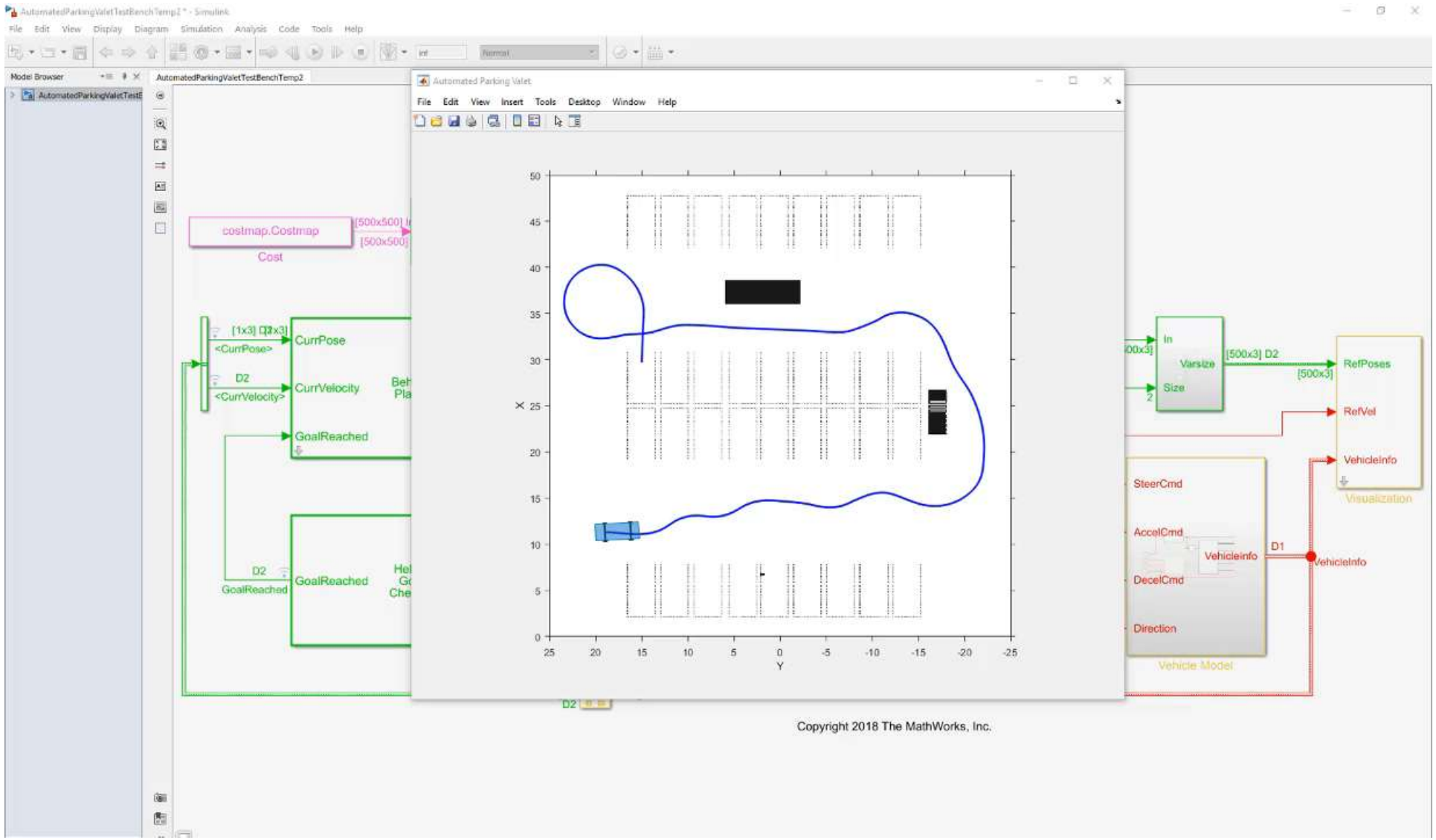
Requirement 1: vehicle can only move forward



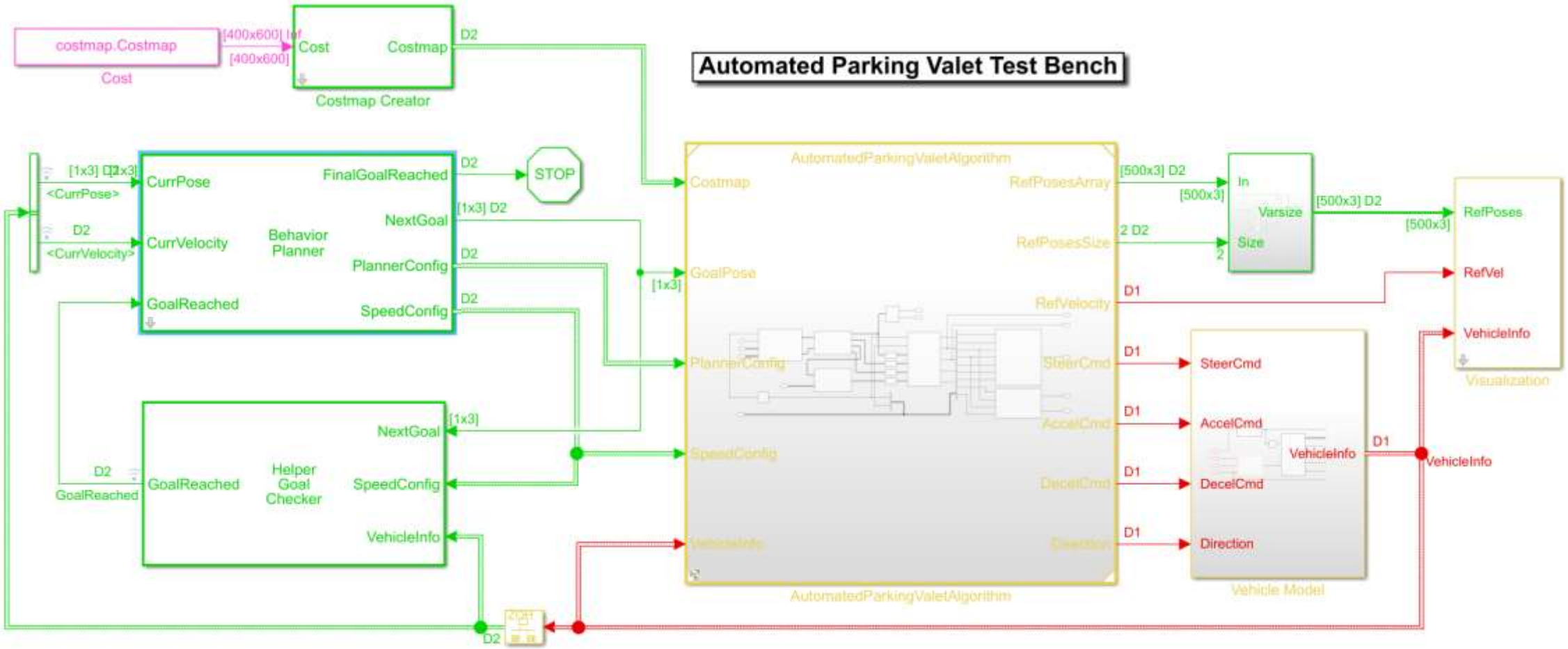
Requirement 2: vehicle can’t cross parking lanes



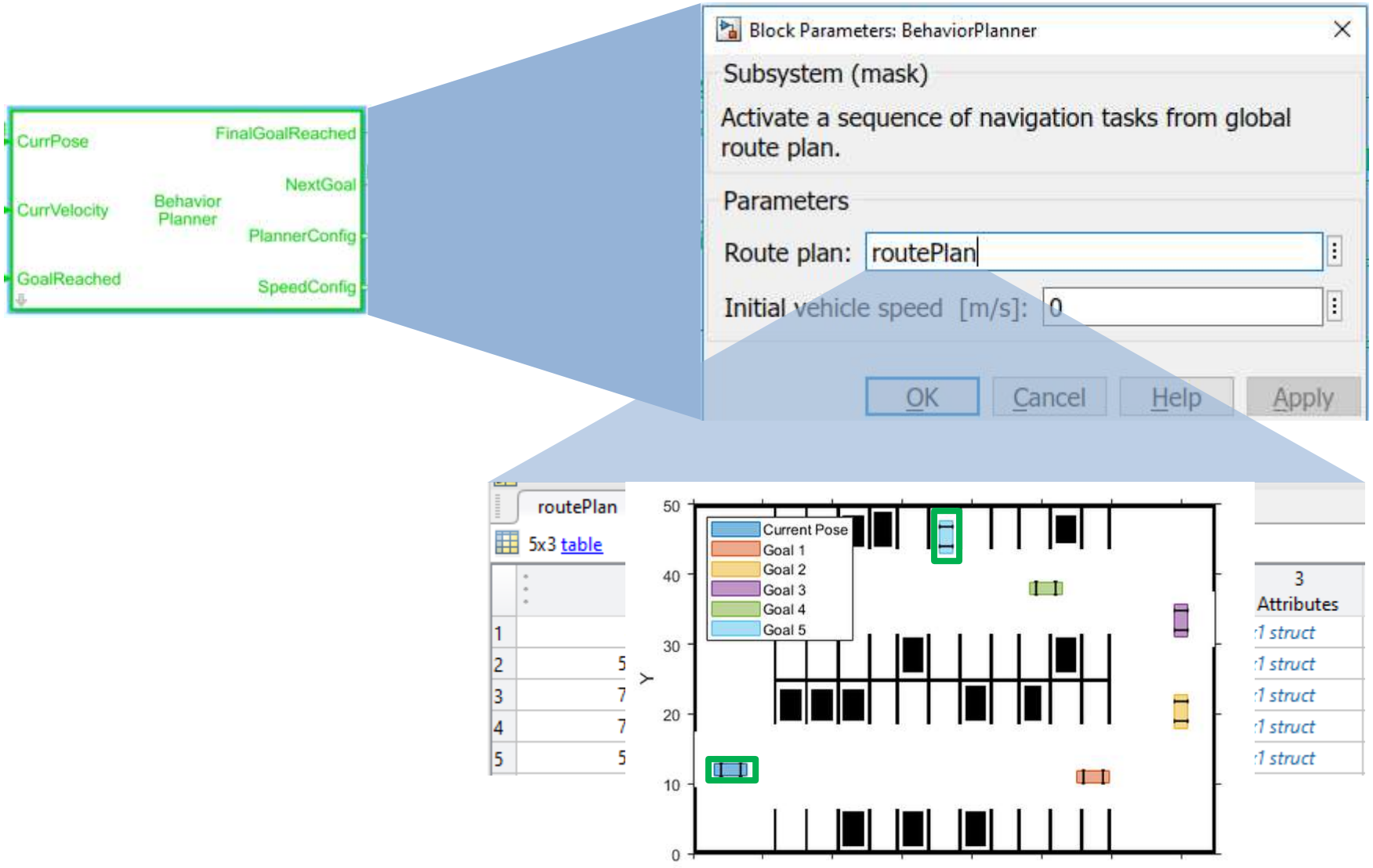
Requirement 3: algorithm must be able to handle loop.



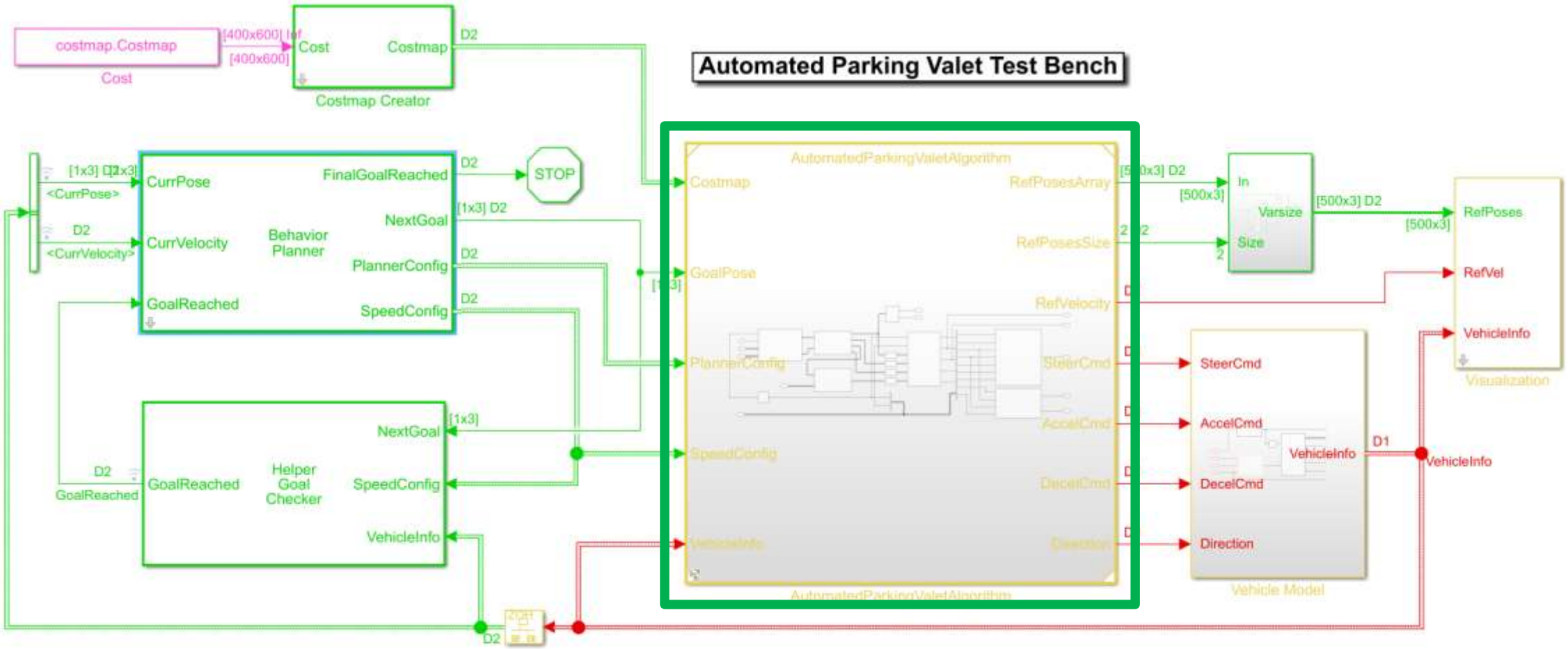
Baseline model in the product



Single test case in the baseline model

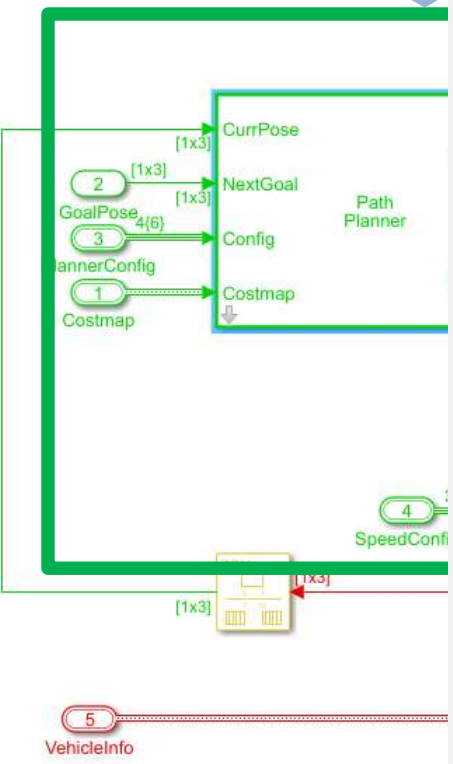


Software model

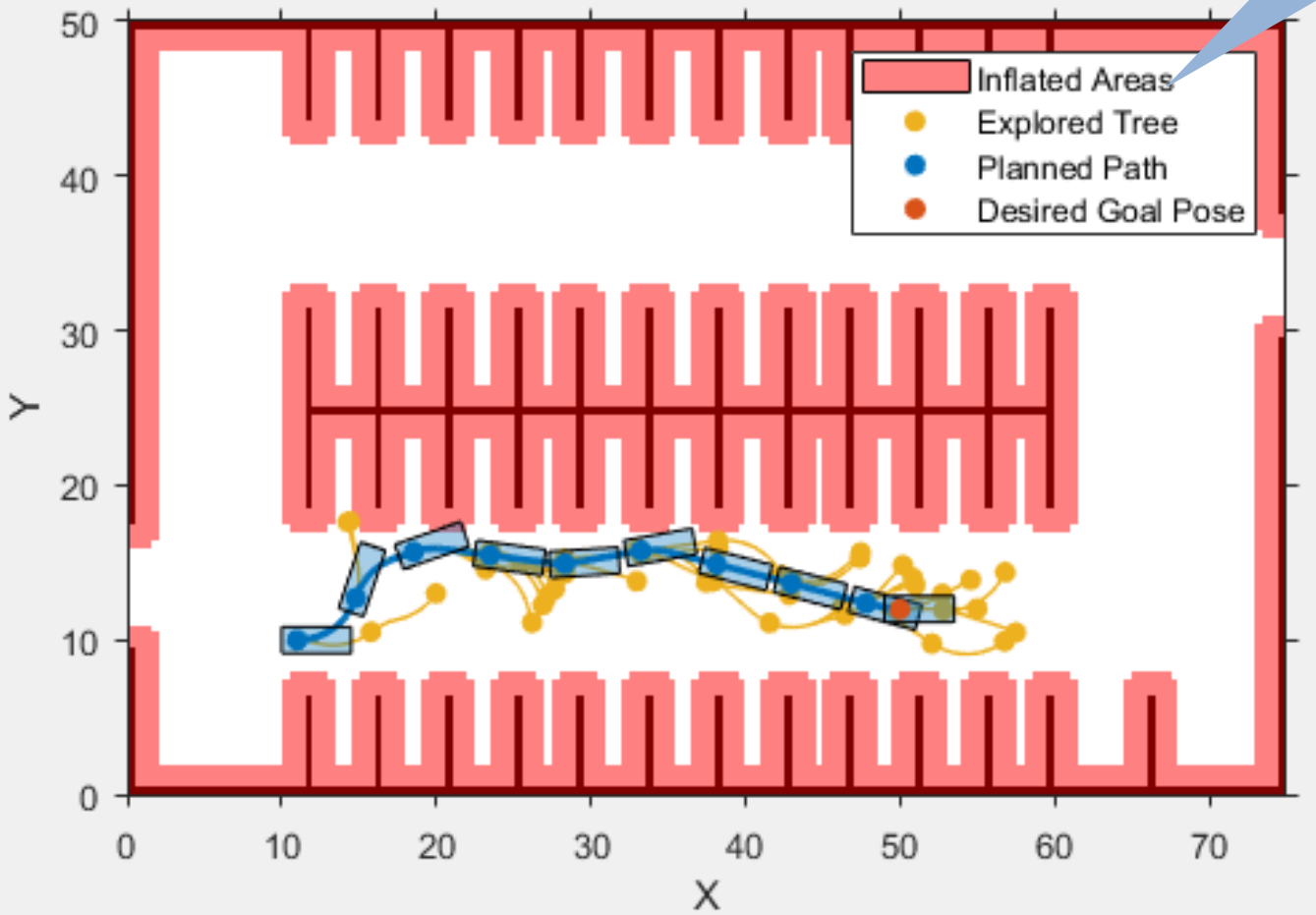


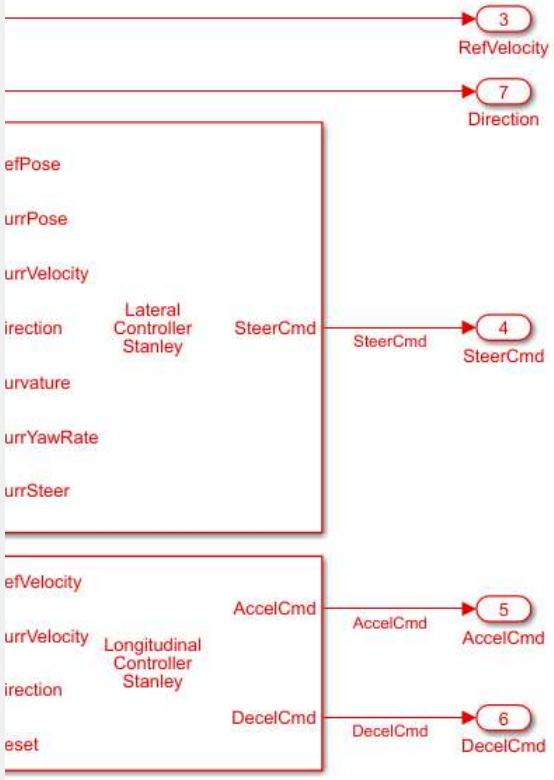
Main modules

Pla



Inflation Collision Checking



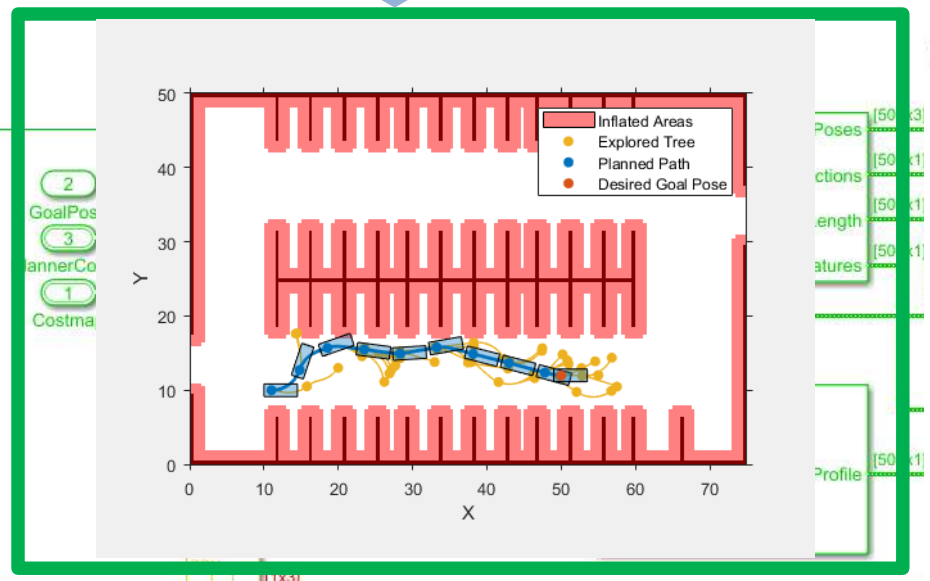


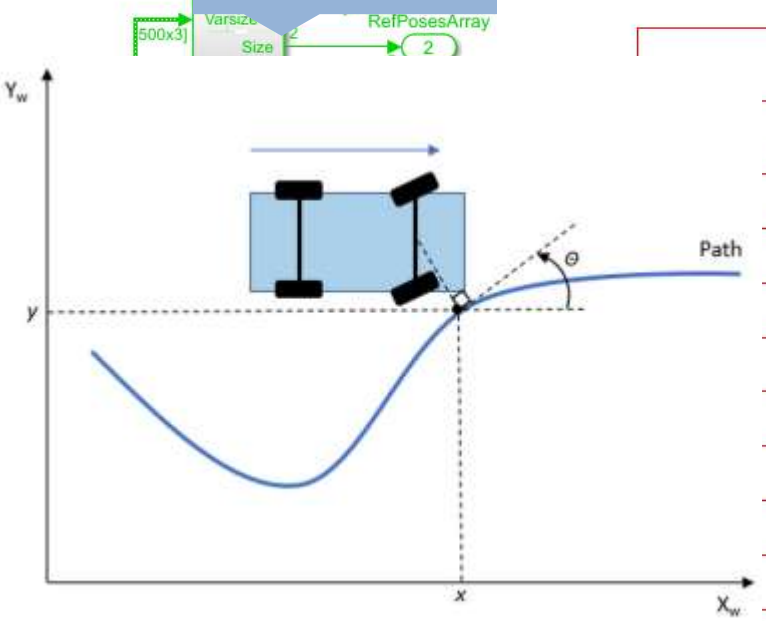
Main modules

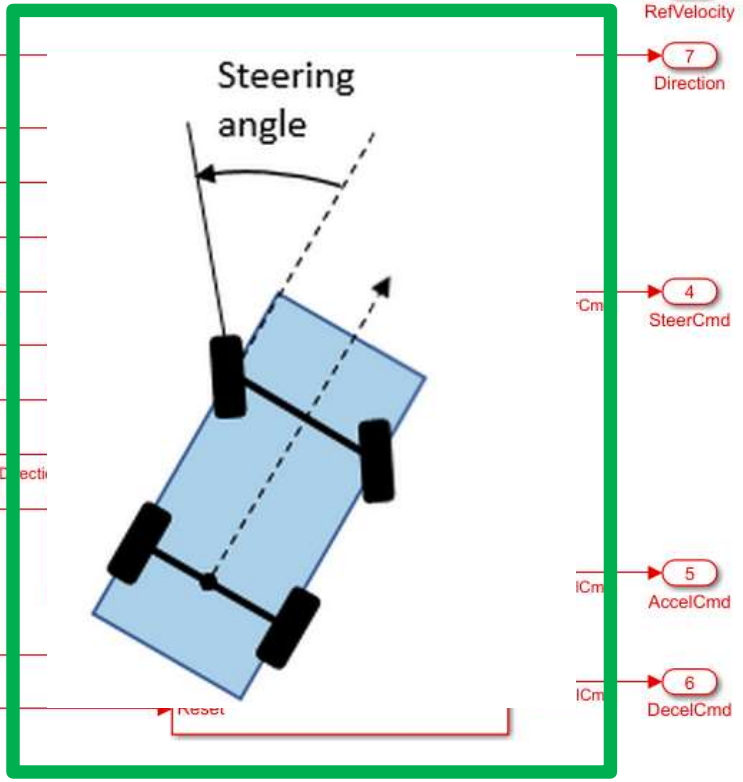
Planning

Path Analyzer

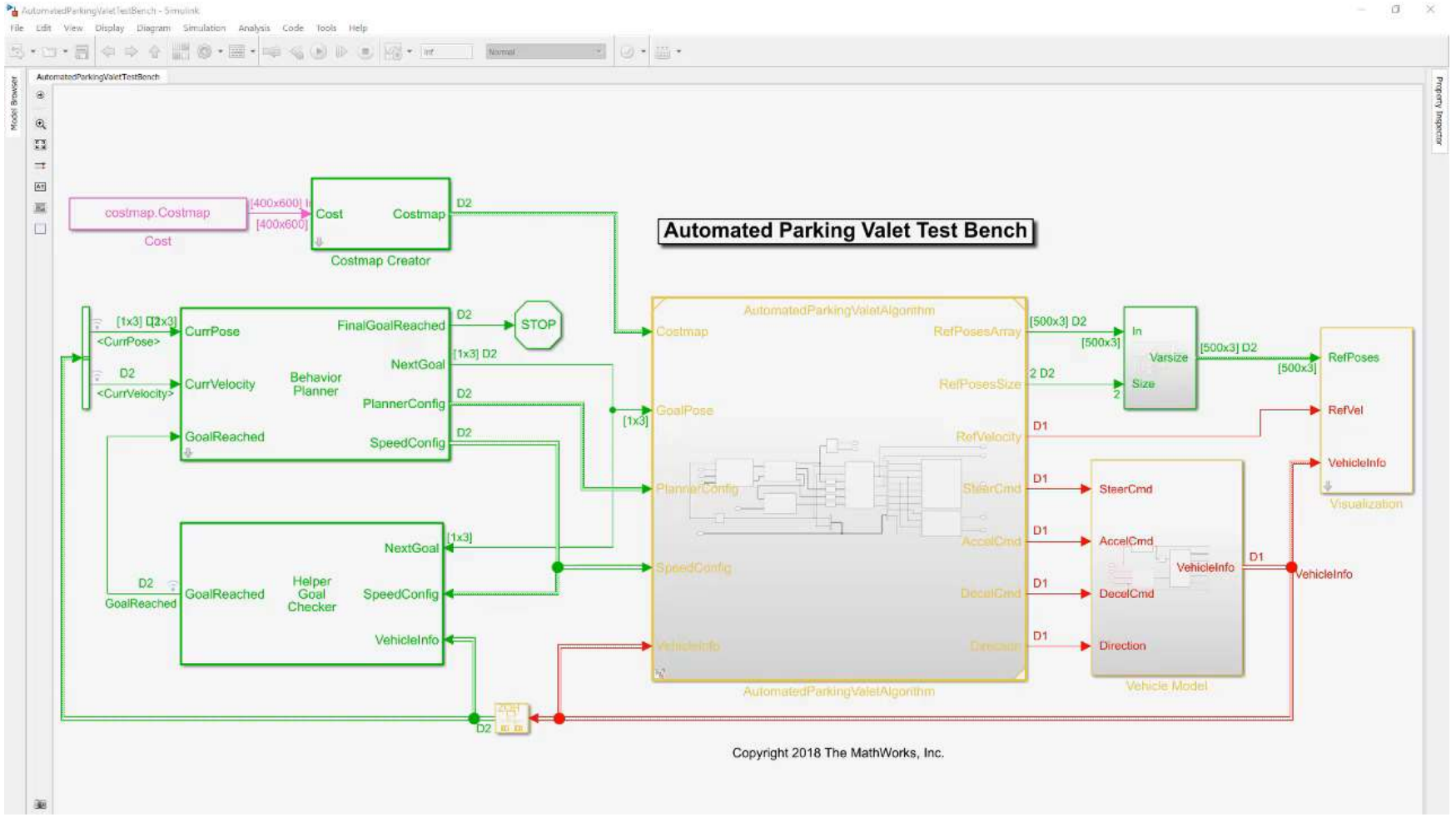
Control



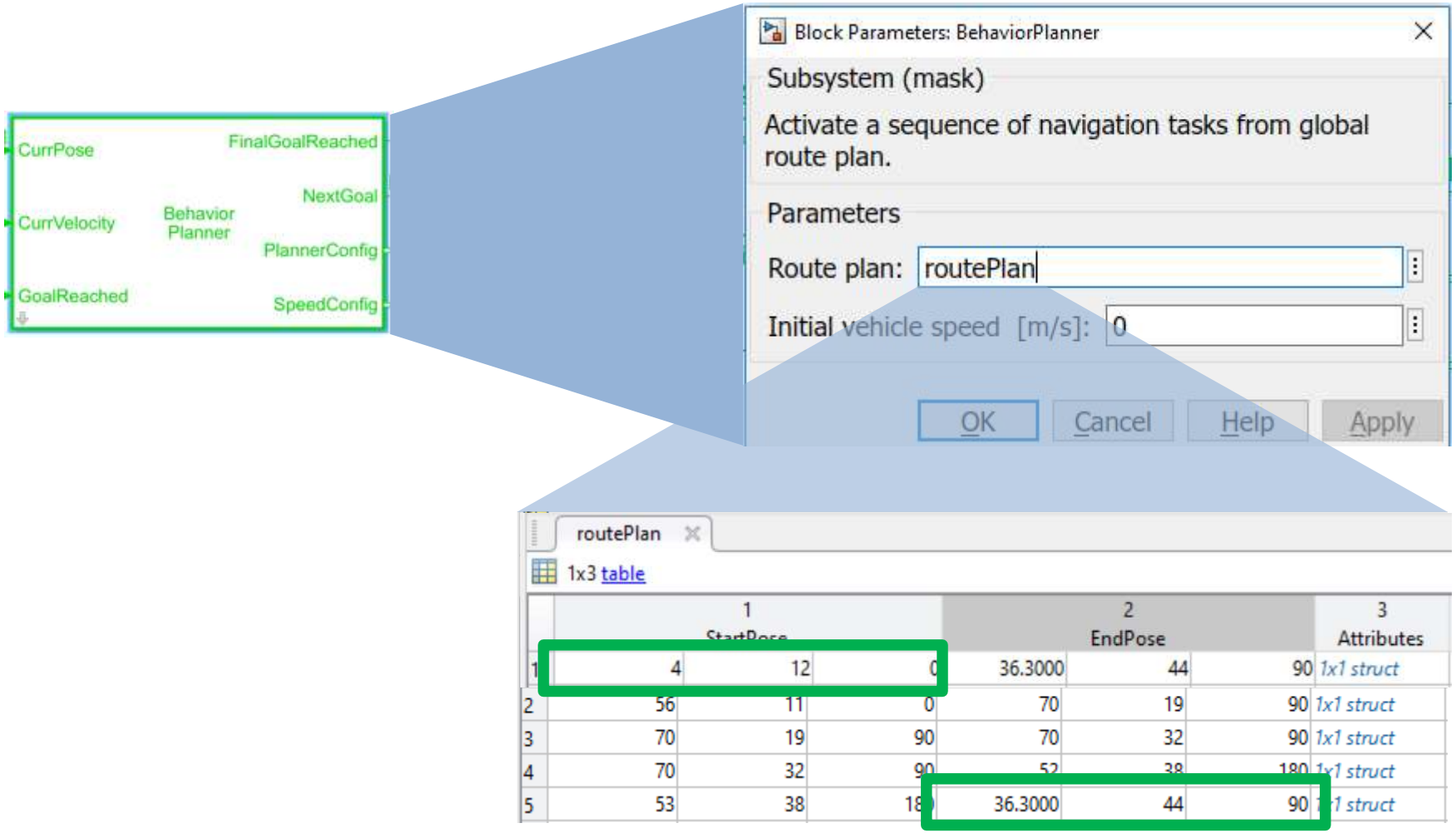




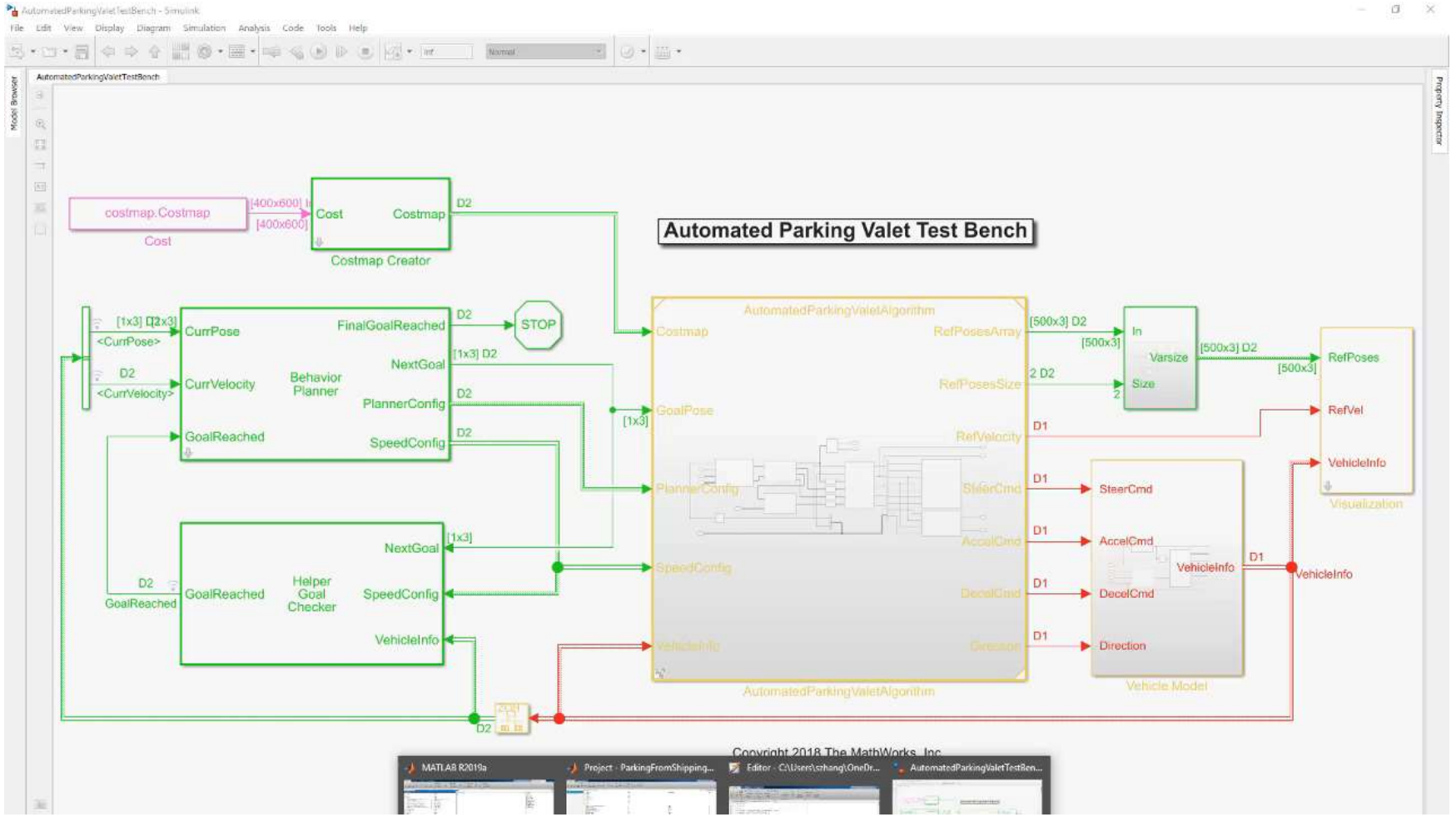
Explore baseline behavior with multiple goal poses



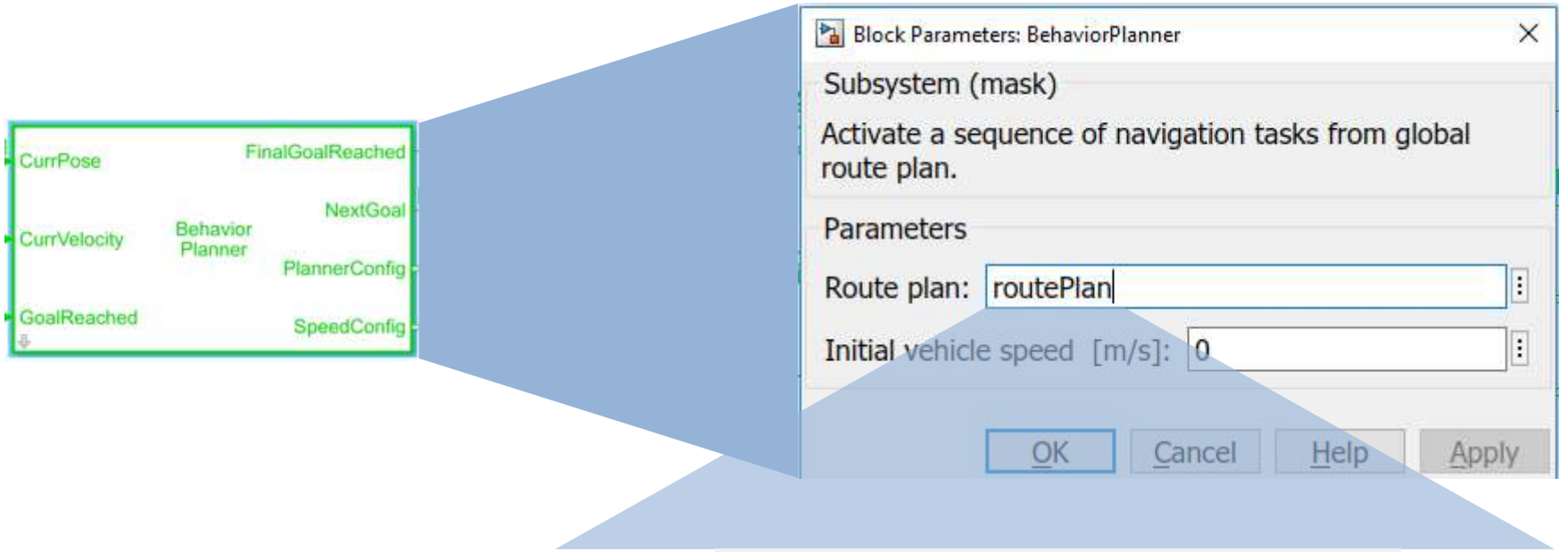
Explore behavior with single goal pose

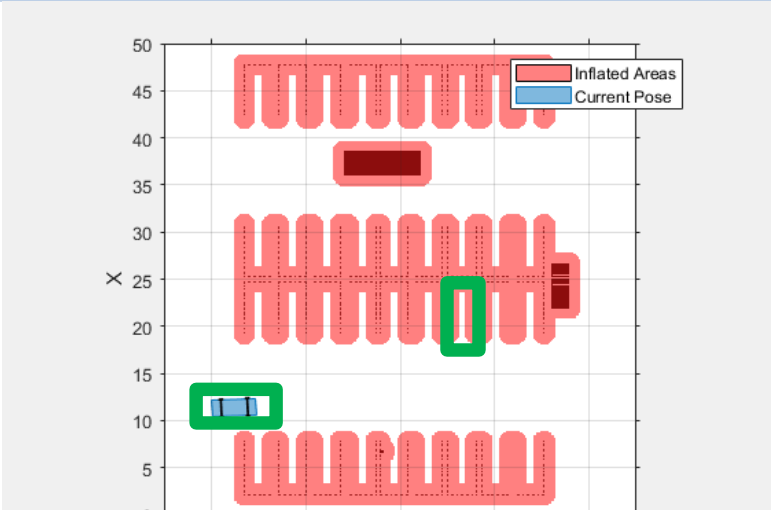


Explore behavior with single goal pose

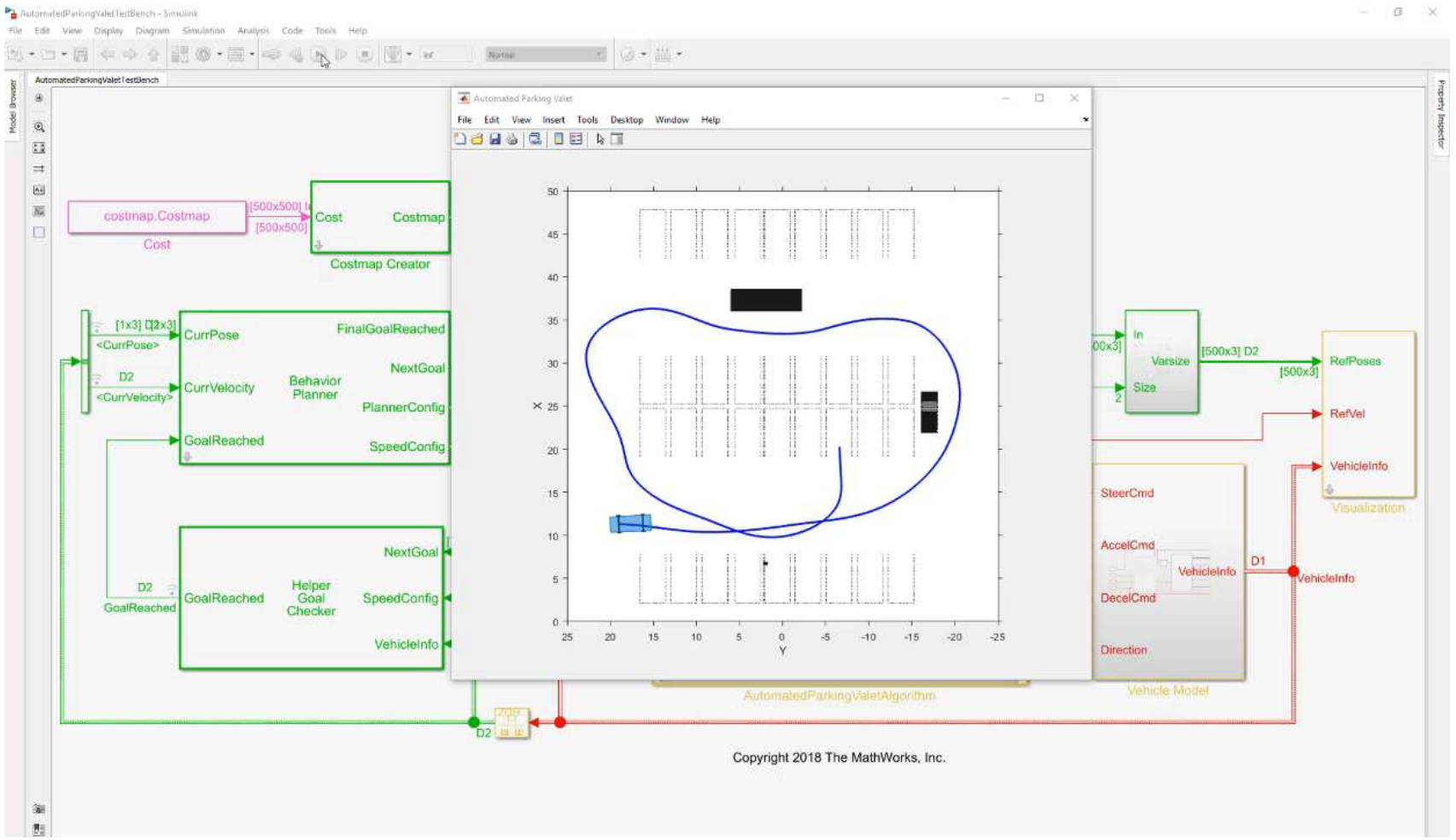


Changing testing condition

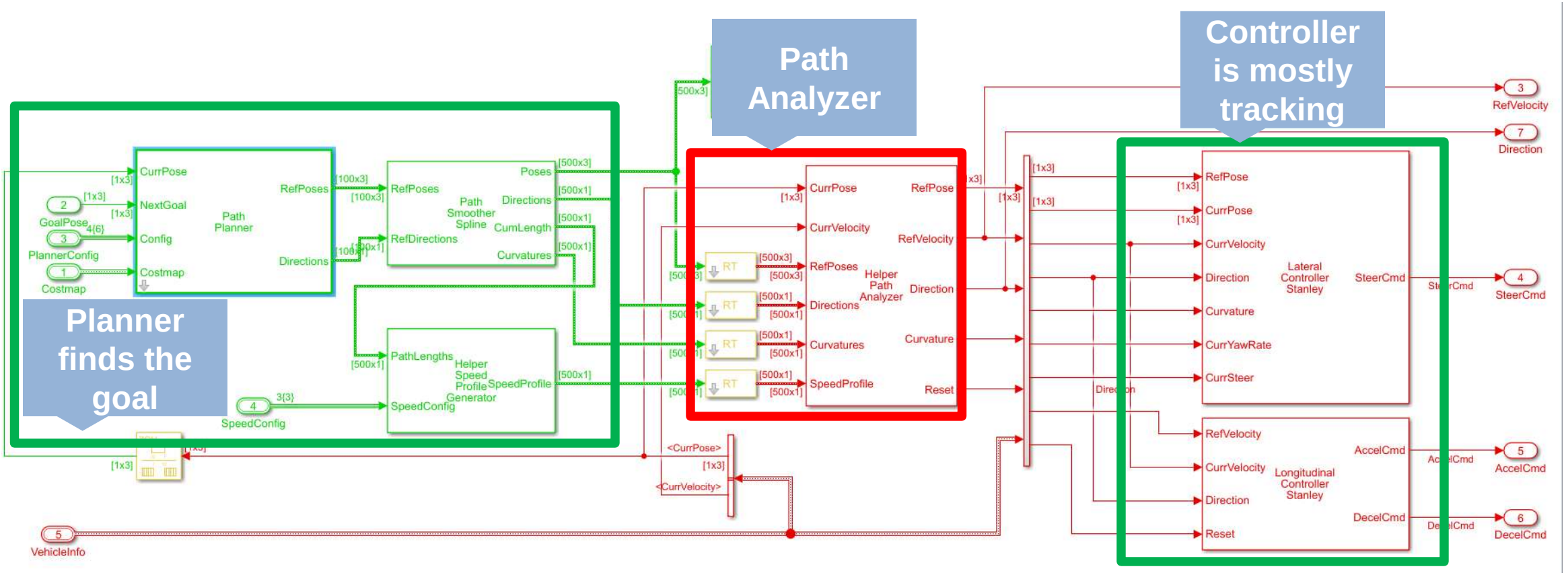




Explore behavior with goal pose that generates a loop in path

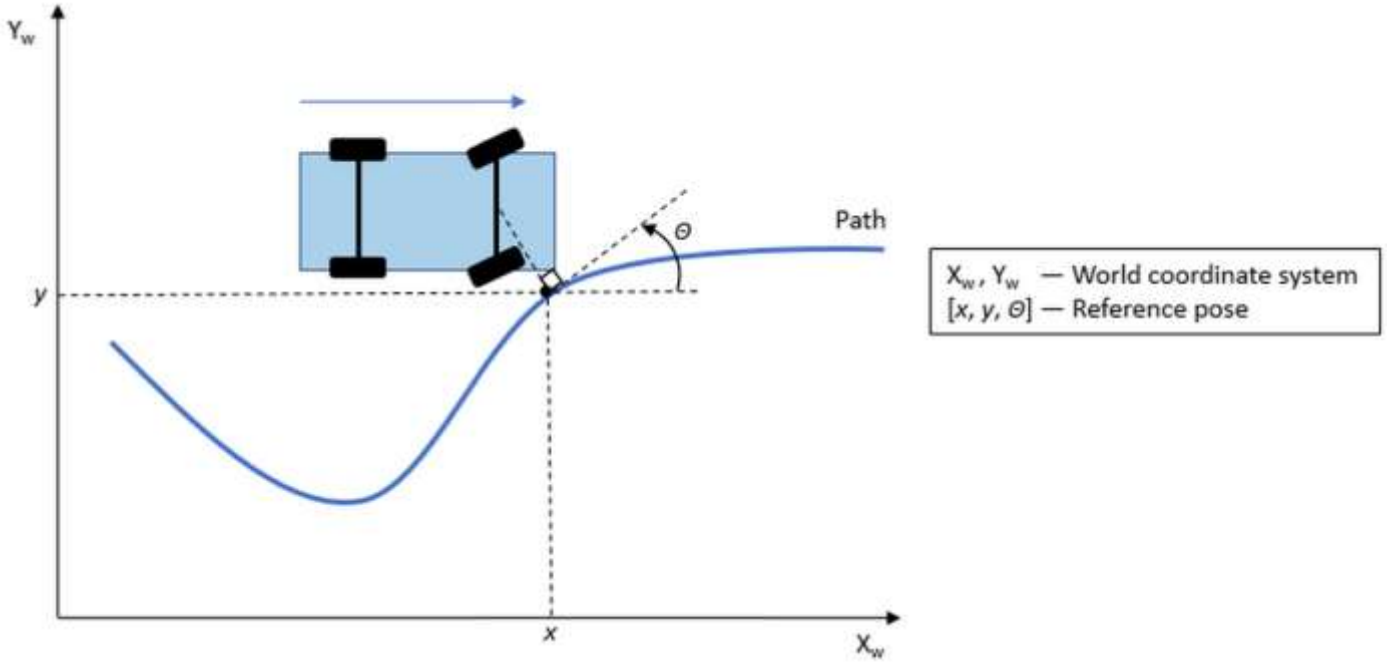


Isolate issue based on simulation results



Existing path analyzer

- Find a point on the path for the vehicle to follow

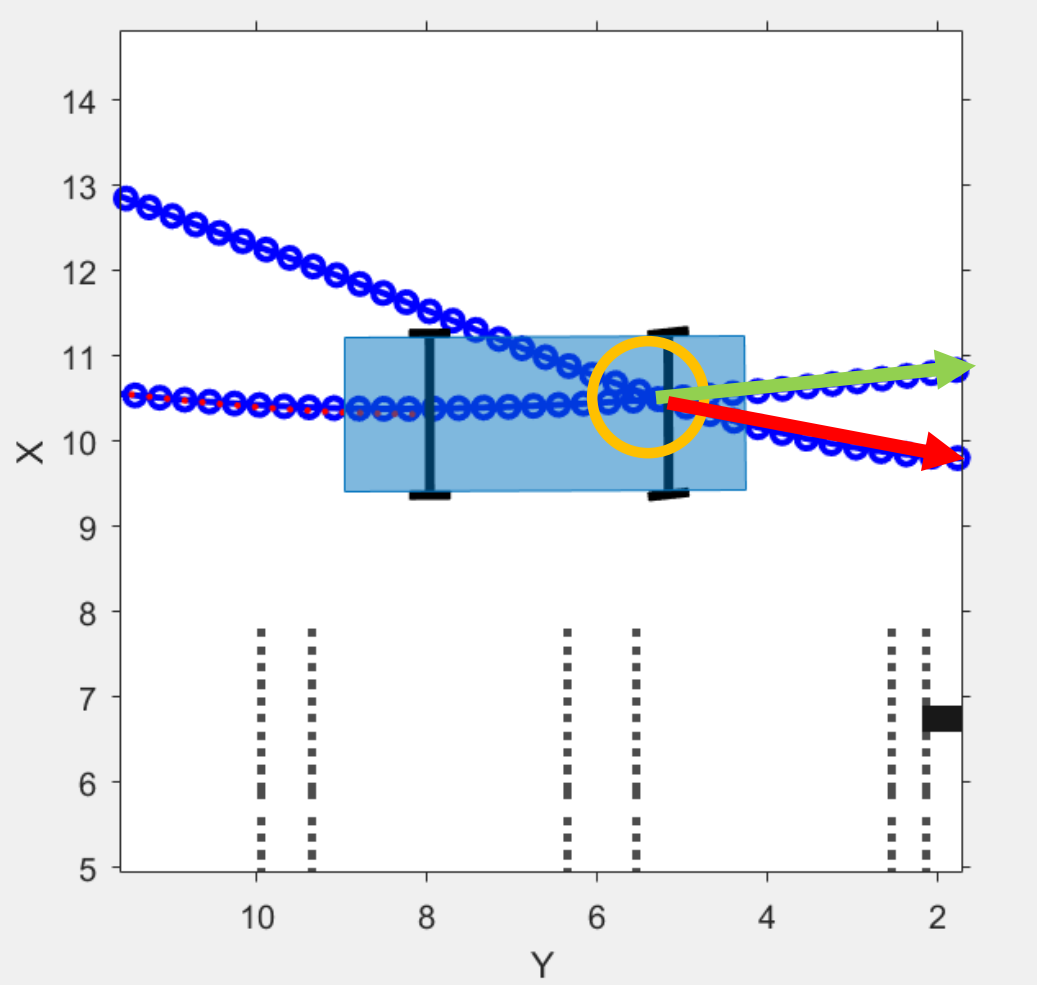


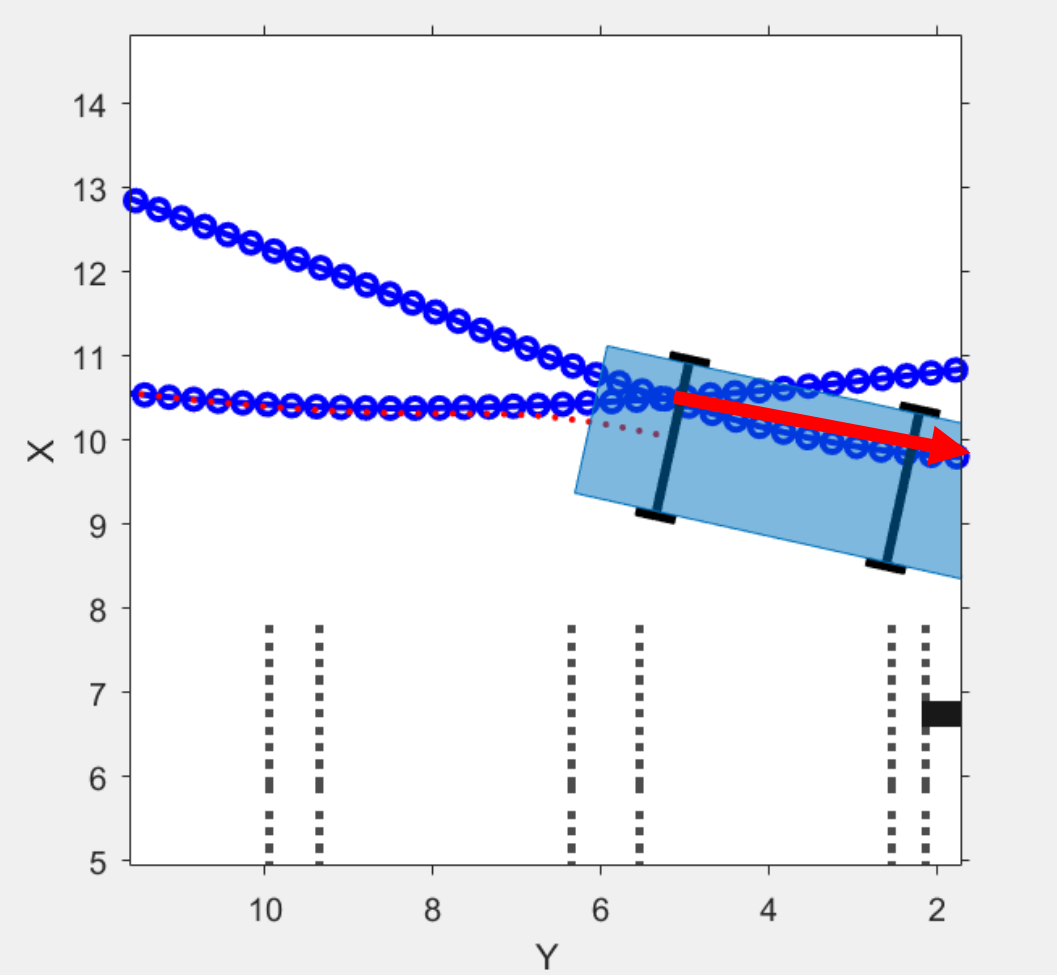

```
% Find the closest point on the reference path
[closestIdx, ~] = find(dis2PointsSquare == min(dis2PointsSquare), 1);

% Enforce to be a scalar in Simulink
closestIdx = closestIdx(1);
```

Minimum distance to entire path

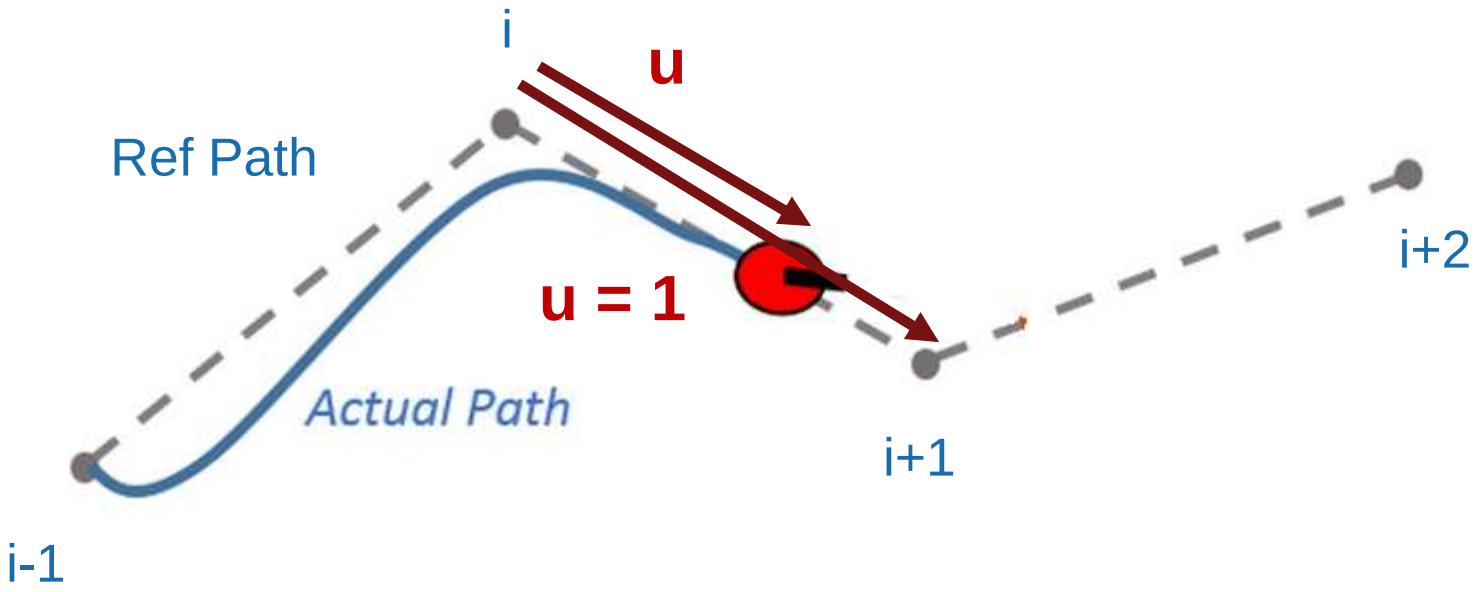
Existing path analyzer





Modified path analyzer

- Find a point on the path for the vehicle to follow

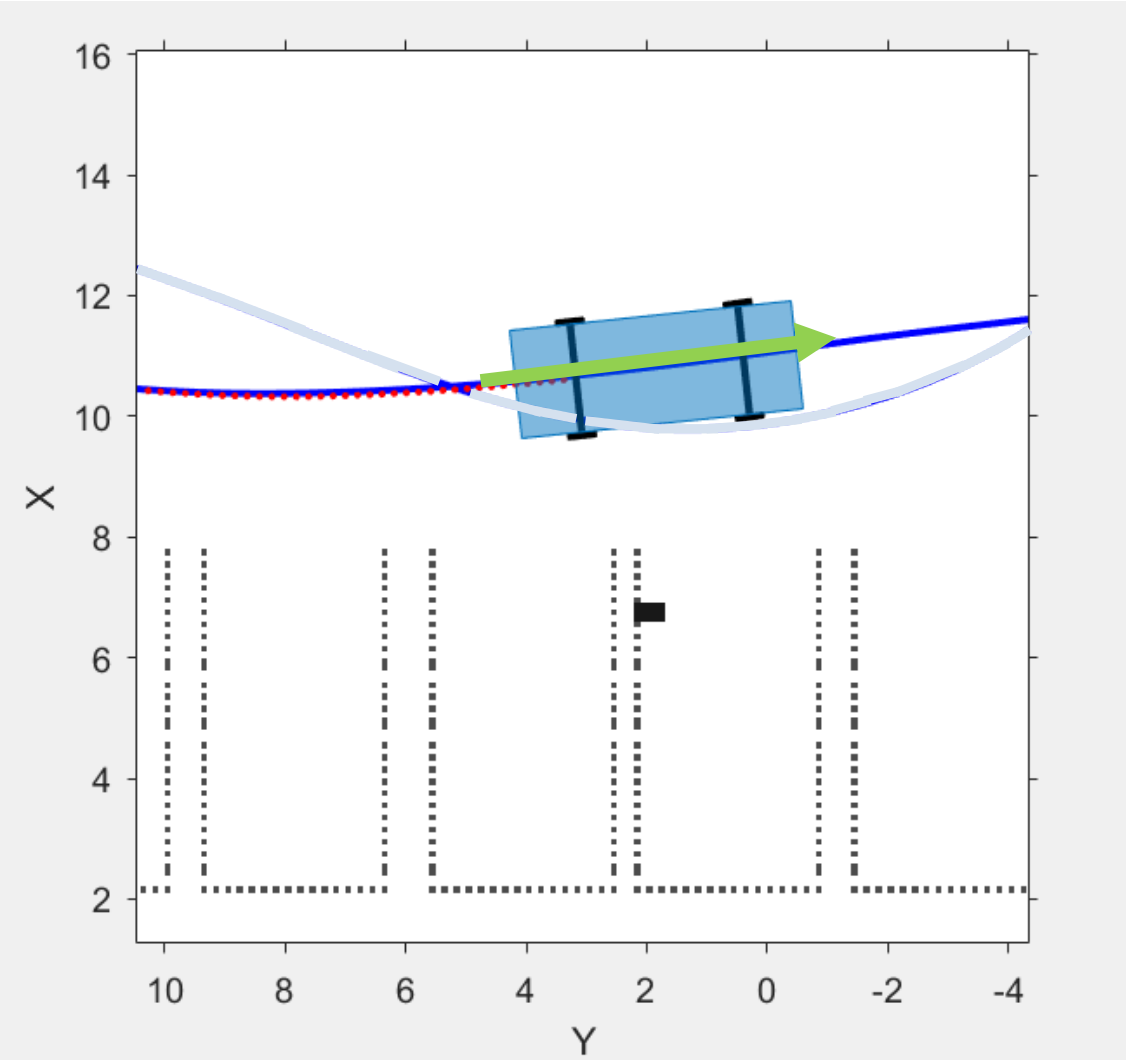


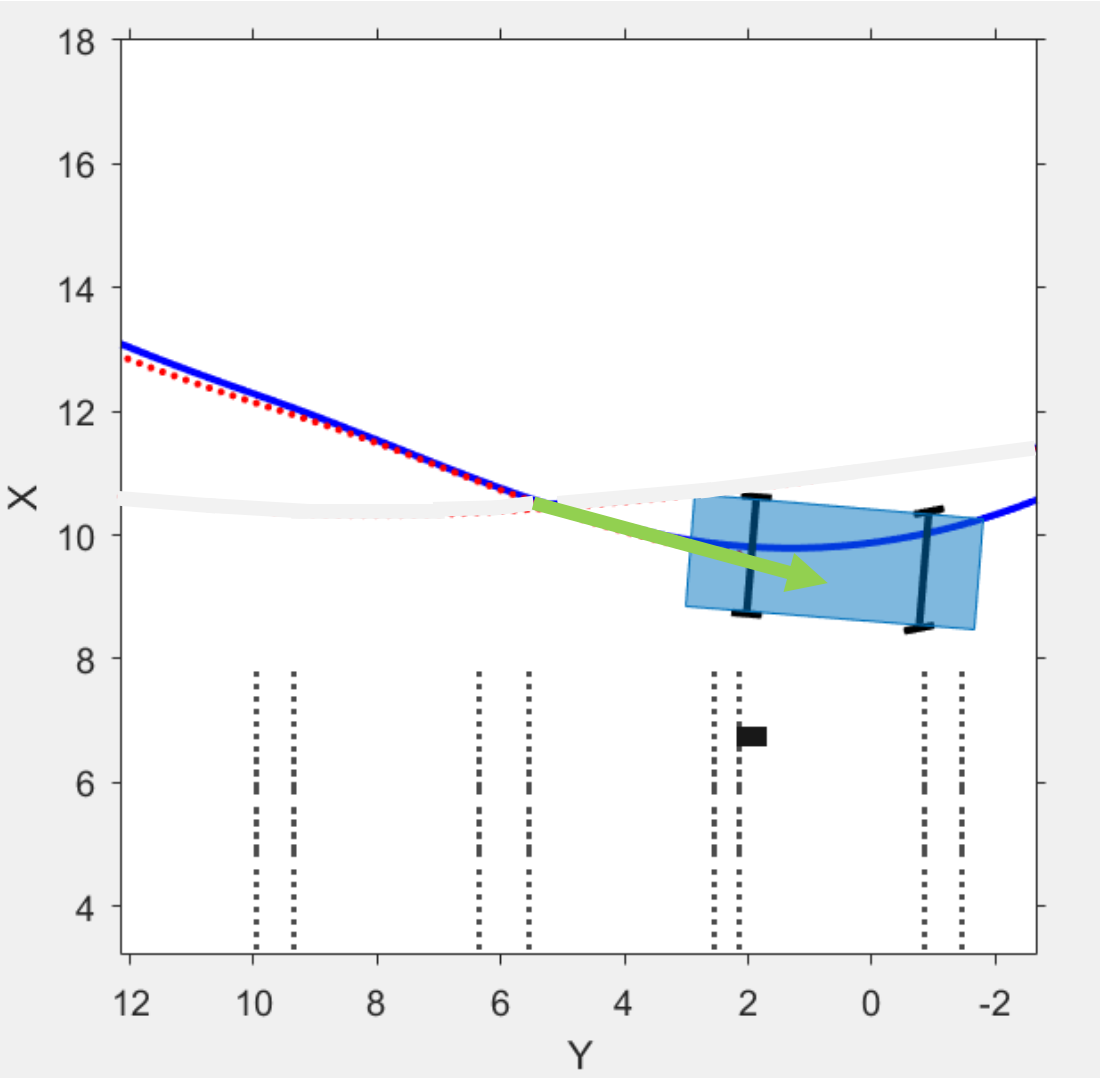

```
% Normalized distance between current position and section starting point
u = (RXY.*DeltaXY)/(DeltaXY.*DeltaXY);

% Find section ending point
indexIncrement = ceil(u-1);
```

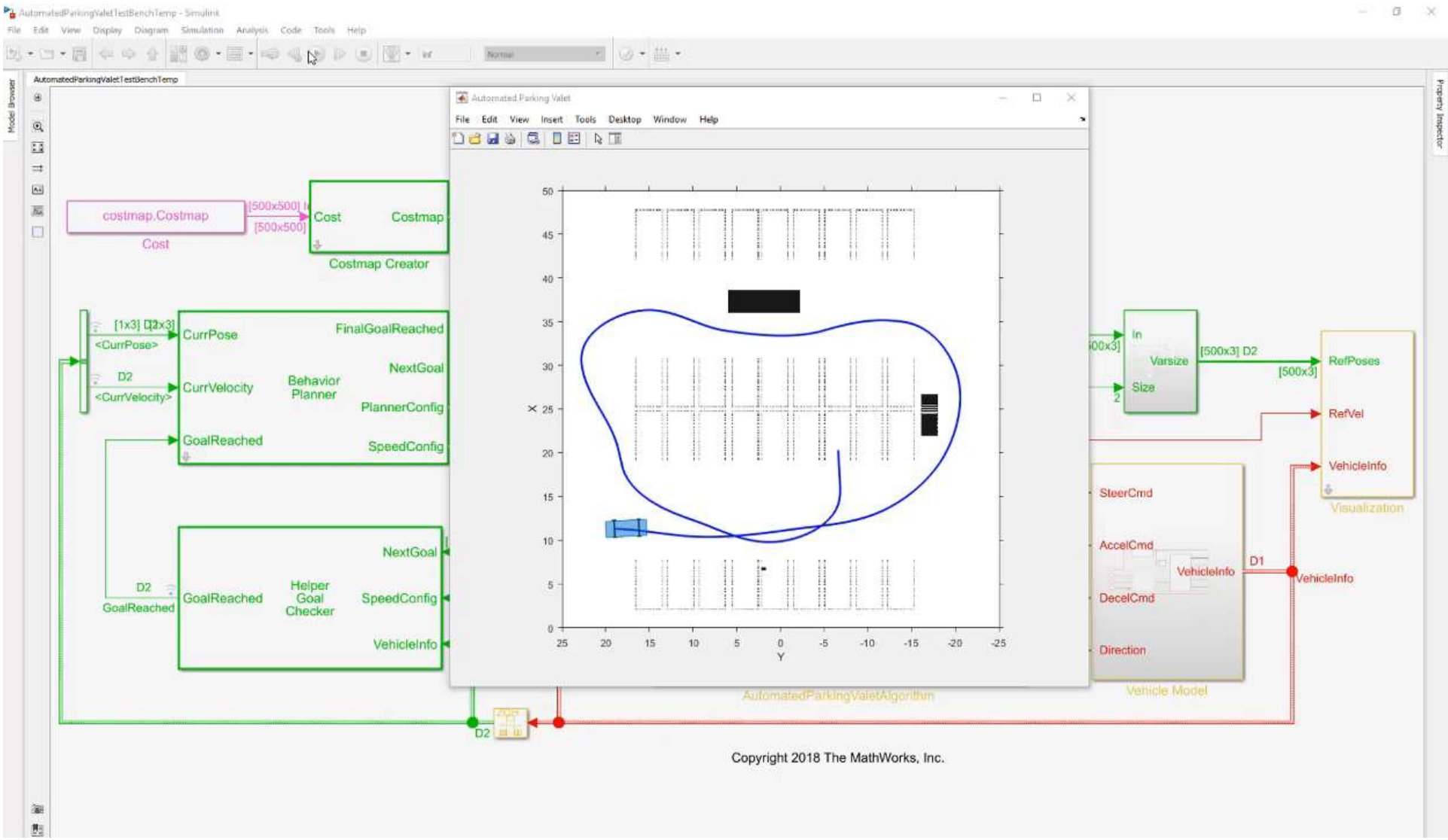
Incremental projection

Modified path analyzer

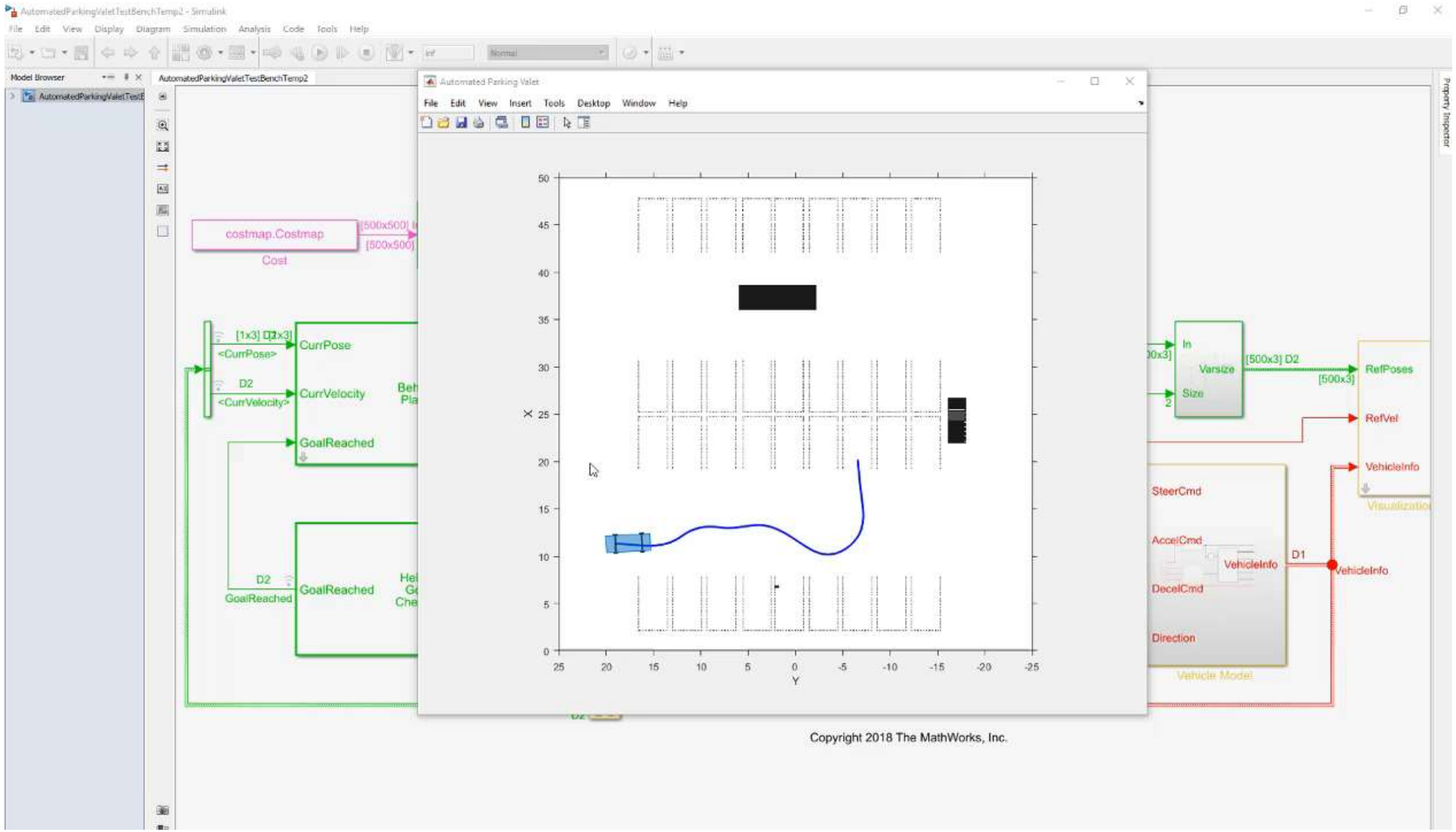




Explore behavior with improved path analyzer



Reduce turning radius and speed



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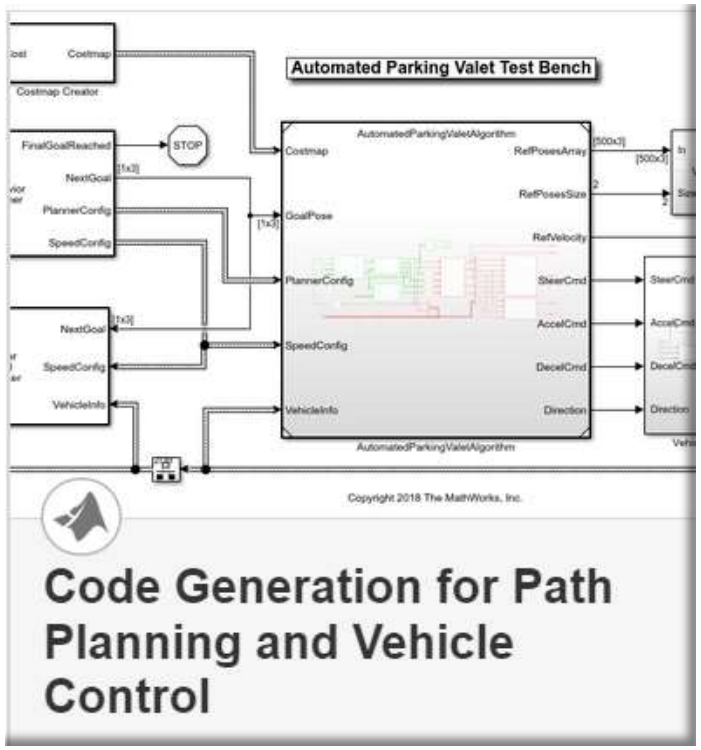
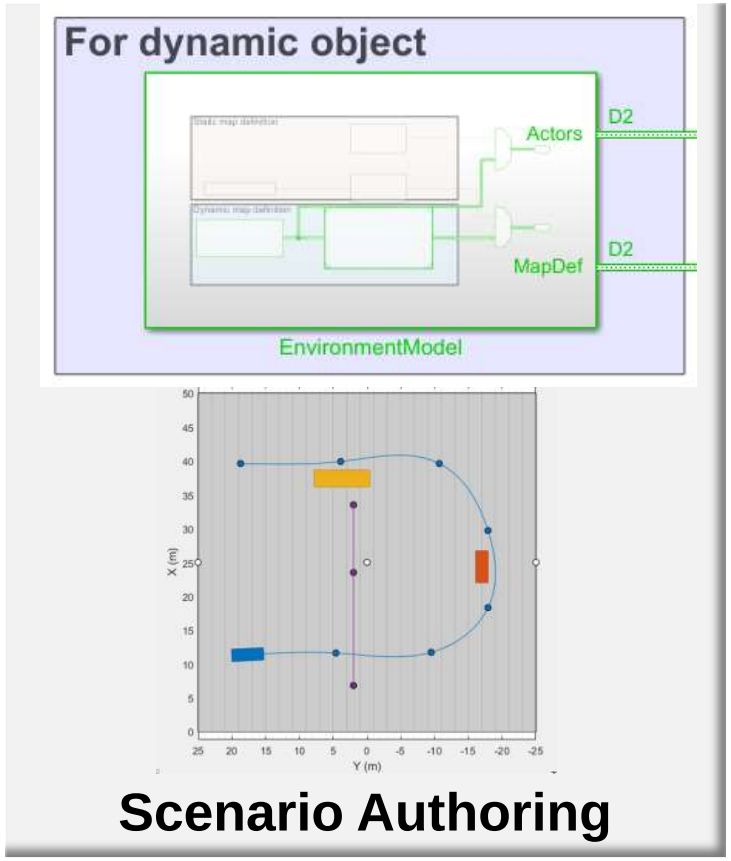
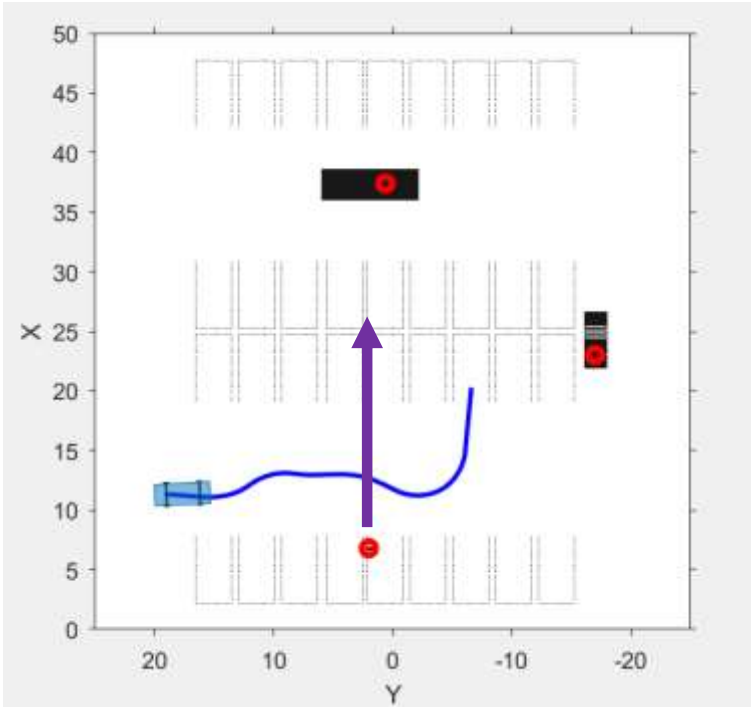
- Explore system robustness with simulation
  - Remove intermedia points
  - Specify different parking maps and spots
  - Identify design issue and improve the design.
- Improve design to handle moving pedestrian
- Test automation for regression tests

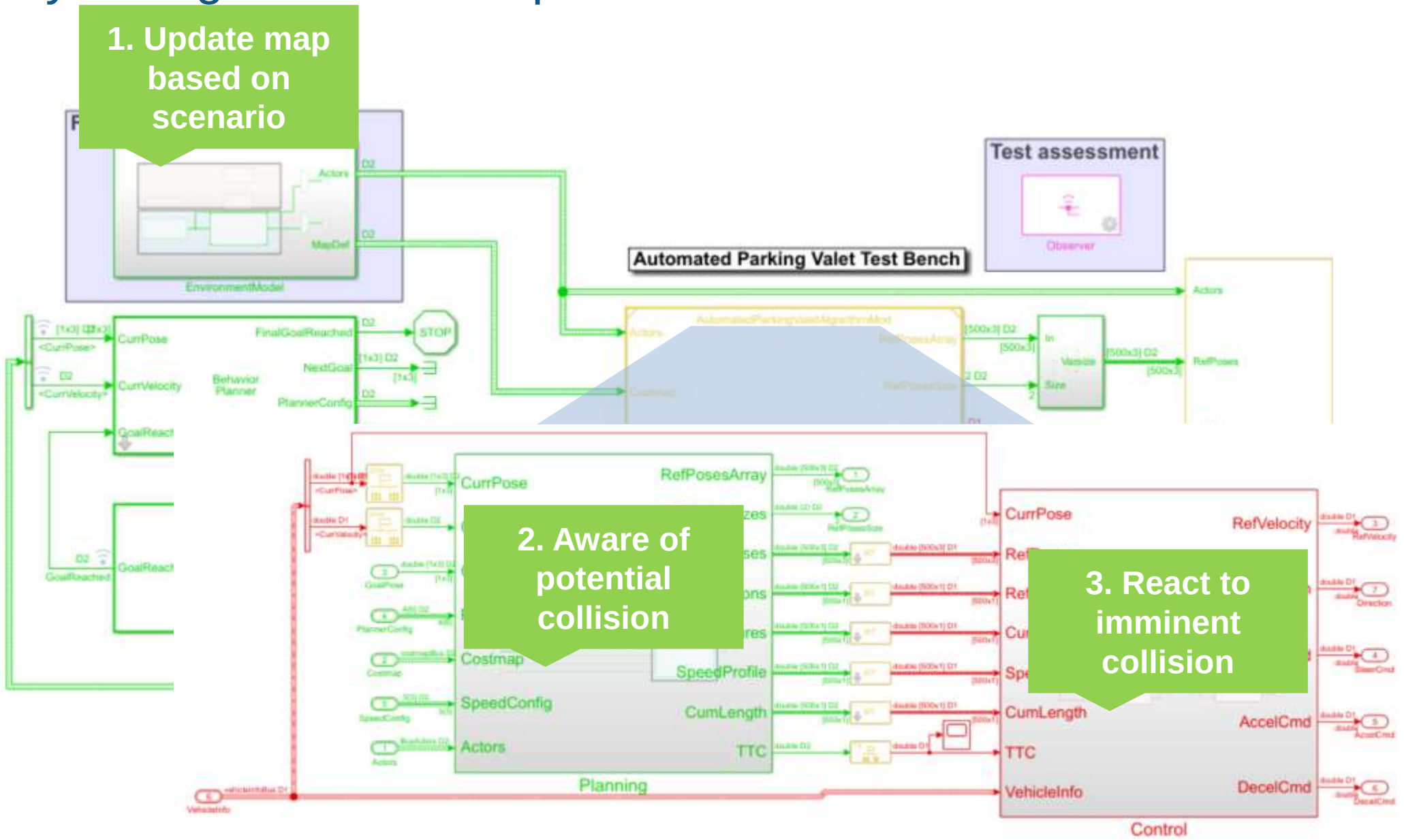
Build test bench to test dynamic scenario



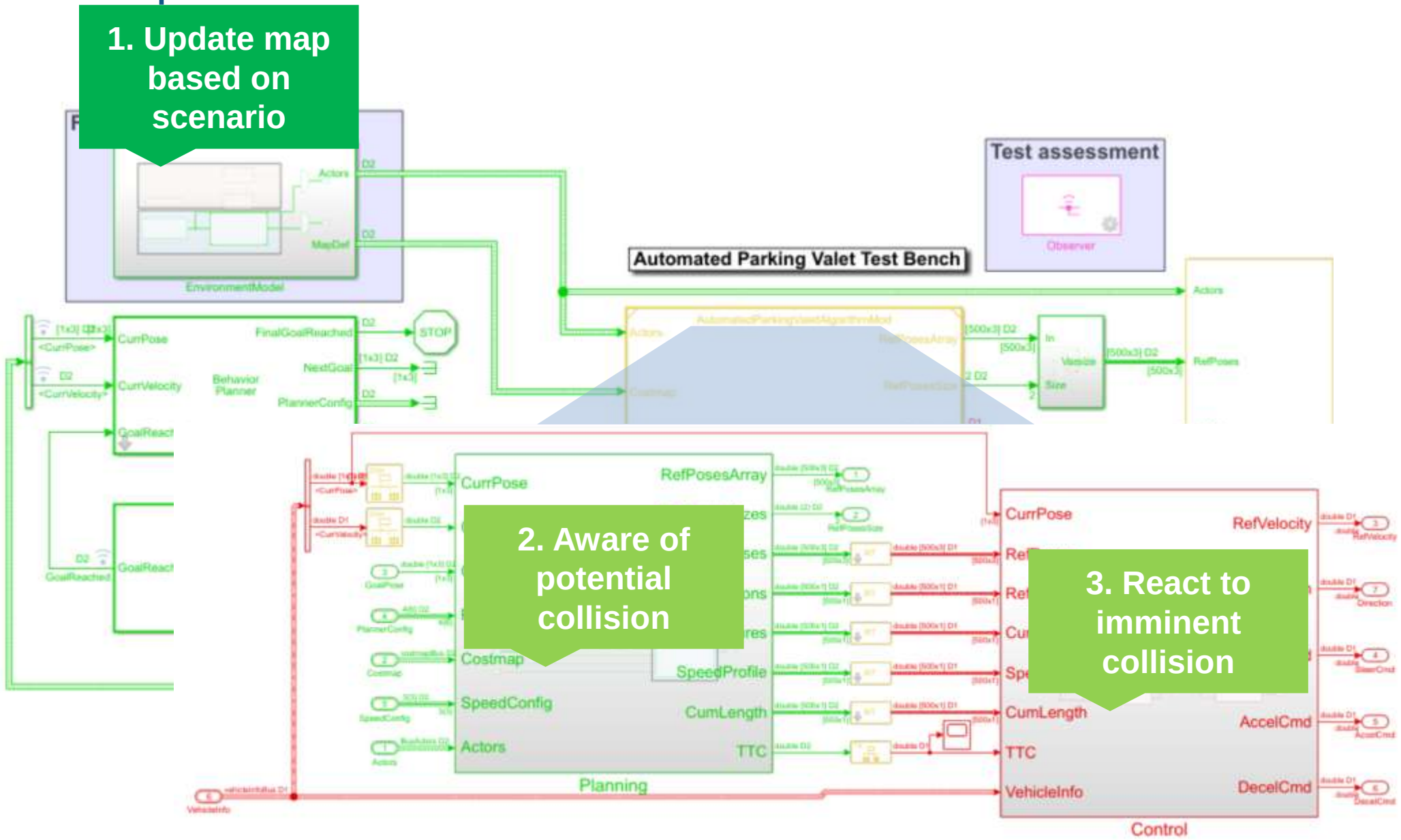




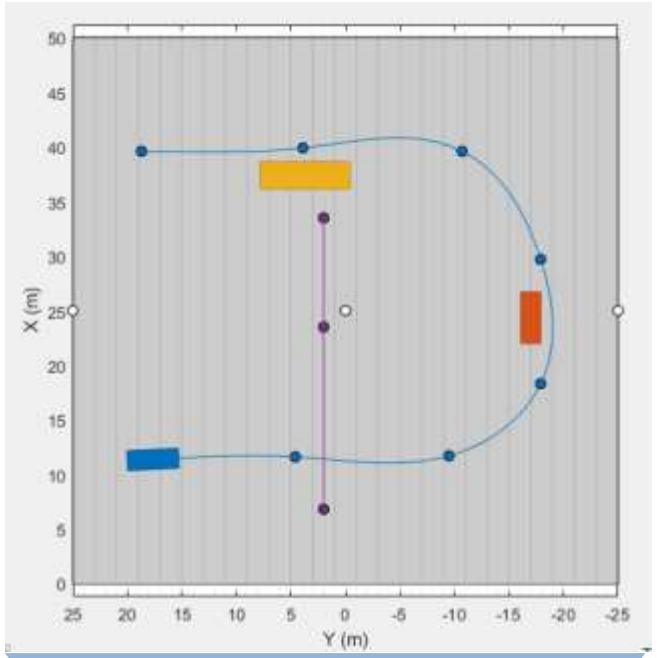
Identify changes to react to pedestrian

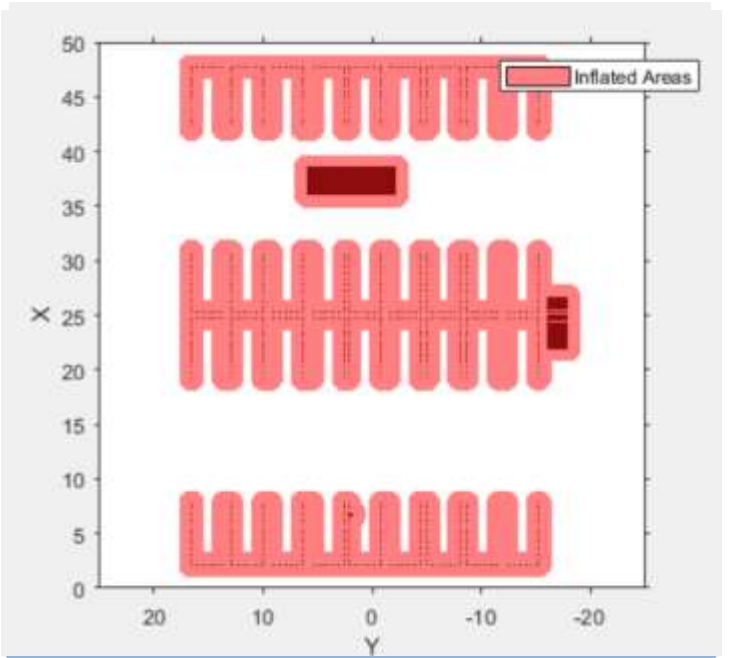


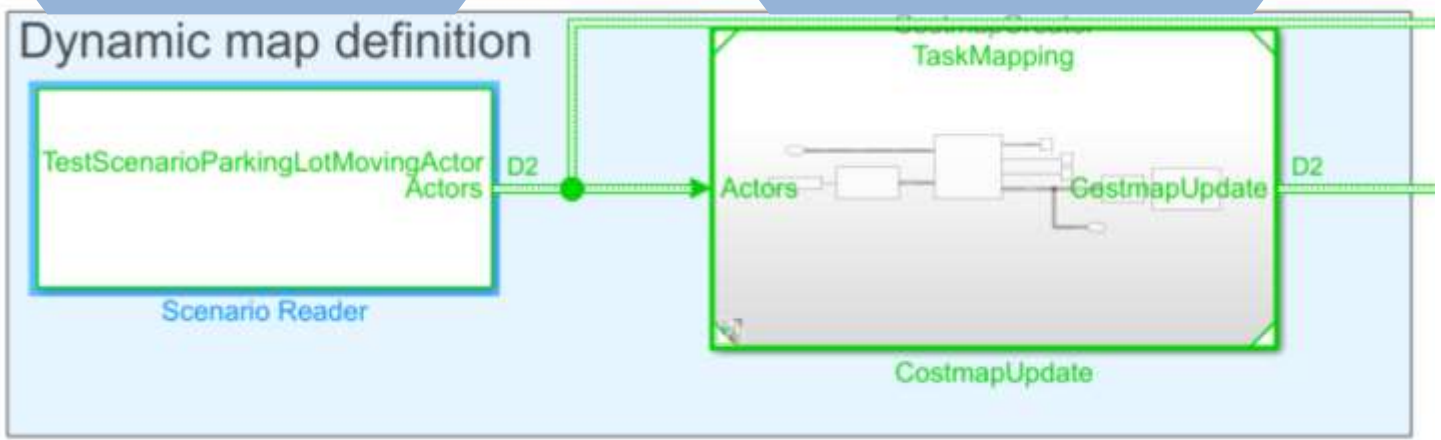
Update map based on scenario



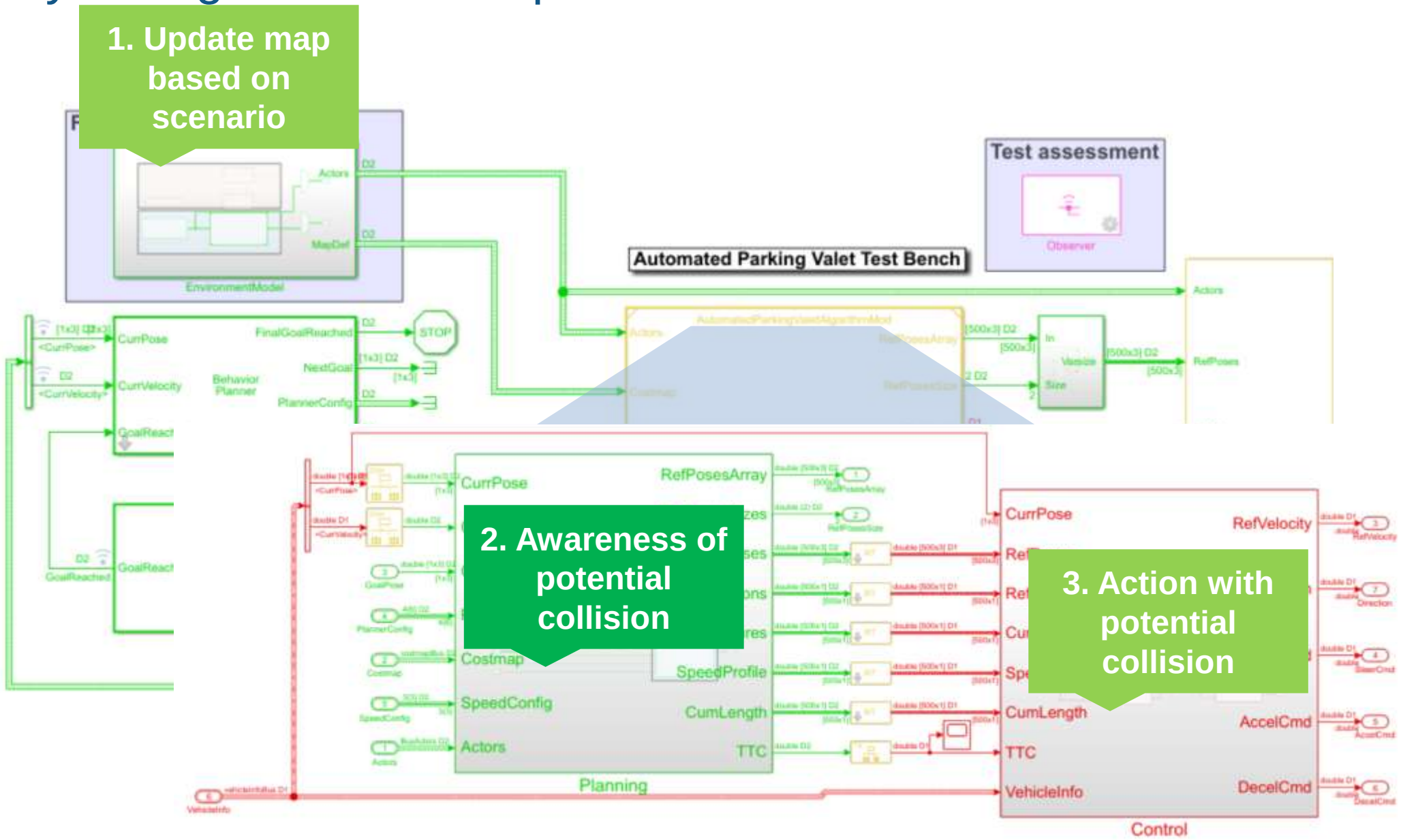
Update map based on scenario



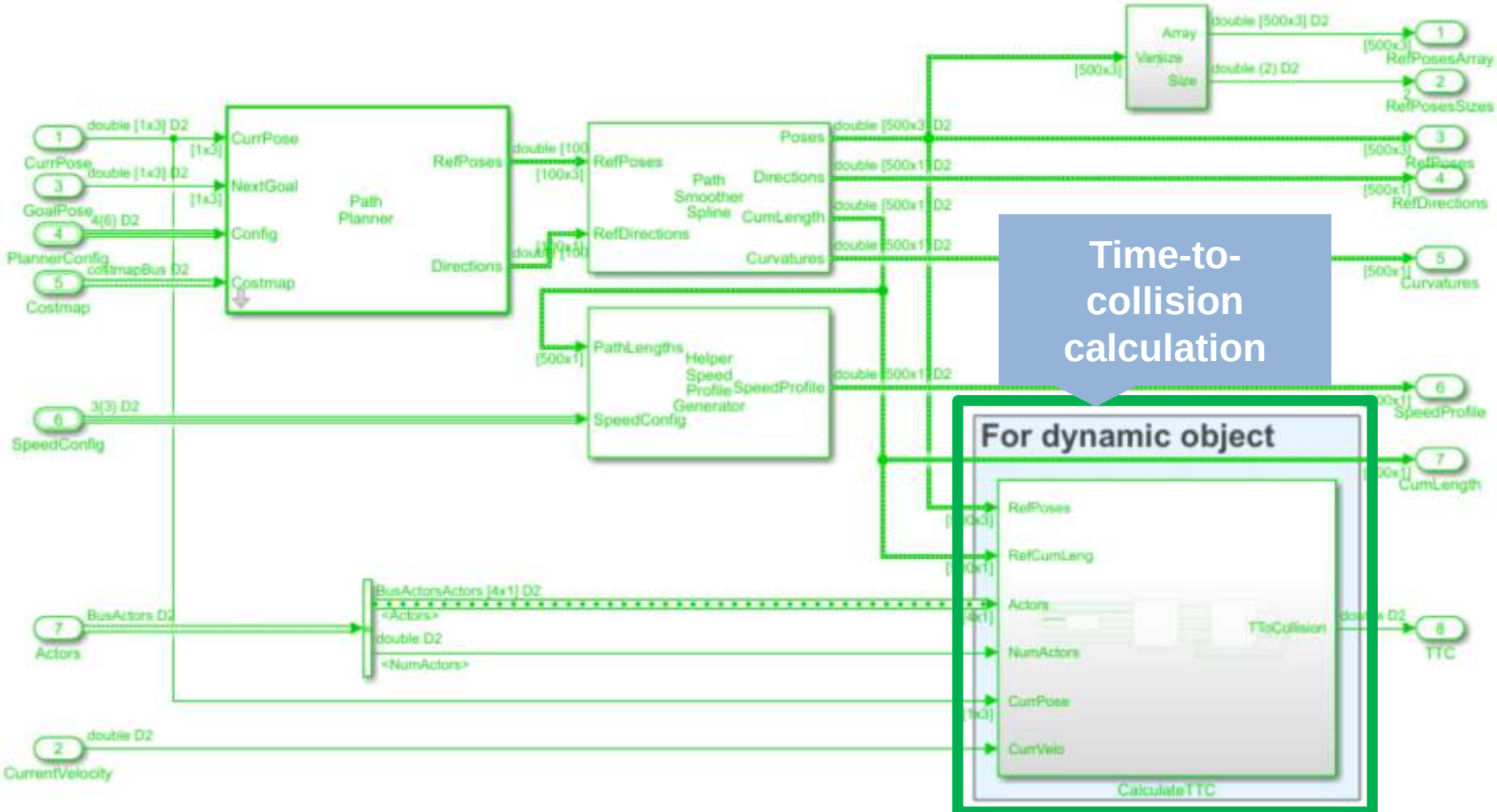




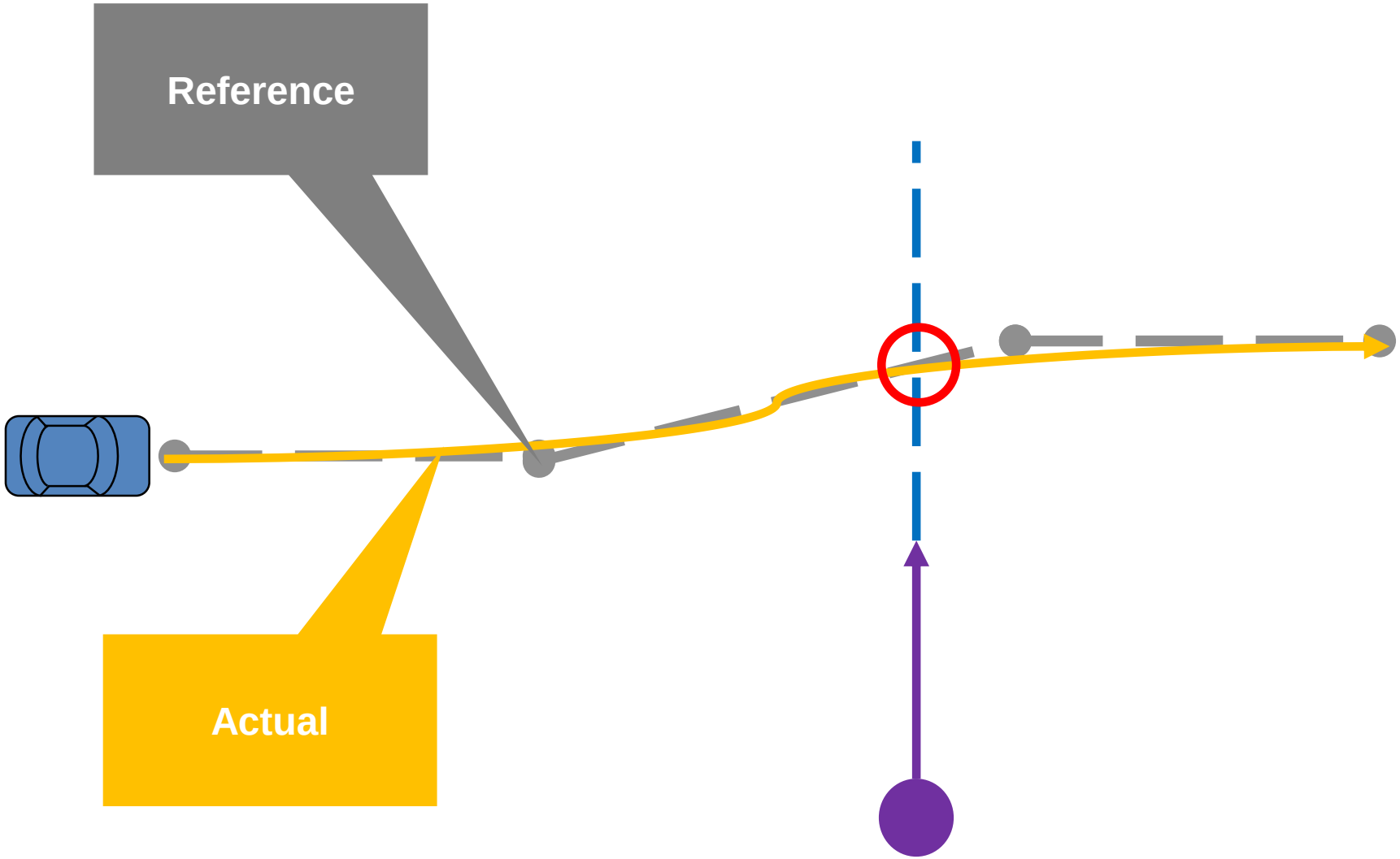
Identify changes to react to pedestrian



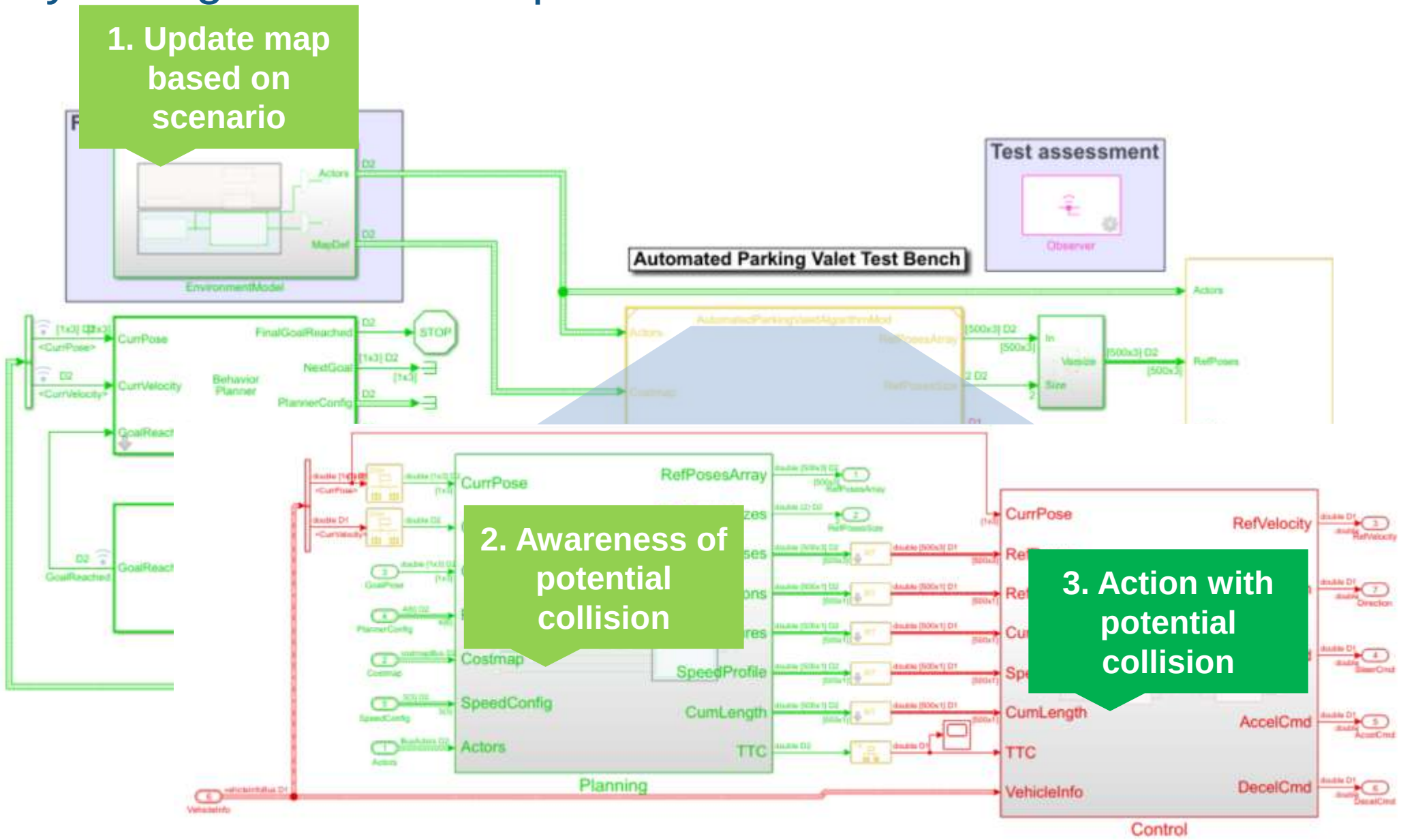
Awareness of potential collision



Time-to-collision with known path

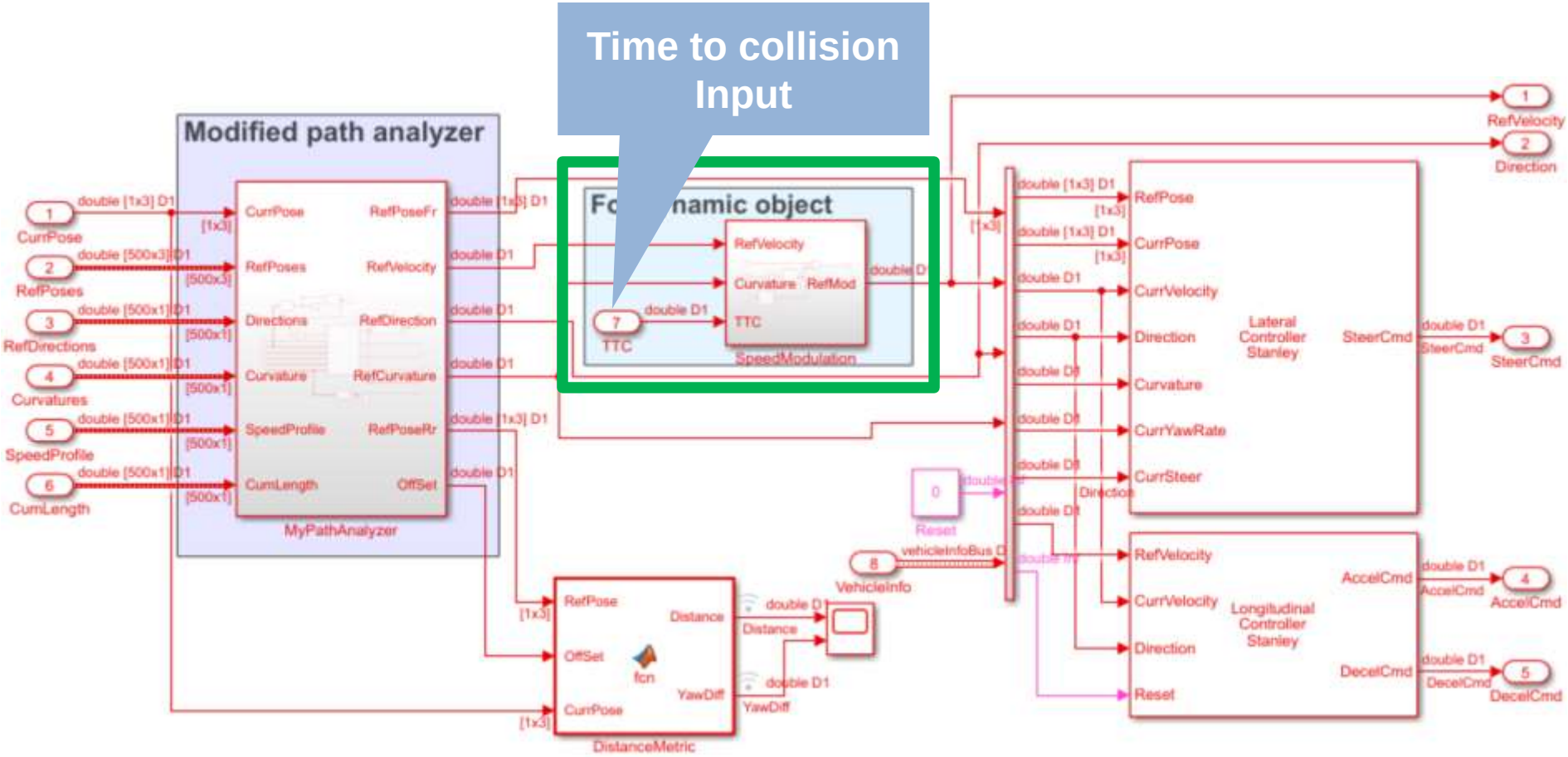


Identify changes to react to pedestrian

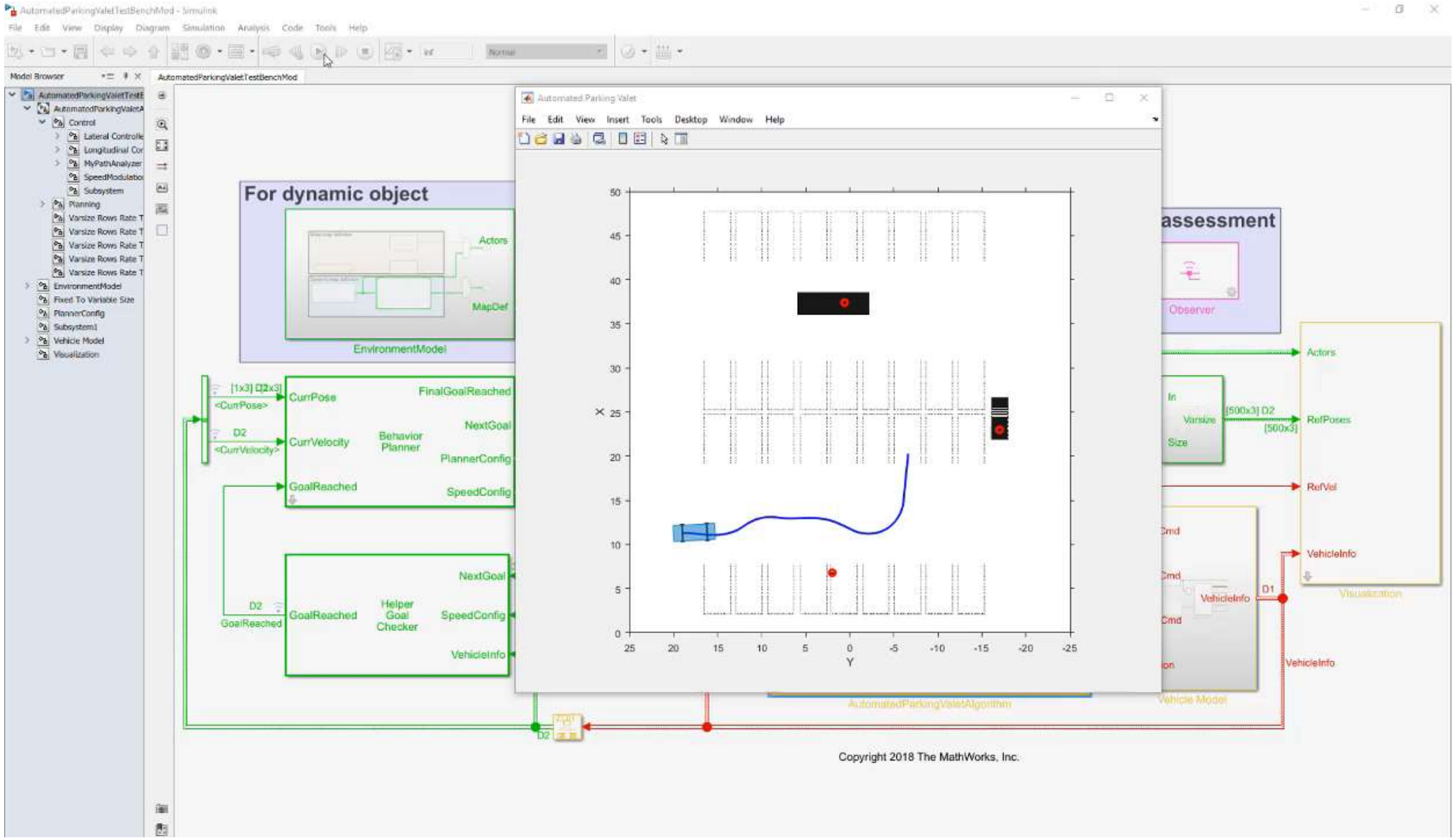


Action with potential collision

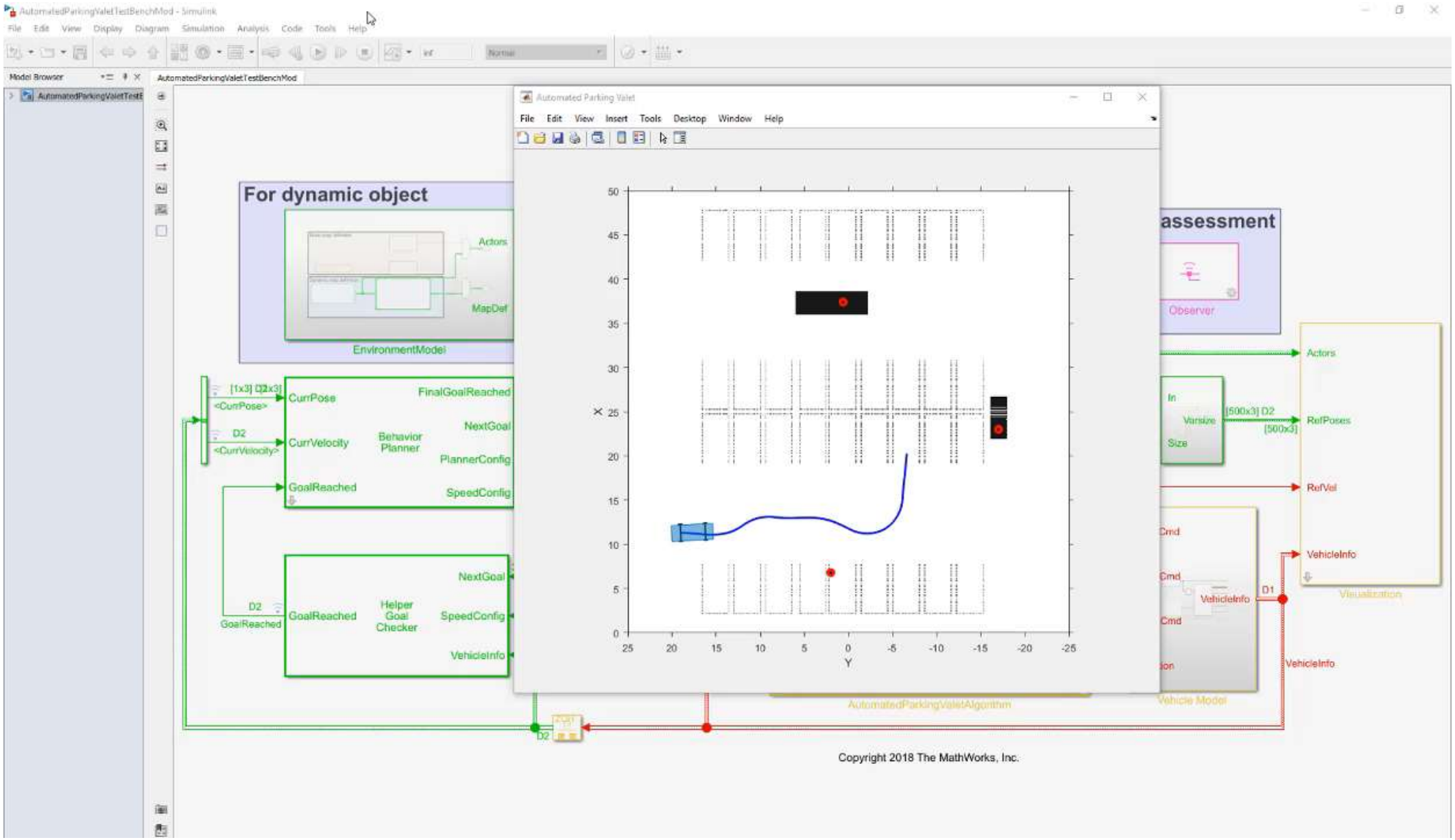
- Reduce speed when TTC is low



Test in dynamic environment



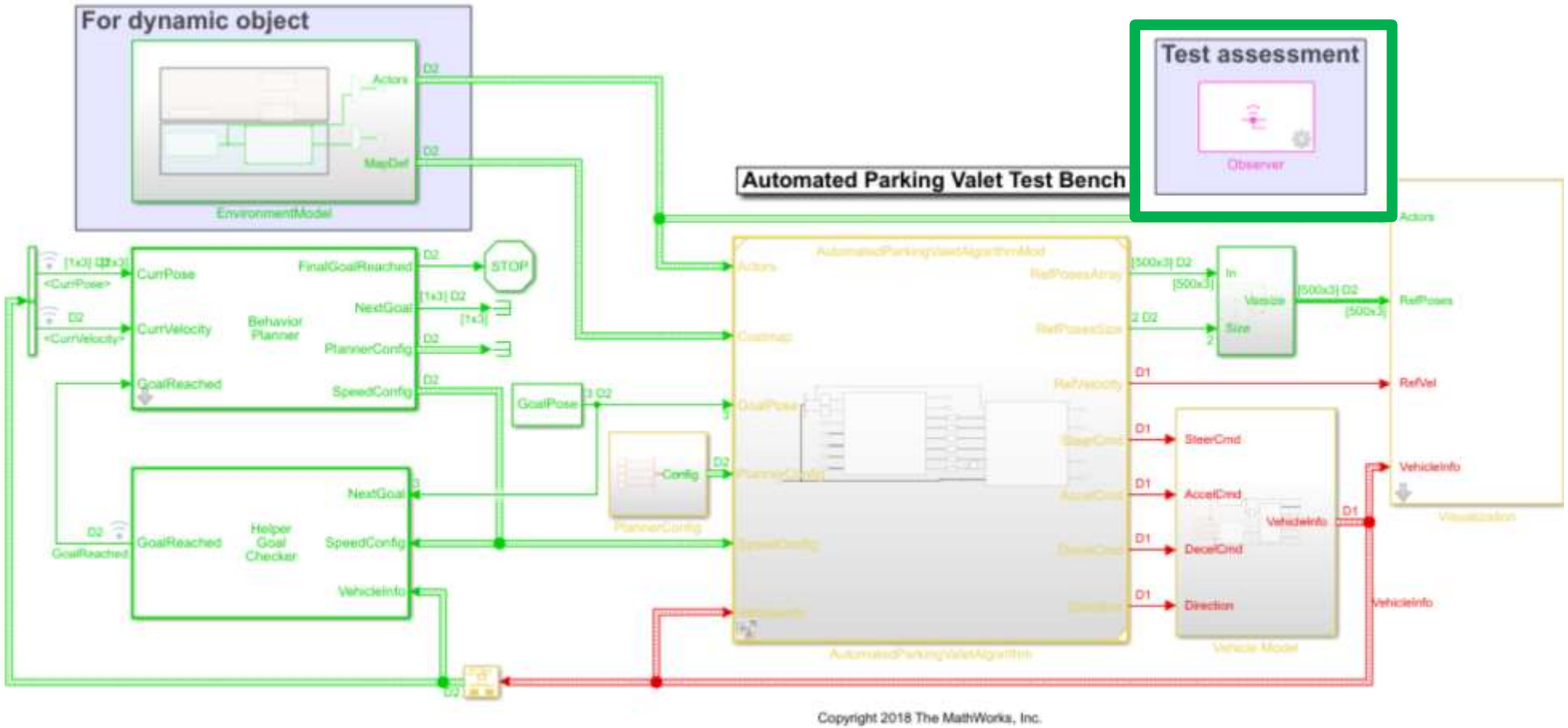
Improve design to handle pedestrians



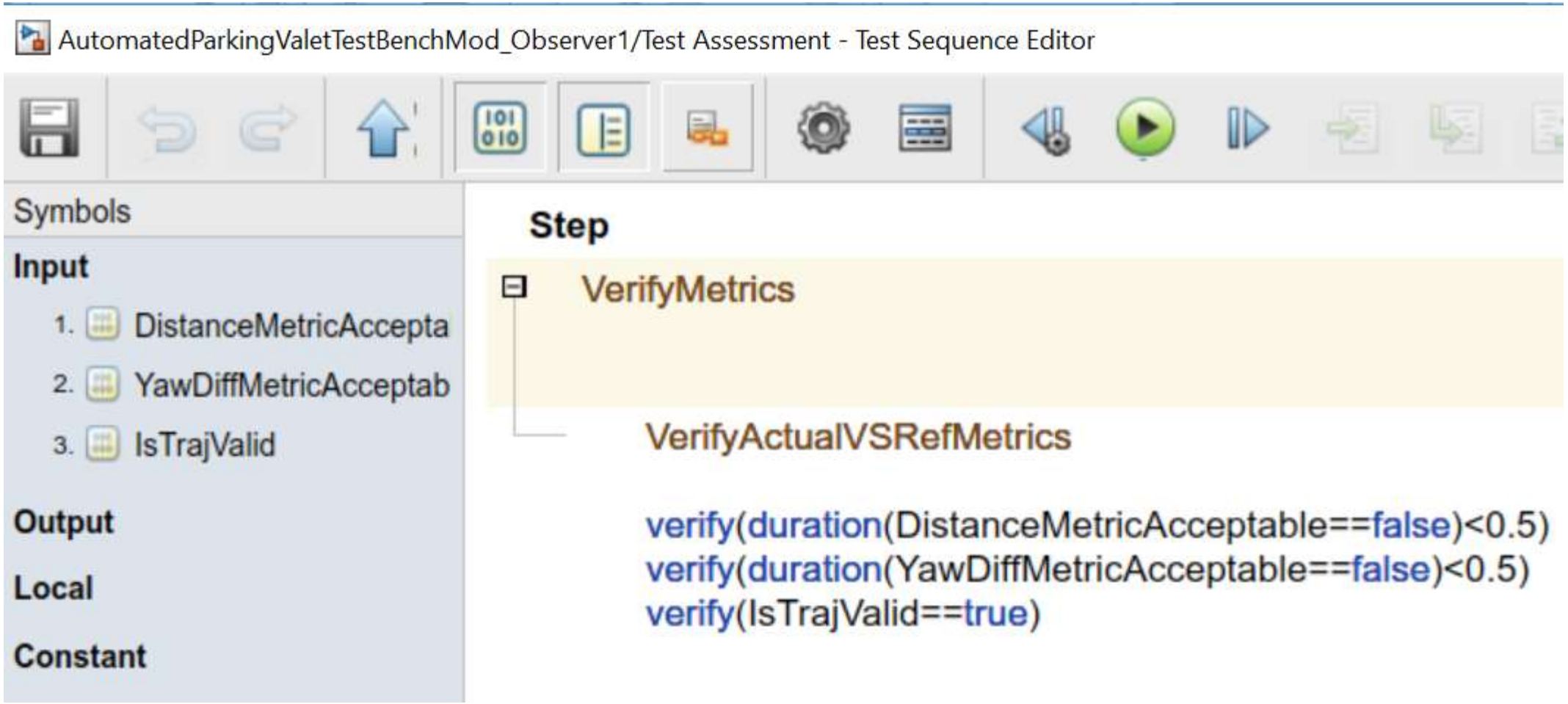
Evaluate Path Planner and Controller for Automated Parking

- Explore system robustness with simulation
  - Remove intermedia points
  - Specify different parking maps and spots
  - Identify design flaws and improve the design.
- Improve design to handle moving pedestrian
  - Add moving pedestrian
  - Create costmap from ground truth
  - Reduce speed based on time-to-collision
- Test automation for regression tests

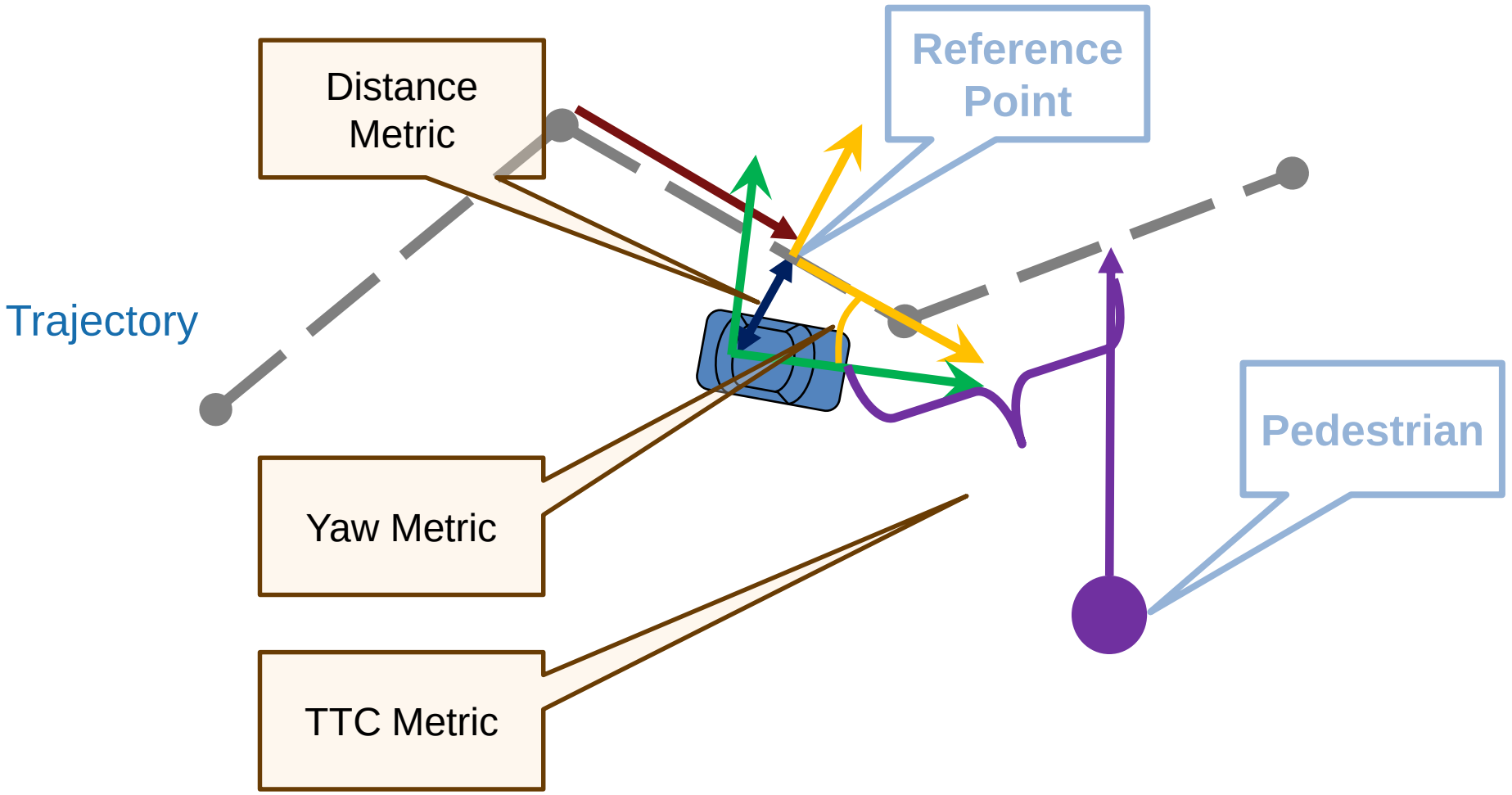
Automate regression testing



Test assessment metrics

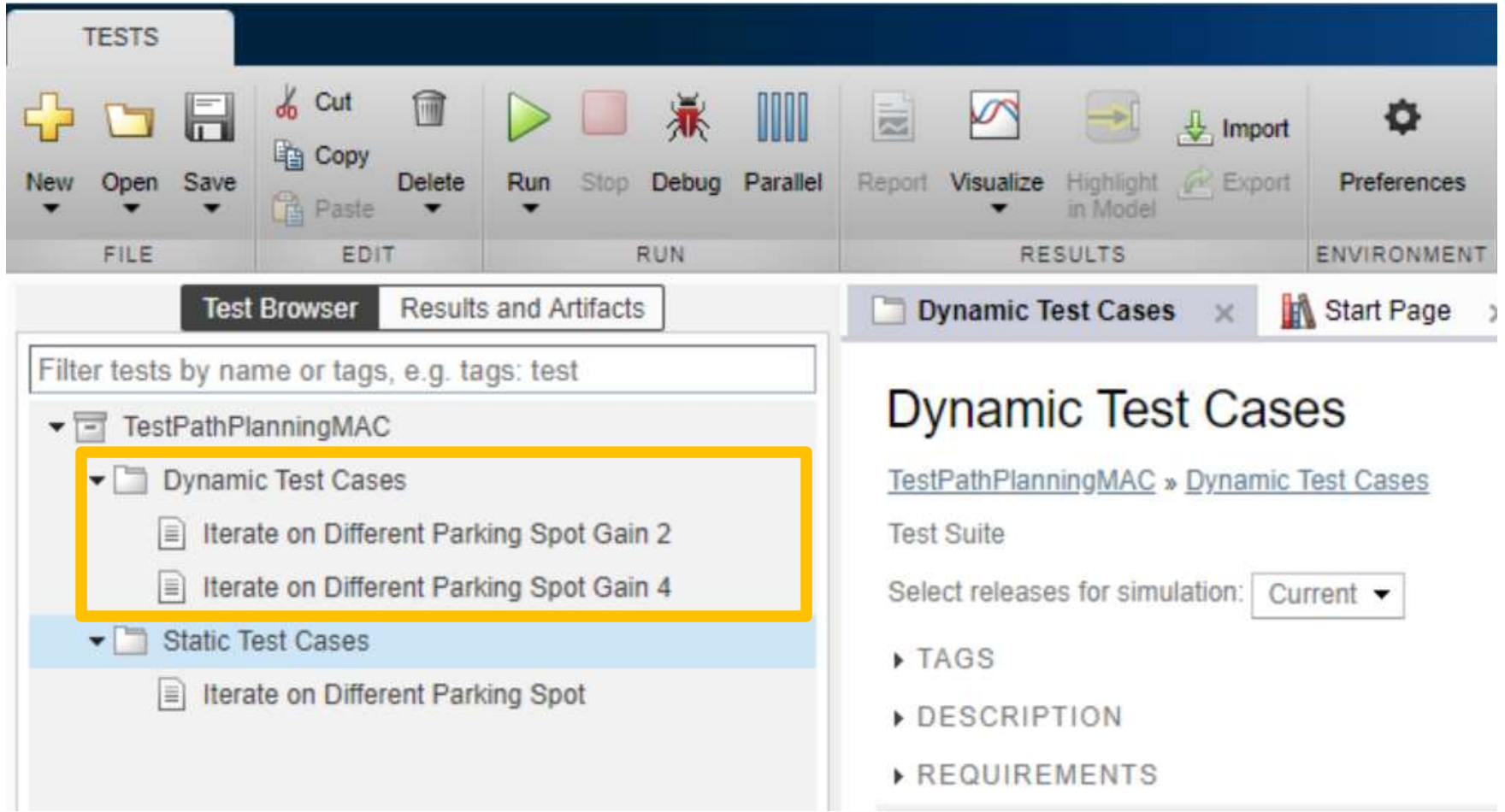


Test assessment metrics

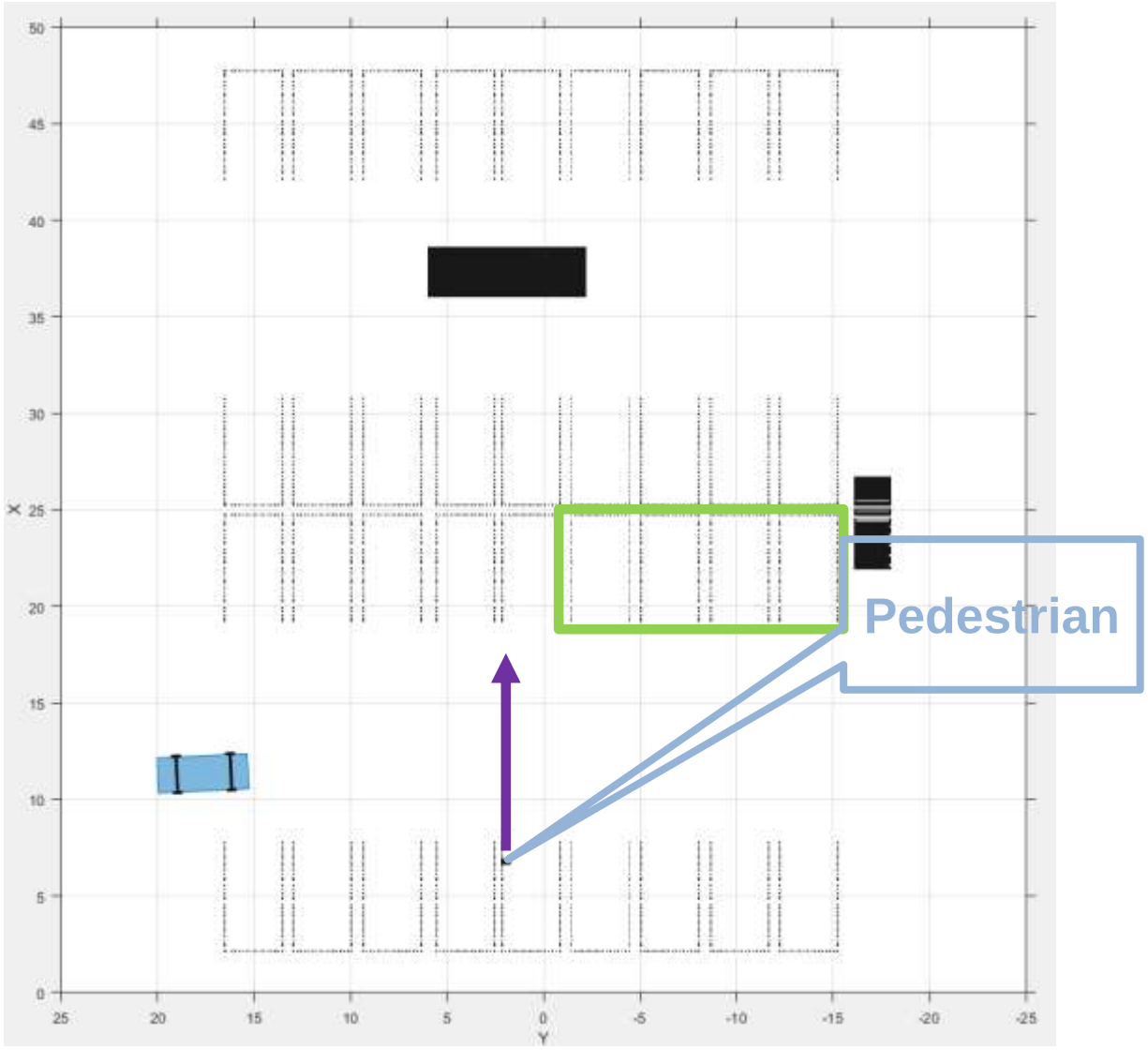


Test iteration

- Tests definition and test management

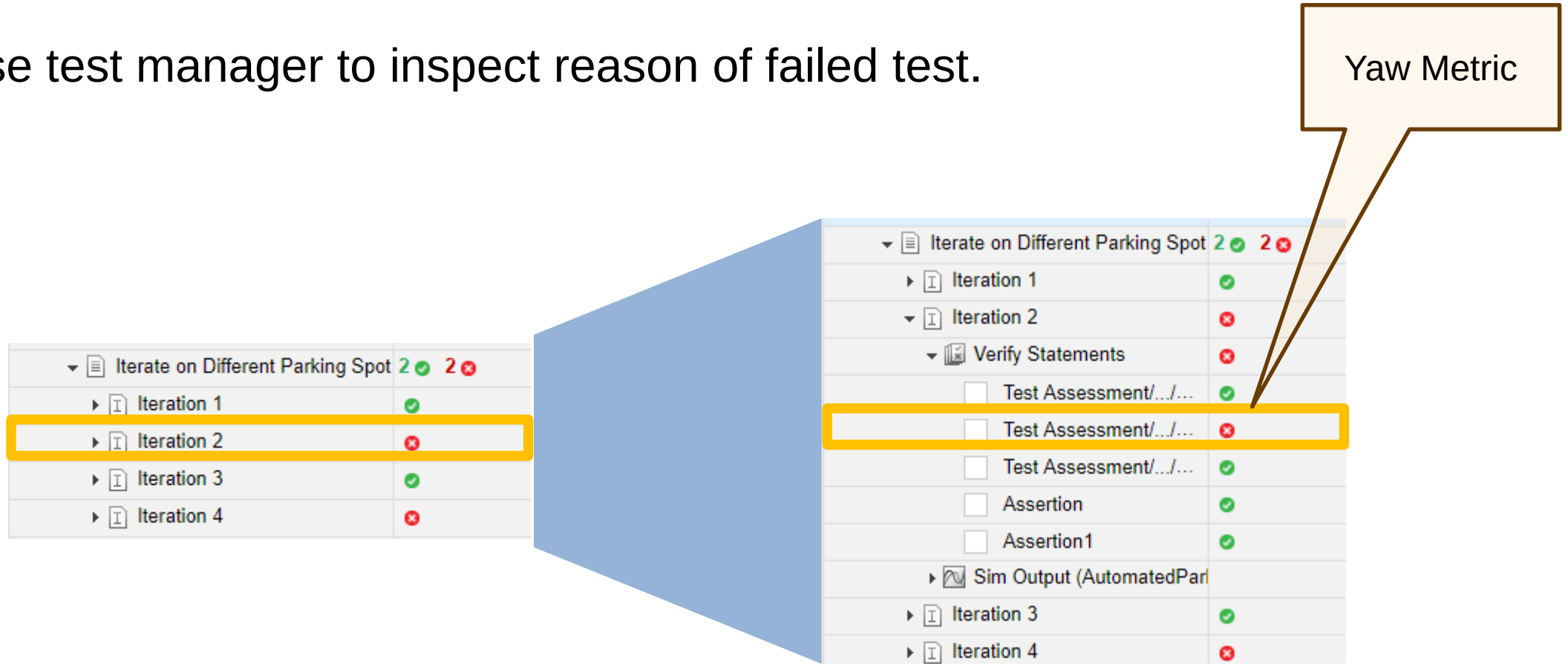


Testing multiple goal poses

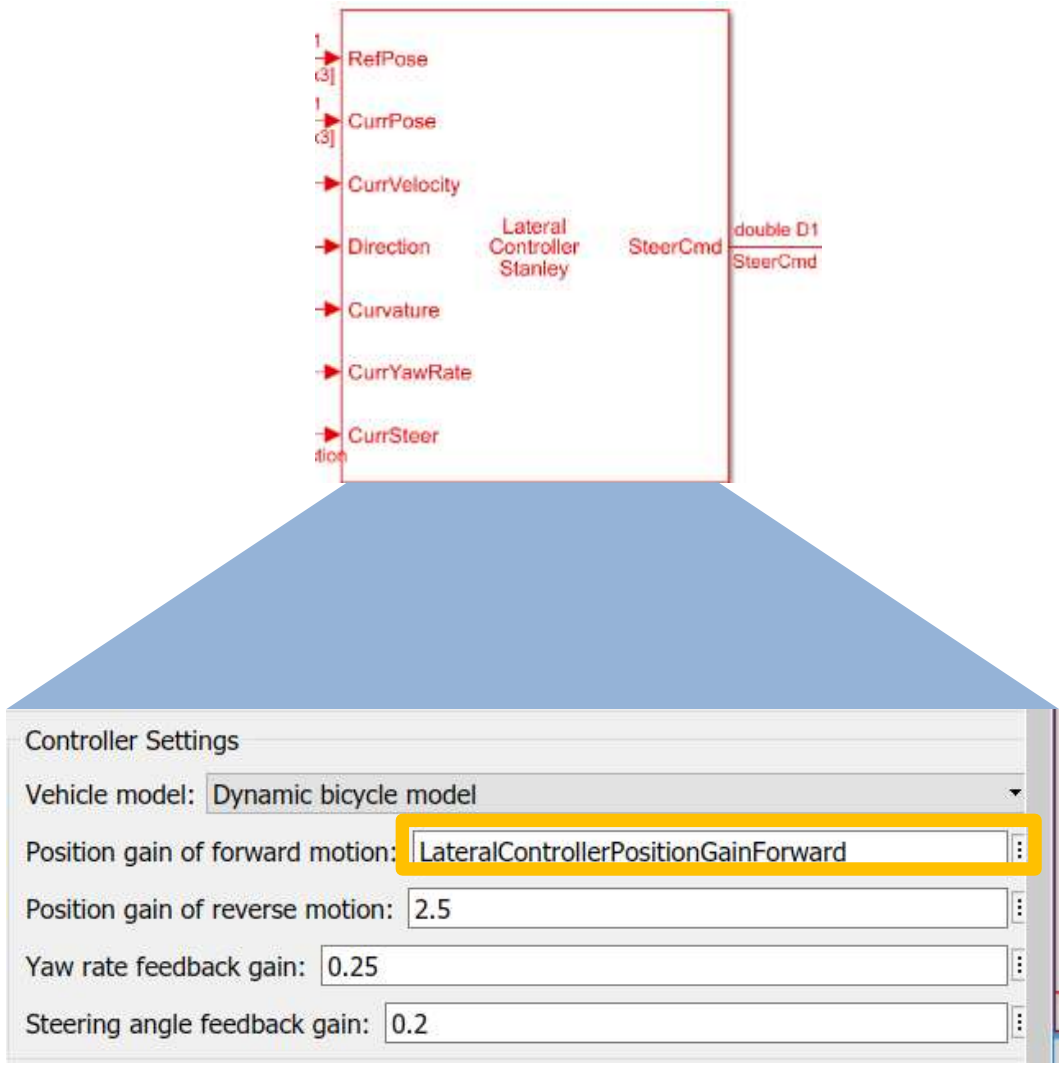


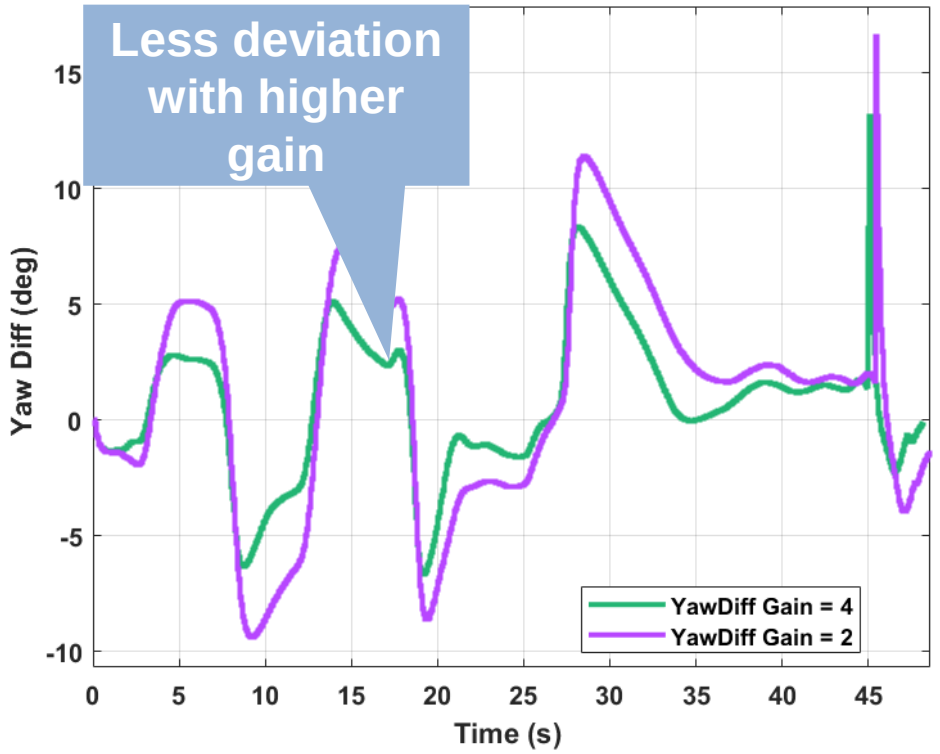
Automate regression testing

- Use test manager to inspect reason of failed test.

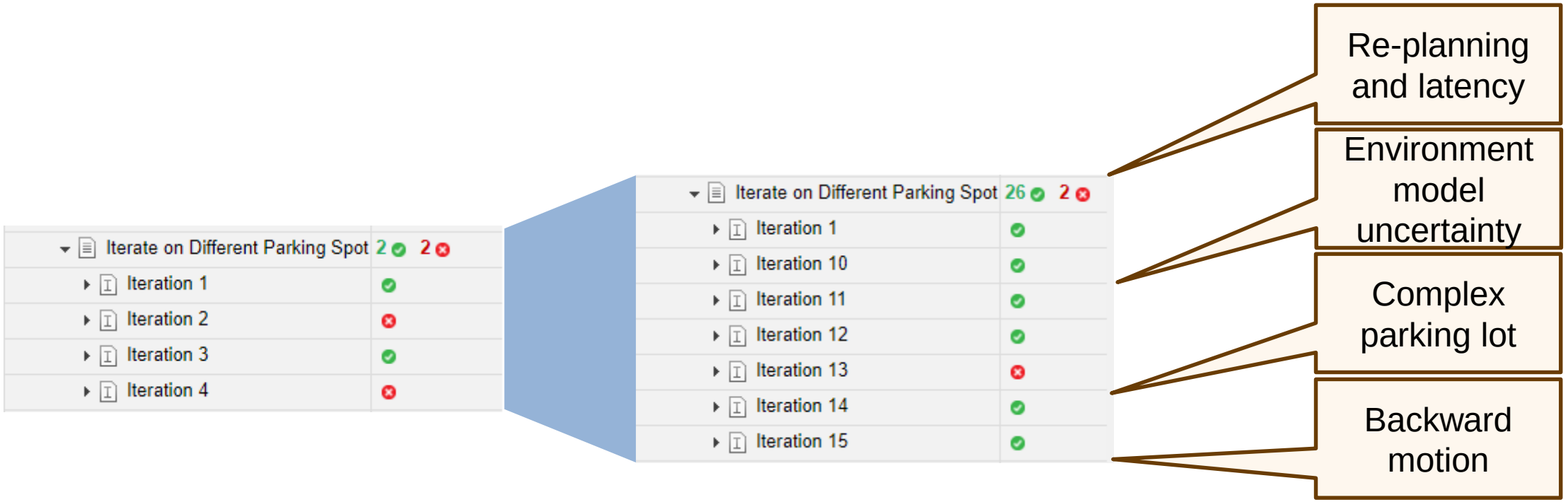


Automate regression testing

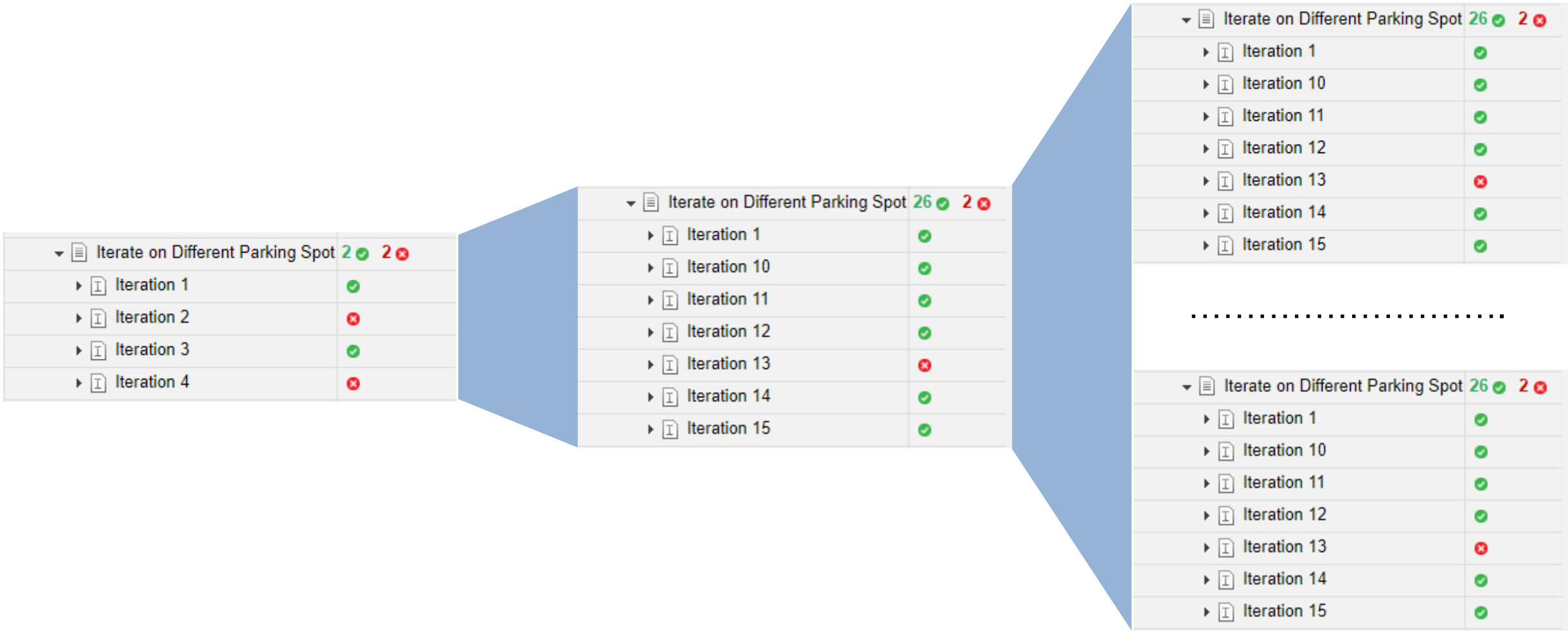




Automate regression testing



Automate regression testing



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- Explore system robustness with simulation
  - Remove intermediate points
  - Specify different parking maps and spots
  - Identify design flaws and improve the design
- Improve design to handle moving pedestrians
  - Add moving pedestrian
  - Create costmap from ground truth
  - Reduce speed based on time-to-collision
- Test automation for regression tests
  - Add metrics for planner and controller
  - Add test case definition/ management