

Closed Loop Requirement Based Testing

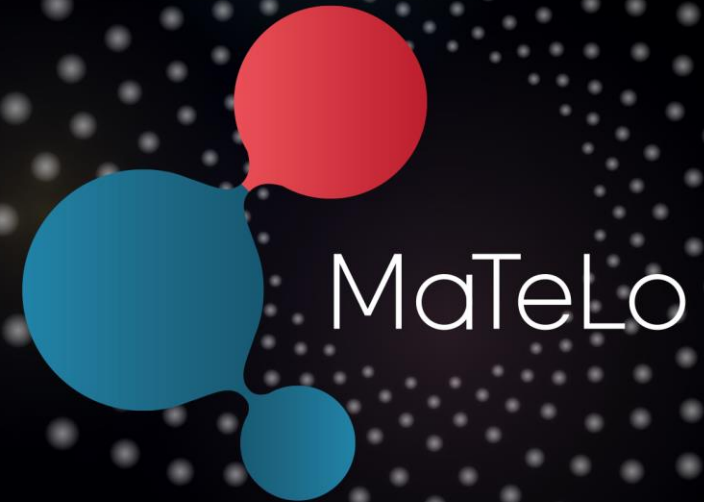
For Autonomous Driving

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ALL4TEC



All4Tec, a Model-Based Company



- Independent Company established in 1998

Inspired from experiences in various Industrial and R&D projects



Autonomous Vehicle
Safety
SVA



RENAULT



Autonomous Vehicle Combinatoric explosion

Test Case combinatorics :1,000,000,000,000,000,000,000

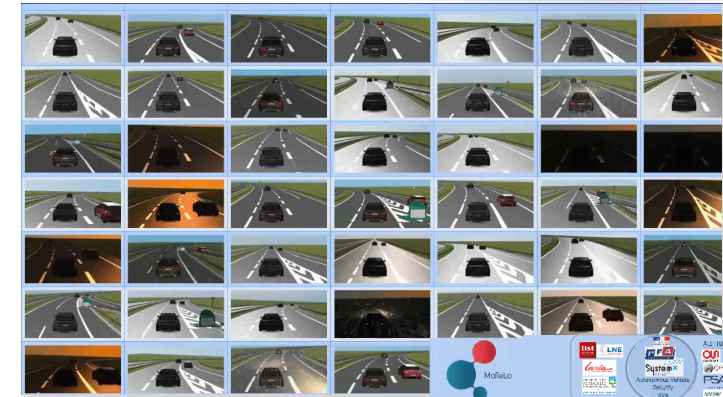
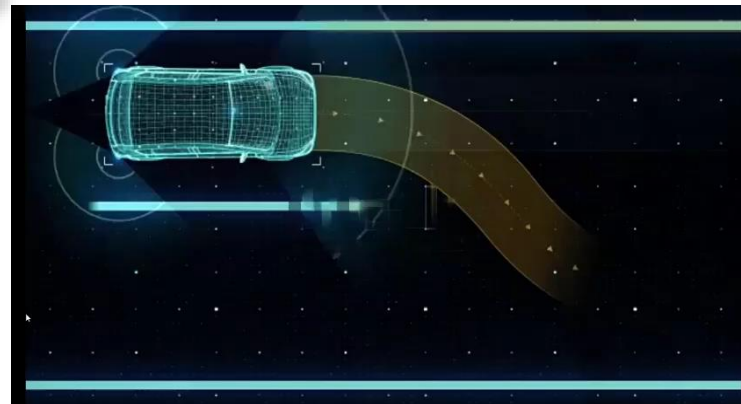
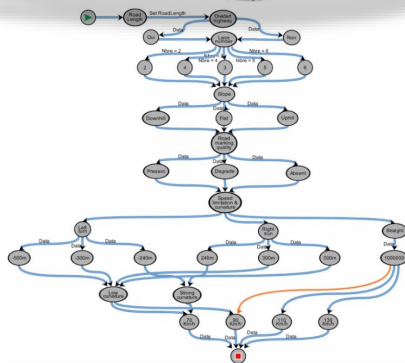
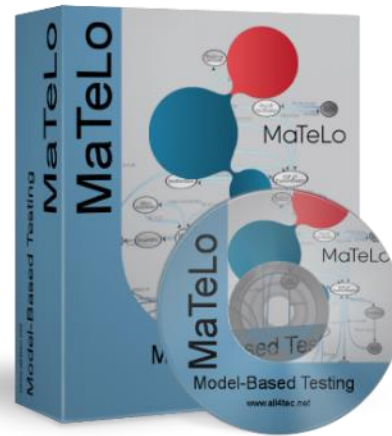


Traditional Testing

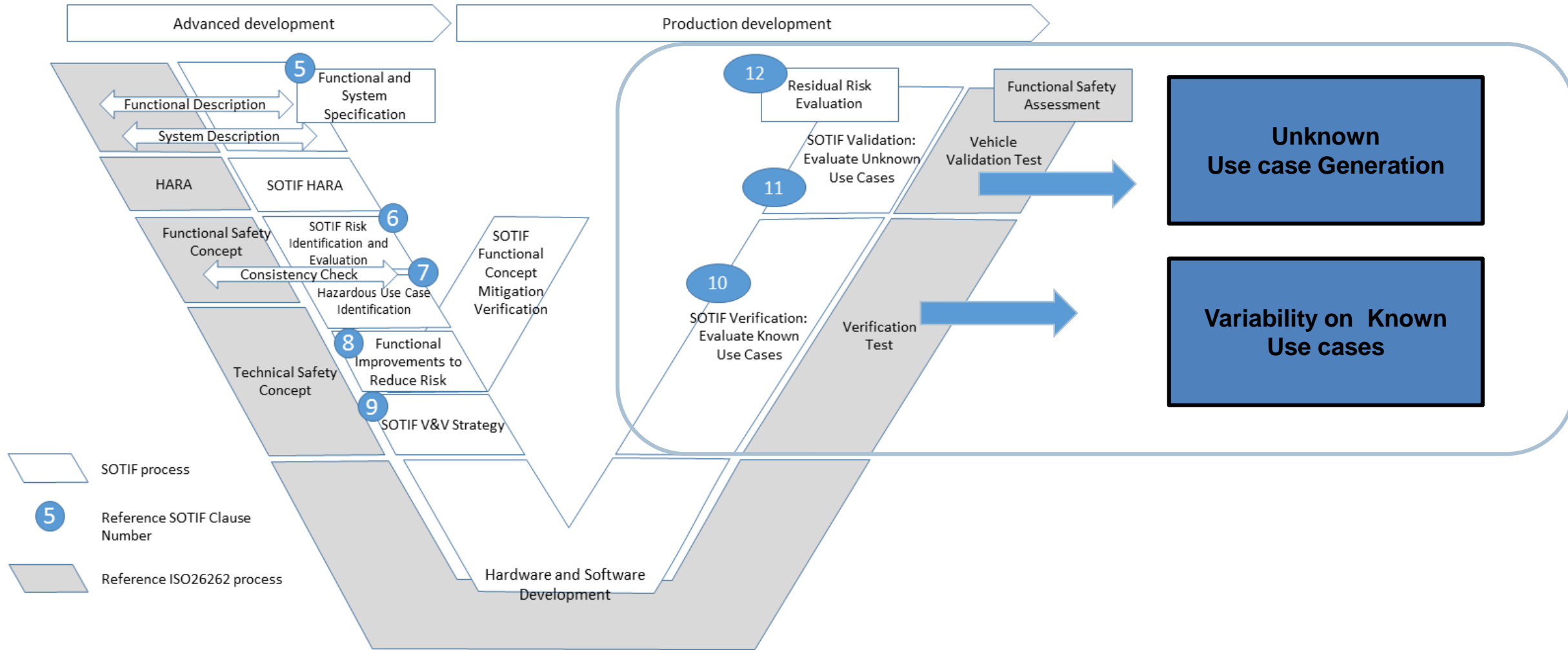


Key Performance
Indicators

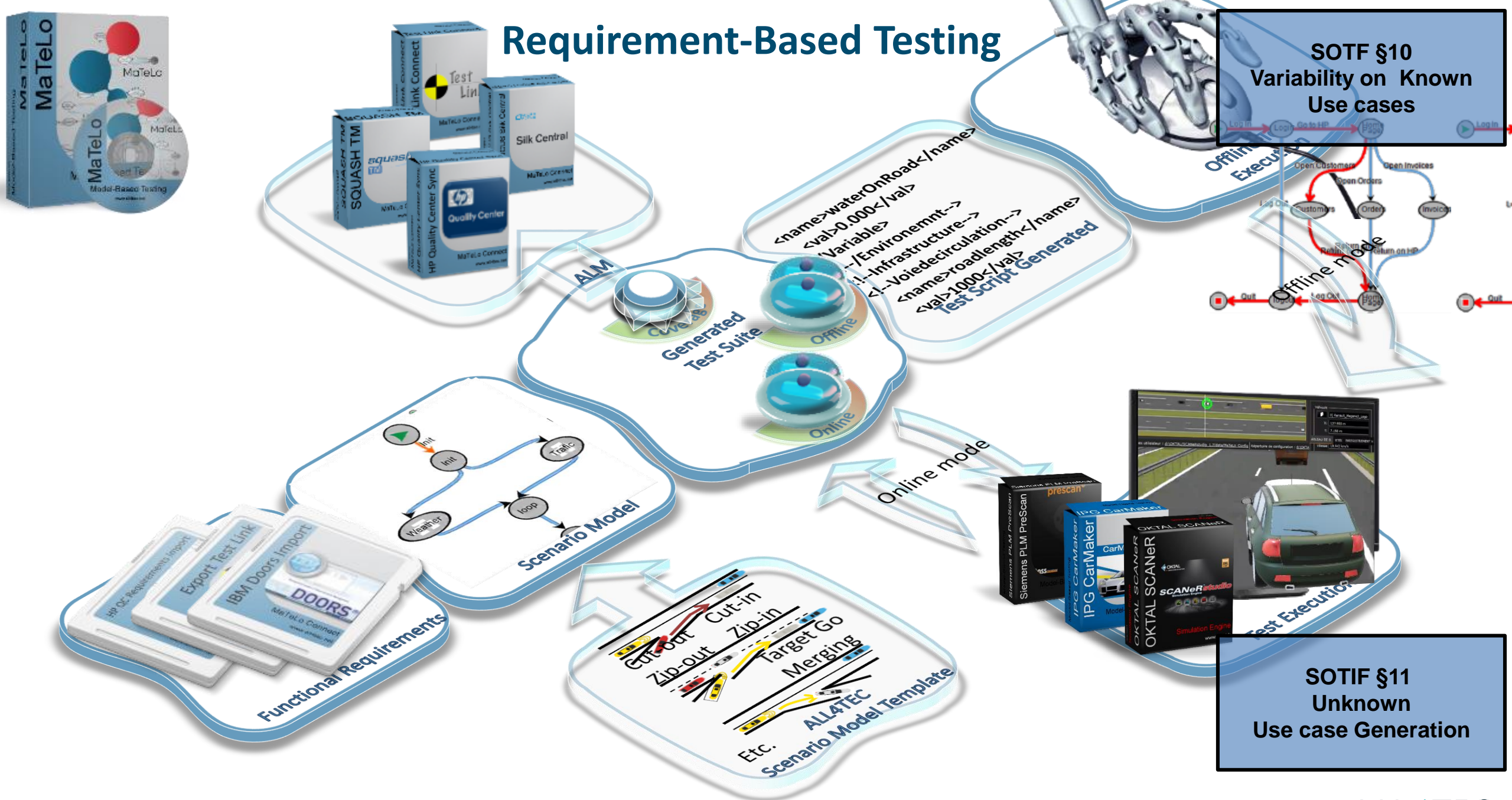
MaTeLo Model Based Testing & AV simulation engine



SOTIF requirements



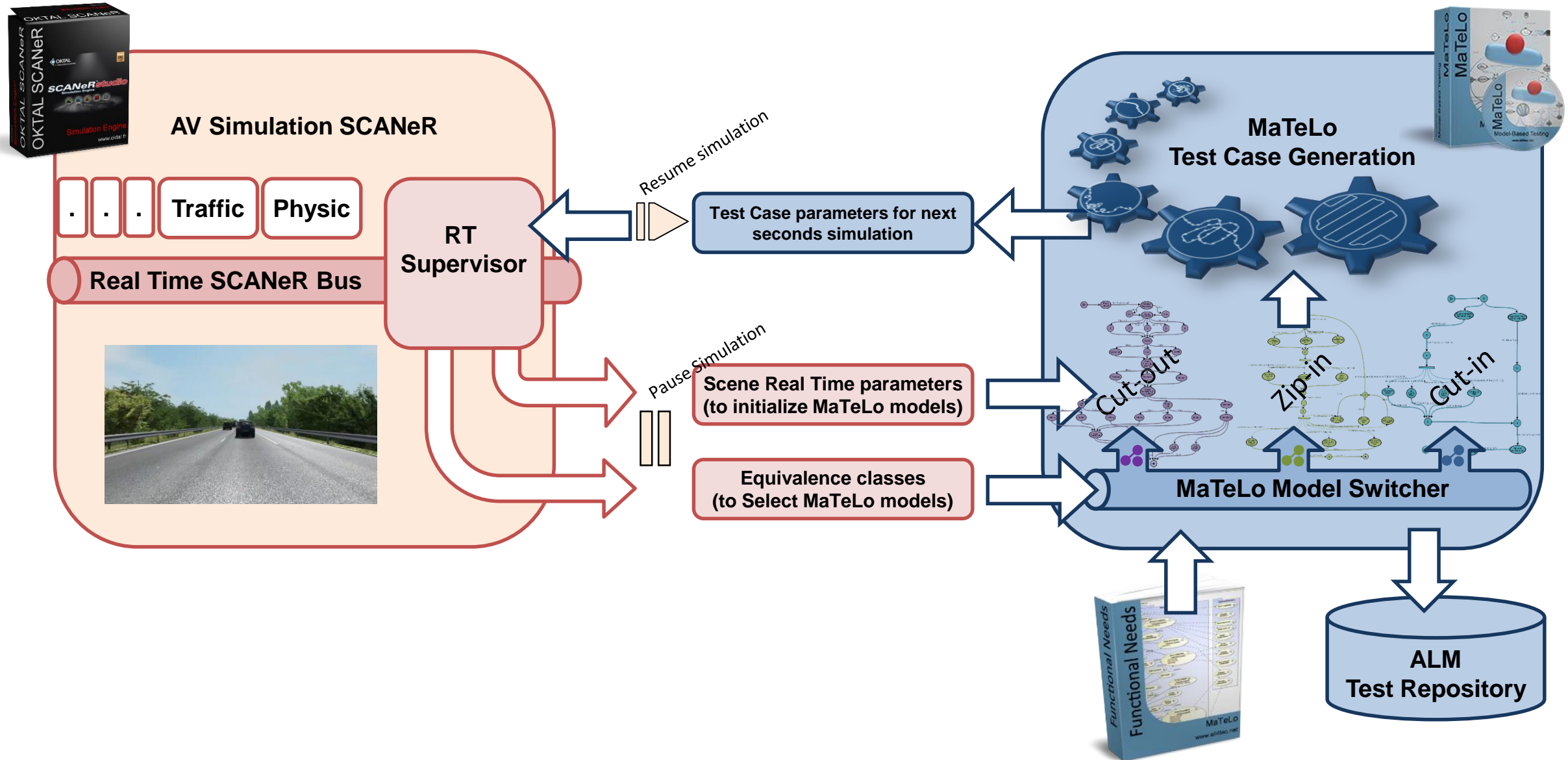
Requirement-Based Testing



SOTF §10
Variability on Known
Use cases

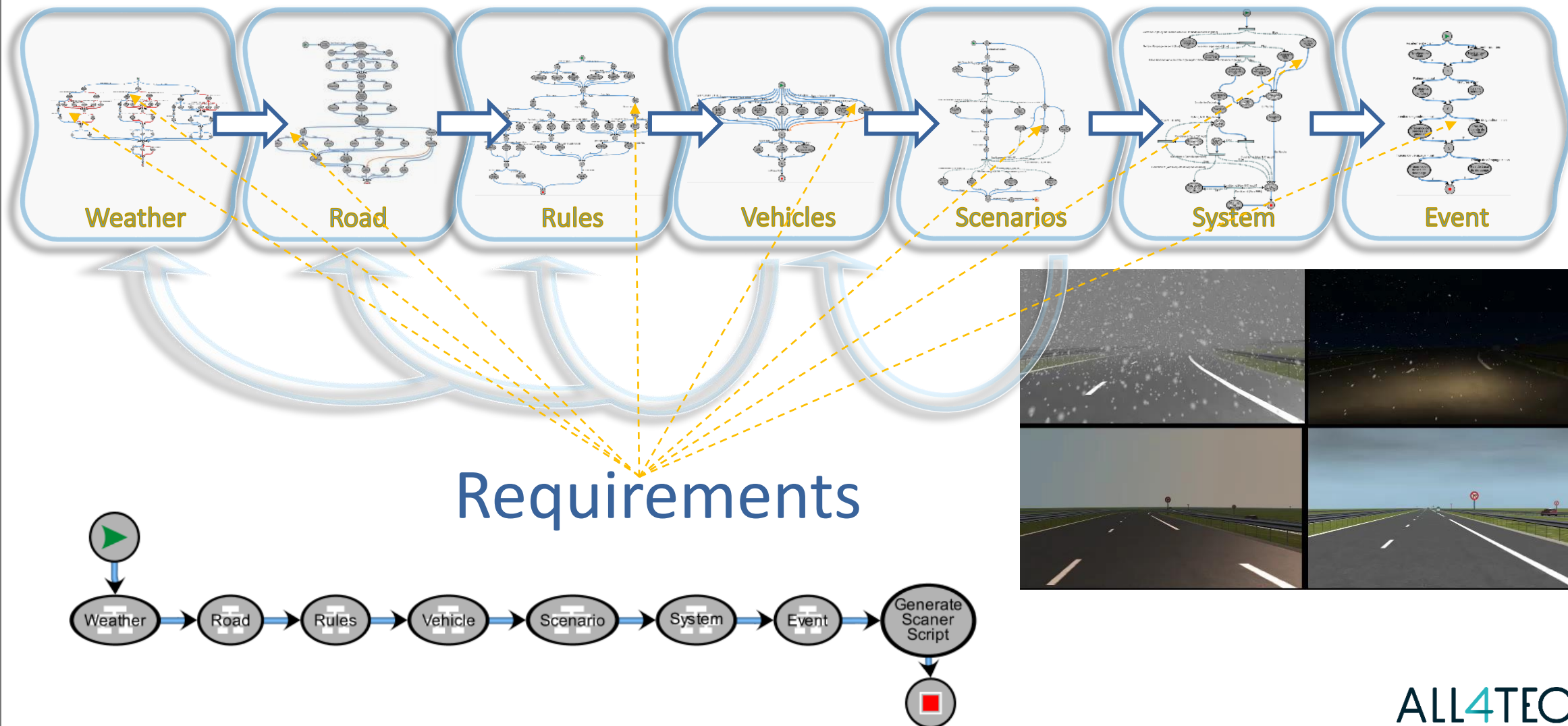
SOTIF §11
Unknown
Use case Generation

Requirement in the Loop

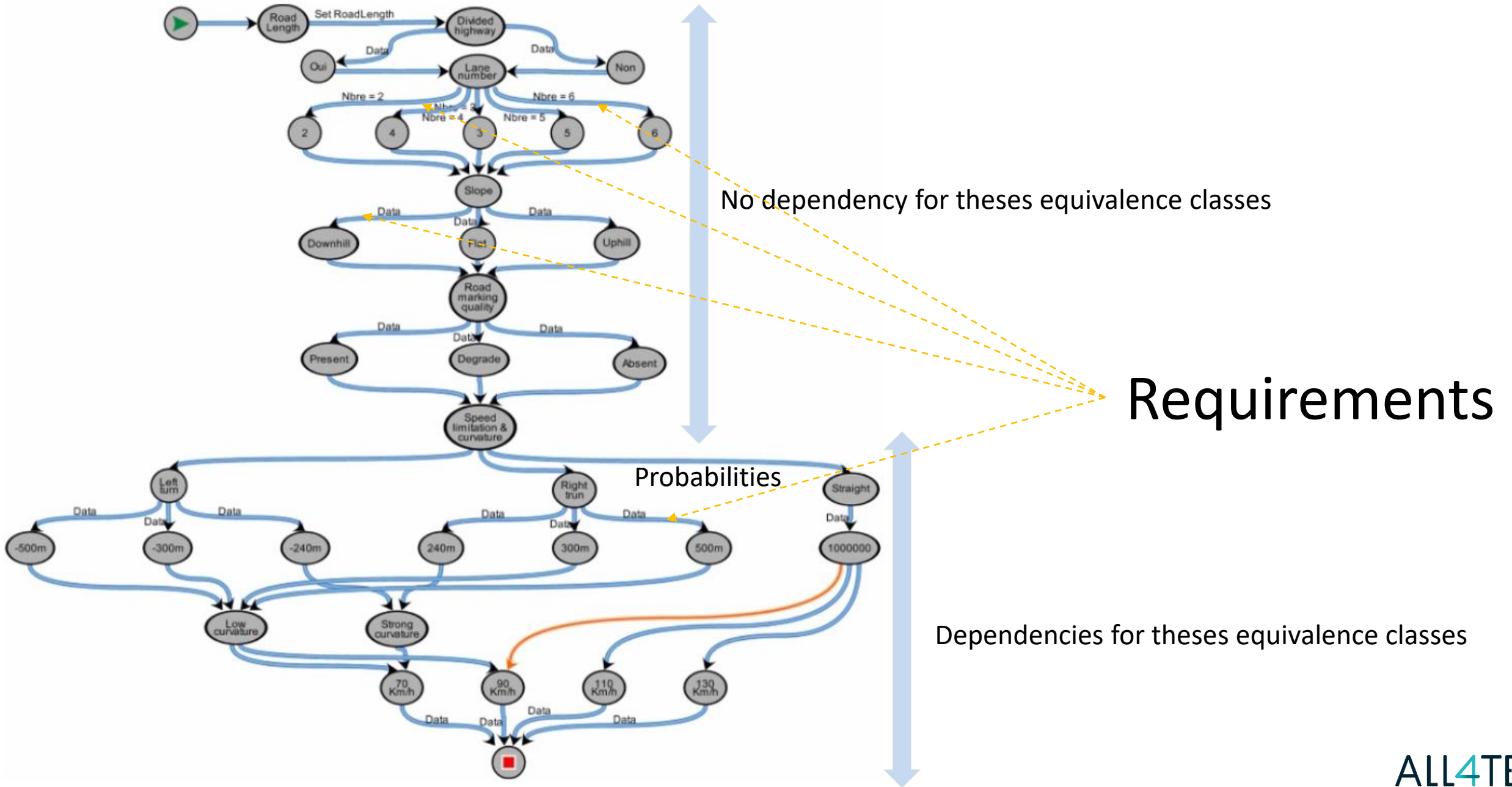


Requirements

The model represents an abstraction of the states of the environment decomposed in main combinatoric families



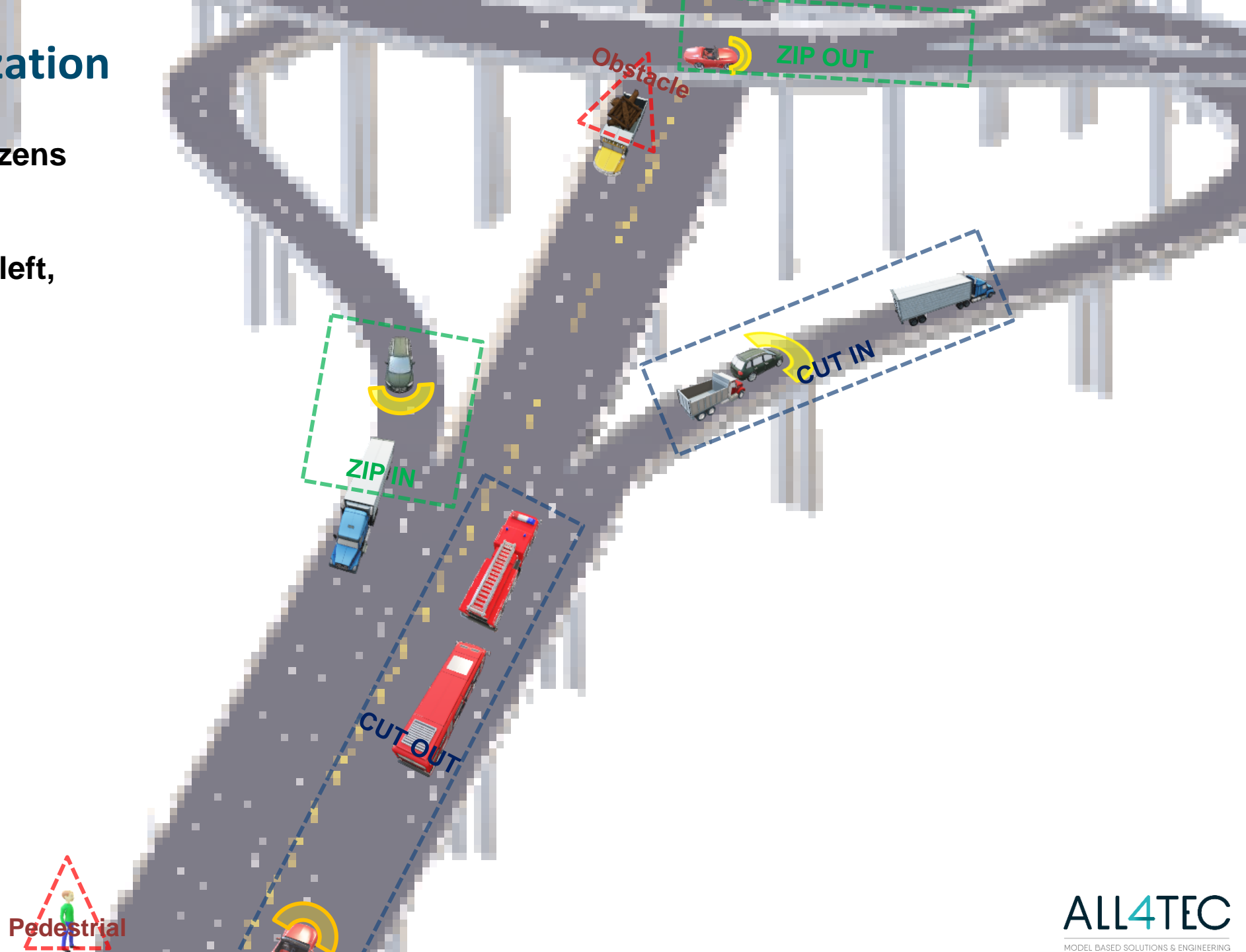
Equivalence class representation and dependencies



Scenarios Categorization

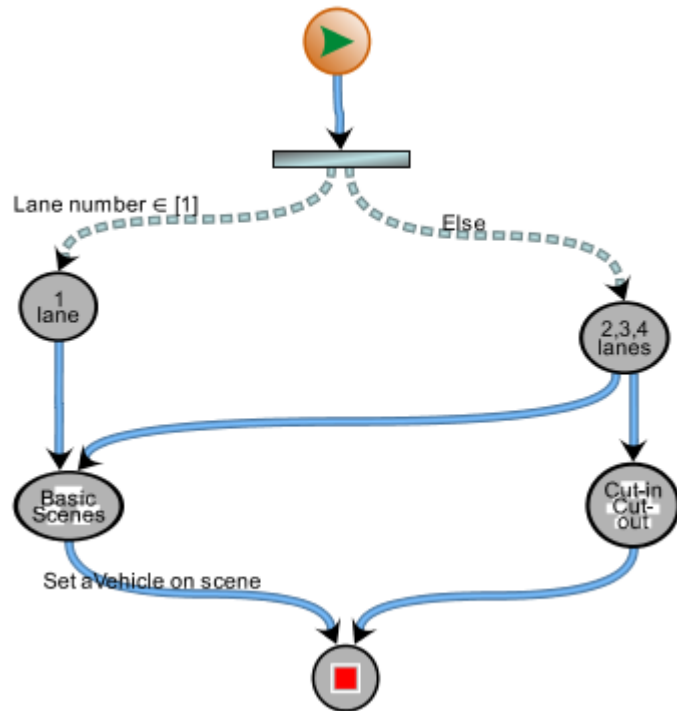
Expert categorization of dozens
risked template scenarios :

- Cut-in from behind from left,
- Cut-out
- Insertion
- Target Following
- Target Go
- Target Stop
- Cut-out Cut-in
- ...



Scenarios Categorization

Each scenario is a sub model
A scenario can only occurs when
depending previous classes are
compliant

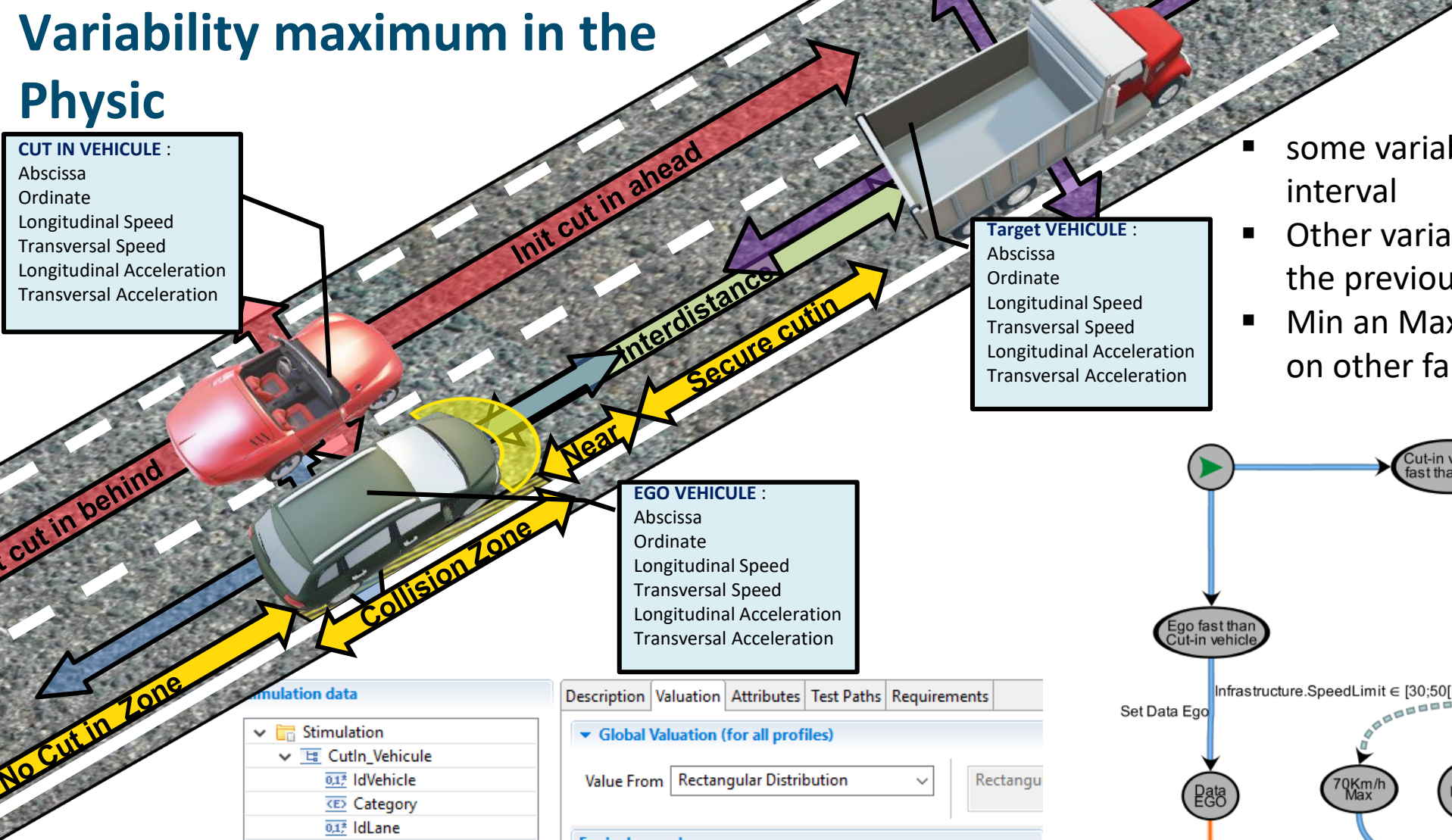


All scenarios are built in order to
achieve the objective with the
maximum determinist



Variability maximum in the Physic

CUT IN VEHICLE :
Abscissa
Ordinate
Longitudinal Speed
Transversal Speed
Longitudinal Acceleration
Transversal Acceleration



Target VEHICLE :
Abscissa
Ordinate
Longitudinal Speed
Transversal Speed
Longitudinal Acceleration
Transversal Acceleration

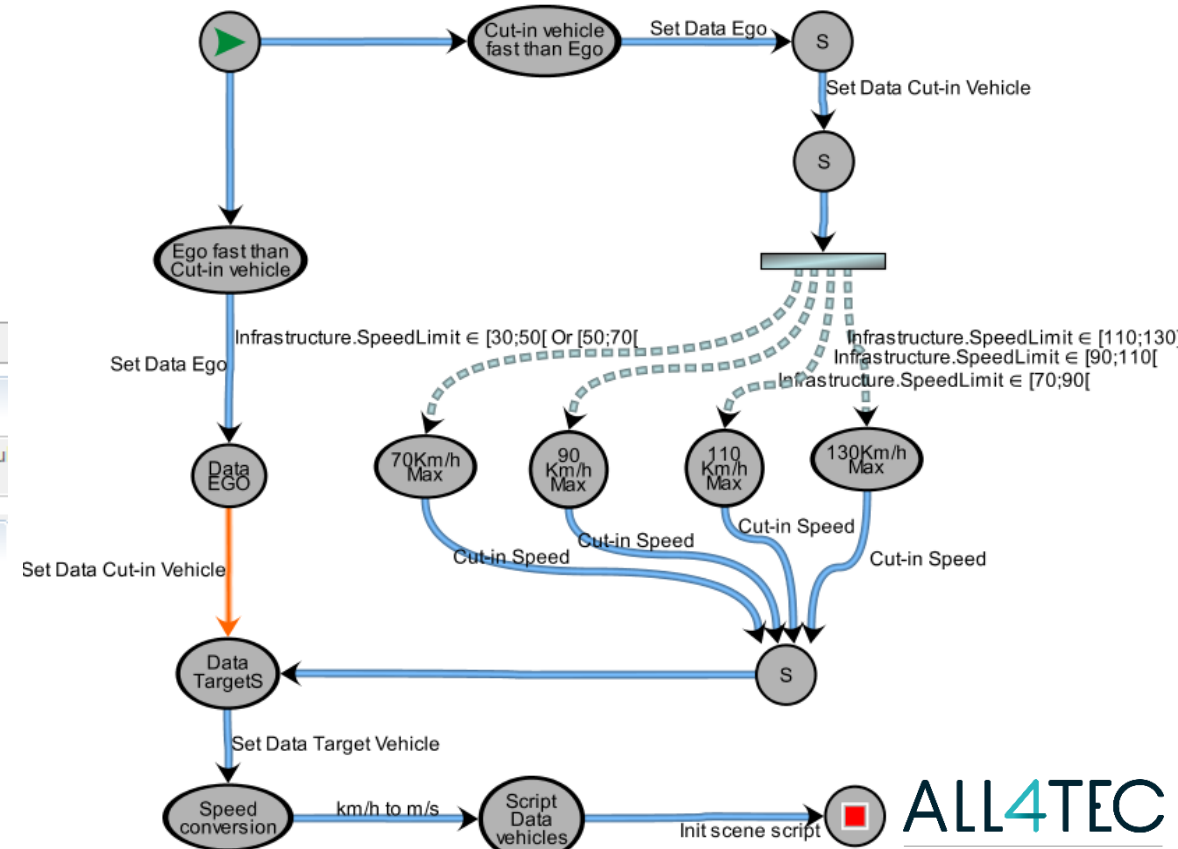
EGO VEHICLE :
Abscissa
Ordinate
Longitudinal Speed
Transversal Speed
Longitudinal Acceleration
Transversal Acceleration

- some variables are randomly drawn in an interval
- Other variables are calculated based on the previous random variables
- Min an Max of each variable can be linked on other family variables

Simulation data

Stimulation
CutIn_Vehicle
IdVehicle
Category
IdLane
Initial Speed
Acceleration
TimeGapWithEgo
TimeGapWithVehicle
DeltaSpeedWithEgo
ManoeuvreTime

Description	Valuation	Attributes	Test Paths	Requirements
Global Valuation (for all profiles)				
Value From	Rectangular Distribution			Rectangu
Equivalence classes				
Name	Ranges	Activation		
EC0	[0.000;30.000[false		
EC1	[30.000;50.000[true		
EC2	[50.000;70.000[false		
EC3	[70.000;90.000[false		
EC4	[90.000;110.000[false		
EC5	[110.000;130.000[false		
EC6	[130.000;250.000]	false		



MODEL FILTERING FROM REQUIREMENT

File Edit Navigate Reports Run Test Suite Window Help

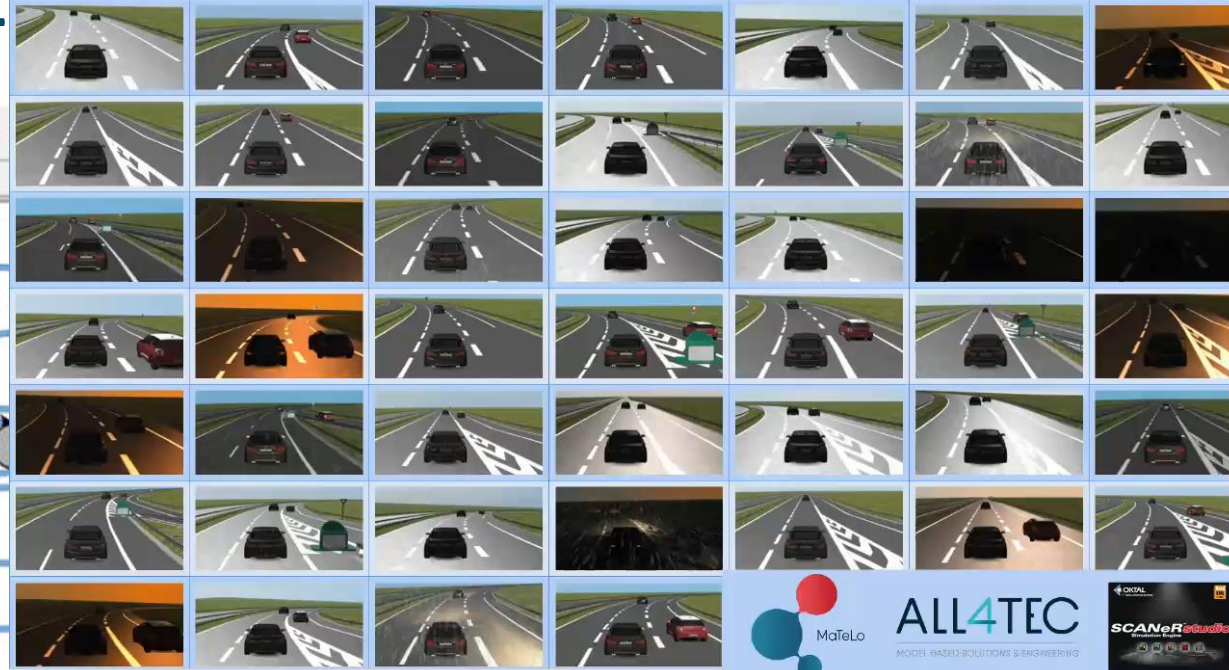
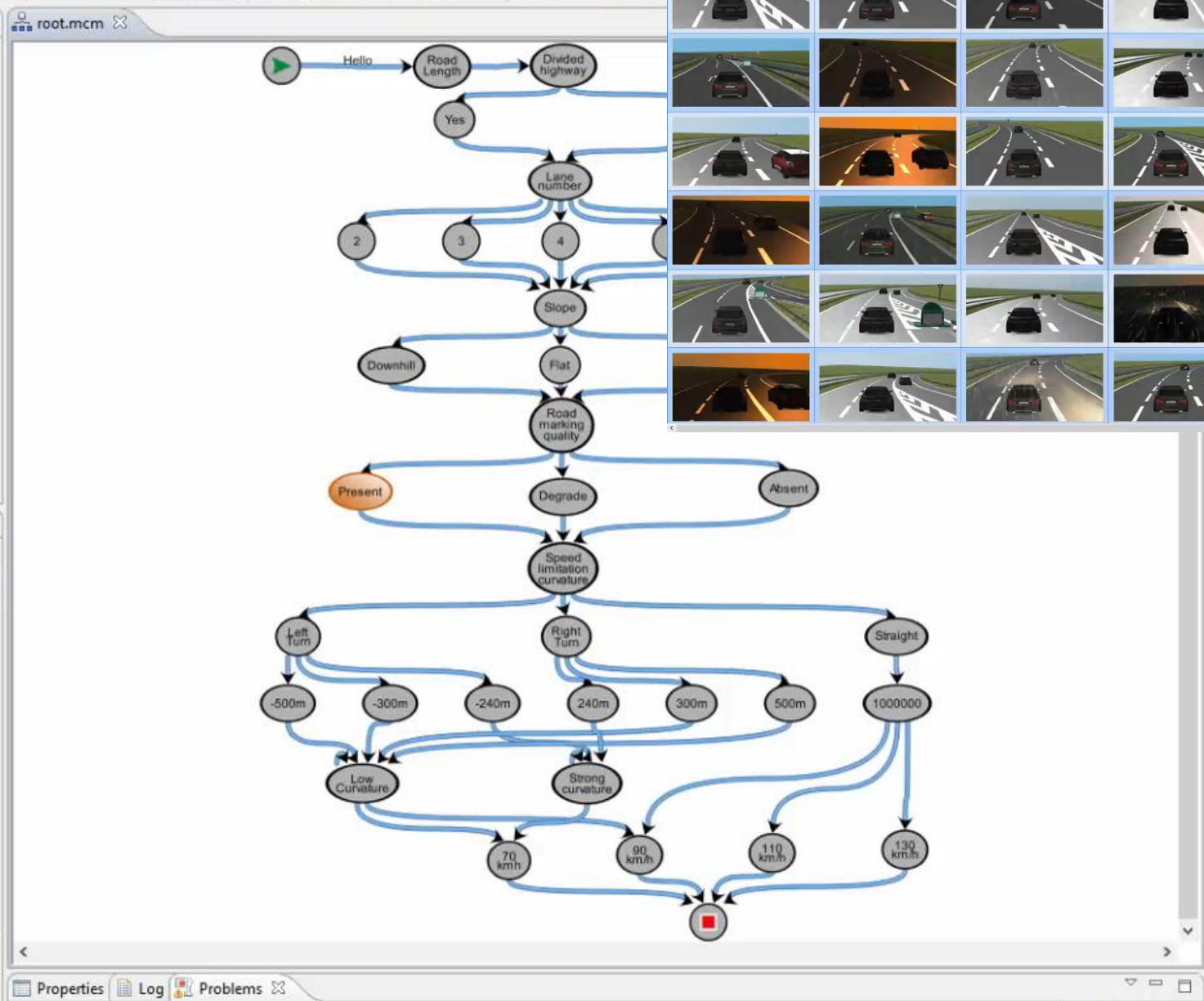
Type Filter Text (? = any character, * = any String)

Project Explorer

- [A4T demo] Online ecommerce
 - Infrastructure
 - Chains
 - root
 - Profiles
 - Reports
 - Test Suites
 - test

Test Suites

Test Suites	Number of Transitions	Nur
Test Suite1	15	
Test Suite2	16	



Groups

- ☐ Specification Document
- ☐ Weather
- ☐ Rules
- ☒ Road
 - ☐ Divided Highway
 - ☐ Yes
 - ☐ No
 - ☐ Lane Number
 - ☐ Slope
 - ☐ Downhill slope
 - ☐ Flat slope
 - ☐ Uphill Slope
 - ☐ Road marquing Quality
 - ☐ Present
 - ☐ Degrade
 - ☐ Absent
 - ☐ Speed limit Curvature
 - ☐ Curvature
 - ☐ Left Turn
 - ☐ Right Turn
 - ☐ Straight
 - ☐ Curvature rate

Generate Generate and execu

o_Config - Simulation modeType de Licence: Core Workstation (single computers)

ONFIGURATION VUE FENÊTRES OUTILS SIMULATION MODE

TERRAIN VÉHICULE SCÉNARIO SIMULATION ANALYSE

demoFAT 7 (3D)

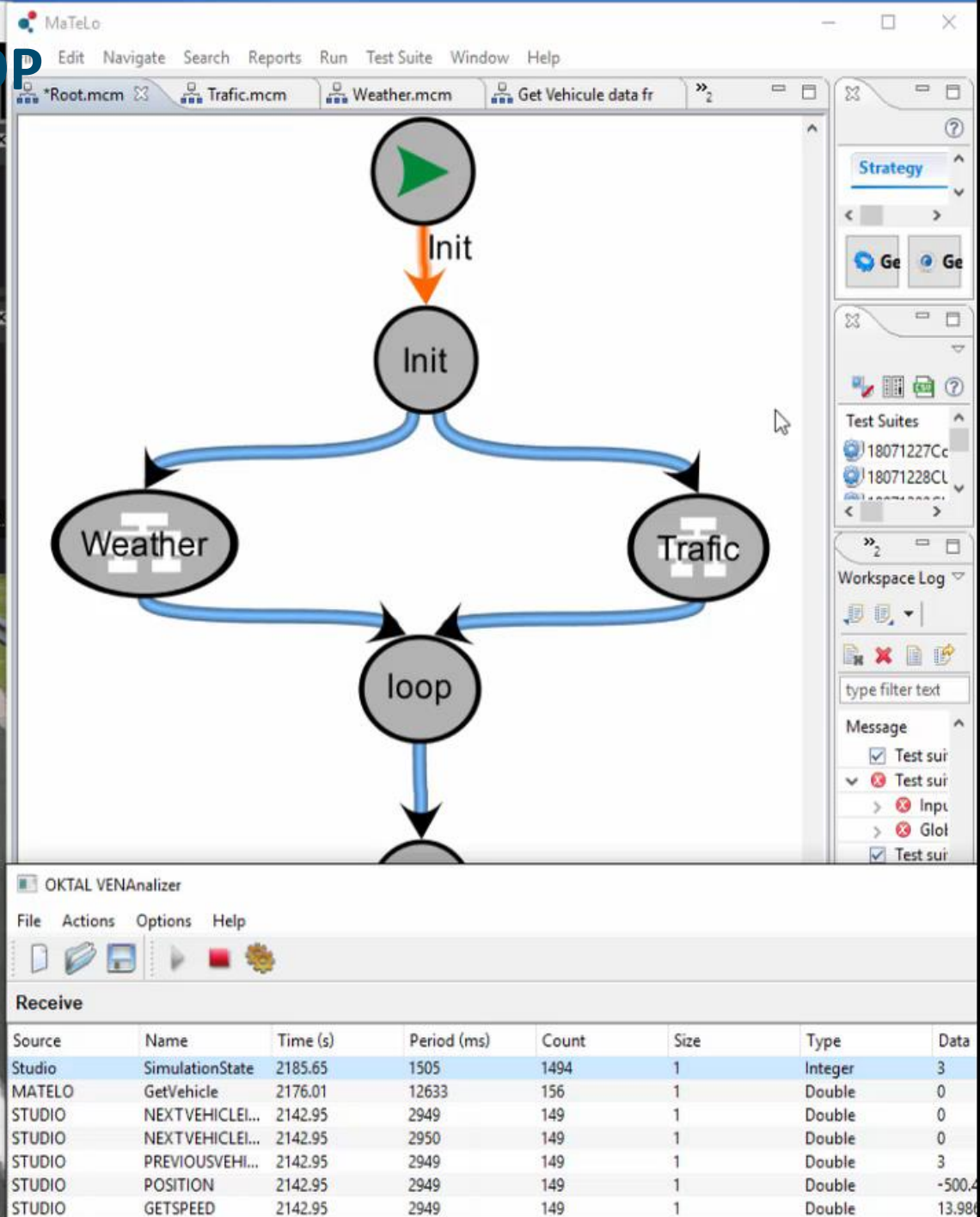
0.000 | lat=0.000239, long=0.002305, elev=-0.000001 | projX=256.612, pr

es utilisateur : d:\OKTAL\SCANeRstudio_1.7\data\MaTel.o_Config | Répertoire de configuration : d:\OKTA

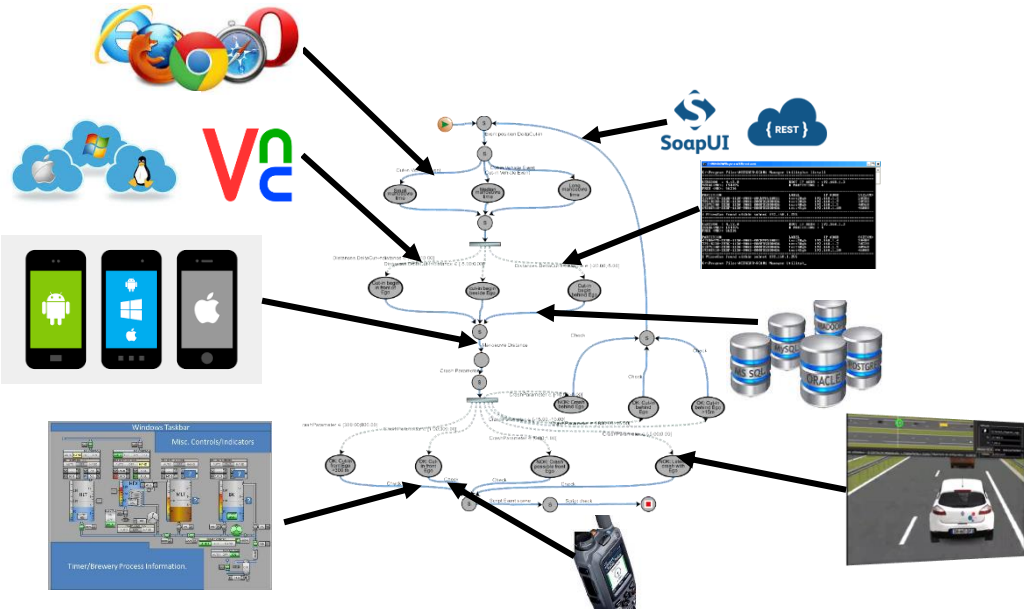
Progress Information

SIMULATION IN CLOSE LOOP

The screenshot shows the MaTel.o simulation interface. At the top, there are tabs for 'ONFIGURATION', 'VUE', 'FENÊTRES', 'OUTILS', 'SIMULATION', and 'MODE'. Below these are sub-tabs for 'TERRAIN', 'VÉHICULE', 'SCÉNARIO', 'SIMULATION', and 'ANALYSE'. The main window is divided into three sections: a 3D view of a car on a road, a top-down view of the road, and a dashboard. The dashboard displays vehicle data for a 'Renault_Megane3_Logo' with coordinates X: 137.903 m and Y: 7.198 m, and a speed of 19.942 km/h. The 3D view shows a white car with license plate 'DH-447-DF' driving on a road. The top-down view shows a road with several cars, one of which is highlighted with a green circle.



Benefits with Online Close Loop Requirement based testing



End 2 End Test Requirement with multiple Technologies



Adapt requirement testing during the test execution

Execute as long as you want with
always different test cases

ALL4TEC

MODEL BASED SOLUTIONS & ENGINEERING



Thank you for your attention



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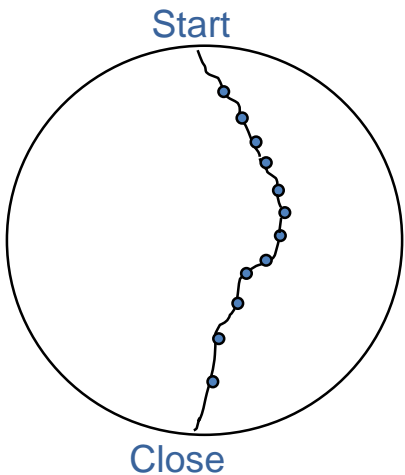
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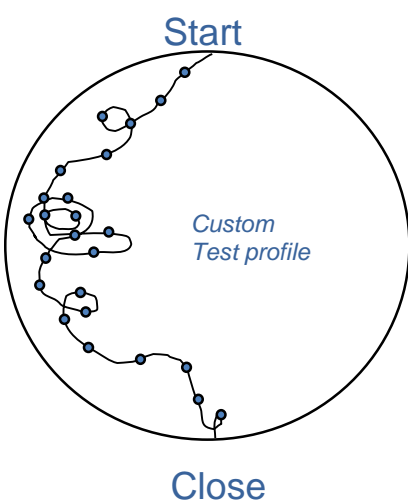
Test Application Life cycle strategy

Most probable approach



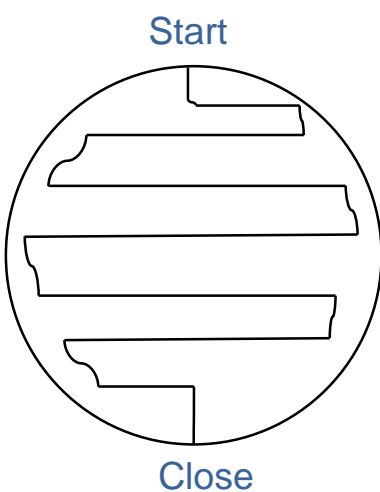
FREQUENCY
FOCUS

Usage & Risk based Approach



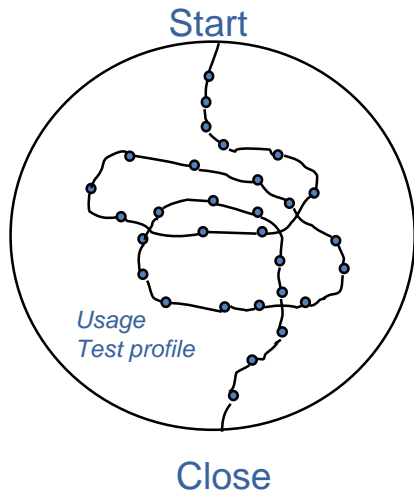
CRITICALITY, COMPLEXITY
UPDATE FOCUS

Arc Coverage approach



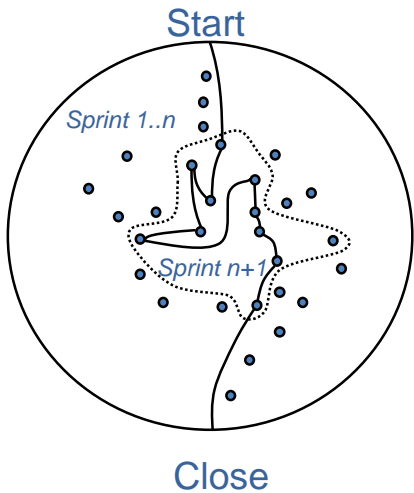
REQUIREMENTS
COVERAGE

Random approach



OPERATIONAL
COVERAGE

Δ Sprint approach

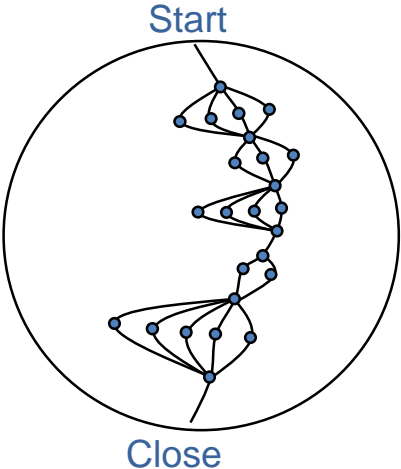
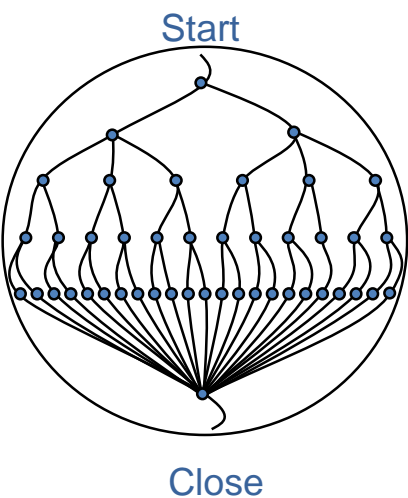
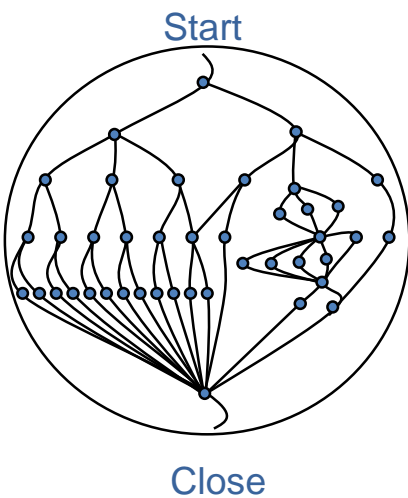
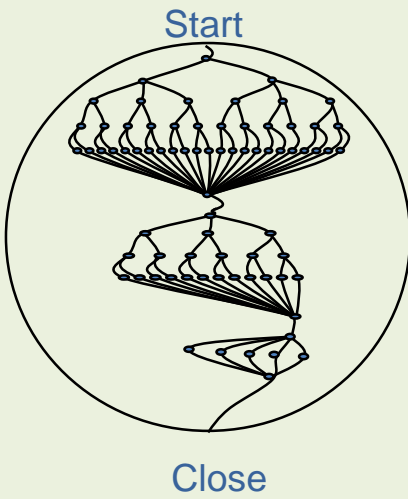


SPRINT N+1 - SPRINT N
COVERAGE

SMOKE TESTING	RISK BASED TESTING	REGRESSION TESTING	COMBINATORY USAGE TESTING	EVOLUTION TESTING Without Regression
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Combinatorics coverage

<p>Minimum Data Coverage</p>  <p>Start</p> <p>Close</p> <p>Minimum number of test</p>	<p>Full Data Coverage</p>  <p>Start</p> <p>Close</p> <p>Large number of test Dependence of classes</p>	<p>Custom Data Coverage</p>  <p>Start</p> <p>Close</p> <p>Specific coverage</p>	<p>Gibbs Sampling</p>  <p>Start</p> <p>Close</p> <p>Fast sampling</p>
Equivalence classes covered one time	Equivalence Classes combinatorics	Custom equivalence class coverage	Converge toward stationary distribution

