AVSIMULATION

AV systems validation using SCANeR studio software

Alex Grandjean– AV Validation project leader

AVSIMULATION PRESENTATION

30 YEARS EXPERIENCE IN SIMULATION, AUTOMOTIVE AND ENGINEERING

SOGECLAIR
OKTAL
>> SIMULATION IN MOTION
SYDAC

65% stake

GROUPE RENAULT

35% stake

AVSIMULATION

SCANeR™

Creation date : 2017
2018 Turnover: 12,5 M €
Employees: 90

Area of expertise:
- Automotive
- Driving simulation
- Autonomous Driving
- Software development

SCANeR™ ACROSS THE INNOVATION LIFECYCLE

Machine Learning

AI

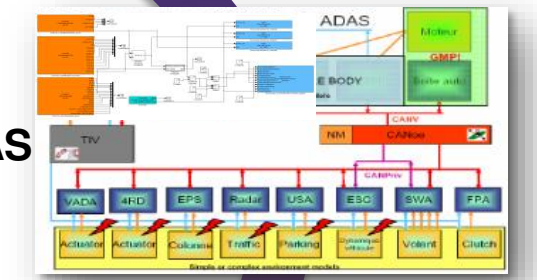
Prototyping

Validation & mass simulation

Virtual Reality - HPC

Headlight

Specification



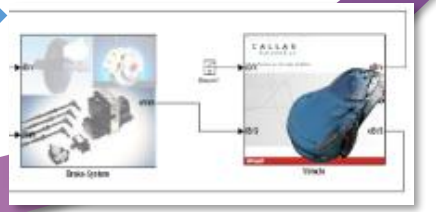
AD / ADAS

GUI & Infotainment

Virtual Testing - Driving Simulation

Development

Vehicle dynamics



Integration

Driver

CAD

WHY SIMULATION FOR AV VALIDATION ?

Billions of Miles Of Testing?

- **Need to test for at least ~3x crash rate to validate safety**
  - Hypothetical deployment: NYC Medallion Taxi Fleet
  - 13,437 vehicles @ 70,000 miles/yr = 941M miles/year
  - 7 critical crashes in 2015 [2014 NYC Taxi Fact Book] [Fatal and Critical Injury data / Local Law 31 of 2014]
    134M miles/critical crash (death or serious injury)
- **How much testing to validate critical crash rate?**
  - Answer: 3x – ~10x the mean crash rate
    - 3x is without any crash
    - If you get a crash, you need to test longer
  - Design changes reset the testing clock
- **Assumes random independent arrivals**
  - Exponential inter-arrival spacing
  - *Is this a good assumption?*

Testing Miles	Confidence if NO critical crash seen
122.8M	60%
308.5M	90%
401.4M	**95%**
617.1M	99%

 7

Is Trillions of Miles of Testing Enough?

- **At best, each road hazard type arrives independently**
  - But, that doesn't tell us how often each event arrives
  - No surprise if distribution of scenarios is heavy-tailed
    - E.g., exponential arrivals, but power law distribution of scenarios
- **Beyond that, conditions are not random/independent**
  - Correlations: geographic region, weather, holiday, commute
  - Betting against a heavy tail edge case distribution is risky
- **Need to think more deeply than "drive a lot of miles"**
  - Need to have some assurance your system will work beyond accumulating miles
  - That's what software safety approaches are for!
    - OK, so what happens if you try to apply ISO 26262? …

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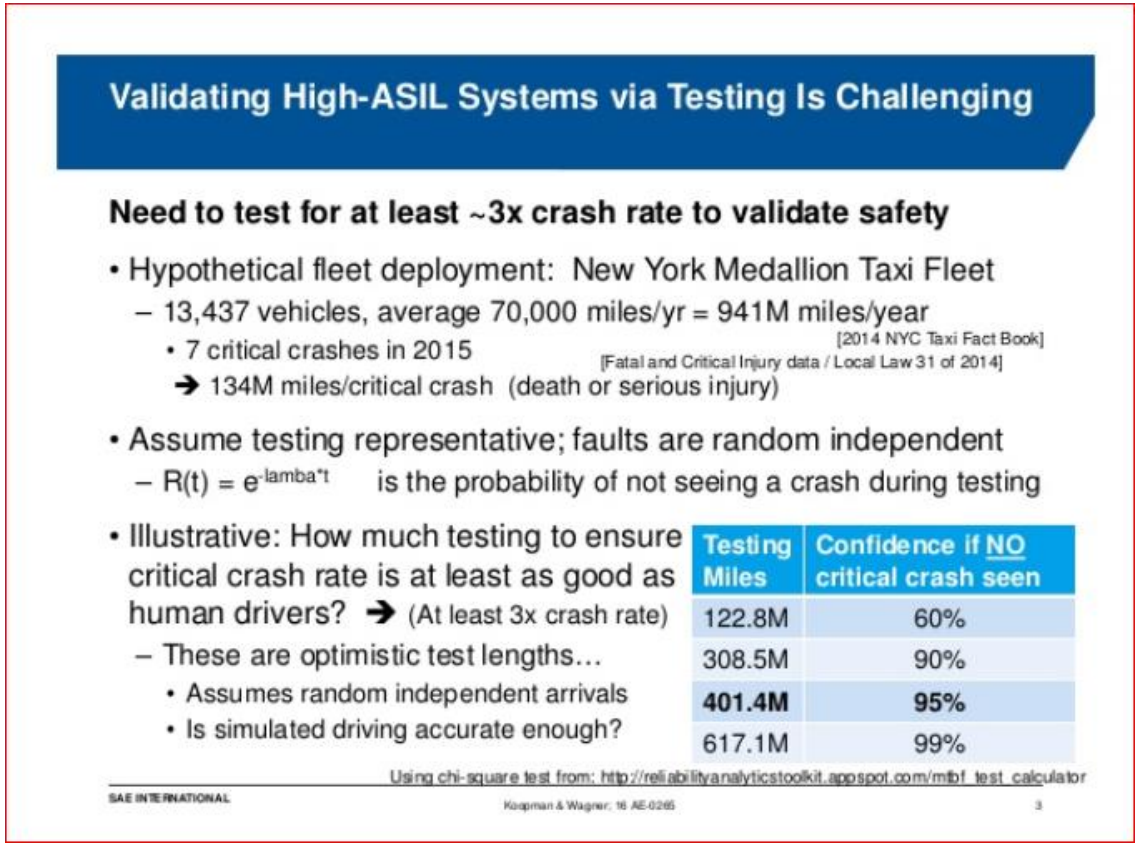
WHY SIMULATION FOR AV VALIDATION ?



Validating High-ASIL Systems via Testing Is Challenging

Need to test for at least ~3x crash rate to validate safety

- Hypothetical fleet deployment: New York Medallion Taxi Fleet
  - 13,437 vehicles, average 70,000 miles/yr = 941M miles/year
    - 7 critical crashes in 2015 [2014 NYC Taxi Fact Book] [Fatal and Critical Injury data / Local Law 31 of 2014]
    - ➔ 134M miles/critical crash (death or serious injury)
- Assume testing representative; faults are random independent
  - $R(t) = e^{-lamba*t}$ is the probability of not seeing a crash during testing
- Illustrative: How much testing to ensure critical crash rate is at least as good as human drivers? ➔ (At least 3x crash rate)
  - These are optimistic test lengths…
    - Assumes random independent arrivals
    - Is simulated driving accurate enough?

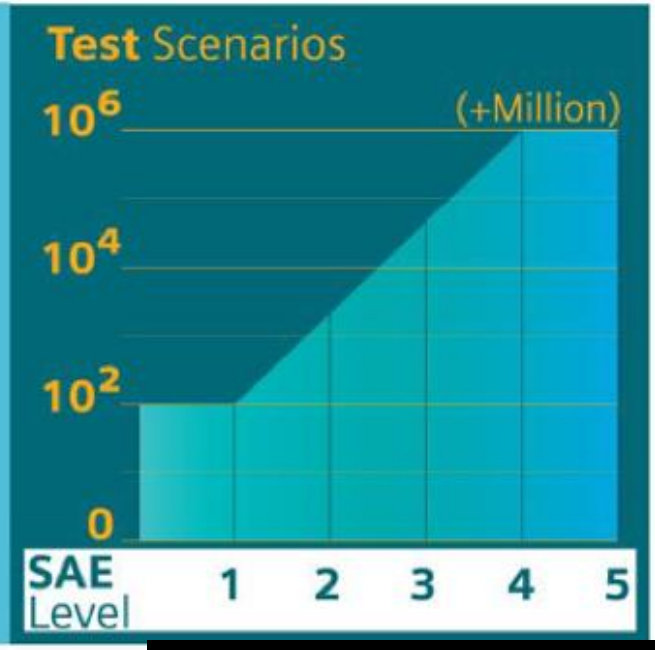
Testing Miles	Confidence if NO critical crash seen
122.8M	60%
308.5M	90%
401.4M	**95%**
617.1M	99%

Using chi-square test from: http://reliabilityanalyticstoolkit.appspot.com/mtbf_test_calculator

SAE INTERNATIONAL Koopman & Wagner; 16 AE-0265 3

WHY SIMULATION FOR AV VALIDATION ?

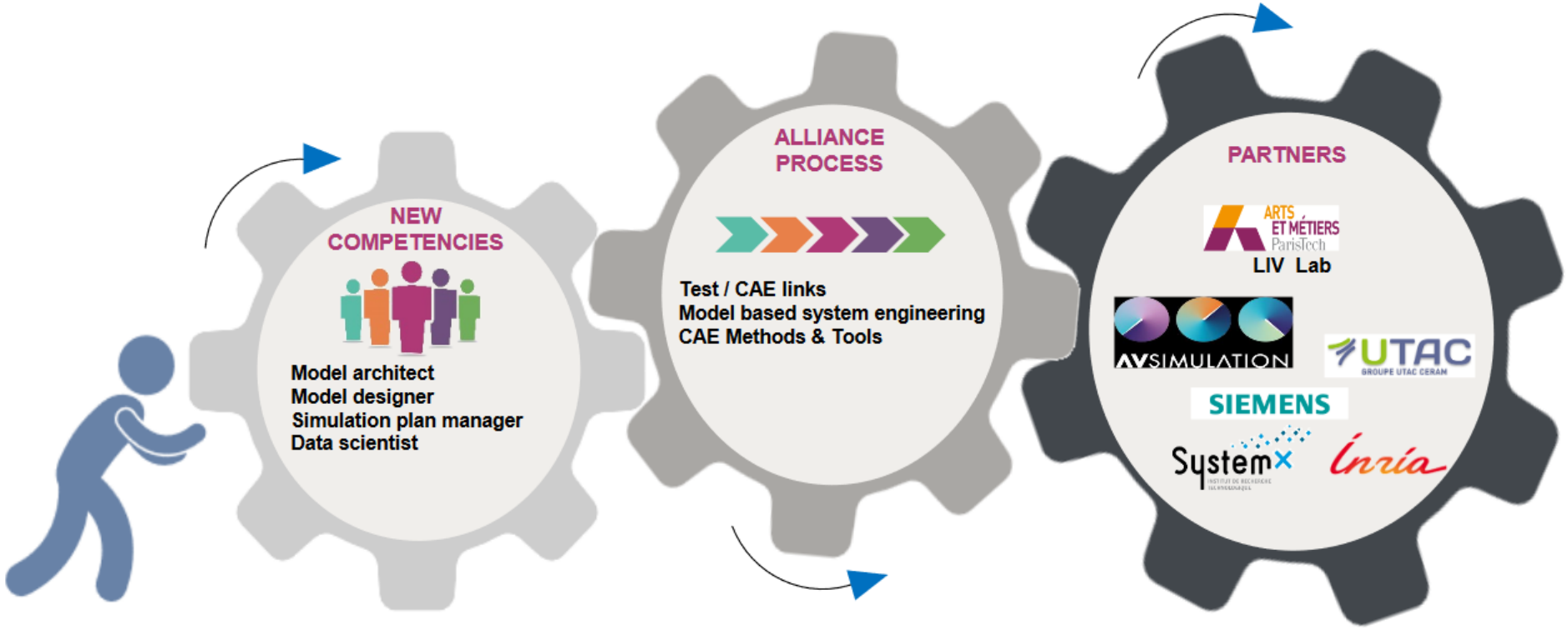
- The number of scenarios to validate controls will explode from SAE automation level 1 to level 5. Physical testing only is no longer feasible.
- "14.2 billion miles of testing is needed"
  Akio Toyoda, CEO of Toyota
  Paris Auto Show 2016



WHY SIMULATION FOR AV VALIDATION ?

WHY SIMULATION FOR AV VALIDATION ?

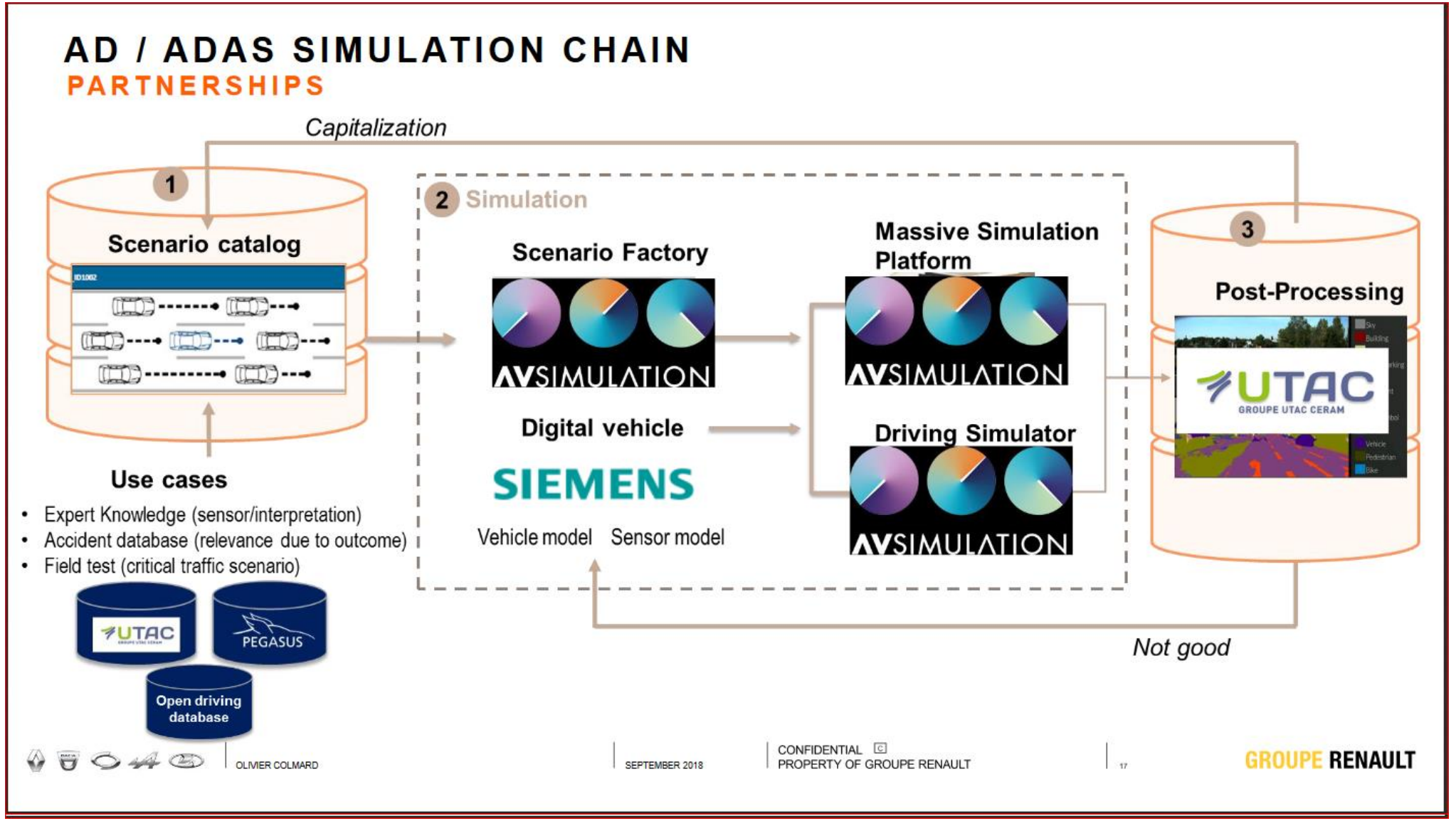
AD SIMULATION ECO-SYSTEM



Simulation and Driving simulator are key to develop and validate new connected and autonomous vehicles

OLIVIER COLMARD | SEPTEMBER 2018 | CONFIDENTIAL © PROPERTY OF GROUPE RENAULT | 26 | GROUPE RENAULT

WE ARE THE BACKBONE OF RENAULT AD SIMULATION

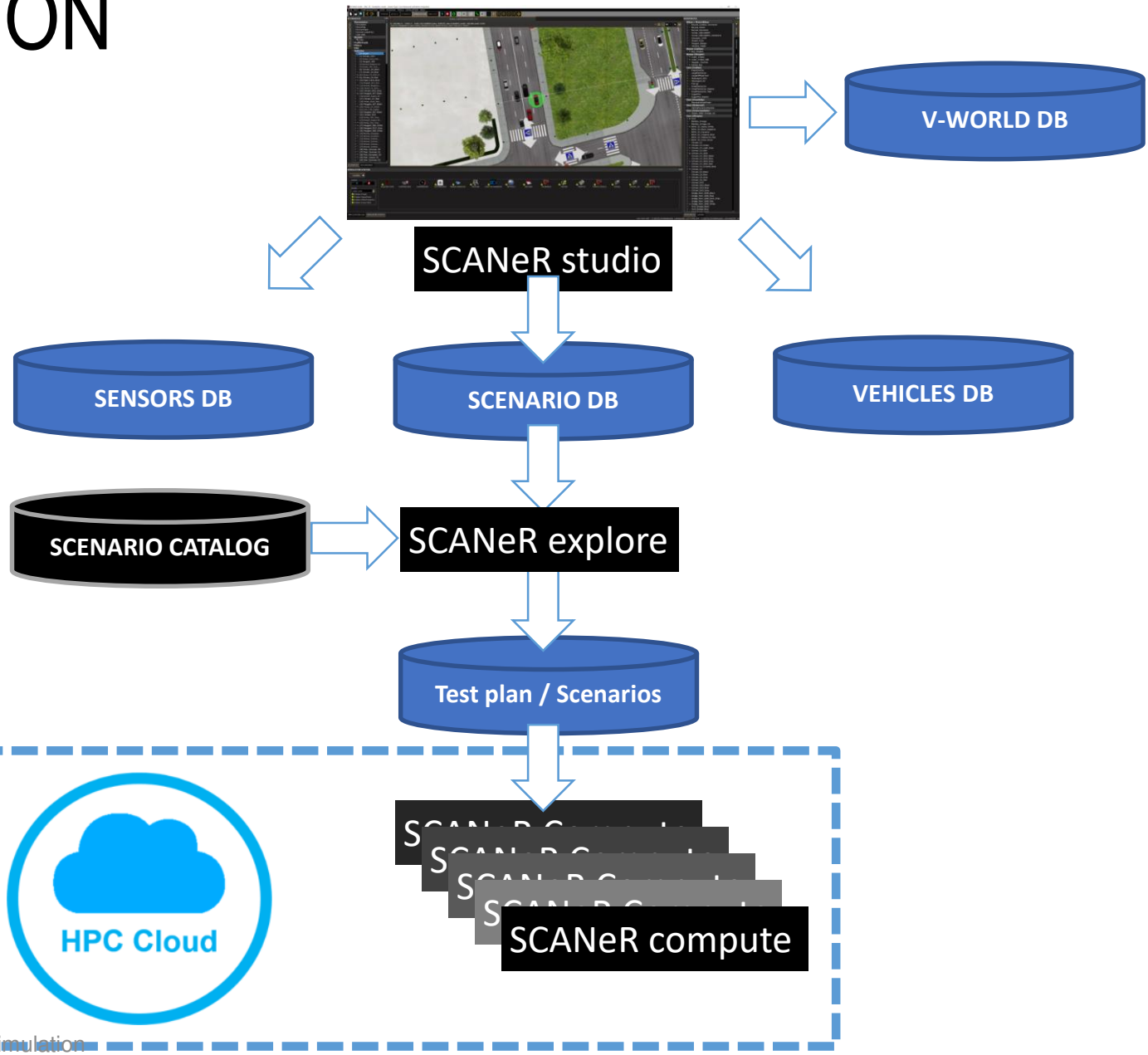


AV VALIDATION CHALLENGES

- **Representative models for the virtual world, sensors, vehicles**
- **Scenario creation & generation**
- **Massive parallel execution**
- **Metrics computation**

SCANeR™ SOLUTION

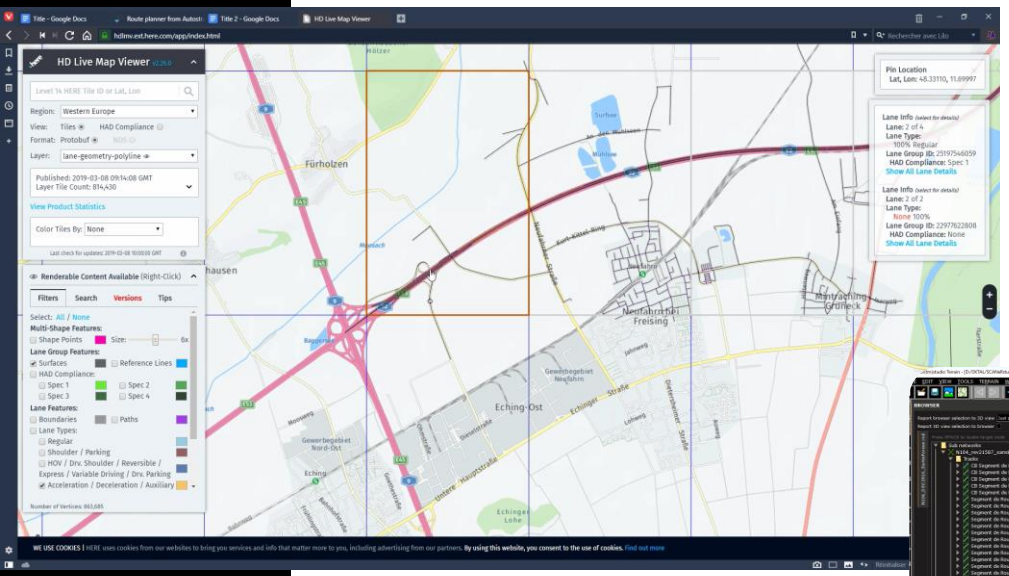
- **SCANeR™ studio**
- **New dedicated products:**
  - SCANeR explore
  - SCANeR compute
  - Scenario Catalog



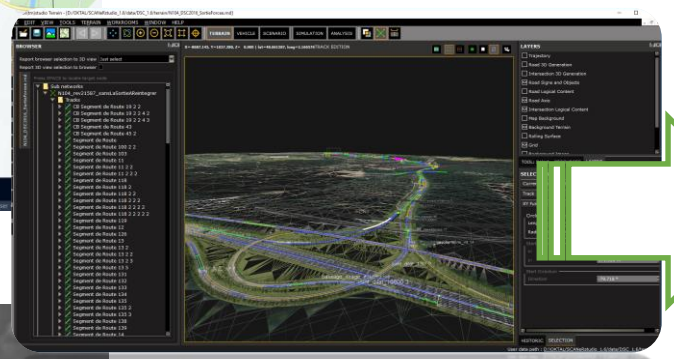
AVSIMULATION

Representative models for the Virtual world, sensors, vehicles

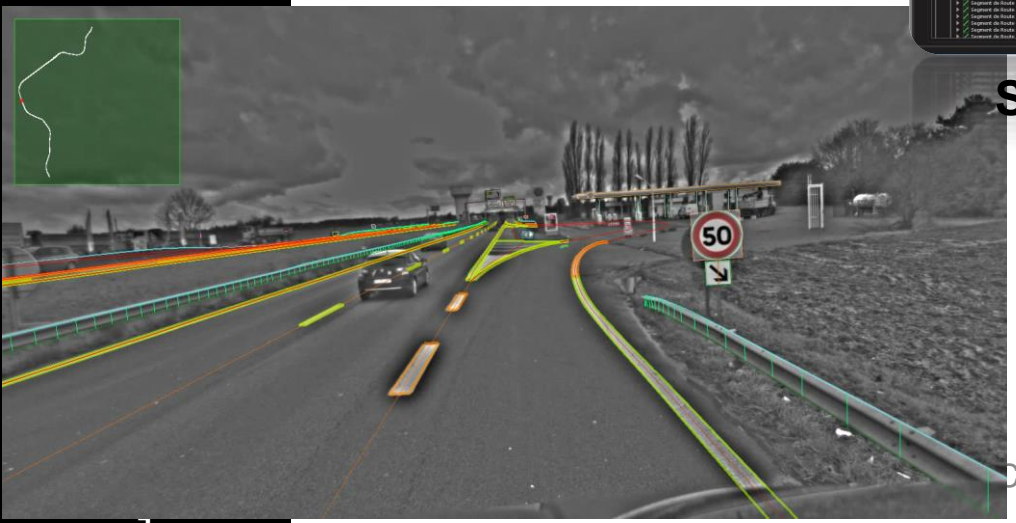
BUILD A DIGITAL WORLD



HD Maps

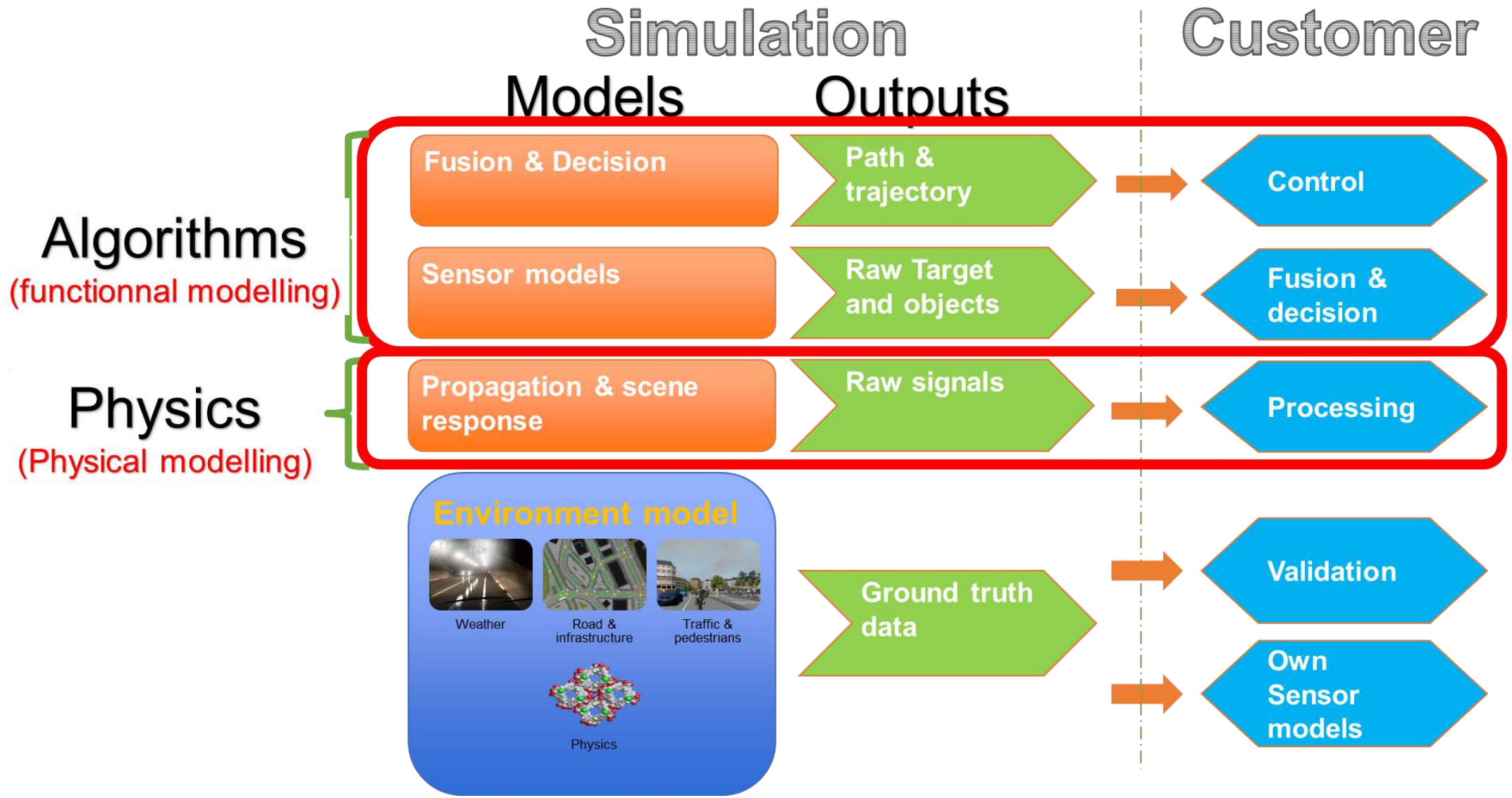


SCANeR™ *studio* : Terrain



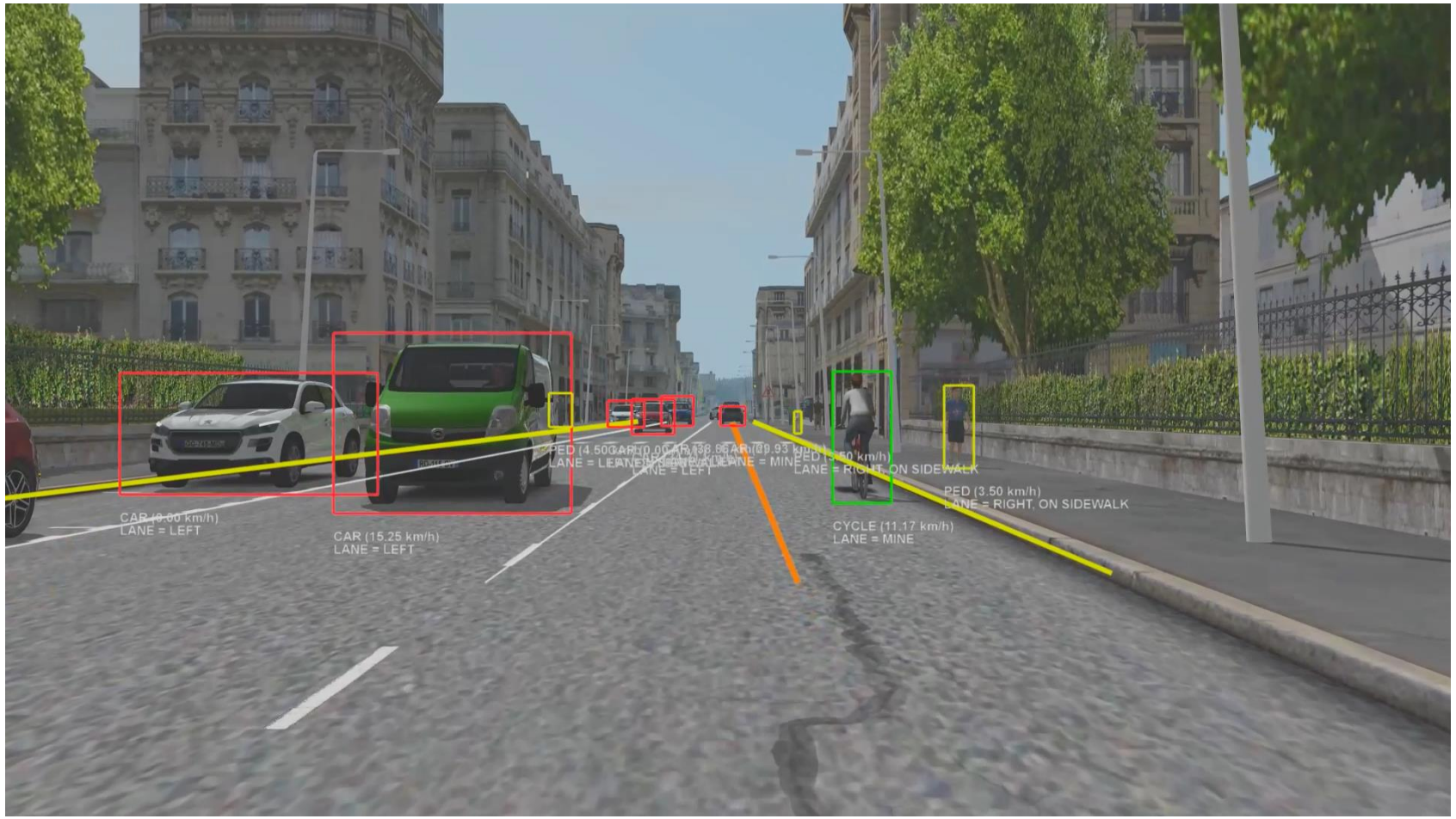
Acquisitions

STRATEGIES FOR SENSOR MODELLING

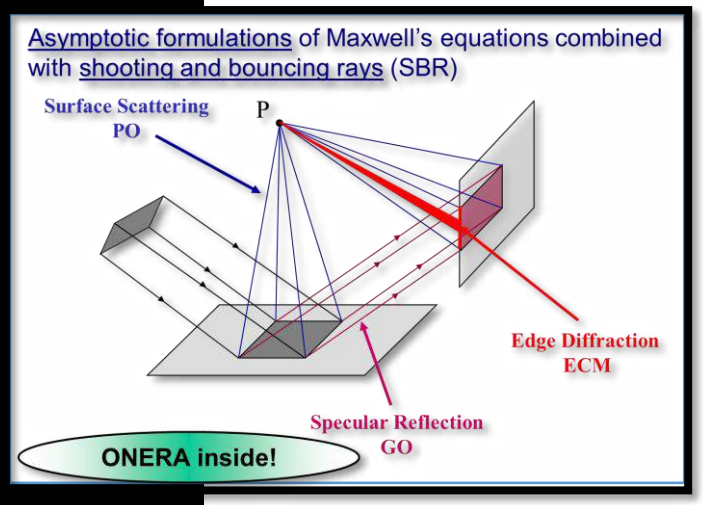


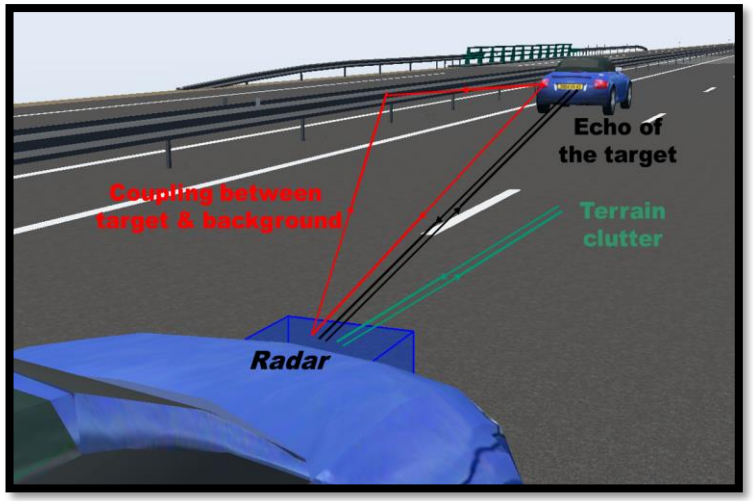
FUNCTIONNAL MODELLING

- **Simulate the algorithms!**



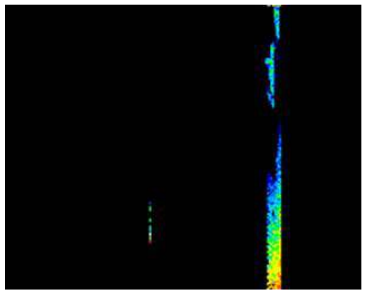
RADAR SIMULATION AT PHYSICAL LEVEL

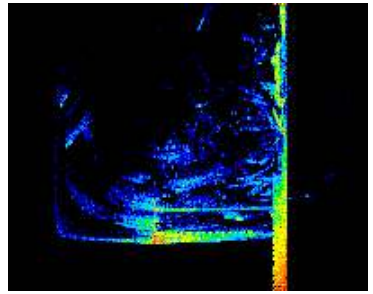




OKTAL-SE Synthetic Environment

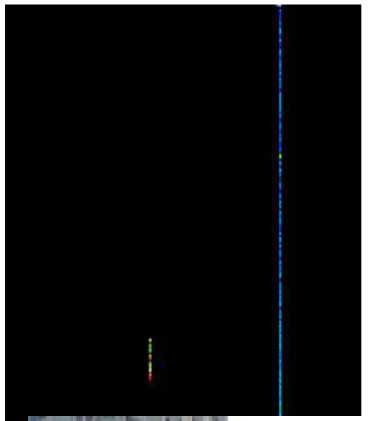
Doppler maps

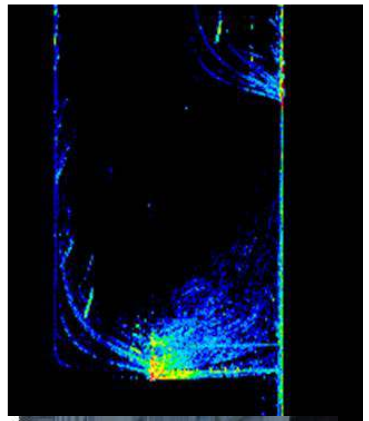


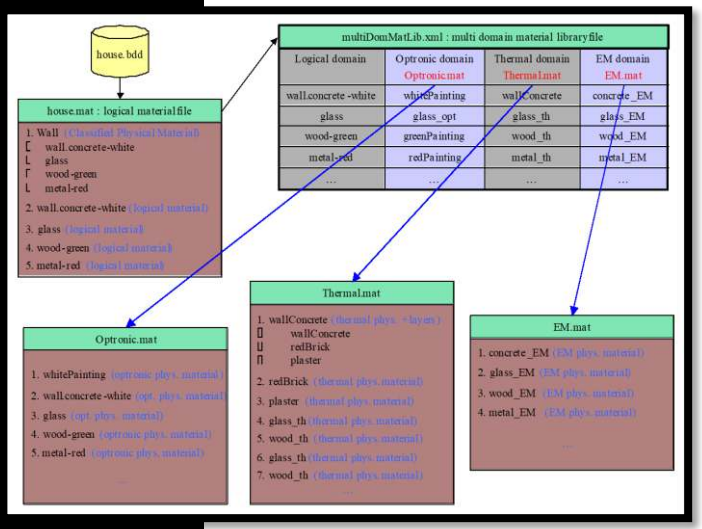


No coupling

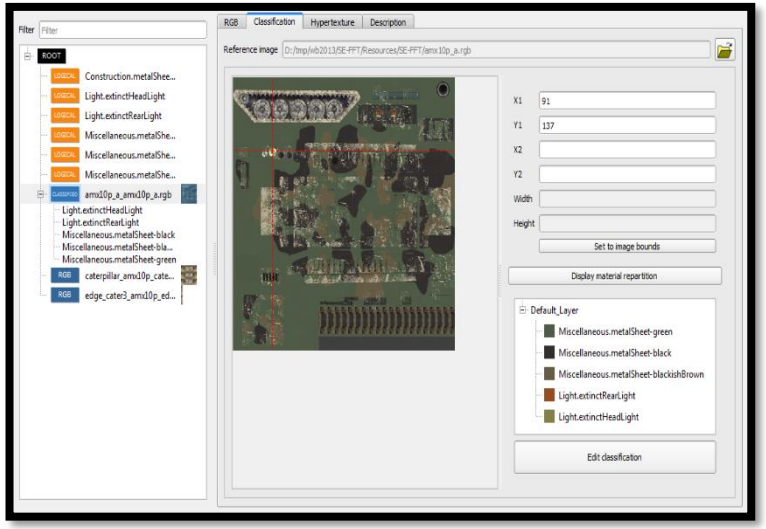
coupling







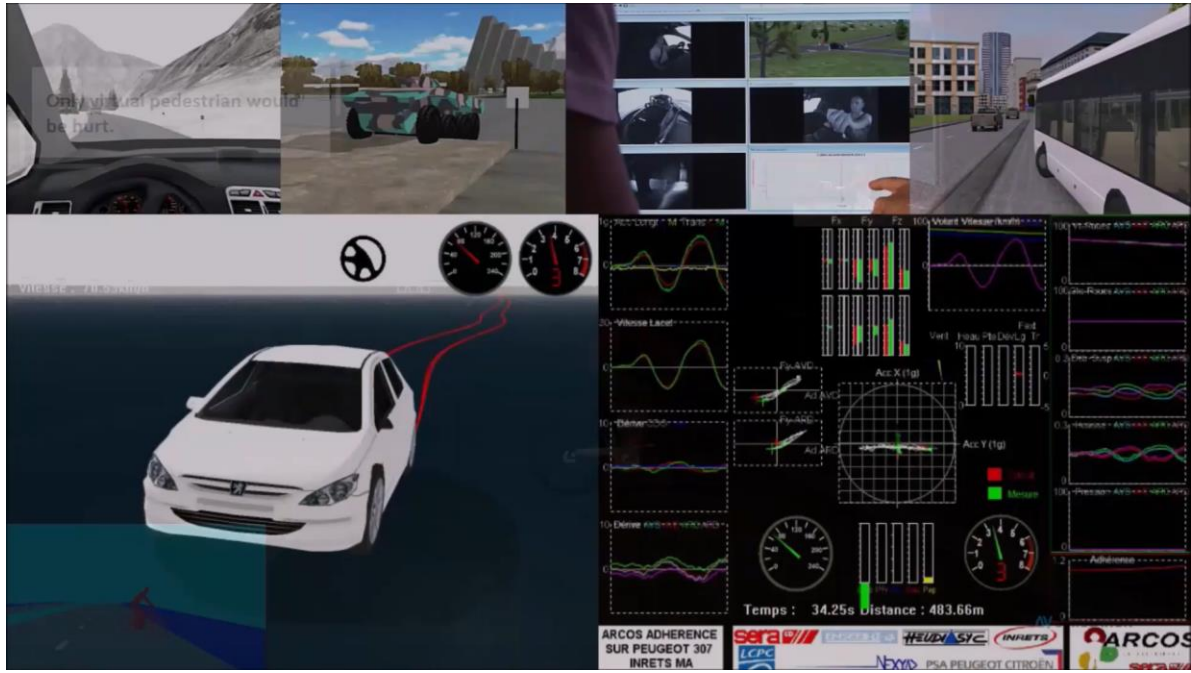
Material database



Object classification

MODELLING THE VEHICLE

- **SCANeR includes CALLAS model**
  - Validated in a large scope of applications
  - C/C++ & Simulink API + FMI to create external Sub-models
- **Generic interface for Dynamic vehicle models**
  - Custom Simulink model
  - C/C++ API
  - Many models of the market
- **Custom Input/Output to exchange internal data with distributed simulation**
- **FMI support**



AVSIMULATION

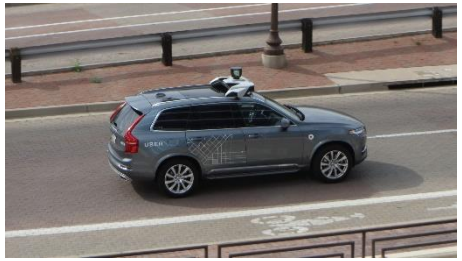
Scenario creation

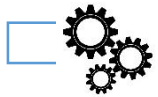
SCENARIO TOOLS AND CATALOG

Fully controlled tests
Replay from drivings
Complex &Interactive

CEESAR
LAB
MOOVE
Renault
PSA

SVA
SVR
ASV Singapor





Other

SCENARIO CATALOG

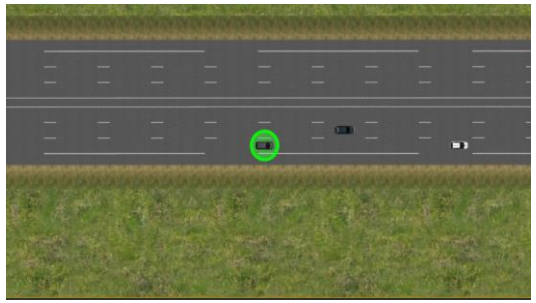
USER SCENARIO

UTAC CERAM
EuroNCAP
C-NCAP
A-NCAP
J-NCAP

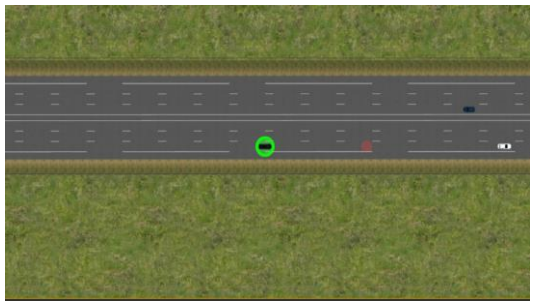
KEY ASPECTS FOR SCENARIO MODELING

- **20 years of expertise of complex interactive scenario**
- **Models**
  - Environment (Infrastructure, Roads, Weather)
  - Traffic (Flows, Densities, Types)
  - Vehicle dynamics
  - Drivers (Real, Trajectory, Commands)
  - Maneuvers (Lane following, Lane change, curves)
  - Systems (ADAS, HMI)
- **Scripting**
  - Intensive function library to interact with models
    - *Interrogate*
    - *Take control*
  - Powerful scripting tools

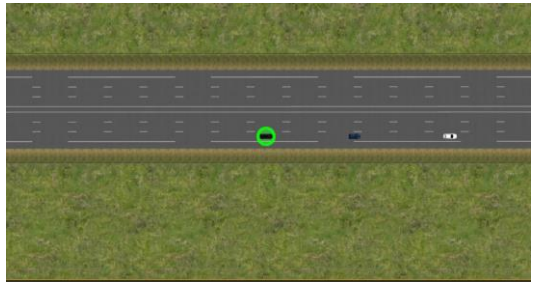
SCENARIO CATALOG PREVIEW



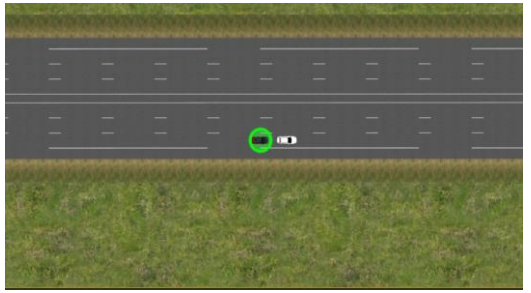
Simultaneous maneuvers



Cut-in

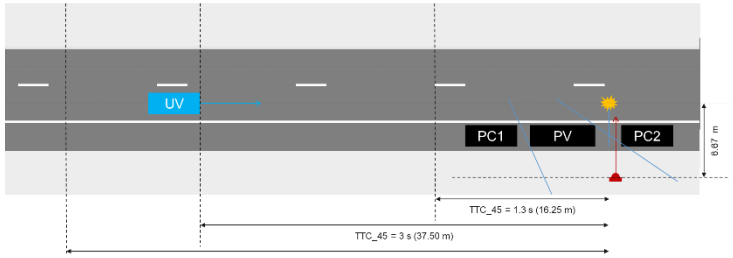


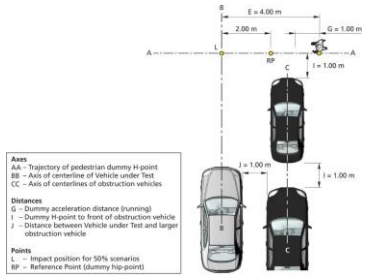
Cut Through



CCRB

CPNC-50 AEB pedestrian

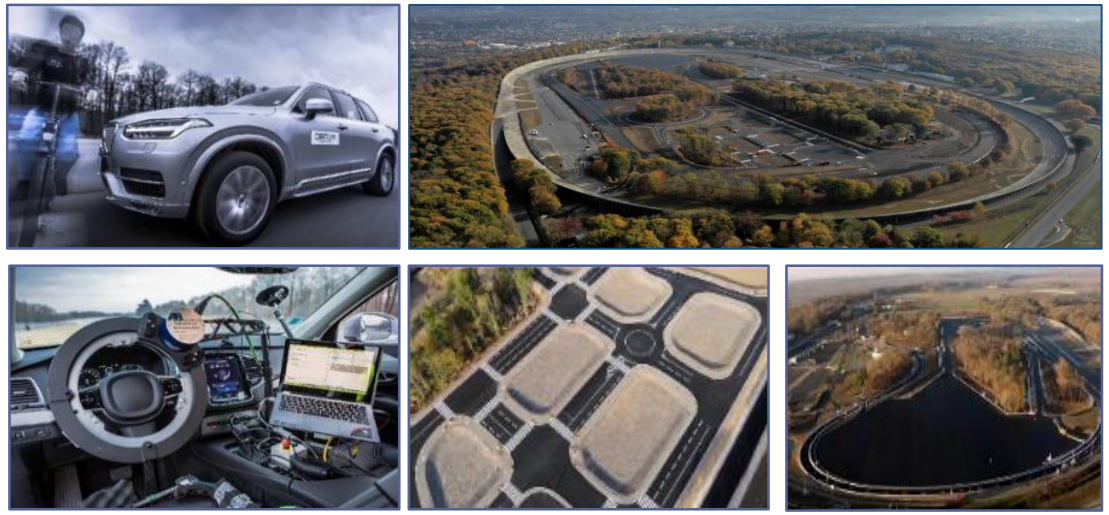




UTAC CERAM COLLABORATION

- UTAC CERAM, french laboratory, EuroNCAP accredited
- Physical UTAC CERAM testing expertise implemented into virtual scenarios
- Correlation between real and virtual test

ISO 17025 Laboratory



TEMO by UTAC CERAM

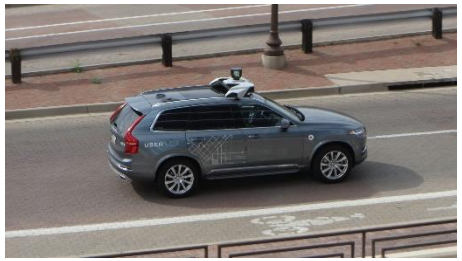
- Official NCAP scenarios (EuroNCAP, ANCAP…)

Car to car scenarios

Bicycle scenarios

Pedestrian scenarios

SCENARIO: IMPORT REAL DATA



Real world test

CSV
Matlab
Ibeo

Sensors record

ScenarioImporter

New

SCANeR™ scenario

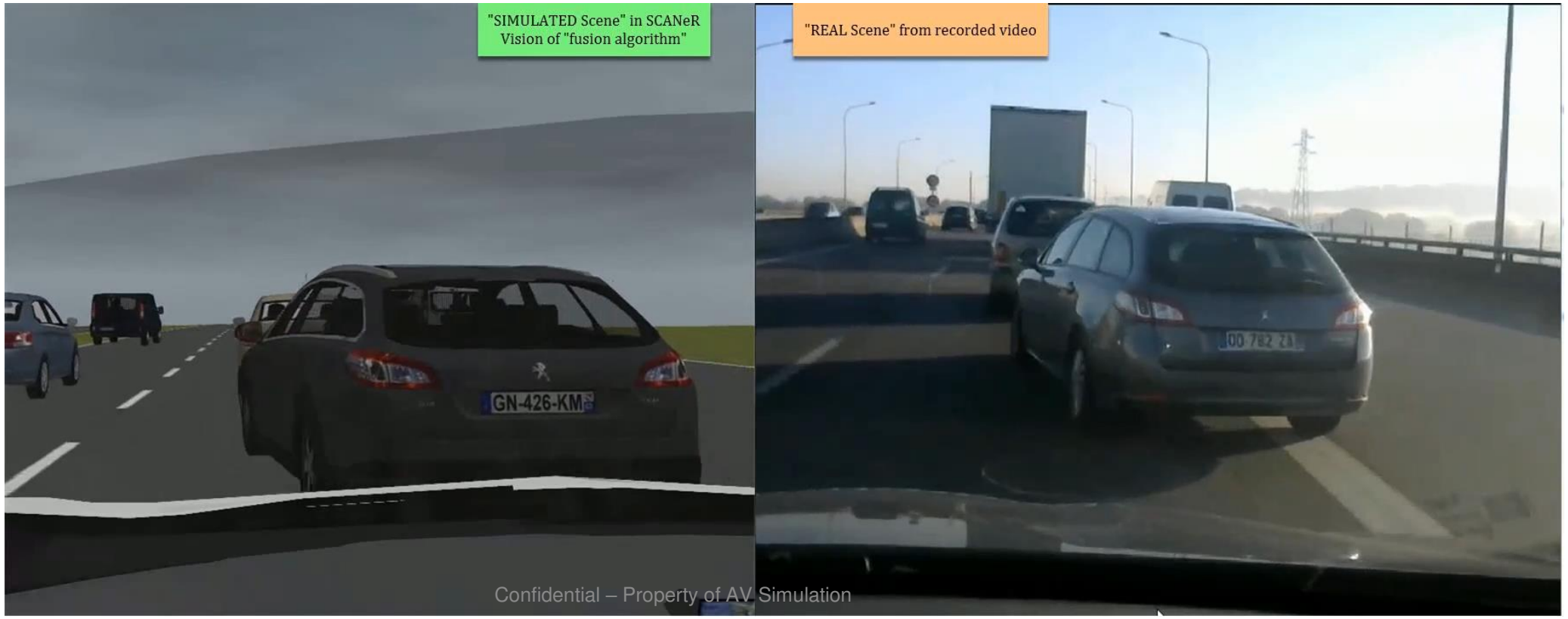
Thousands through Scenario parametrization

SCANeR™ scenario

SCENARIO: IMPORT REAL DATA

- **Very sensitive to the data quality**
  - Ego position must be accurate
  - bad detection ➔bad scenario.
- **Vehicle position and road position matching**

Courtesy of Renault

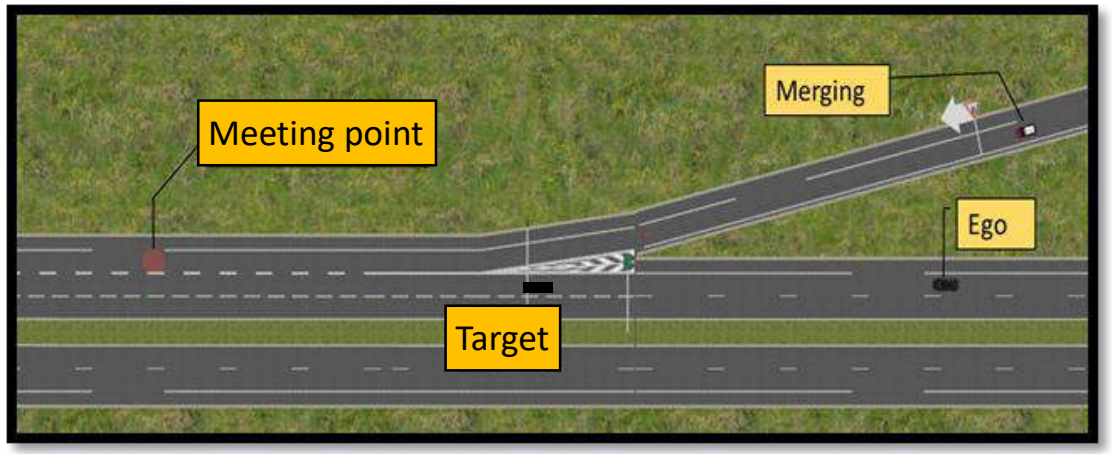


AVSIMULATION

Scenario generation

MOTIVATION

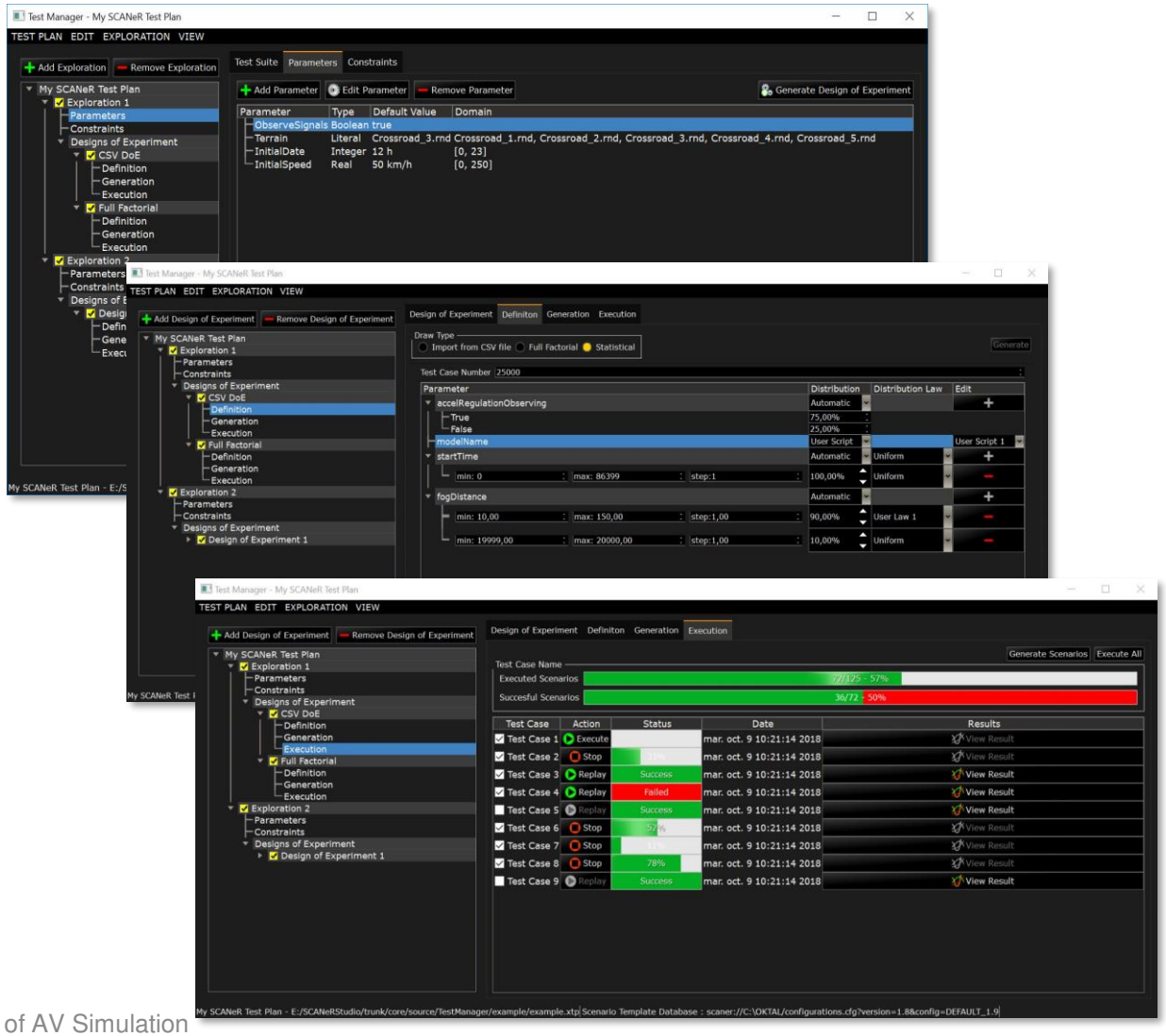
- **Parameters:**
  - Ego speed
  - Merging vehicle acceleration
  - Gap at meeting point
  - Delta speed at meeting point
  - Merging vehicle lane change duration
  - Gap with target
  - Meeting point abscissa
  - Merge lane length
  - Slope
  - Curvature
  - Time of day
  - Weather conditions
- **5 variations for each → almost 5M scenarios**



Merging scenario

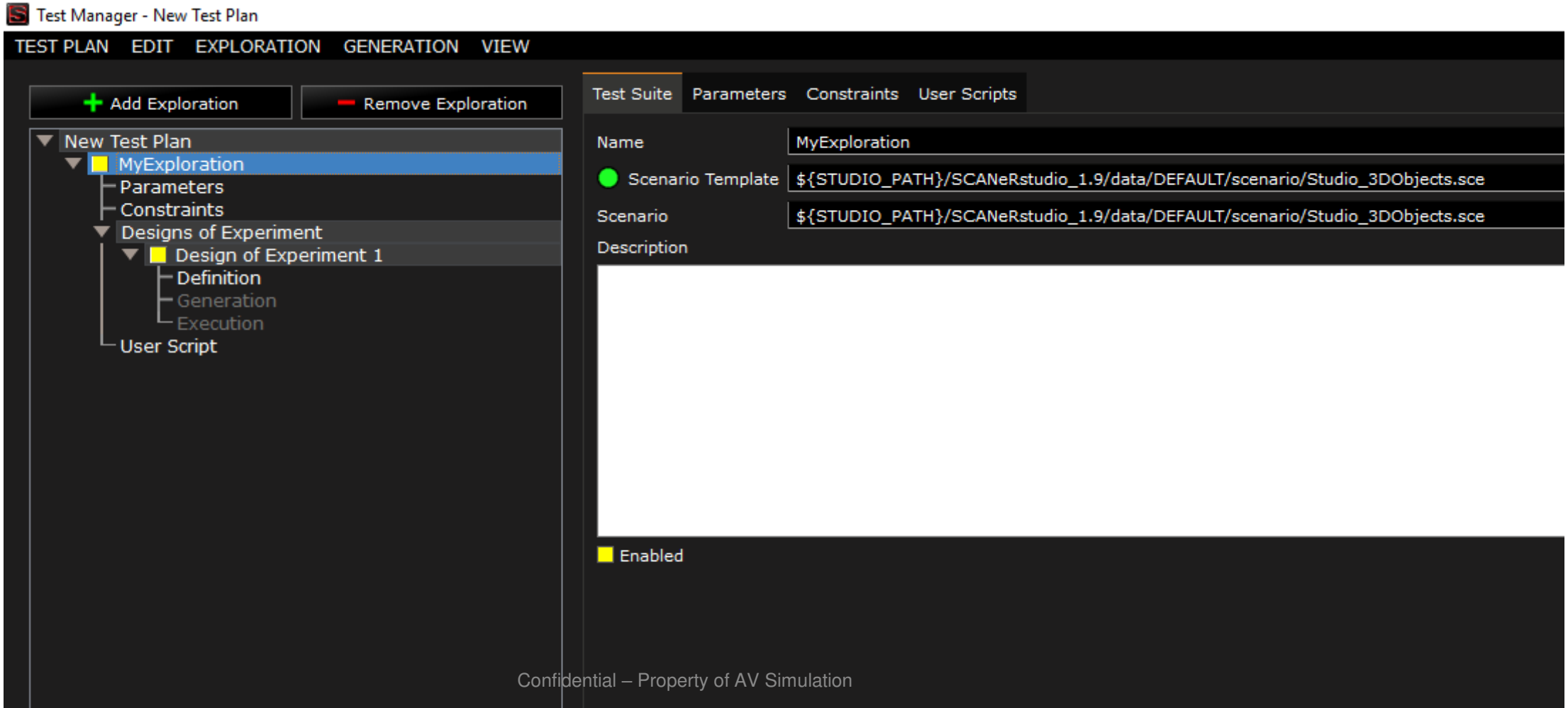
SCANeR explore

- **Test plan editor**
  - Statistical distribution laws
  - Parameters constraints
  - Support all scenario parameters
  - Customizable with python
- **Scenario generator**
- **SCANeR Compute launcher**
- **Job monitoring**
- **Results analysis**

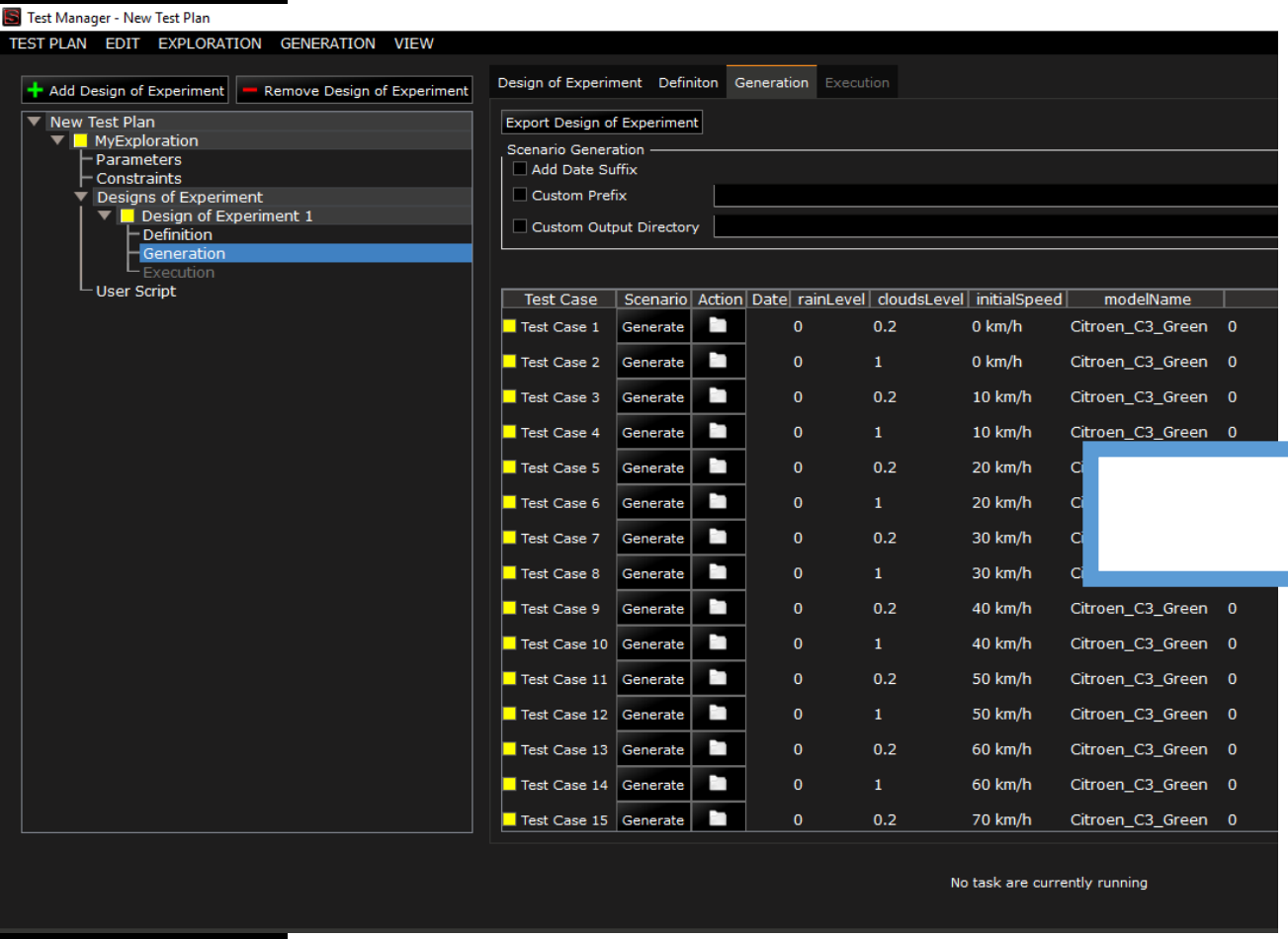


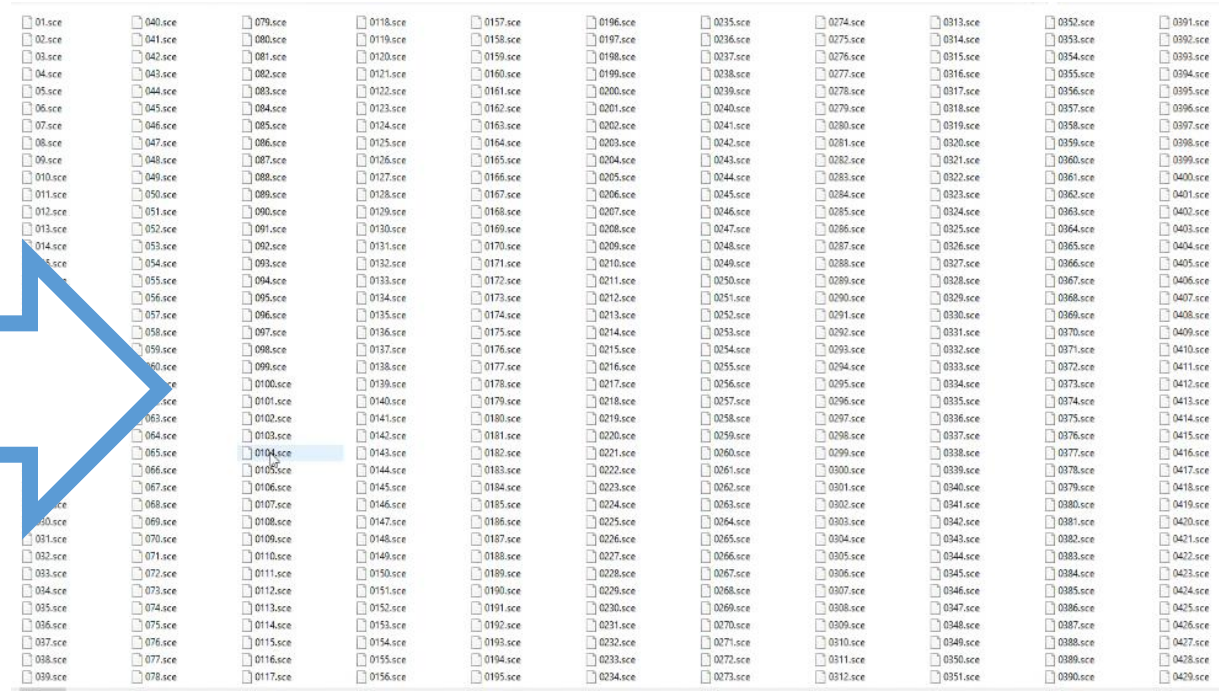
SCANeR explore

- **Create test plans & exploration based on scenarios**

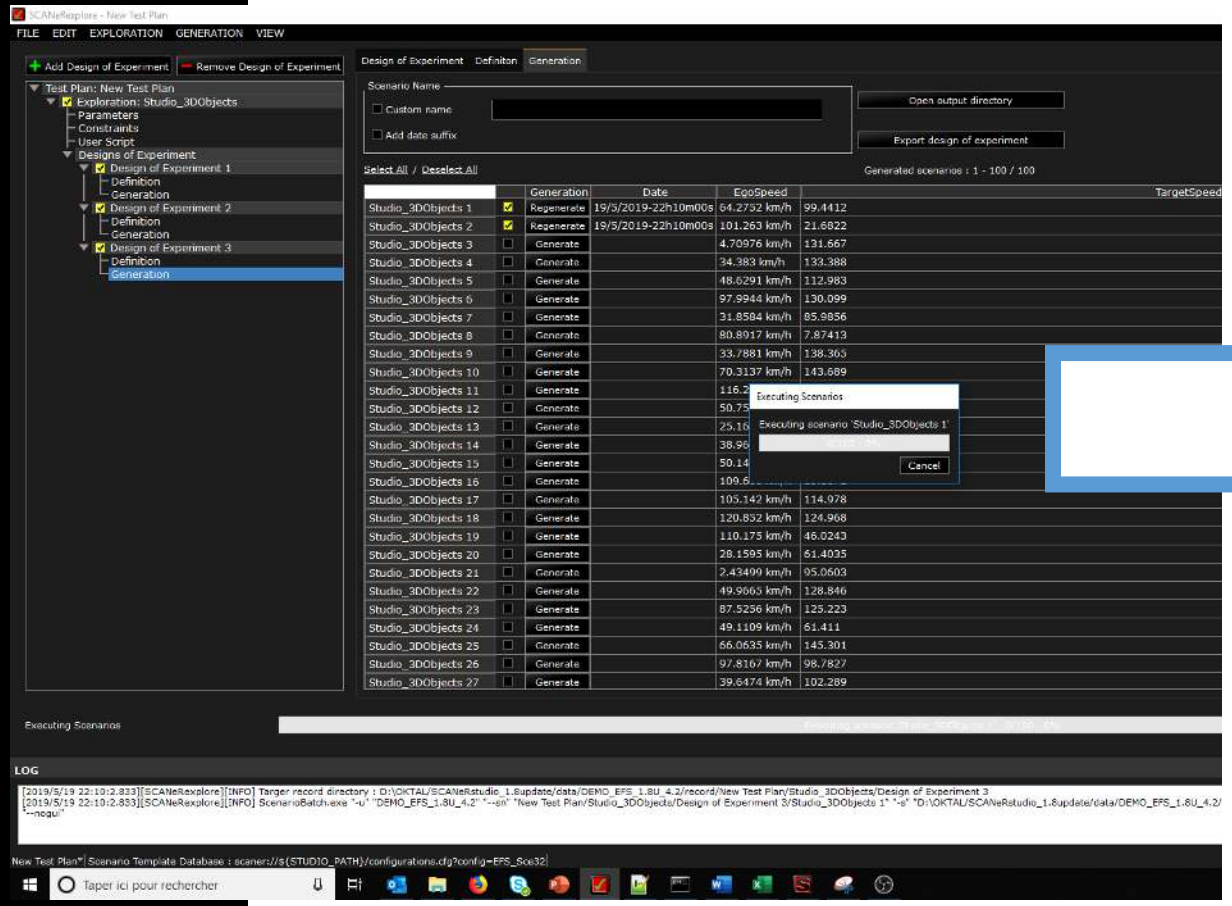


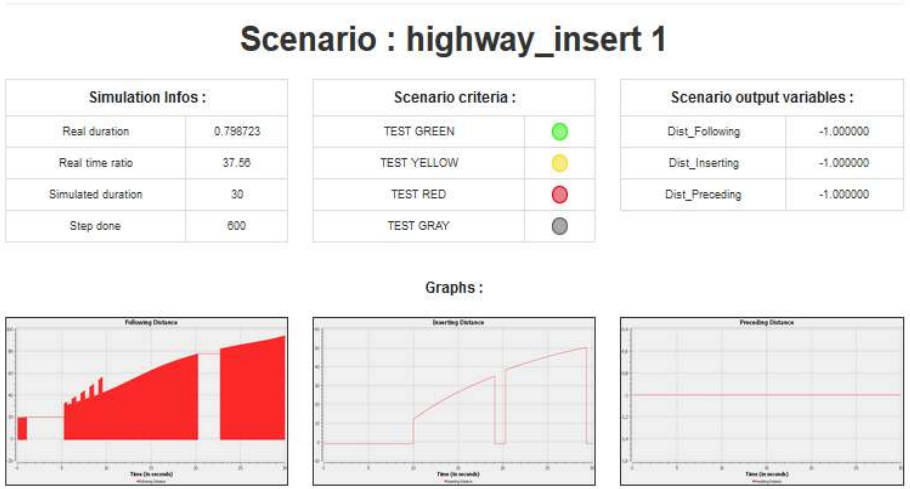
SCANeR explore: SCENARIO GENERATION

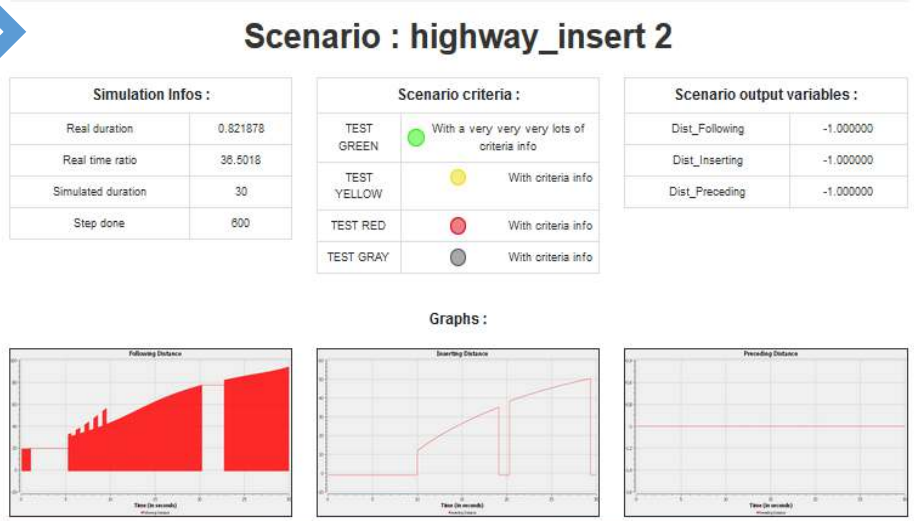




SCANeR Explore: SCENARIO EXECUTION & REPORT

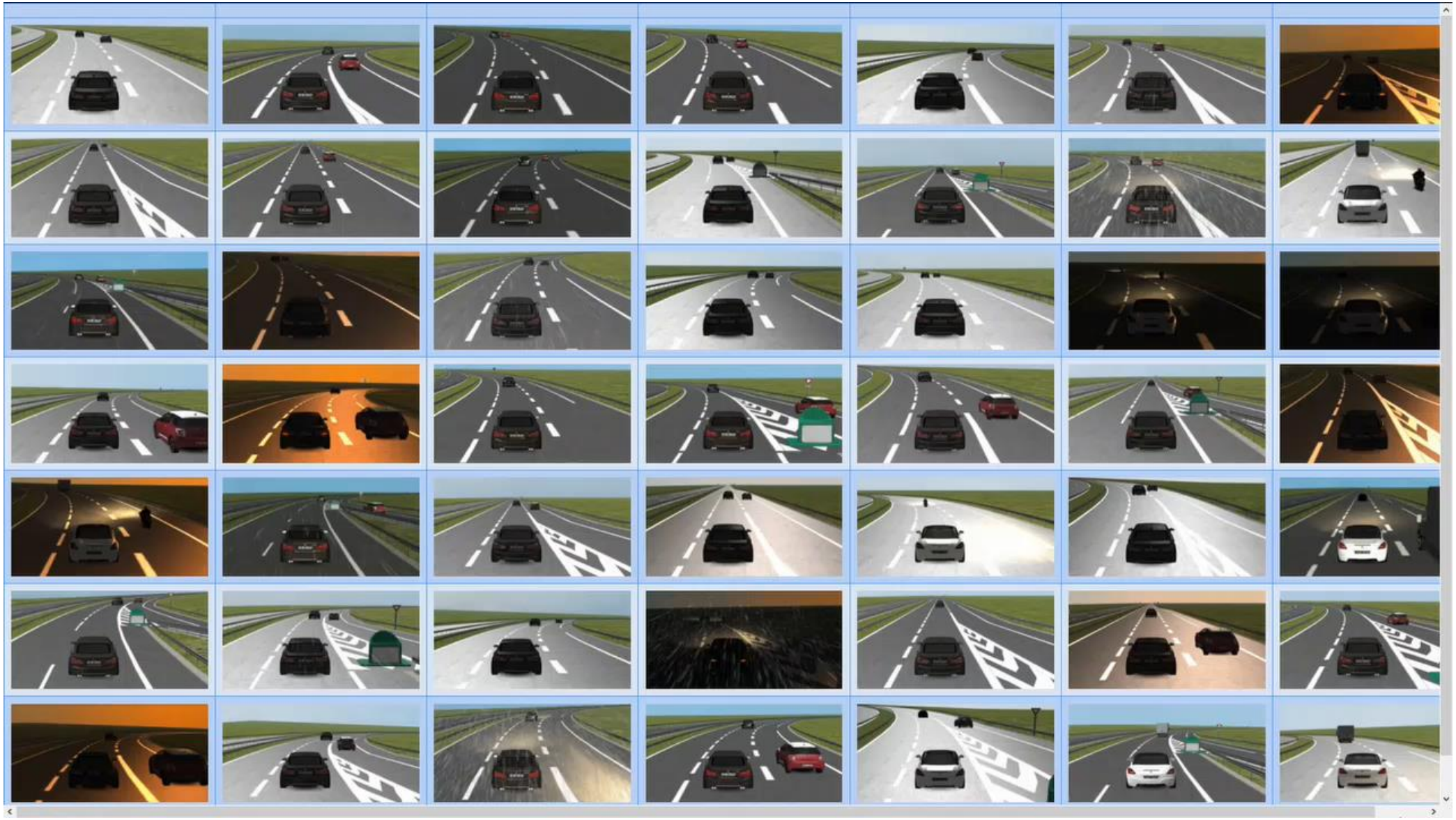






AVSIMULATION

SCENARIO GENERATION

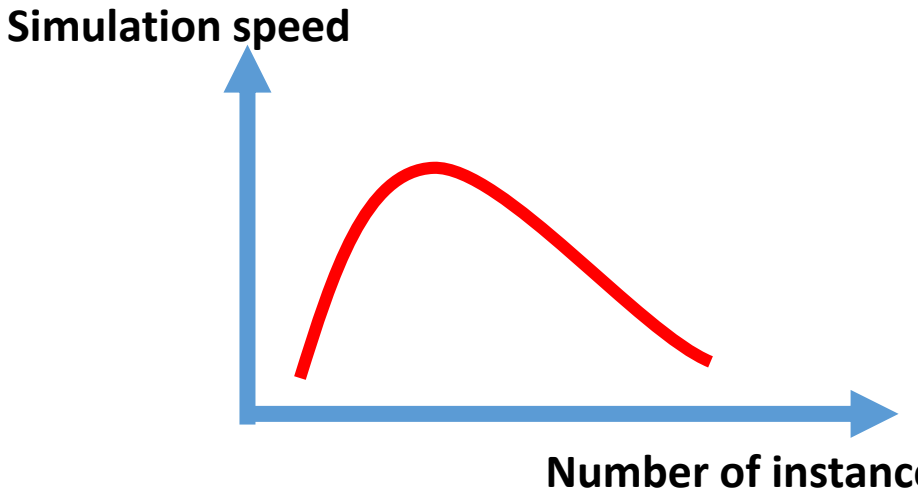


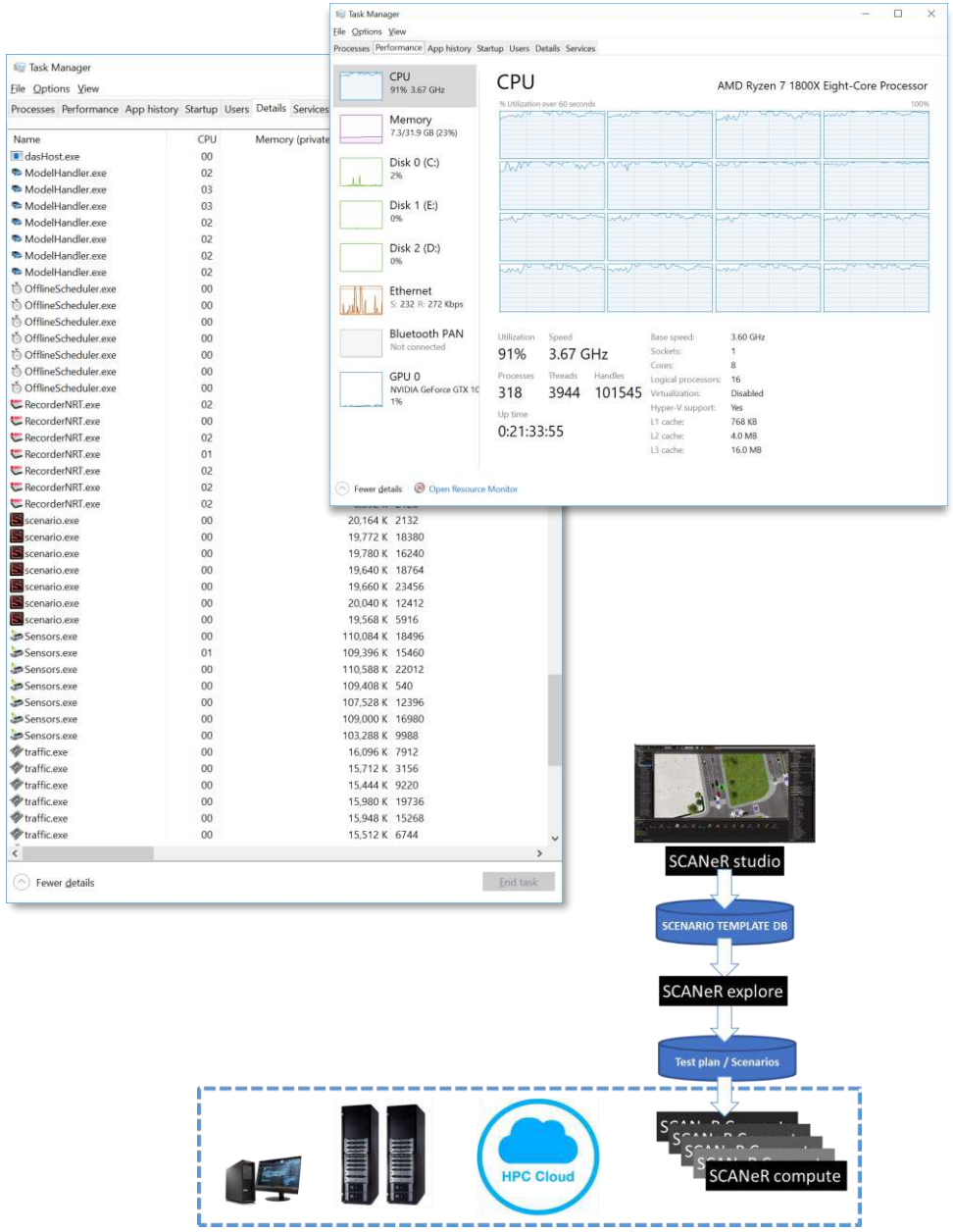
AVSIMULATION

Massive parallel execution

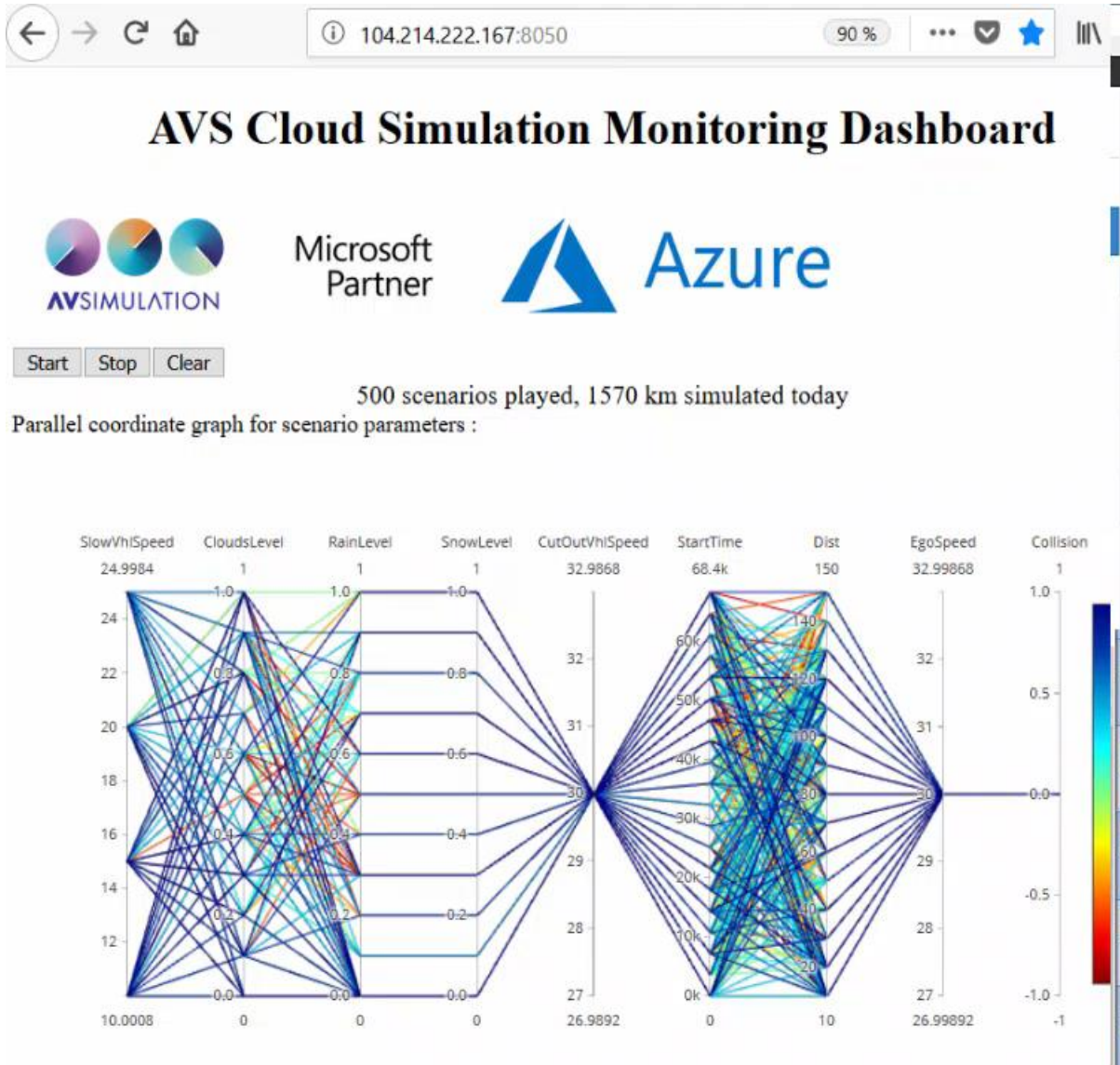
SCANeR compute

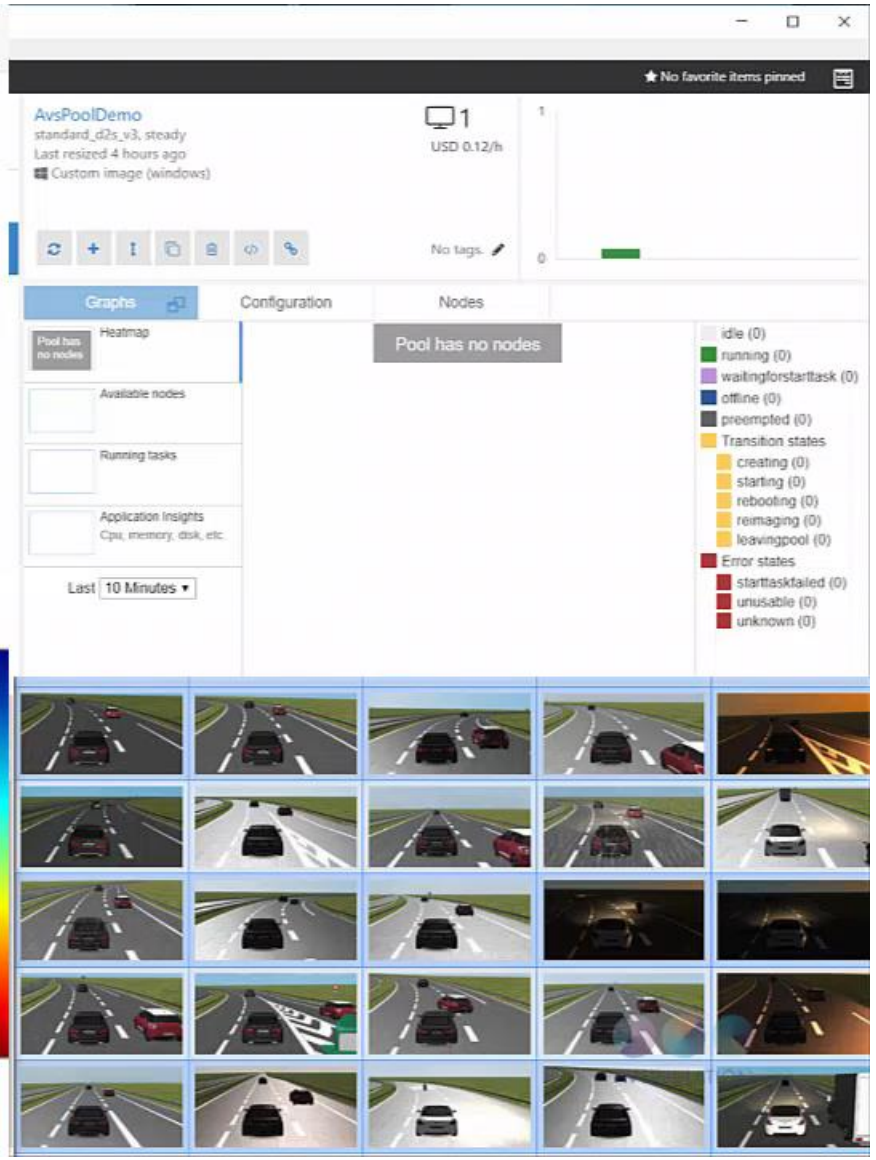
- Solver version of SCANeR
  - Easy to deploy
  - Multiple instances on the same node
  - Windows (Pro/Server)
  - Linux (Ubuntu LTS/CentOS 7)
  - Compatible with standard job scheduling tools (LSF, PBS, …)





MASSIVE SIMULATION IN THE CLOUD





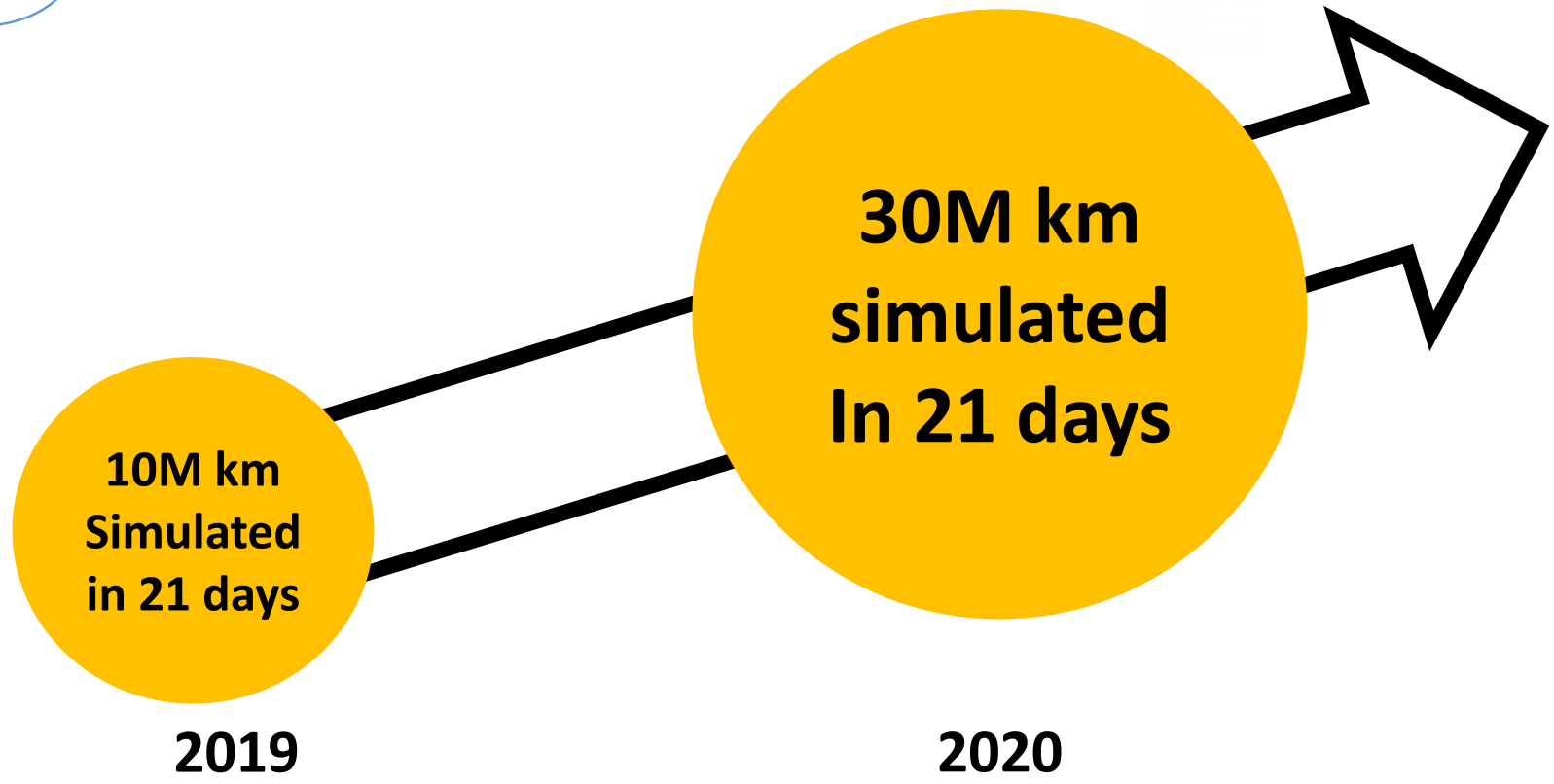
AVSIMULATION

Results

MASSIVE SIMULATION @ GROUPE RENAULT

SCANeR™

is deployed on Renault HPC infrastucture and cloud powered by Microsoft Azure



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