

Smart Testing of Intelligent Systems

SIA SIMULATION NUMERIQUE 2021

DIGITAL EDITION // 7 & 8 AVRIL 2021

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dSPACE SARL, Burospace, 91570 BIEVRES

Conférence & Exposition
7 et 8 avril 2021



Avec le support de
l'industrie automobile
Française



LE COMITÉ
DES CONSTRUCTEURS
FRANÇAIS D'AUTOMOBILES



Agenda

1. Motivation and Introduction
2. Scenario-Based Testing Workflow
3. Smart Testing
4. Summary and Conclusion



Verifying Functions for Autonomous Driving

- Number of tests increasing
- Millions of kilometers to be driven

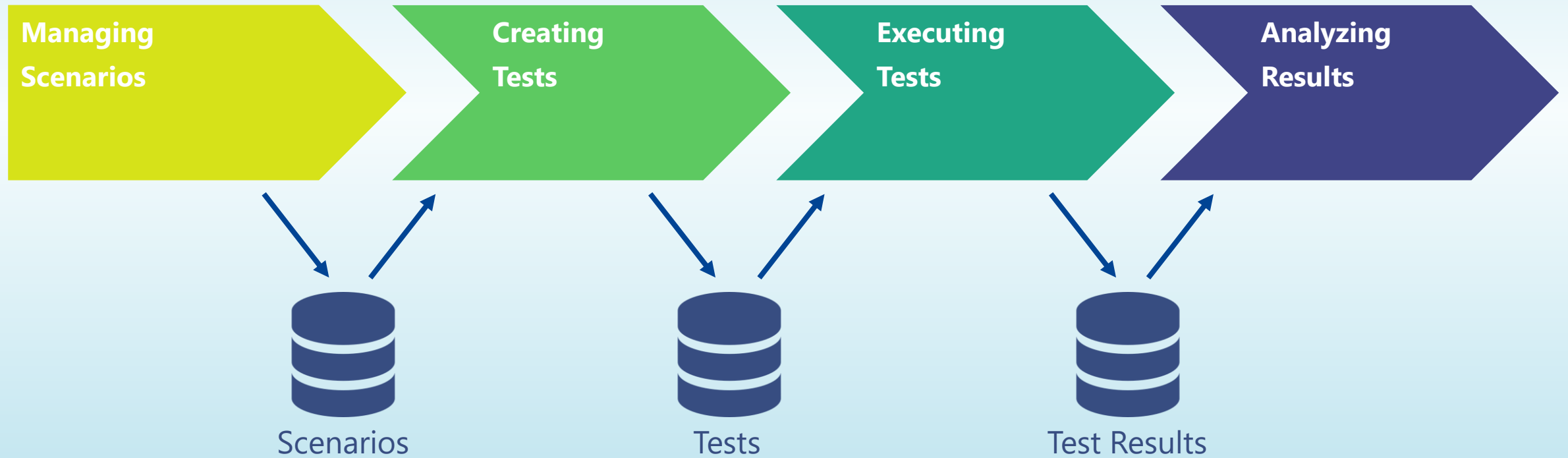
- Scenario-based SIL instead of Requirement-based HIL
- Parallelizing SIL → Cluster/Cloud Simulation

- Standard Scenario-based testing is still too time-consuming
→ Smart Scenario-based testing

1 Mio km / new feature $10^8 - 10^9$ km
1 Mio km in 3 days in the future

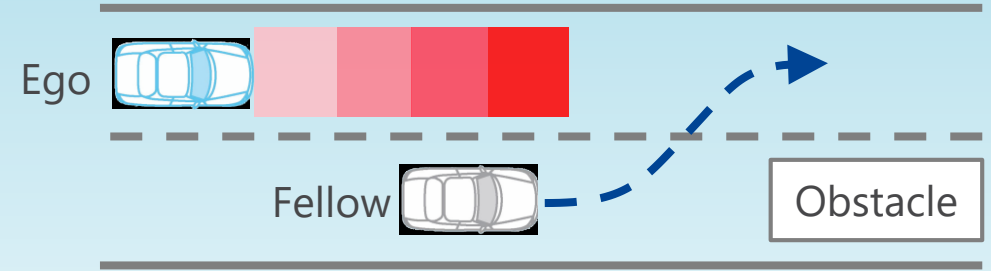


Test Workflow





Scenario Management



Managing
Scenarios



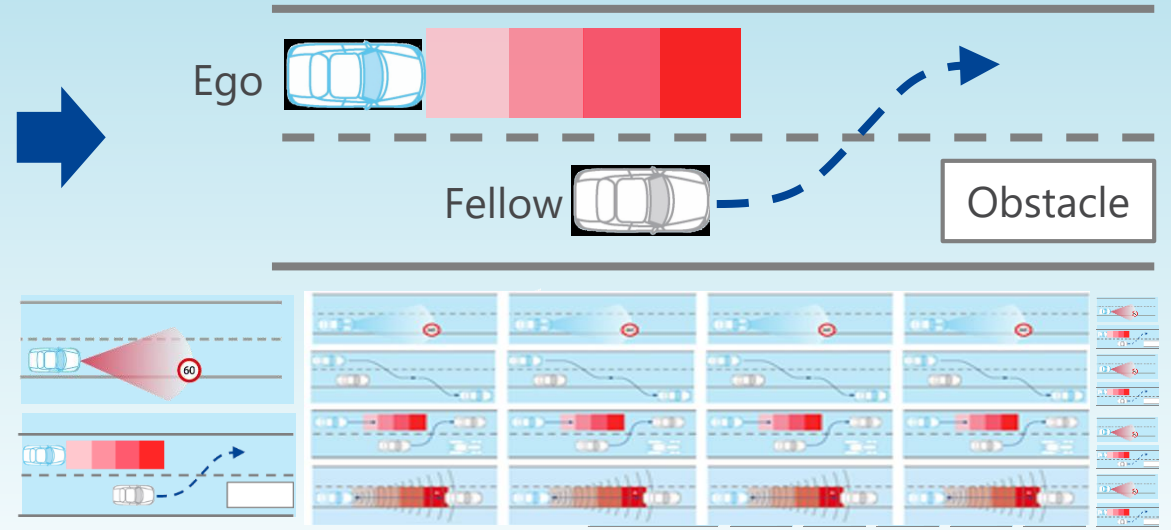
Scenario:

- Road, e.g., shapes, lanes
- Maneuver, e.g., velocity profiles
- Traffic, e.g., fellows

Scenario Management



Managing Scenarios

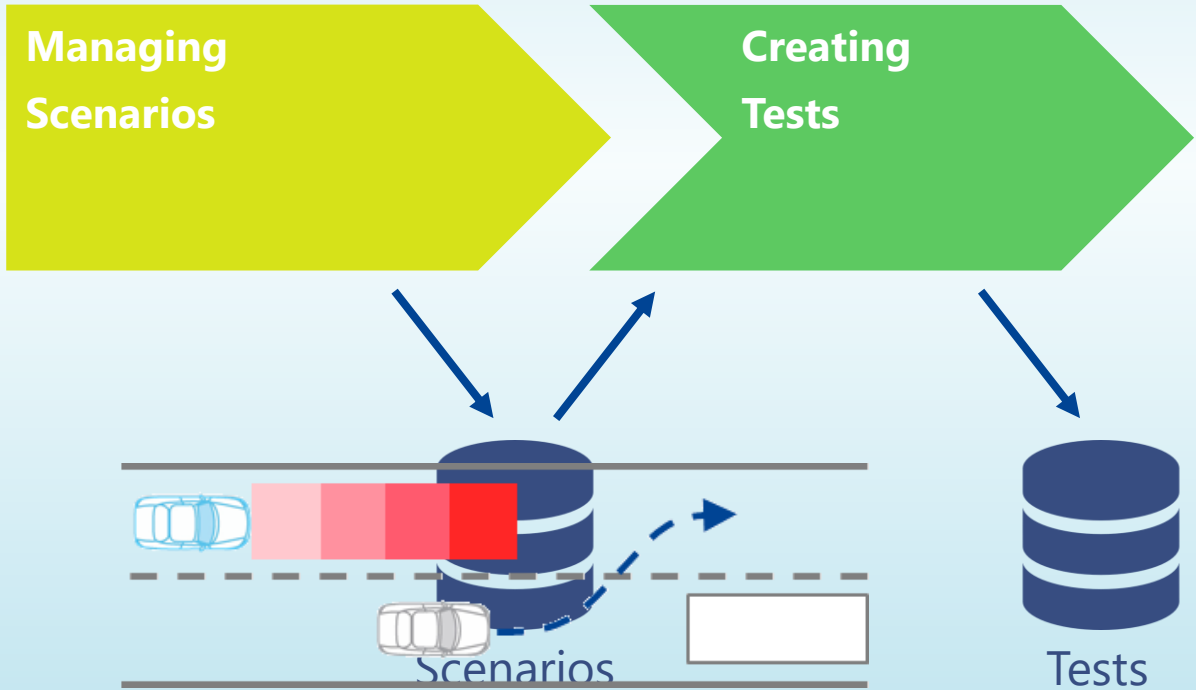








Scenario-Based Test Creation



Scenario Configuration

v_{Ego}

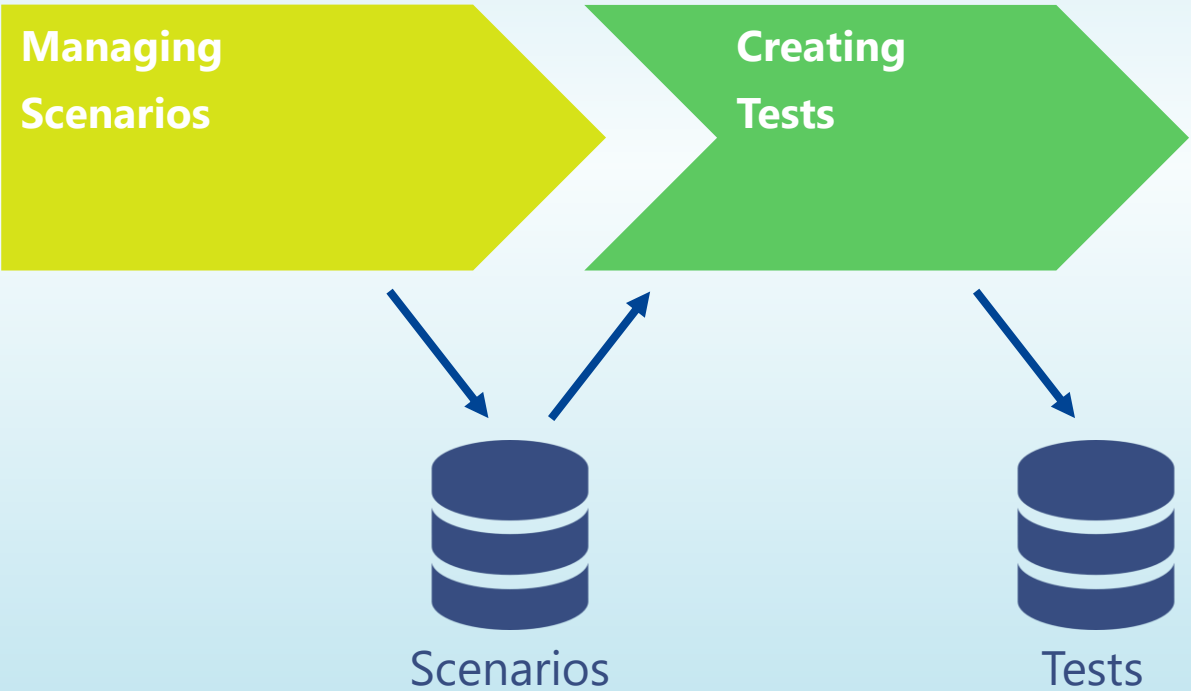
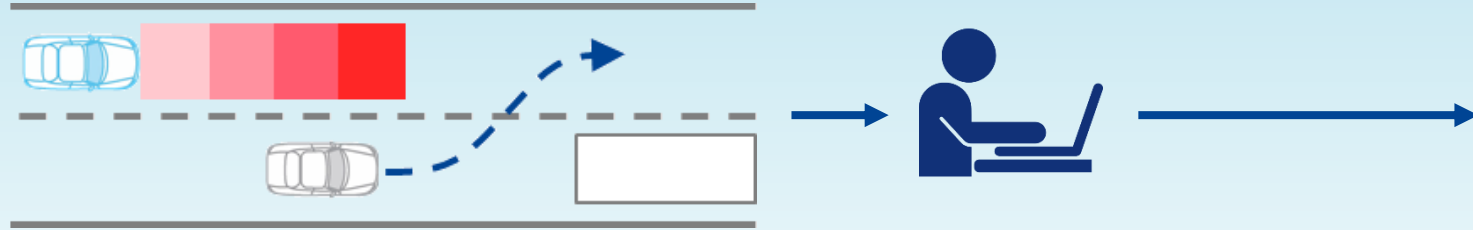
$distance$ v_{Fellow}

Obstacle

Parameter Variation

v_{Ego} [km/h]	v_{Fellow} [km/h]	$distance$ [m]	...	Other Parameters
105	80	25		
110	85	25		
115	90	25		
105	90	25		
...		

Scenario-Based Test Creation



Scenario Configuration

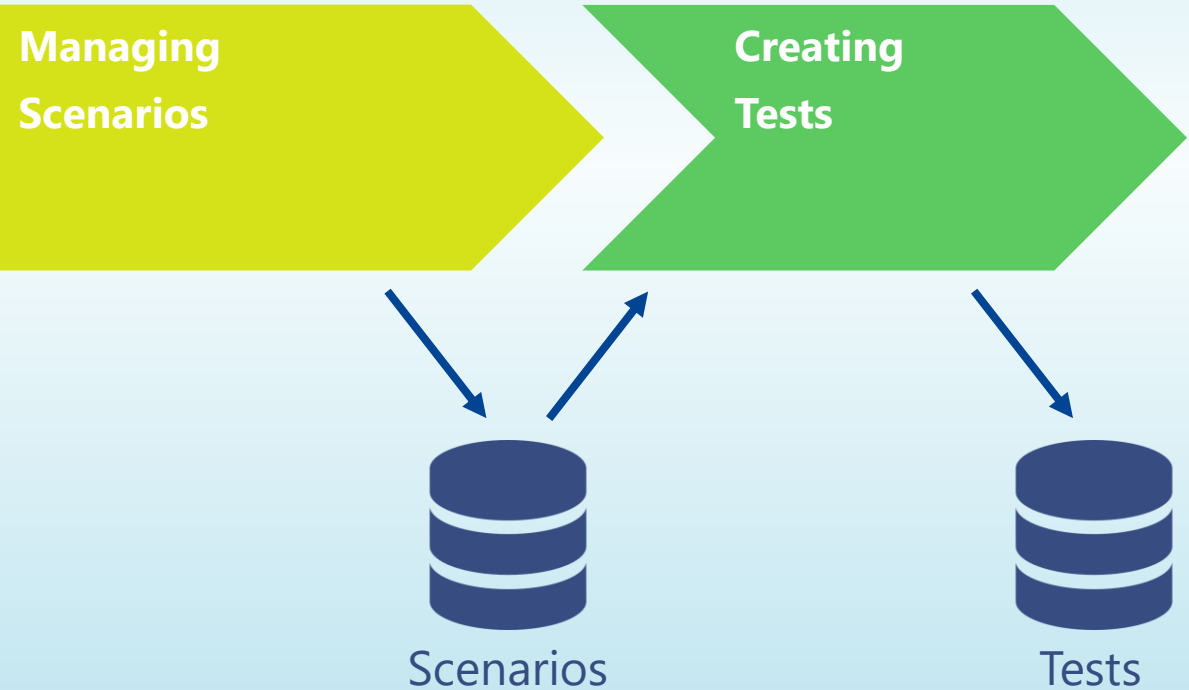
The diagram shows a top-down view of a road with a blue ego car, a grey fellow car, and a red obstacle. The ego car's speed is labeled v_{Ego} , the fellow car's speed is v_{Fellow} , and the distance between them is labeled *distance*. The obstacle is labeled 'Obstacle'.

Parameter Variation

v_{Ego} [km/h]	v_{Fellow} [km/h]	<i>distance</i> [m]	...	Other Parameters
105	80	25		
110	85	25		
115	90	25		
105	90	25		
...		

Test Creation

Scenario-Based Test Creation



Scenario Configuration

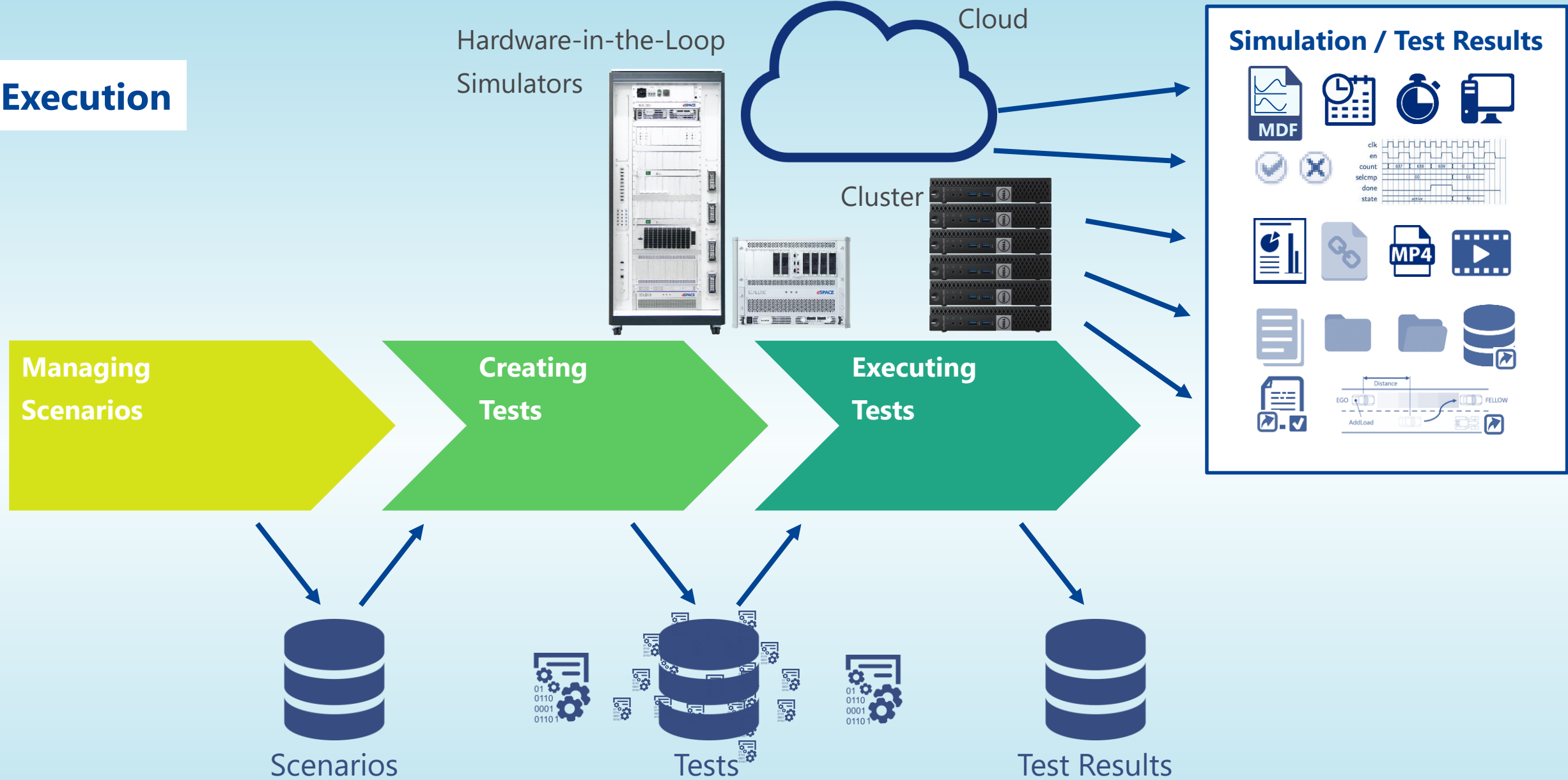
v_{Ego} $distance$ v_{Fellow} Obstacle

Parameter Variation

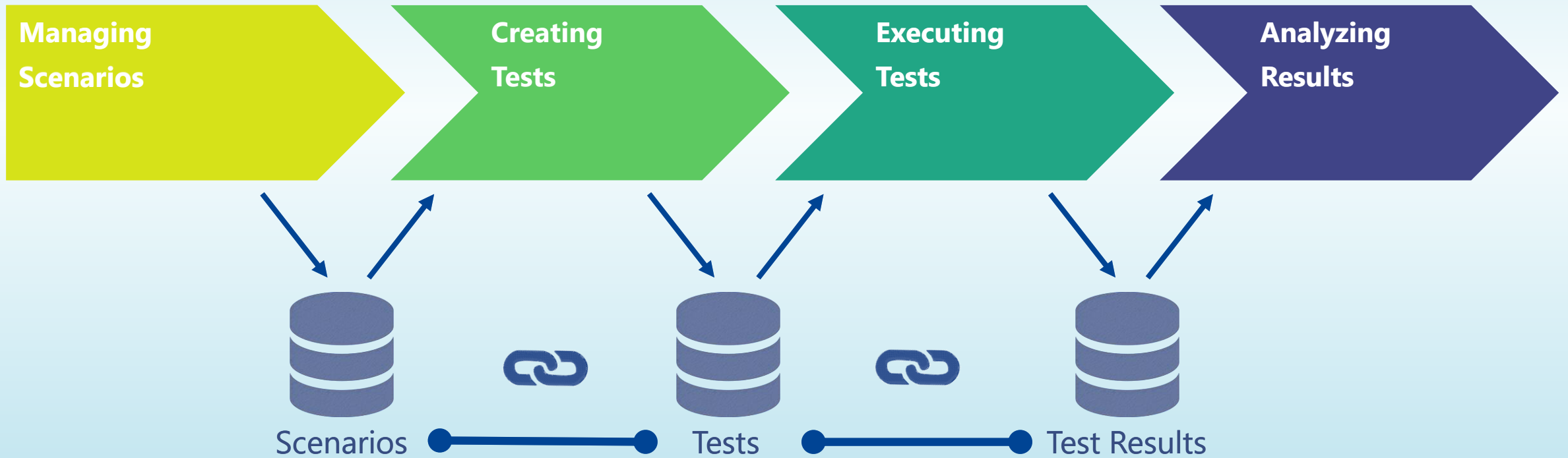
v_{Ego} [km/h]	v_{Fellow} [km/h]	$distance$ [m]	...	Other Parameters
105	80	25		
110	85	25		
115	90	25		
105	90	25		
...		

Test Creation

Execution



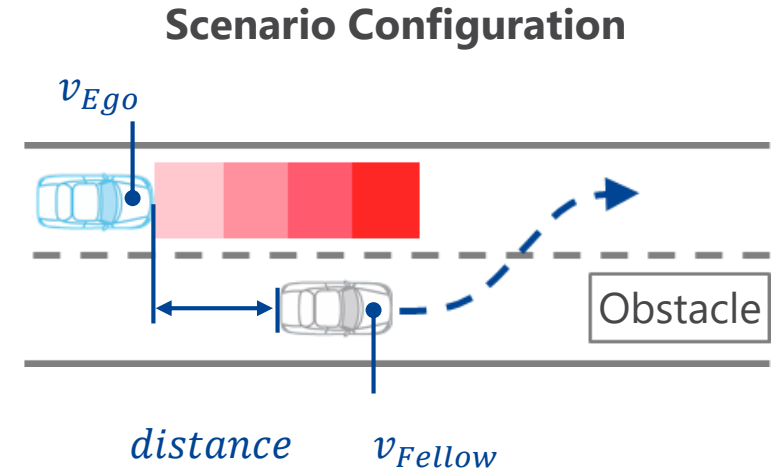
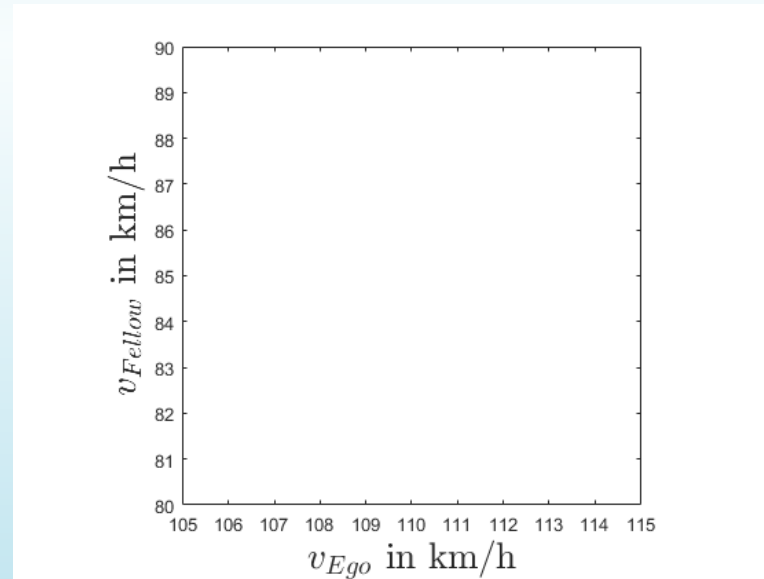
Analyzing Results



Smart Testing

Parameters:

- Ego velocity: $v_{Ego} \in [105,115]$ km/h
- Fellow velocity: $v_{Fellow} \in [80,90]$ km/h
- ...



Parameter Variation

v_{Ego} [km/h]	v_{Fellow} [km/h]	$distance$ [m]	...	Other Parameters
105	80	25		
110	85	25		
115	90	25		
105	90	25		
...		

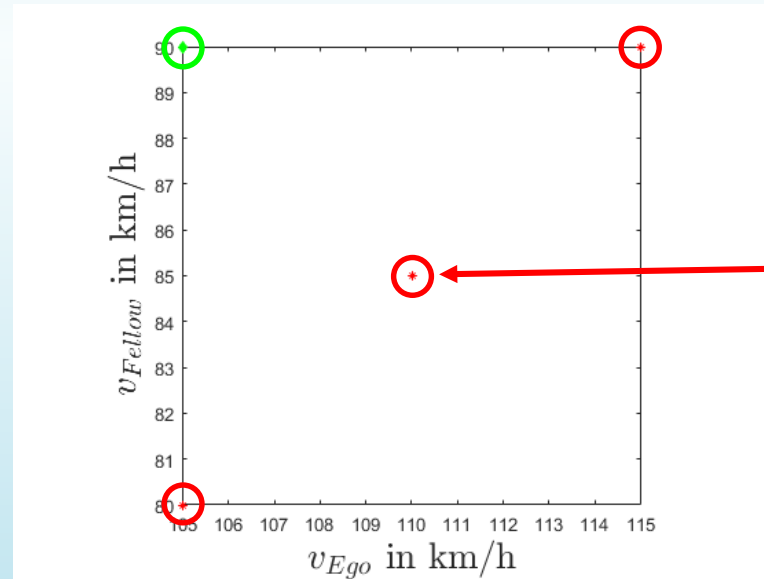
Test Creation

Smart Testing

Parameters:

- Ego velocity: $v_{Ego} \in [105,115]$ km/h
- Fellow velocity: $v_{Fellow} \in [80,90]$ km/h
- ...

- New parameter variation
- ◆ No crash case
- * Crash case



Scenario Configuration

v_{Ego}
 $distance$ v_{Fellow} Obstacle

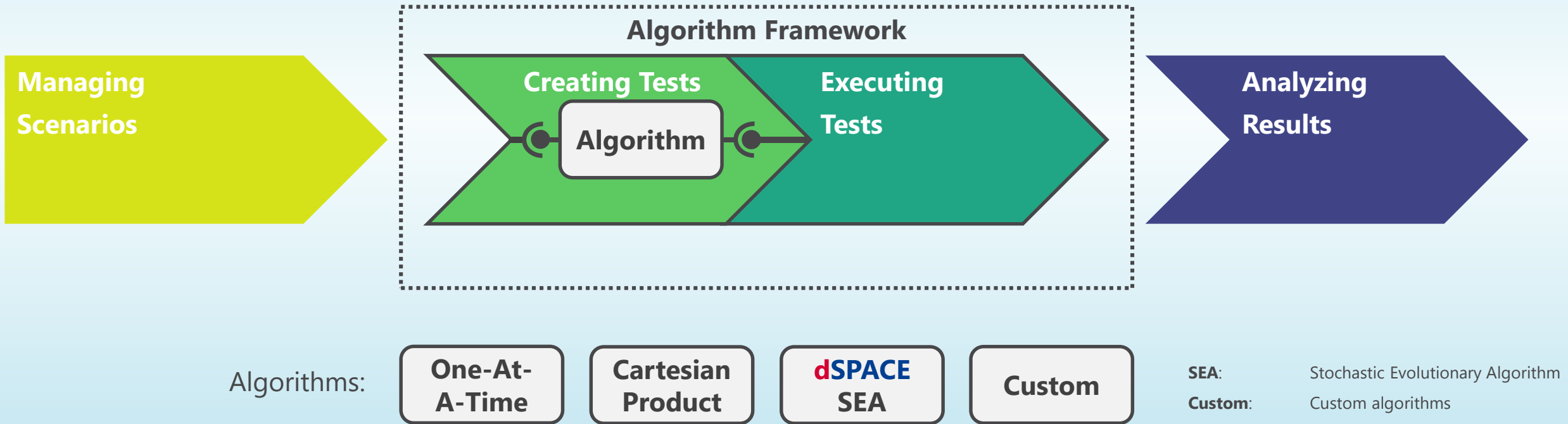
Parameter Variation

v_{Ego} [km/h]	v_{Fellow} [km/h]	$distance$ [m]	...	Other Parameters
105	80	25		
110	85	25		
115	90	25		
105	90	25		
...		

Automatic

Test Creation

Smart Testing

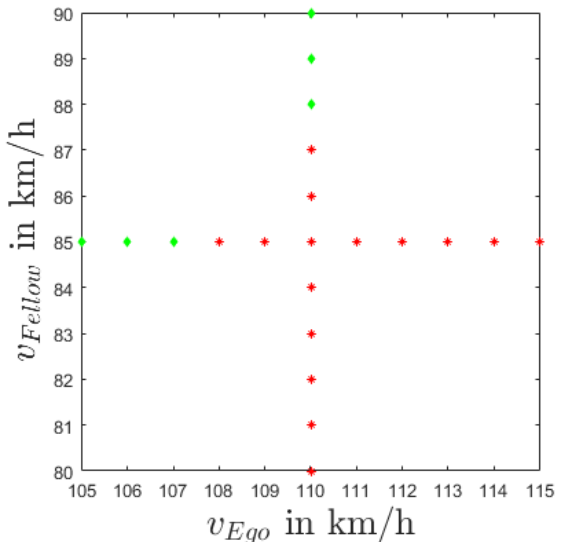


Smart Testing

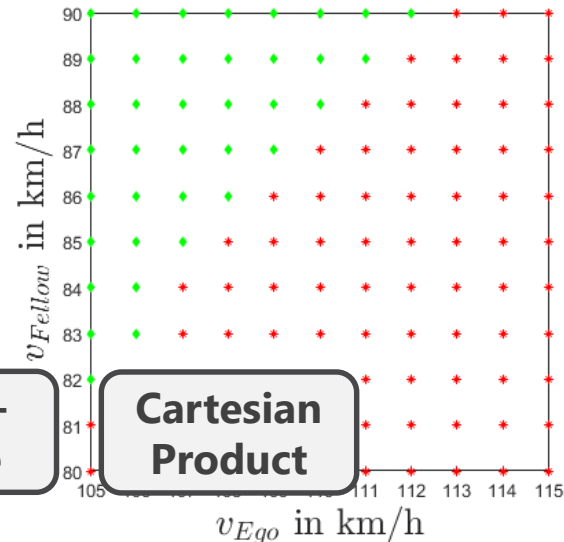
- New parameter variation
- ◆ No crash case
- * Crash case

One-At-A-Time

Cartesian Product



One-At-A-Time



Cartesian Product

Scenario Configuration

Diagram illustrating a scenario configuration. A blue car (Ego) is following a grey car (Fellow) at a distance. The Ego car's speed is v_{Ego} and the Fellow car's speed is v_{Fellow} . An obstacle is present ahead of the Fellow car. A red gradient bar indicates a range of parameter variations.

Parameter Variation

v_{Ego} [km/h]	v_{Fellow} [km/h]	distance [m]	...	Other Parameters
105	80	25		
110	85	25		
115	90	25		
105	90	25		
...		

Automatic

Test Creation

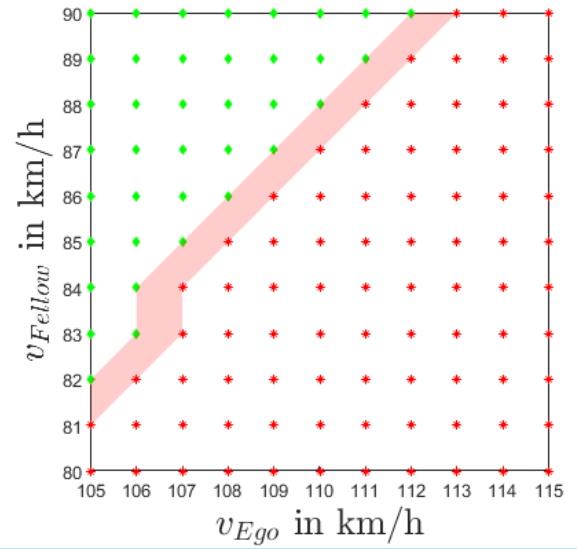
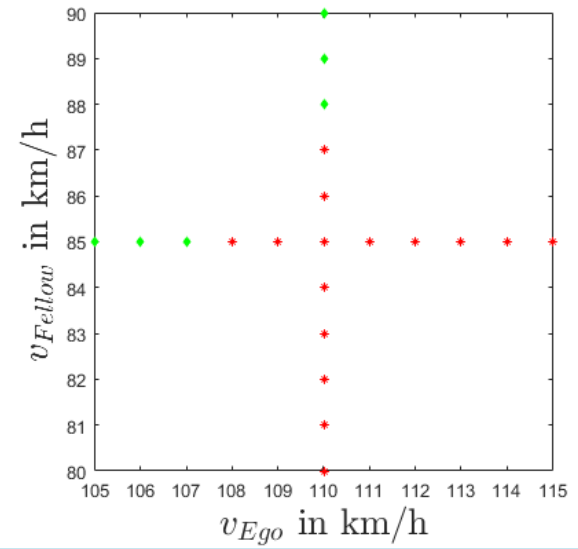
Smart Testing

- Objectives of Scenario-based testing:
 - Good test coverage of the parameter space
 - Identification of critical test cases

- New parameter variation
- ◆ No crash case
- * Crash case

One-At-A-Time

Cartesian Product



Scenario Configuration

v_{Ego}
 $distance$ v_{Fellow} Obstacle

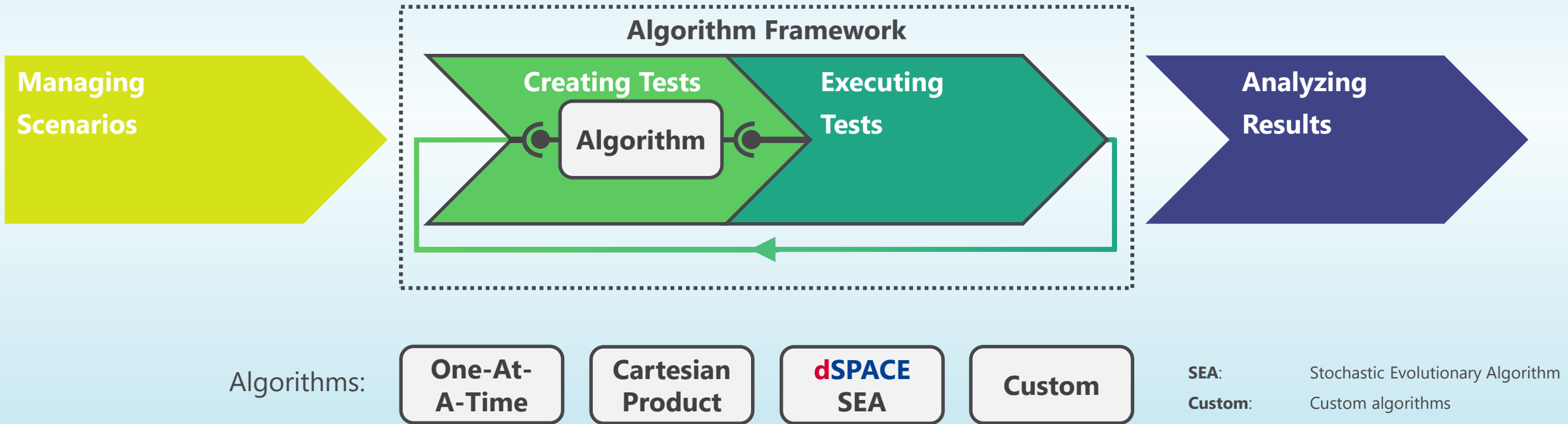
Parameter Variation

v_{Ego} [km/h]	v_{Fellow} [km/h]	$distance$ [m]	...	Other Parameters
105	80	25		
110	85	25		
115	90	25		
105	90	25		
...		

Automatic

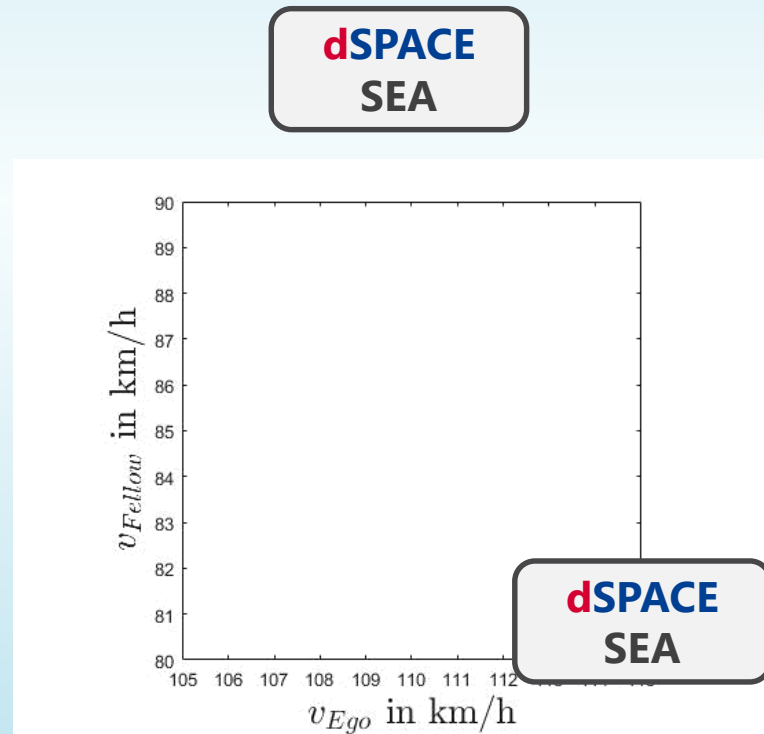
Test Creation

Smart Testing



Smart Testing

- Smart Testing: Learning from former results
- Iterative test parameter generation based on smart (mathematical) algorithms

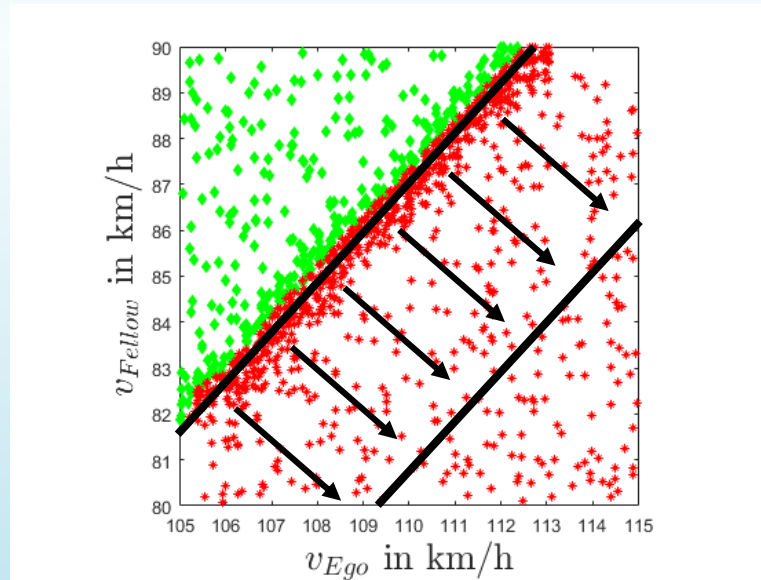


- New parameter variation
- ◆ No crash case
- * Crash case

SEA: Stochastic Evolutionary Algorithm
Custom: Custom algorithms

Smart Testing

- Interpretation of the algorithm results



- New parameter variation
- ◆ No crash case
- * Crash case

Smart Testing

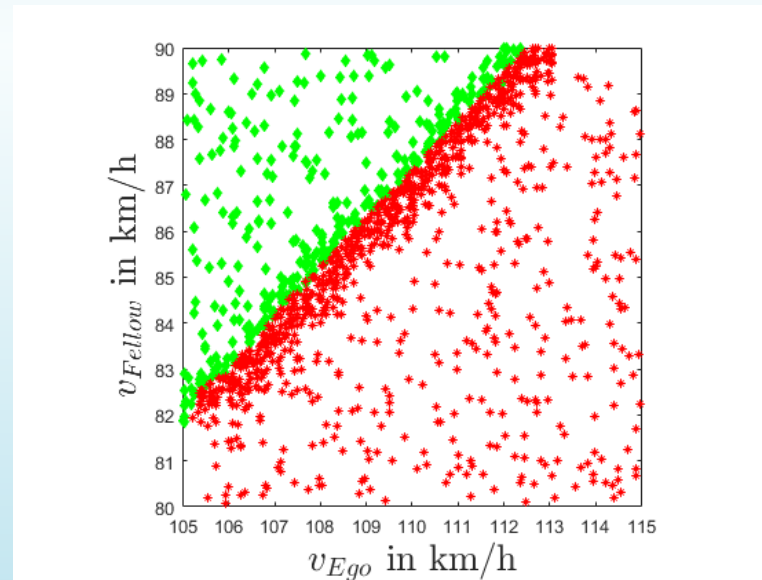
- Interpretation of the algorithm results
- Evaluation using continuous objective functions



0
No Crash

1
Crash

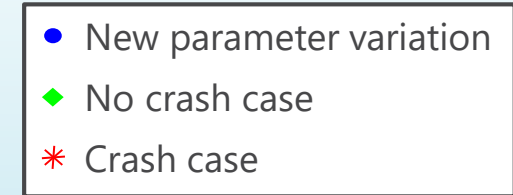
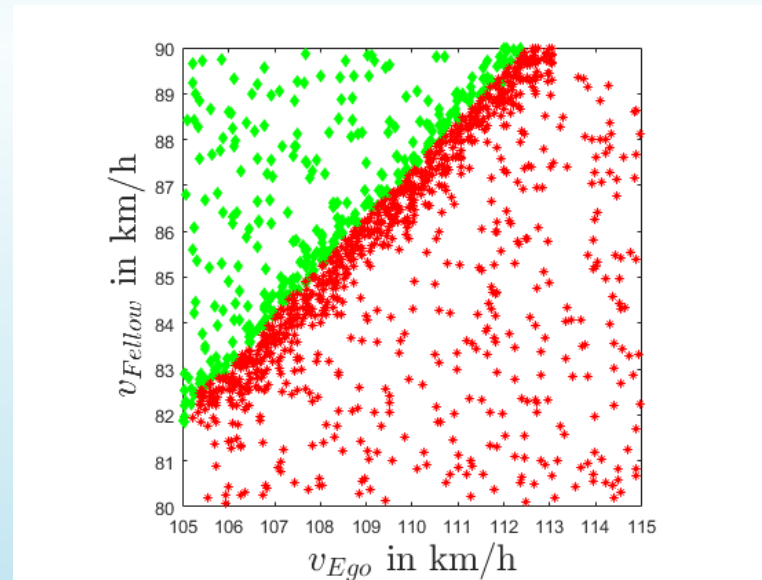
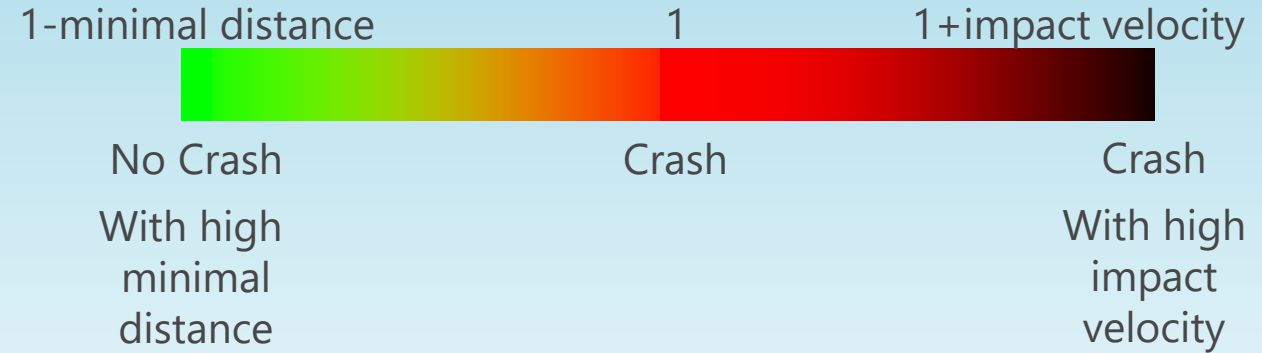
With high
minimal
distance



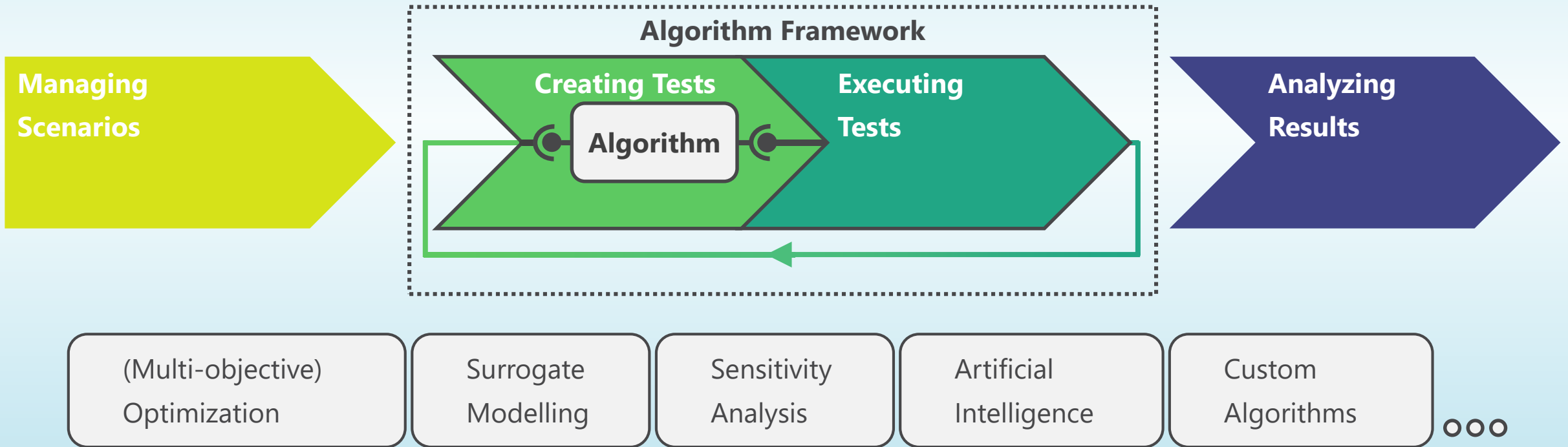
- New parameter variation
- ◆ No crash case
- * Crash case

Smart Testing

- Interpretation of the algorithm results
- Evaluation using continuous objective functions
- Other objectives like comfort or fuel consumption



Smart Testing



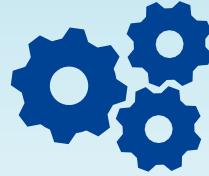
Benefits and Features



Store



Cloud



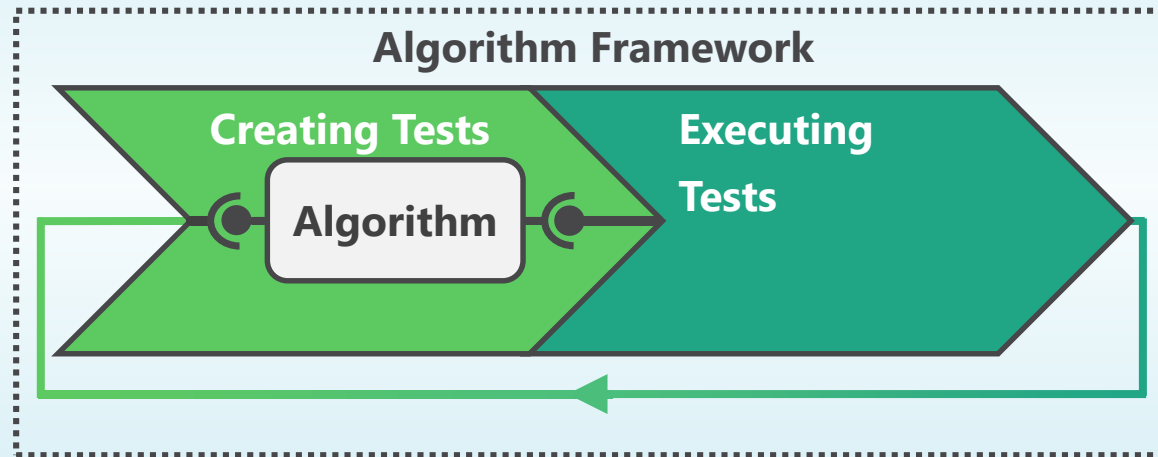
Automatic



Smart



Customizable



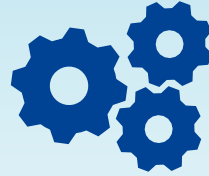
Future Prospects



Store



Cloud



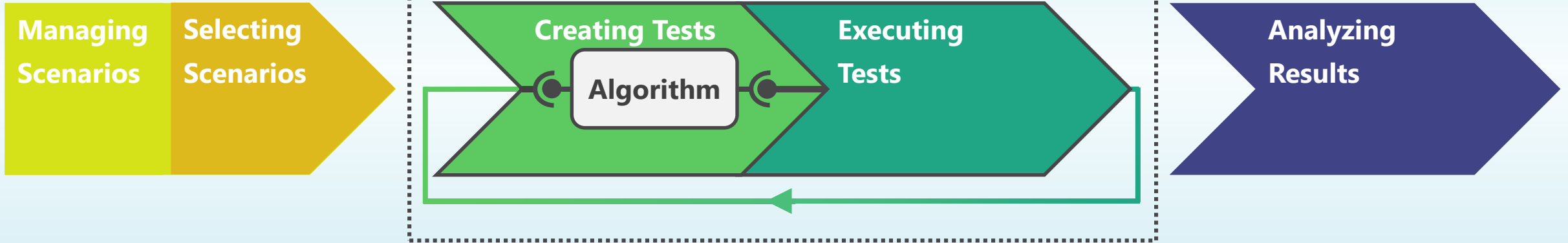
Automatic



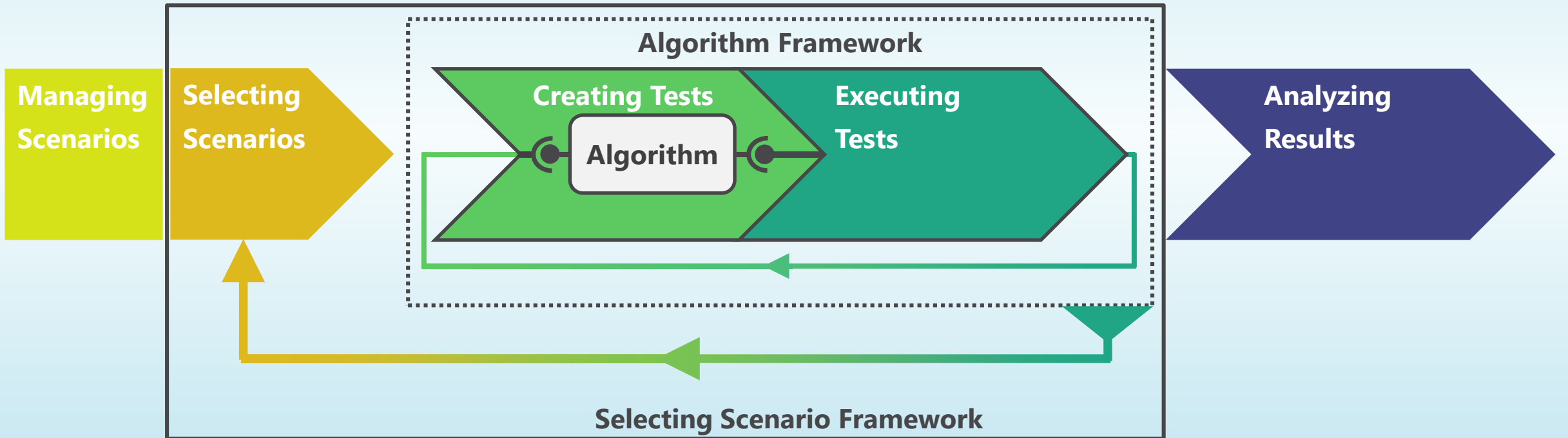
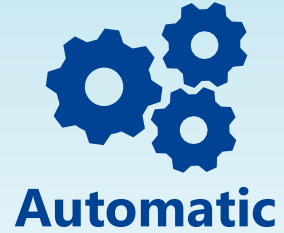
Smart



Customizable



Future Prospects



MERCI POUR VOTRE ATTENTION

JE RÉPONDRAIS À VOS QUESTIONS LORS DE LA TABLE-RONDE
POSEZ VOS QUESTIONS DANS LE CHAT !

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