# Prediction of Occupant safety utilizing Machine Learning and CARLA Autonomous drive simulation software

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# Crash tests


2022 SUBARU BRZ
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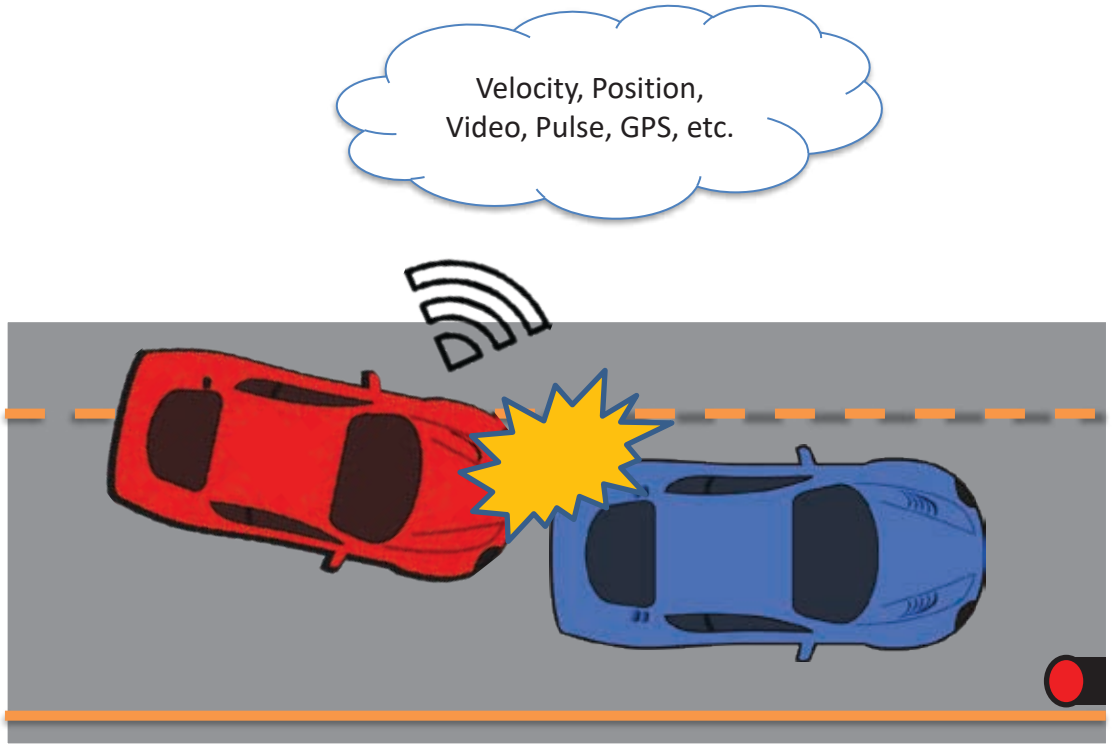
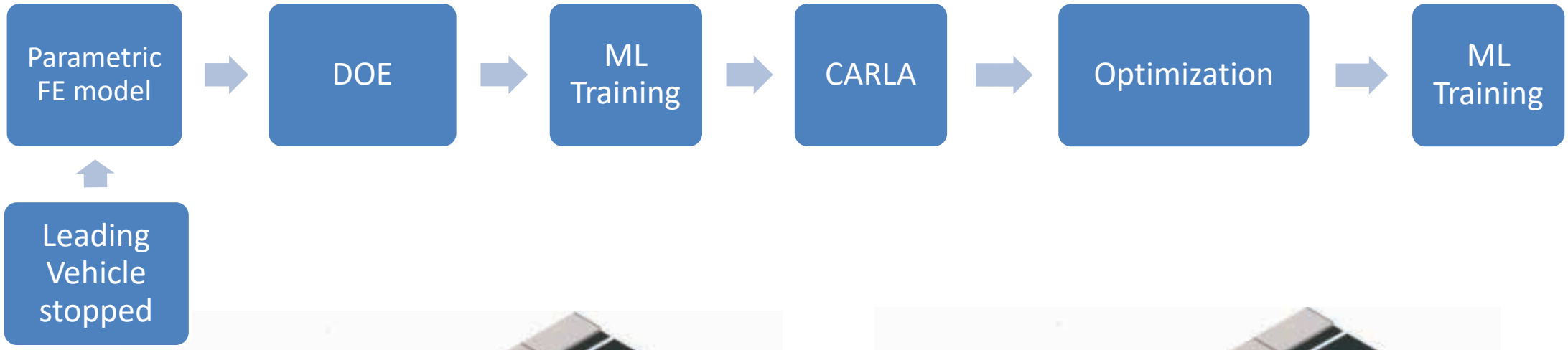
EURO NCAP

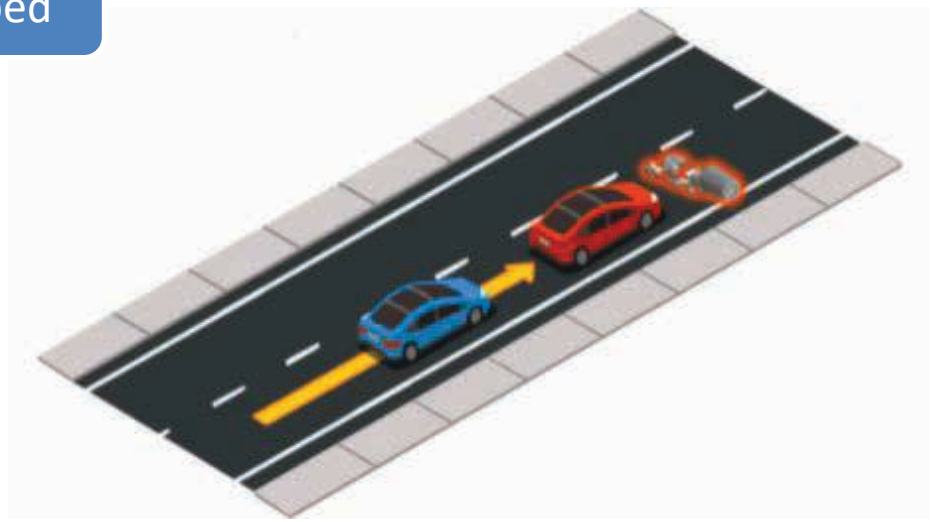
# Real world crash data

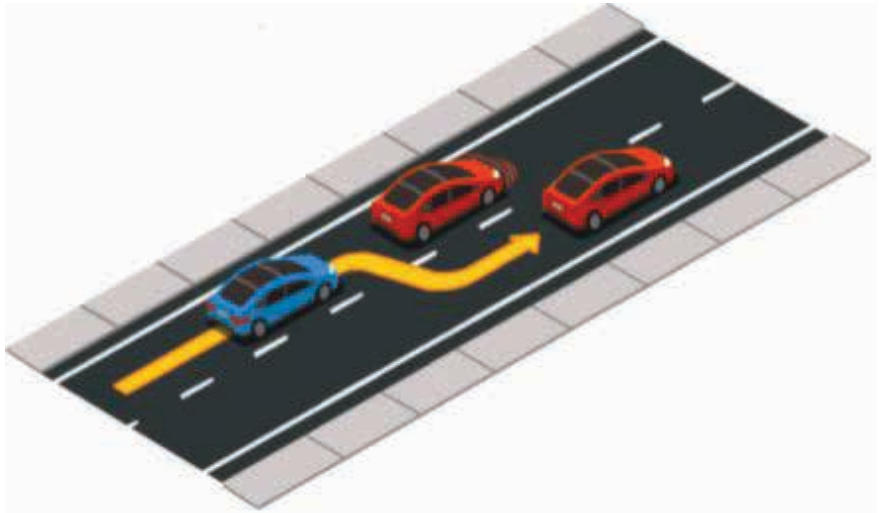



- Collection of data from the field
- Simulate and Correlate data with injury
- Machine Learning models to Predict Injury for a new crash
- Optimize car safety features to act as best as possible to reduce injury
- Machine Learning models to assign optimum values to the safety features that result in minimum Injury

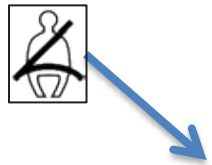
# Process

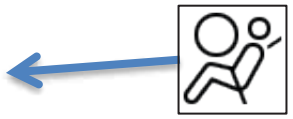

Parametric FE model
DOE
ML Training
CARLA
Optimization
ML Training
Leading Vehicle stopped





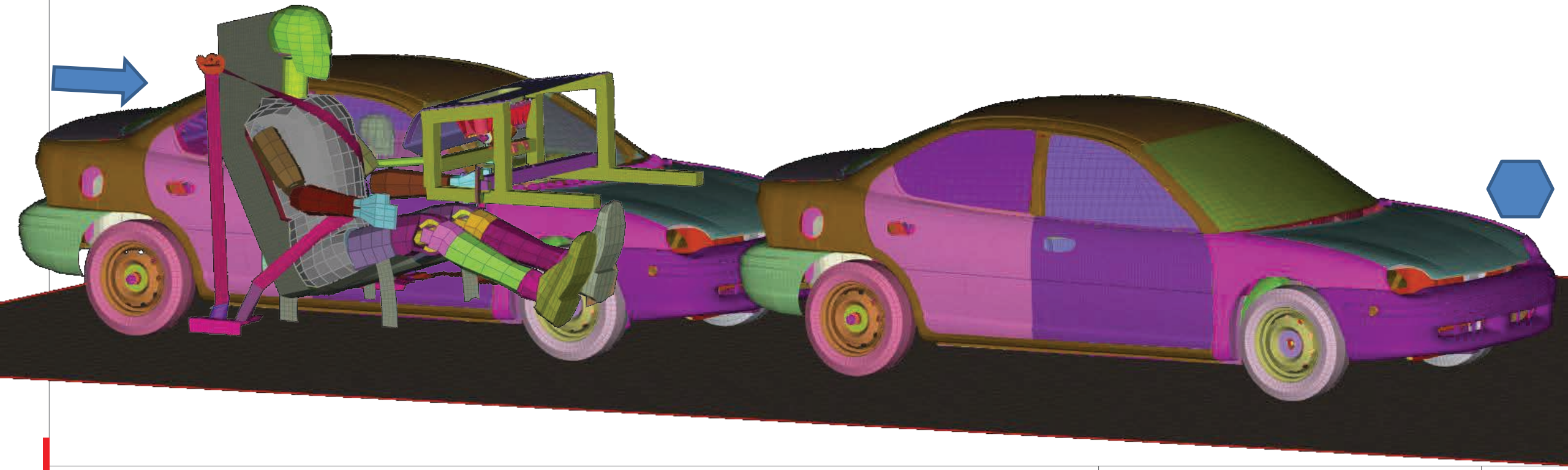
# Pre processing



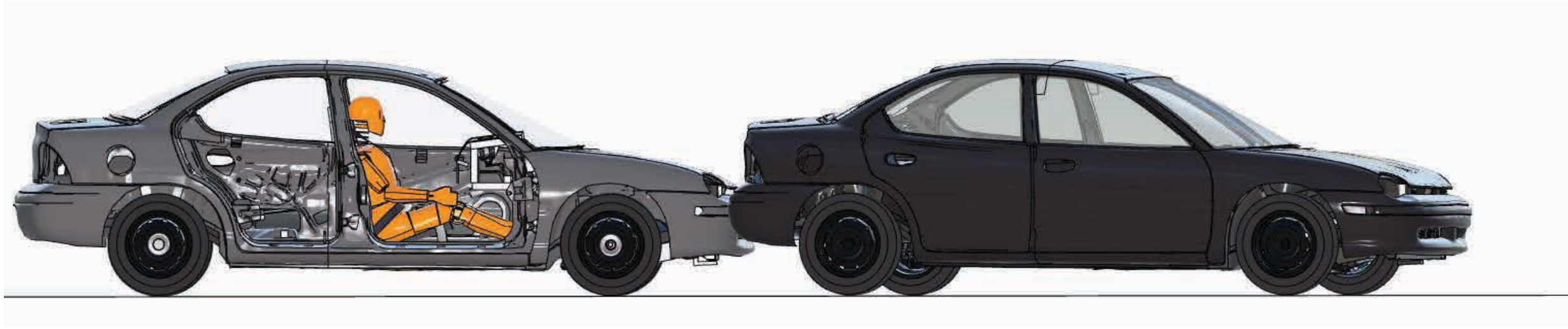


Two car crash

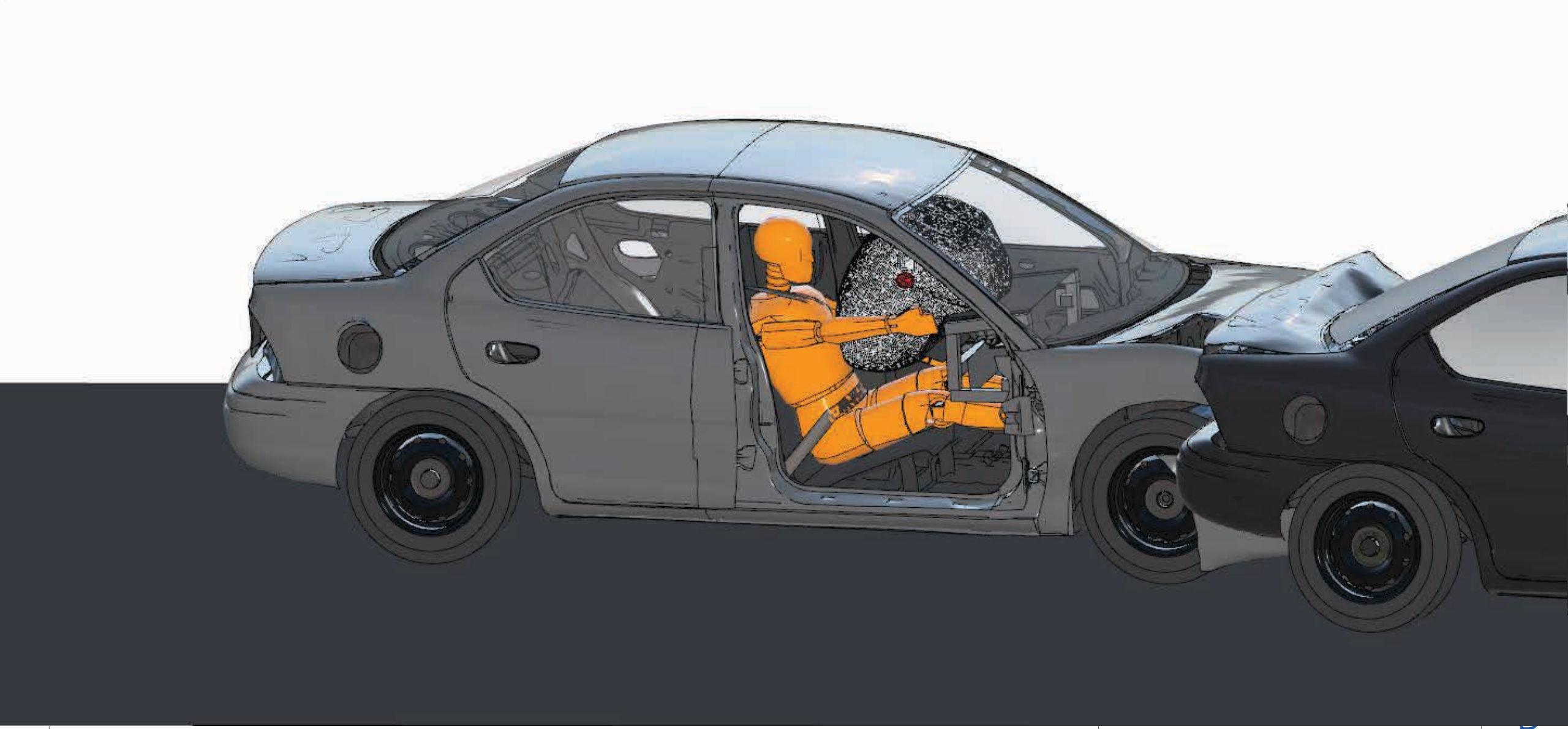
- Rear car velocity, front car stationary
- Dummy (RIGID)
- Seatbelt with sliprings, pre-tentioner and retractor
- Airbag



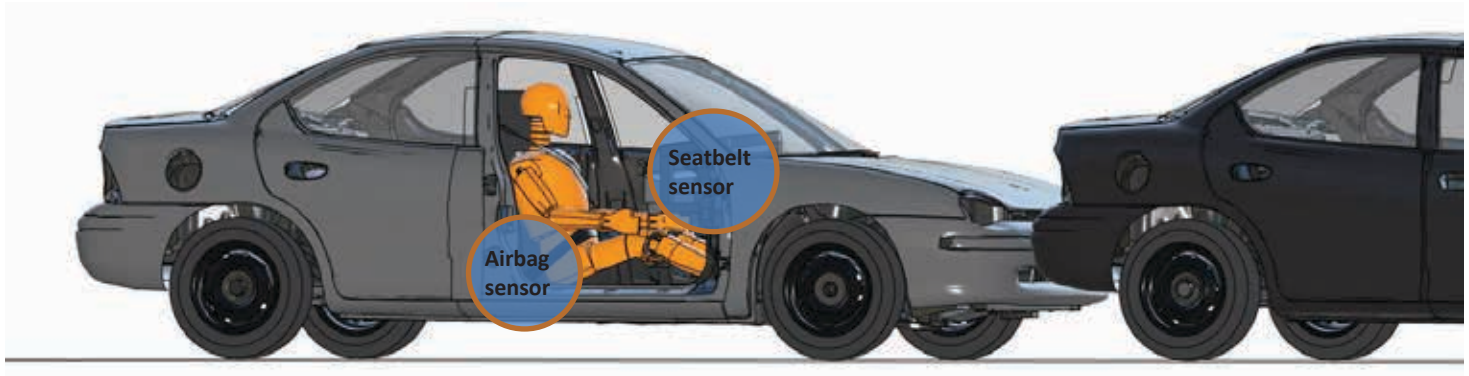
# Crash case with Dummy and airbag



# Crash case with Dummy and airbag

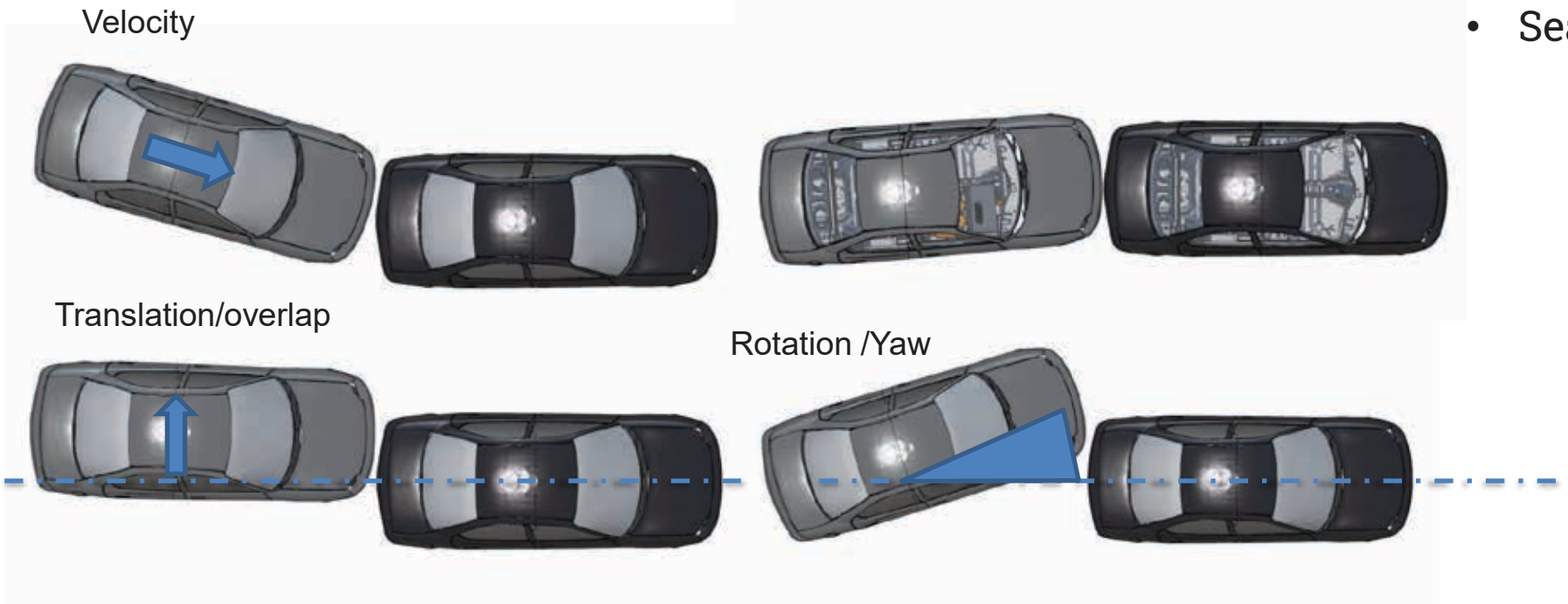


# Parametric model

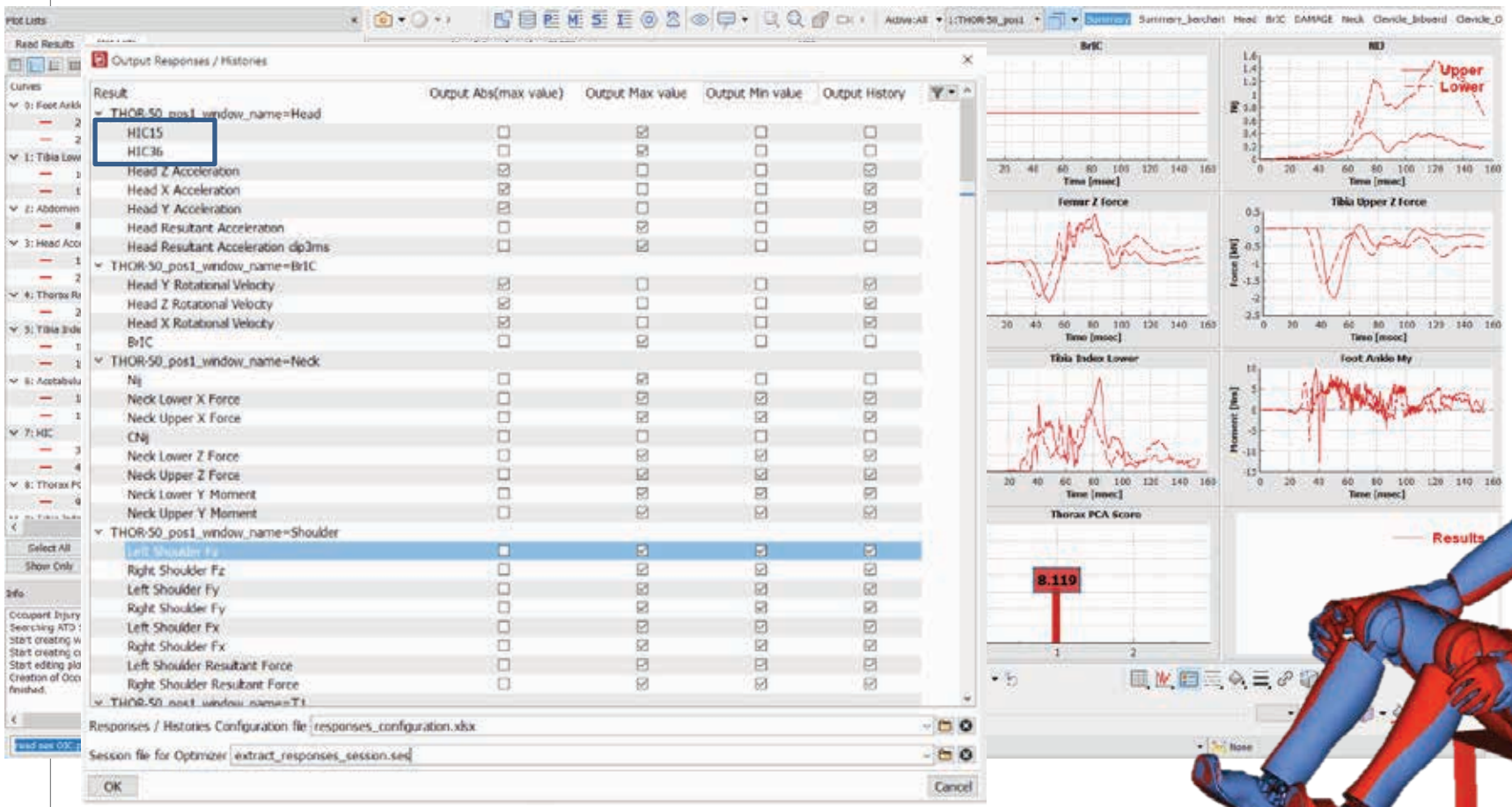



## Design Variables

- Velocity (15 to 80 km/h)
- Translation Y (0-605 mm)
- Rotation Z (18 to -18 deg)
- Airbag trigger offset time
- Seatbelt trigger offset time



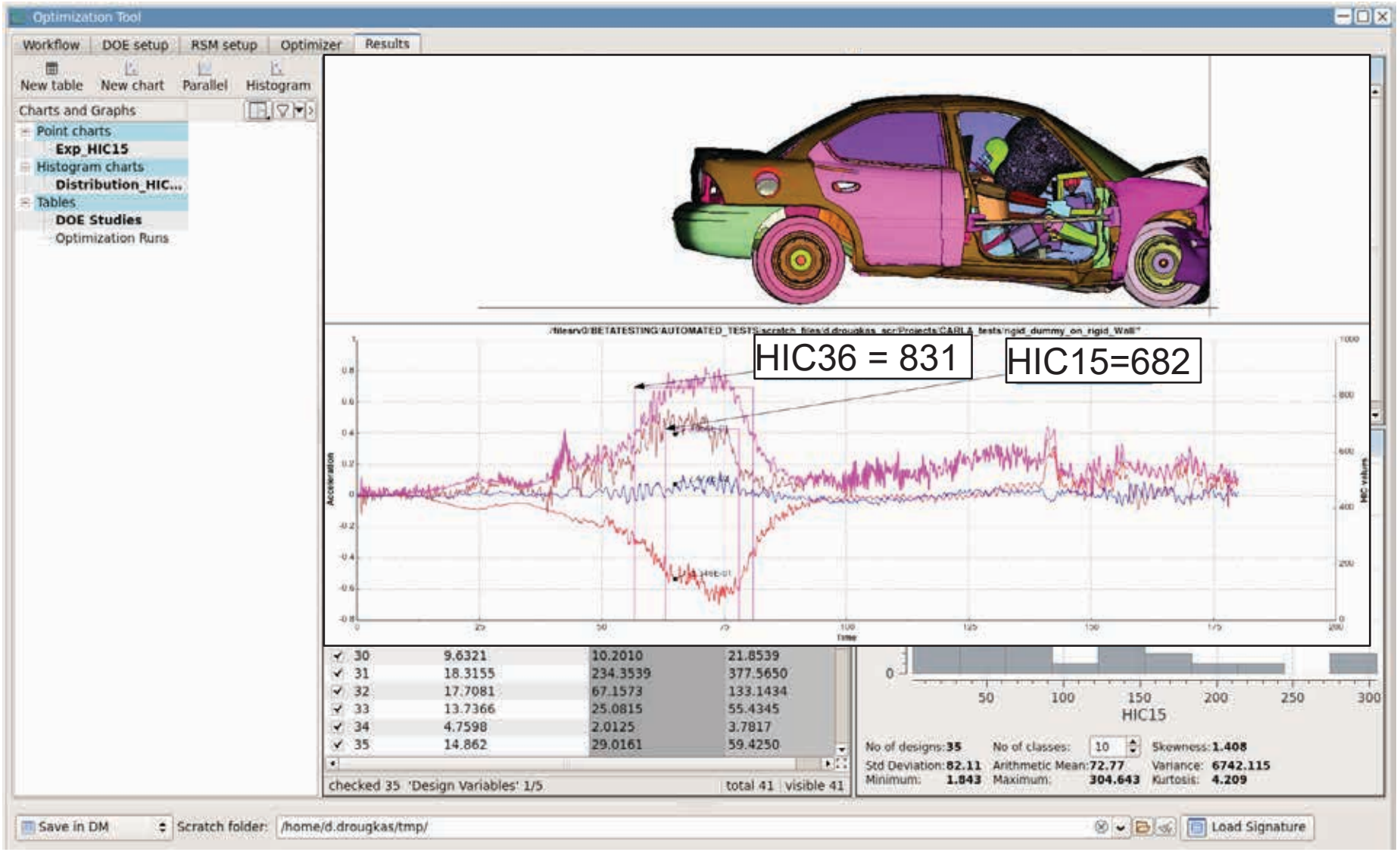
# Post Processing - HIC




## Responses

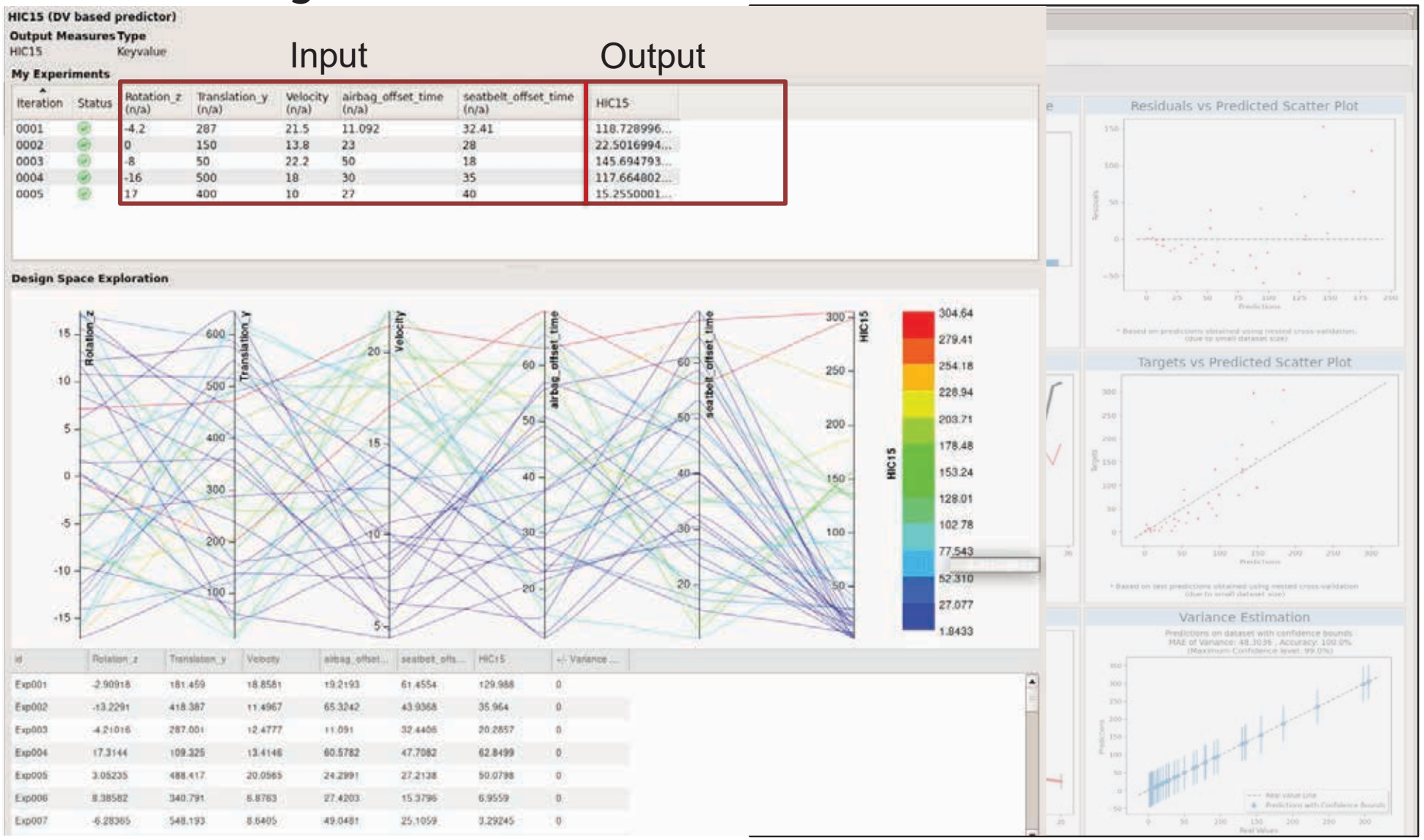
- HIC15
- HIC36

# DOE with 35 experiments




- Workflow with Design Variables
- DOE Results

# ML Training for HIC15




ML Predictor able to predict HIC15 instantly

KPIs to determine Predictor's accuracy

# Random crash scenarios generated with CARLA

65 scenarios with collisions collecting data regarding

- Velocity
- Rotation (Yaw)
- Translation (Y relative coordinate)

Frame: 2443

First Actor\Car:
Coordinates: (0.0, 0.0, 0.0) (m)
Rotation(Roll, Pitch, **Yaw**): (-6.103515625e-05, 9.56226431299001e-05, **0.025603188201785088) (deg)**

Ego Car:
Coordinates: (-4.489141400073389, **0.0907816611885199**, 0.0005099102854728699) **(m)**
Rotation(Roll, Pitch, **Yaw**): (0.013231619261205196, -0.05990075692534447**, -0.02273559384047985) (deg)**
Velocity: **69.94589683661746(km/h)**

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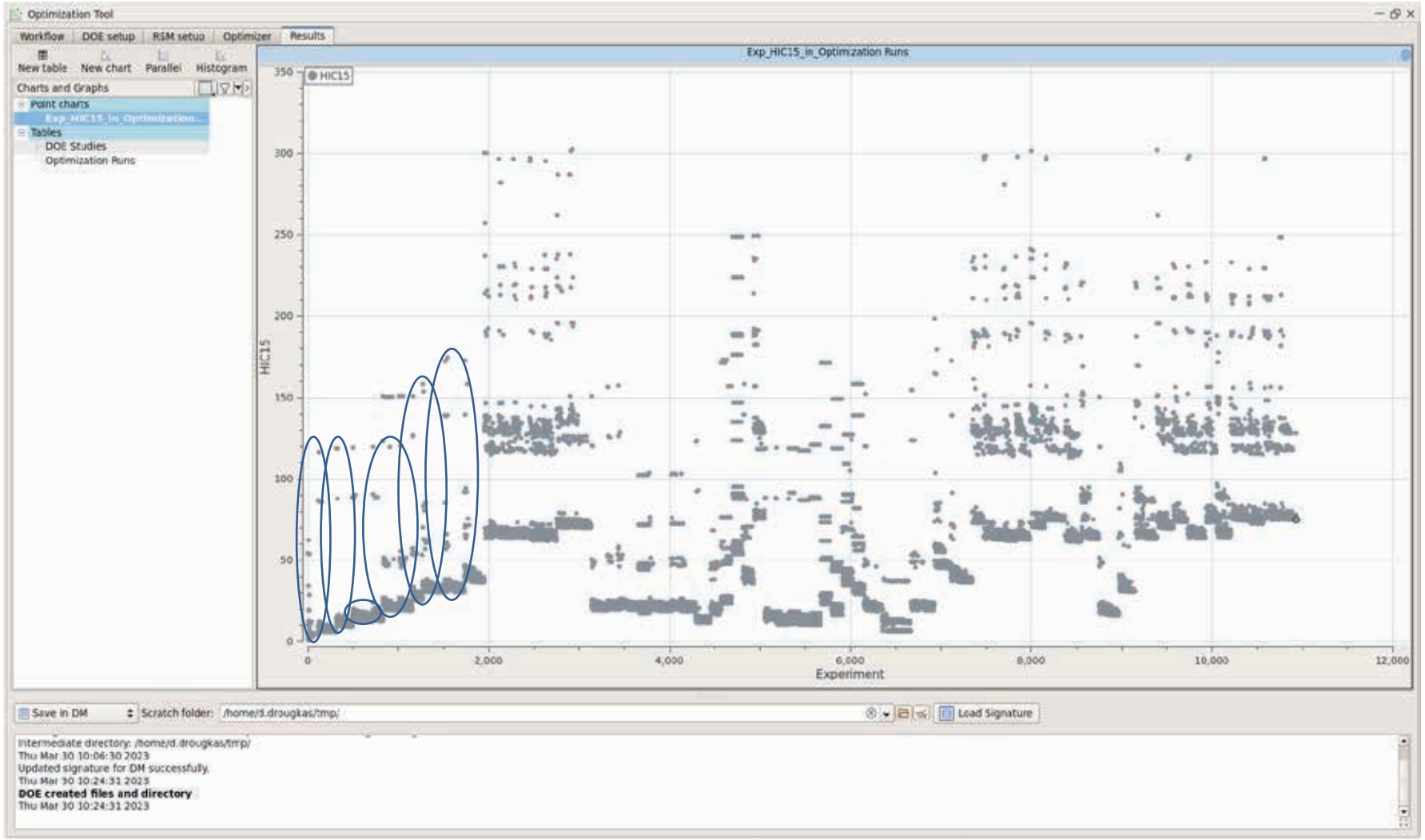
COLLISION:

Frame: 2444

Intensity: 32273.26057267041 N*sec(kg*m/sec)

# Optimization of safety features

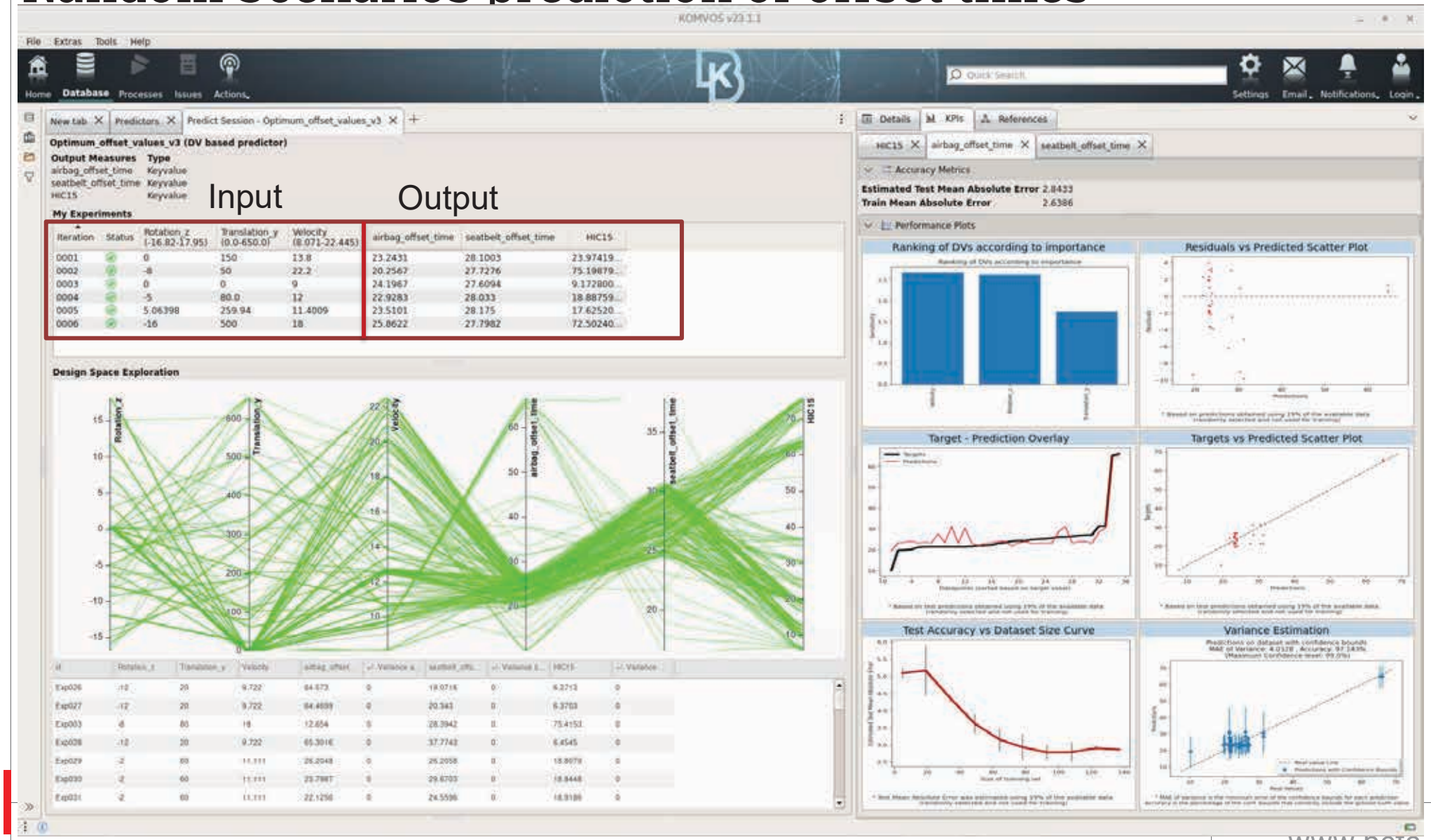



Airbag and Seatbelt trigger offset values optimized for each scenario (65 different) to minimize HIC15

Velocity, Rotation and Translation parameters were constant during optimization

The optimum experiments with minimized HIC15 created a new data set.

# Random Scenarios prediction of offset times




ML Predictor able to predict the trigger offset times that result in the lowest possible injury instantly

KPIs to determine Predictor's accuracy

# Random Scenarios prediction validation

| Scenario | Input | | | Output -Prediction | | | FE Result | Absolute error |
|---|---|---|---|---|---|---|---|---|
| | Rotation Z (Deg) | Translation Y (mm) | Velocity (mm/ms) | Airbag offset (ms) | Seatbelt offset (ms) | HIC15 | FE HIC15 | |
| 1 | 0 | 150 | 13.8 | 23.2431 | 28.1003 | 23.974 | 29.838 | 5.864 |
| 2 | -8 | 50 | 22.2 | 20.2567 | 27.7276 | 75.198 | 85.339 | 10.140 |
| 3 | 0 | 0 | 9 | 24.1967 | 27.6094 | 9.172 | 5.554 | 3.618 |
| 4 | -5 | 80 | 12 | 22.9283 | 28.033 | 18.887 | 14.681 | 4.206 |
| 5 | -5.06 | 259.9 | 11.4 | 22.2304 | 27.7675 | 17.366 | 15.542 | 1.824 |
| 6 | -16 | 500 | 18 | 25.86.22 | 27.7982 | 75.798 | 90.86 | 15.062 |

# Summary - Conclusion

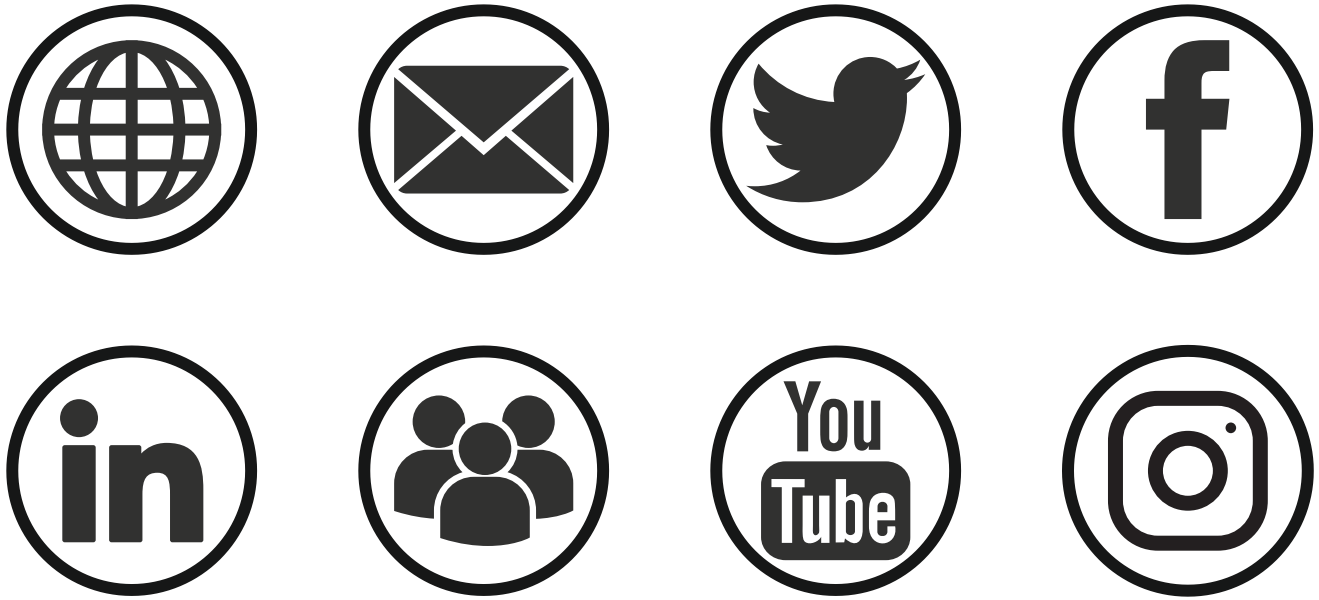
- DOE with parametric two car crash case with dummy, seatbelt and airbag.
- Trained Machine Learning Predictors to “replace” solver for simulation results
- Random crash scenarios generated in CARLA based on most common crash cases based on NHTSA
- Predictors used in optimization to identify optimum airbag and seatbelt offset time, minimizing the Head injury criterion for each of the generated crash scenarios
- Trained Machine Learning model to provide optimum airbag and seatbelt offset time values when given a new crash scenario (Velocity, Rotation, overlap)
- Validation shows small difference between predicted HIC and calculated HIC, for the predicted optimum offset times

✓ Modern cars could take advantage of such a functionality that can provide the best controls settings customized to the accident while it takes place, aiming to achieve the lowest possible injury

# Future work

- Various vehicles (pick up, SUV)
- Image based techniques to simulate cameras or Lidars that identify the vehicles (position and type) in proximity and estimate their velocities.
- Active safety parameters found in modern vehicles, such as Automatic Emergency Brake, Emergency steering, etc.
- Weather conditions
- Head on, or barrier collisions

BETA
SIMULATION SOLUTIONS

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