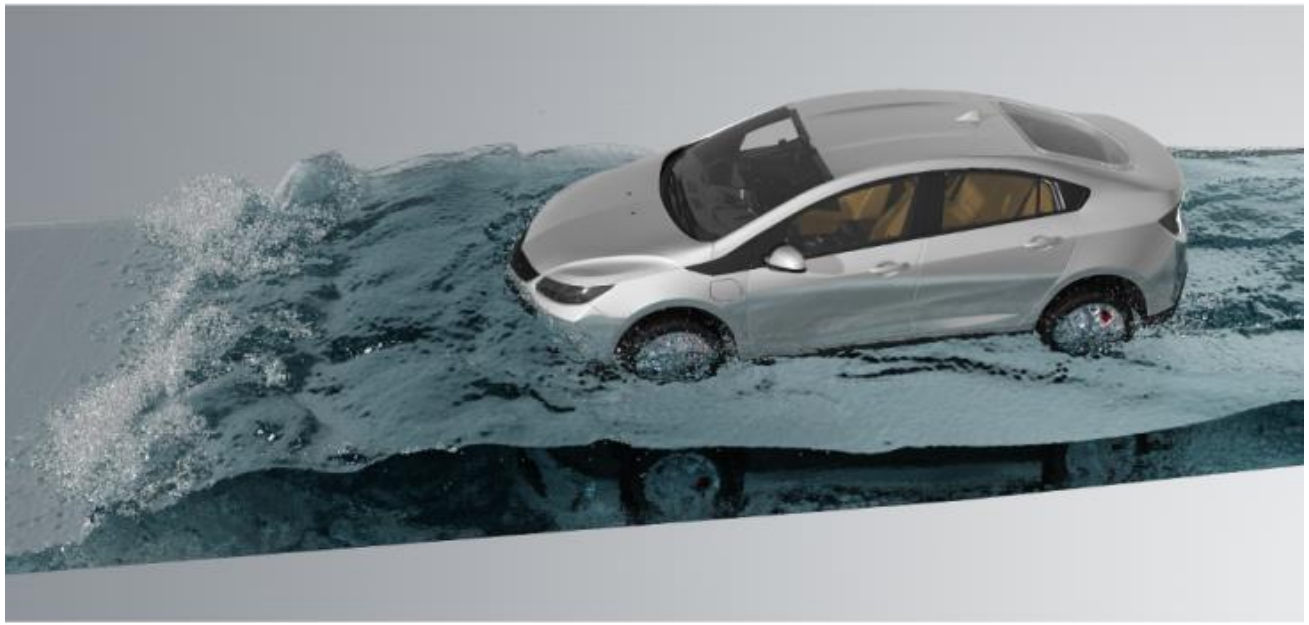
AVL Simulation Meets Testing Conference 2019- Water Wading And Water Splash Simulation At Mahindra Automotive North America

Angus Lock - Mahindra Automotive North America

Introduction

- Mahindra North America have conducted an extensive evaluation of PreonLab by FIFTY2
- The primary use cases are water wading and splash, but we have also evaluated it for drainage from the cowl and doors, fuel tank filling and wiper performance
- PreonLab is a particle based solver using PREON® technology
- The advantage of this approach is the speed of solution compared to typical RANS solvers
- Some first experiences are shared



Water Splash

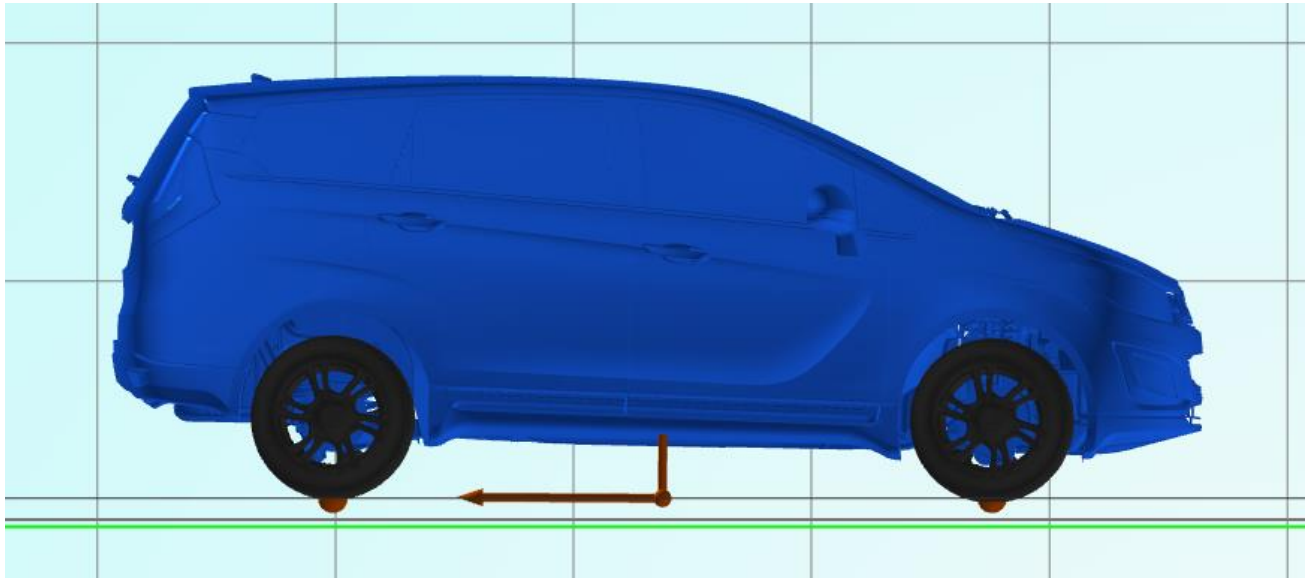
- Mahindra test at a range of vehicle speeds and water depths to evaluate splash performance
- The particular case I'm presenting was run at 50kph and a water depth of 70mm
- Initial particle size chosen was 10mm in order to quickly assess the behavior
- This was run on 40 cores on a local workstation (7h 57m) and then 224 cores on MANA's cluster (1h 27m)
- A final run was conducted with a particle size of 6mm to check for convergence
- We expected this to take (10/6)^4 times longer to run – i.e. 7.7 times longer or approximately 11 hours but it actually only took 8 hours and 44 minutes

MARAZZO

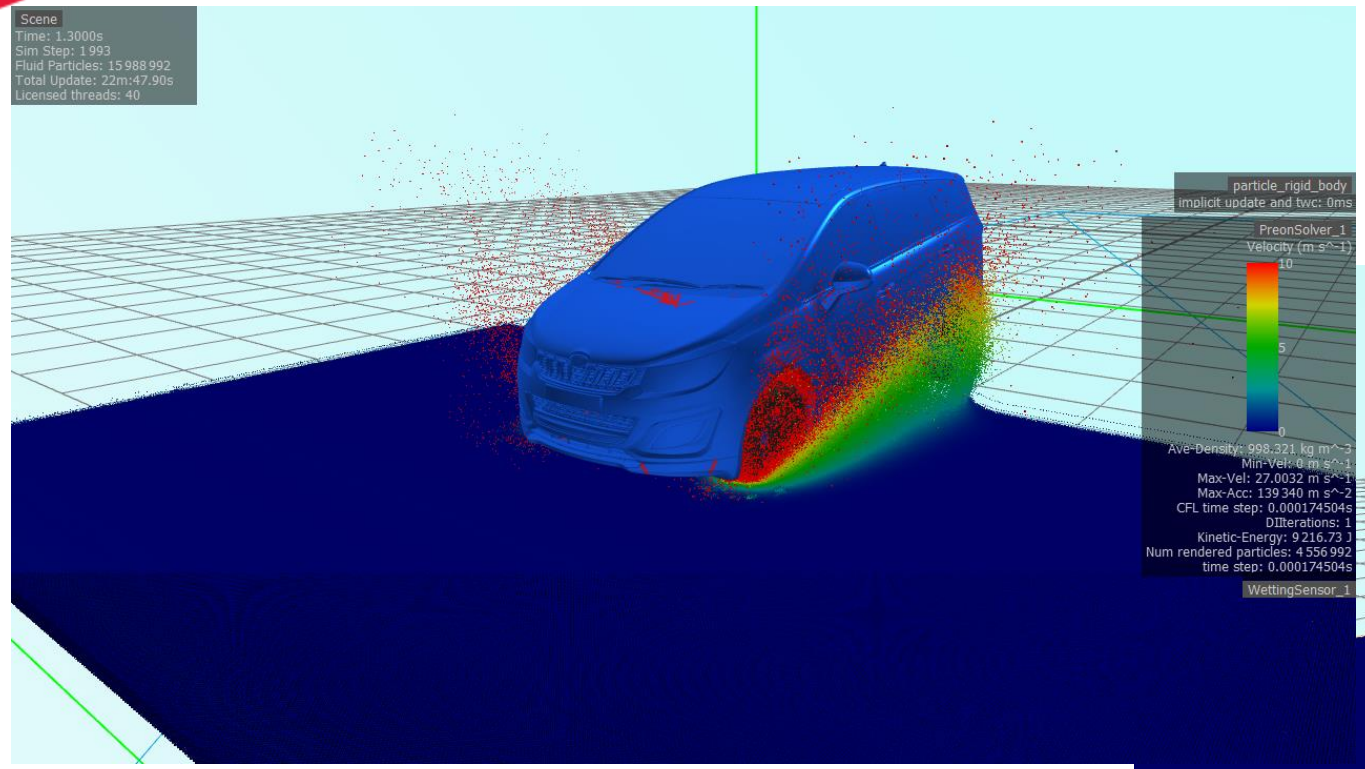
Water Splash

- PreonLab makes it easy to set up the movement of the vehicle through the splash channel by using a scripted approach
- First transform points are created at the contact patch of a front and rear tire
- Then all the user has to enter is start and finish times and the vehicle speed and the vehicle position is calculated automatically for each frame
- In addition you can enter suspension data for the vehicle to account for the hydrodynamic forces acting on it
- Finally cameras can be locked to the body transform group so that they track the vehicle through its movement

```python
import math
import preonpy

"""
Preconditions:
- The car must drive along the x-axis.
- The geometry of the road under the car must be named "wading_channel".
- The objects "Point_1" and "Point_2" must identify the points where a front and a rear wheel touch the ground. These points should share the same x-coordinate.
- There must be a transform group "TransformGroup" which controls the transformation of the whole car.
- The script does not keyframe the wheel rotation. You need to set this up manually.

If these preconditions are too restrictive for your case, please contact the Fifty2 support (support@fifty2.eu) and we will find a solution.
"""

# User-defined parameters (define your values here)
t = 0            # Point in time at which movement starts in seconds
t_end = 4        # Point in time at which movement ends in seconds
timestep = 0.02  # Integration timestep, time between two generated
                 # keyframes in seconds

def speed(t):    # Speed of the car in m/s w.r.t time t in seconds. Leave this constant unless you intend to use a dynamic velocity profile
    return 13.9

```

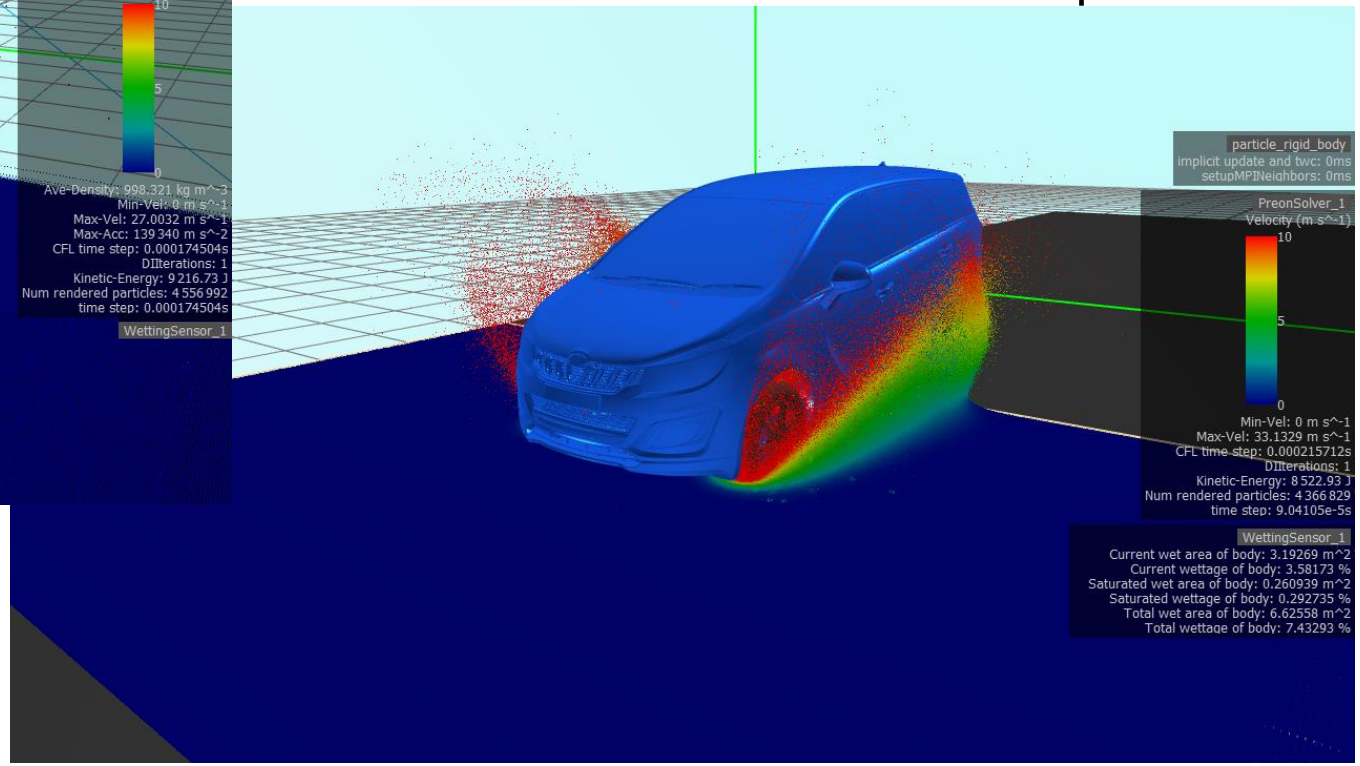


Water Splash – Resolution Dependence



10mm particle size

6mm particle size



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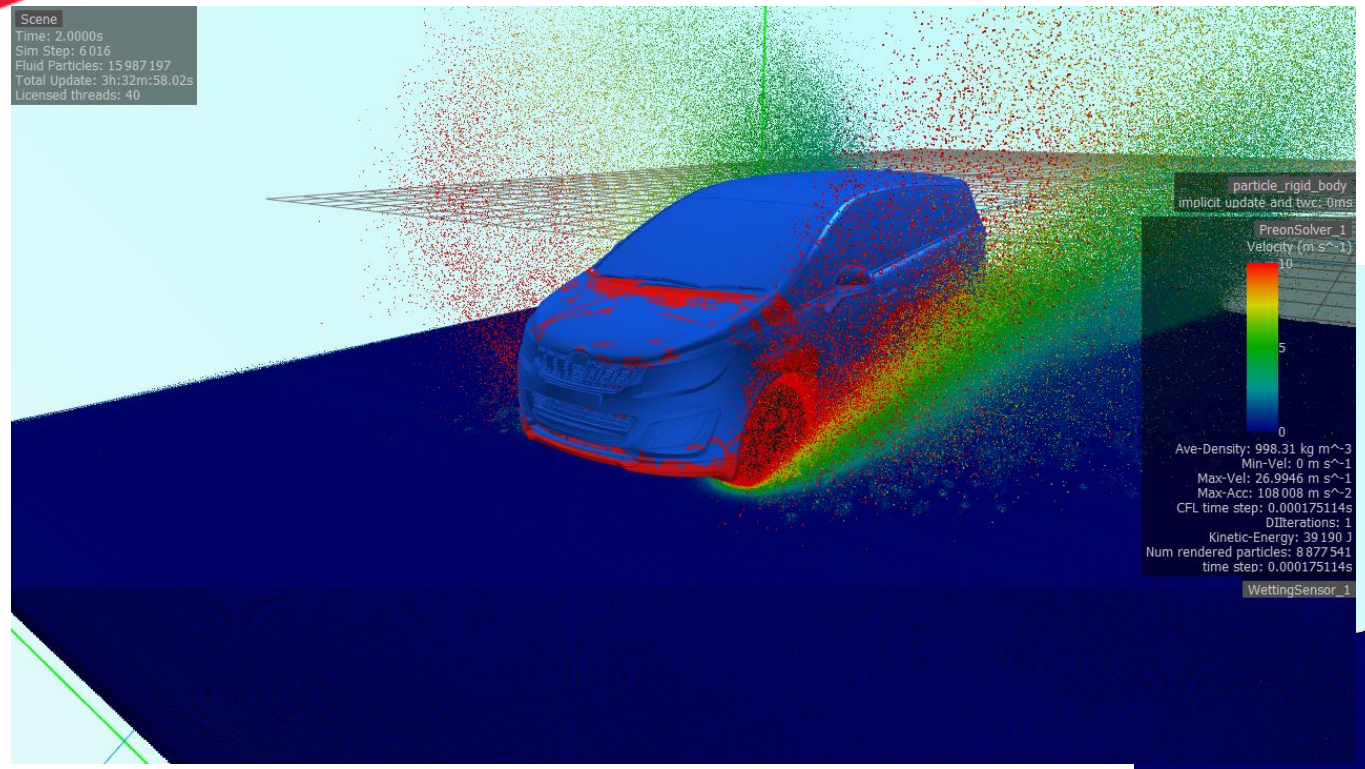

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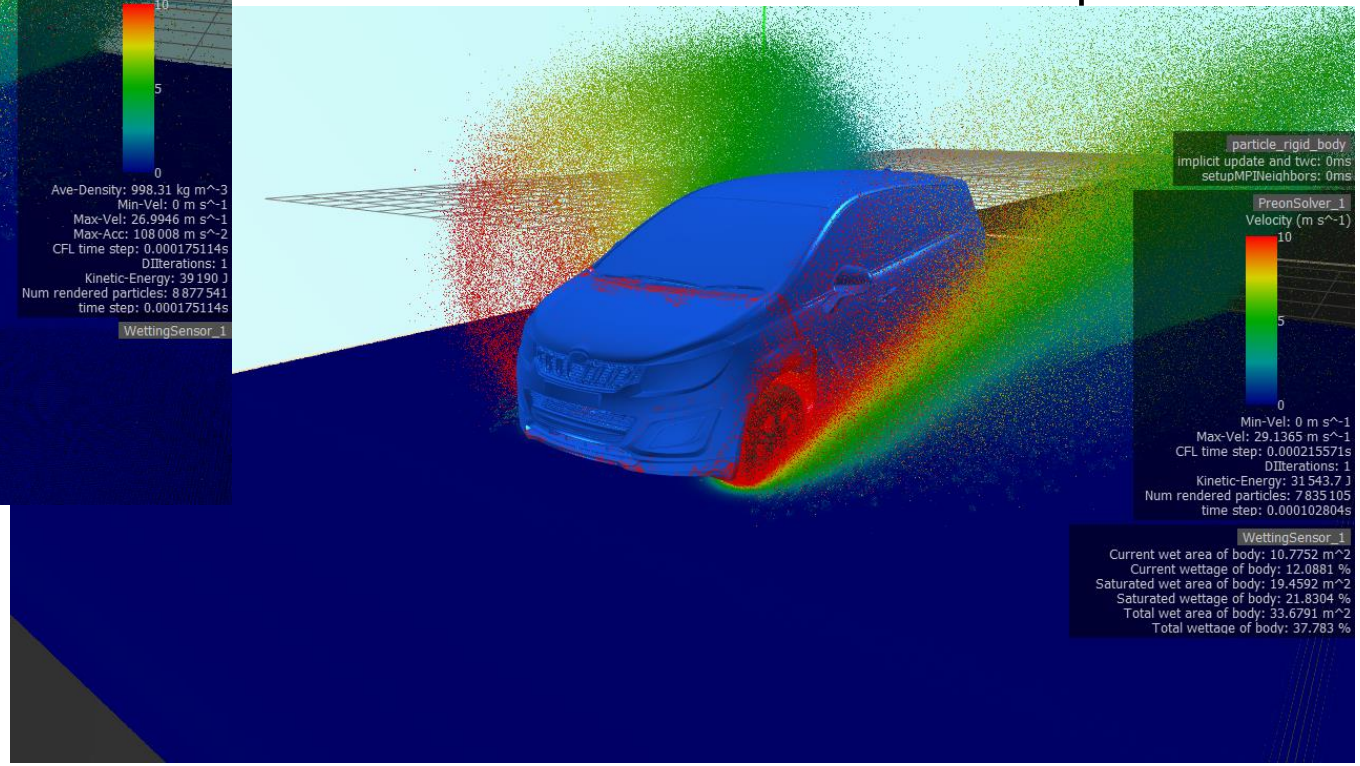

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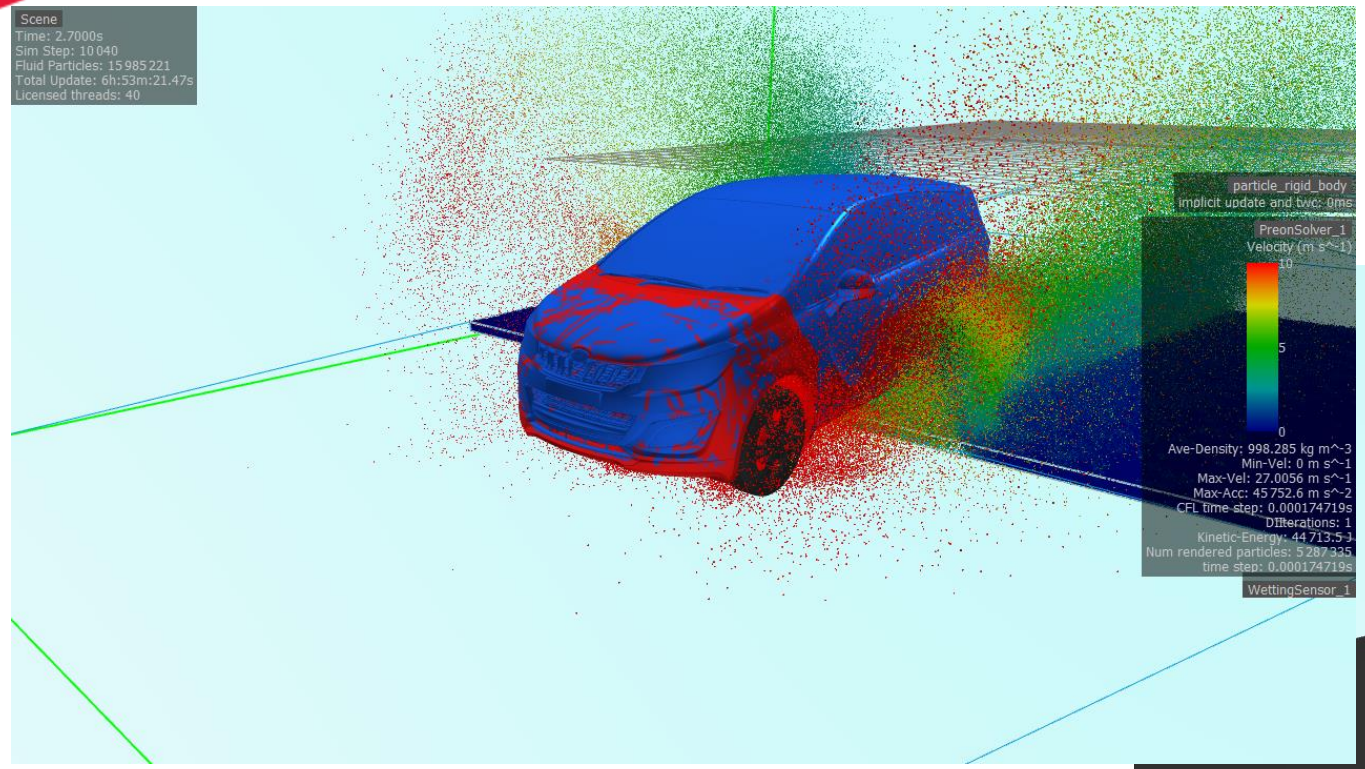

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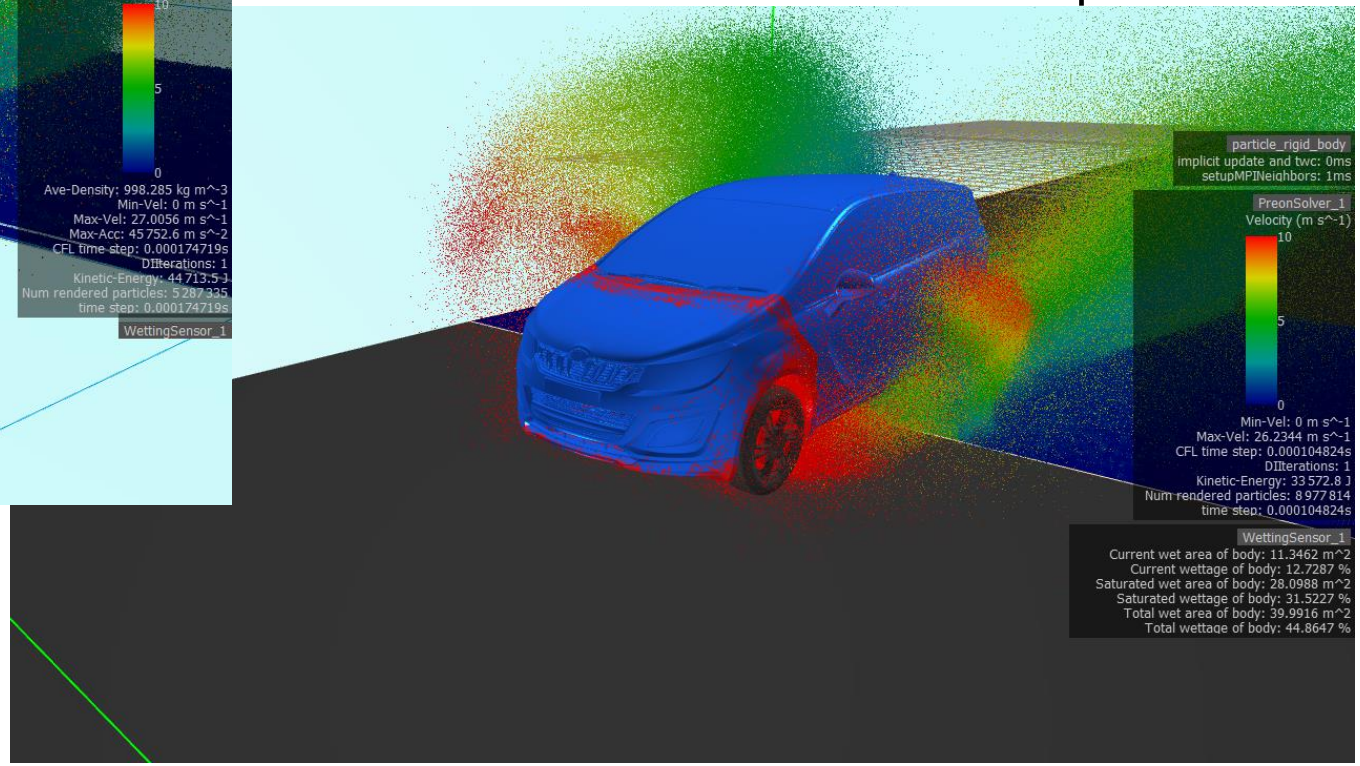

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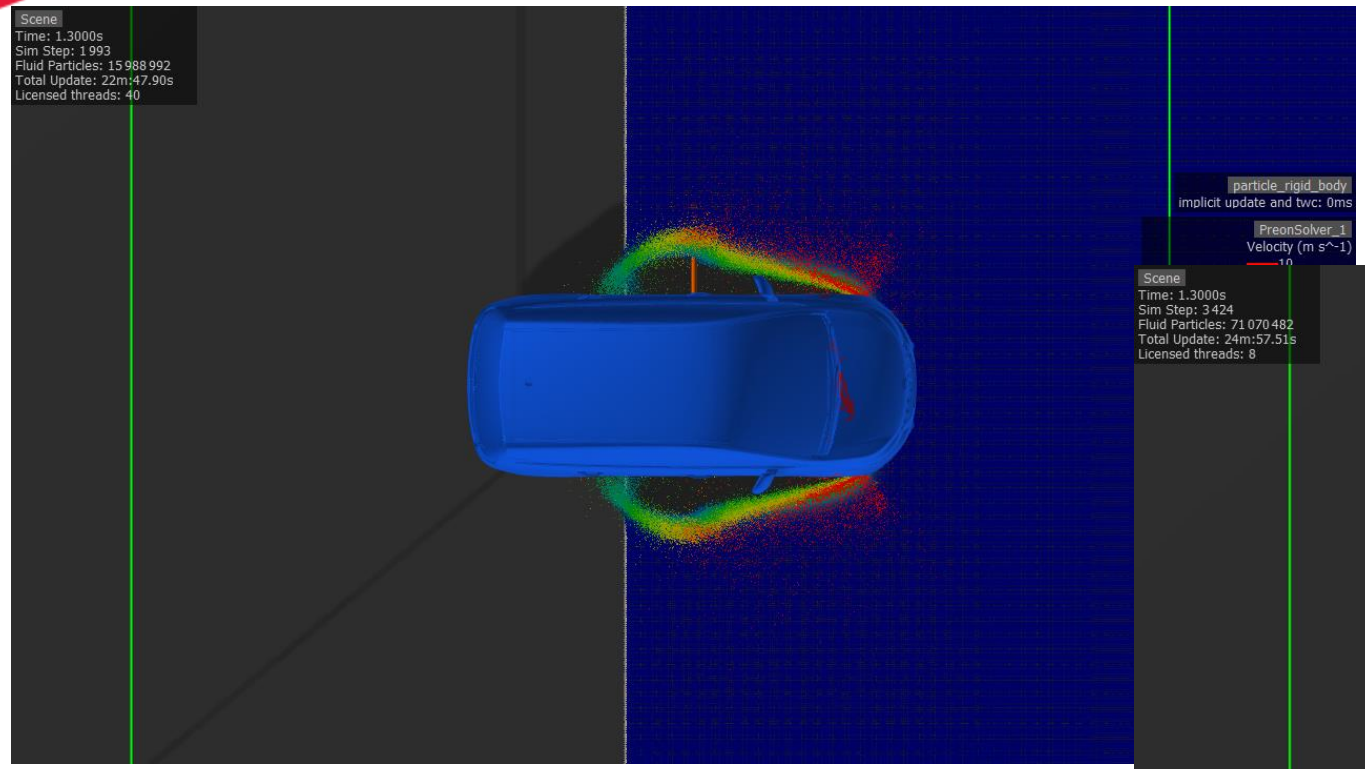

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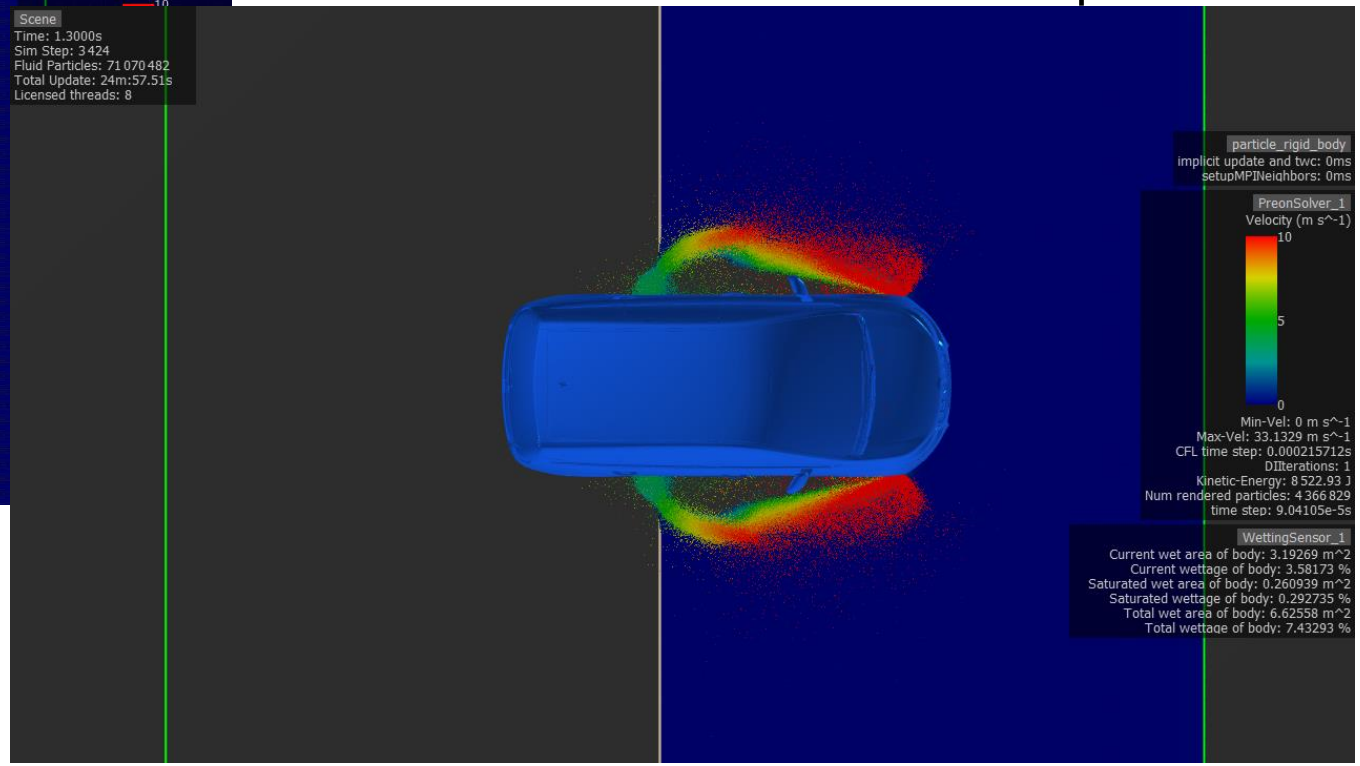

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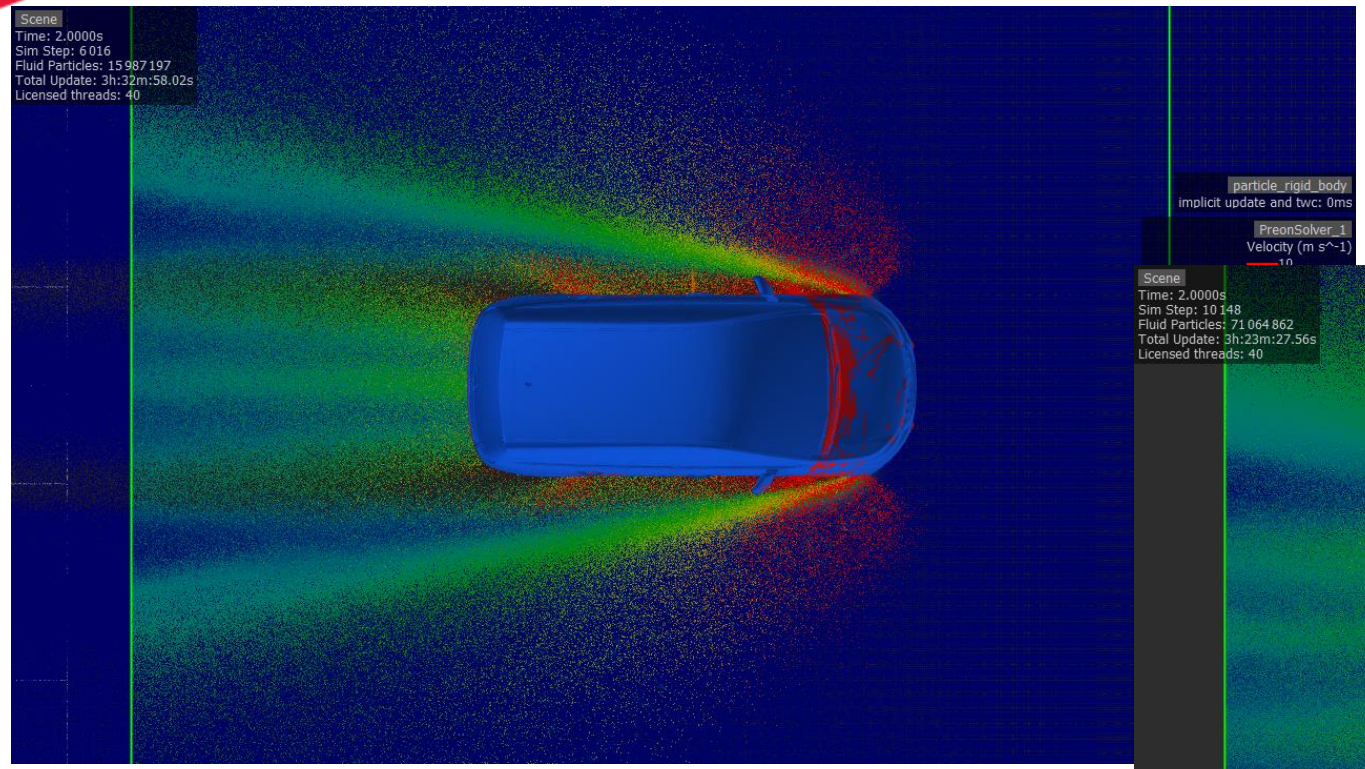

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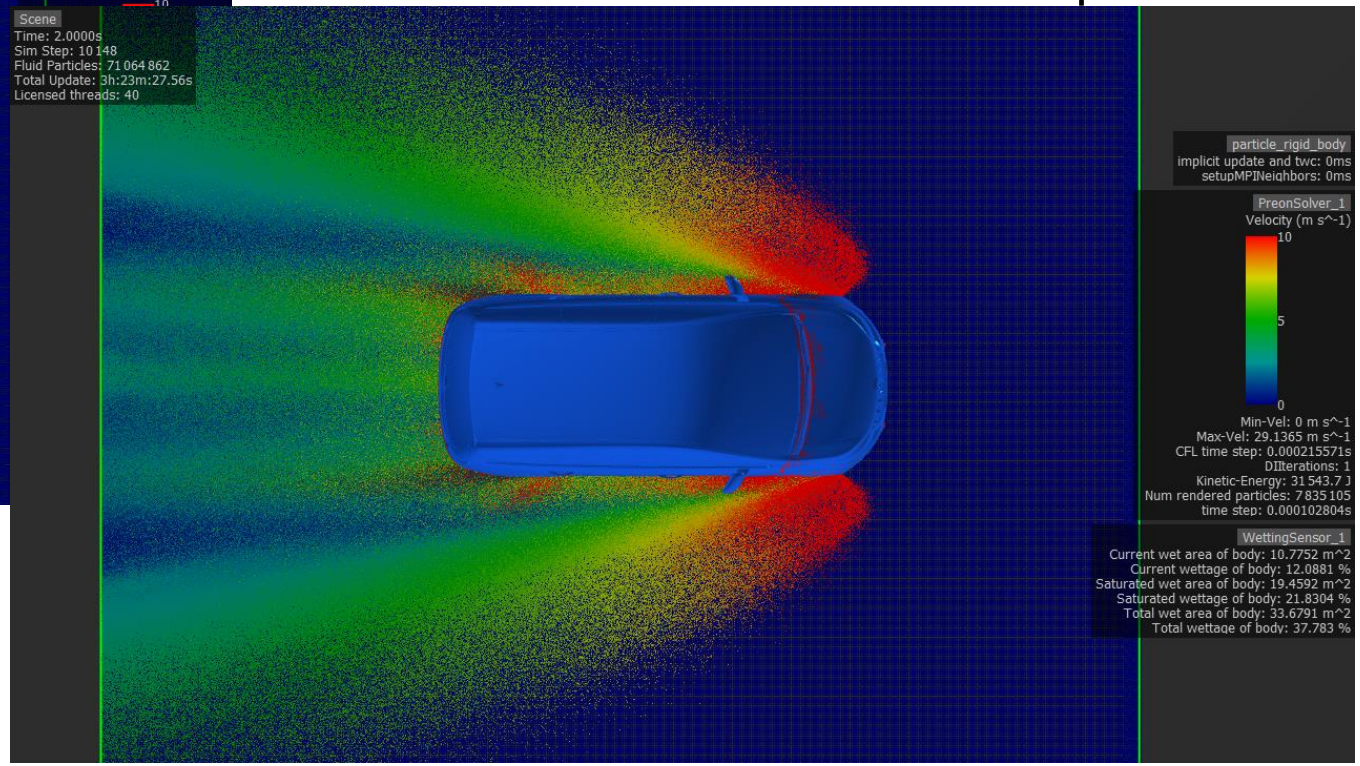

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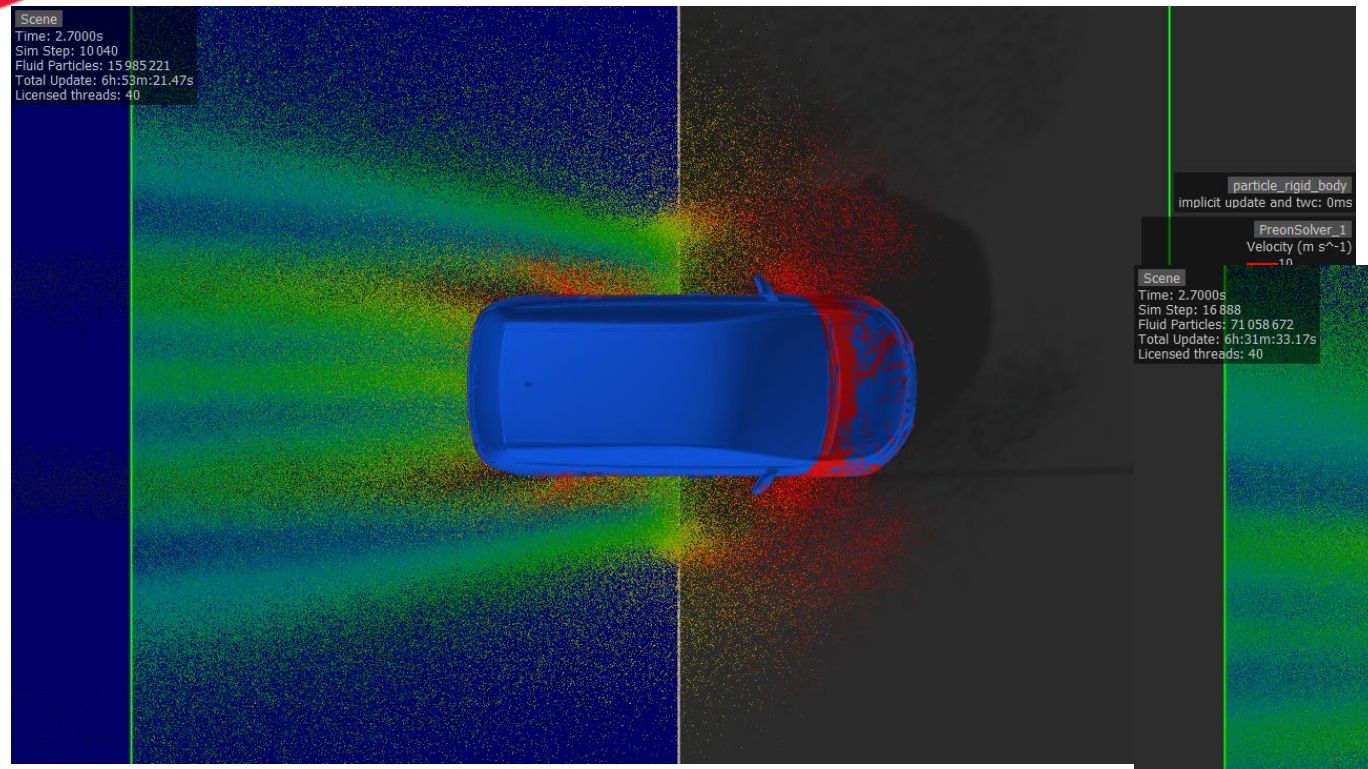

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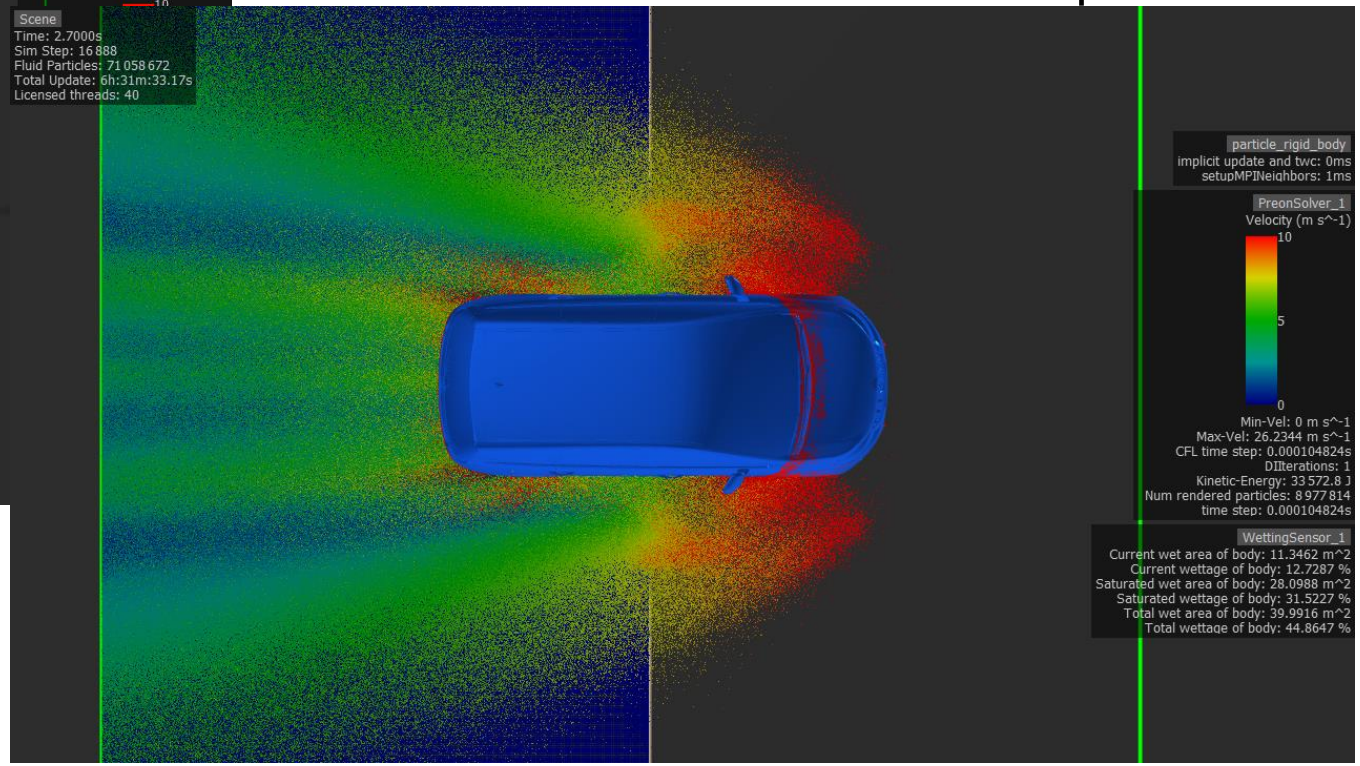

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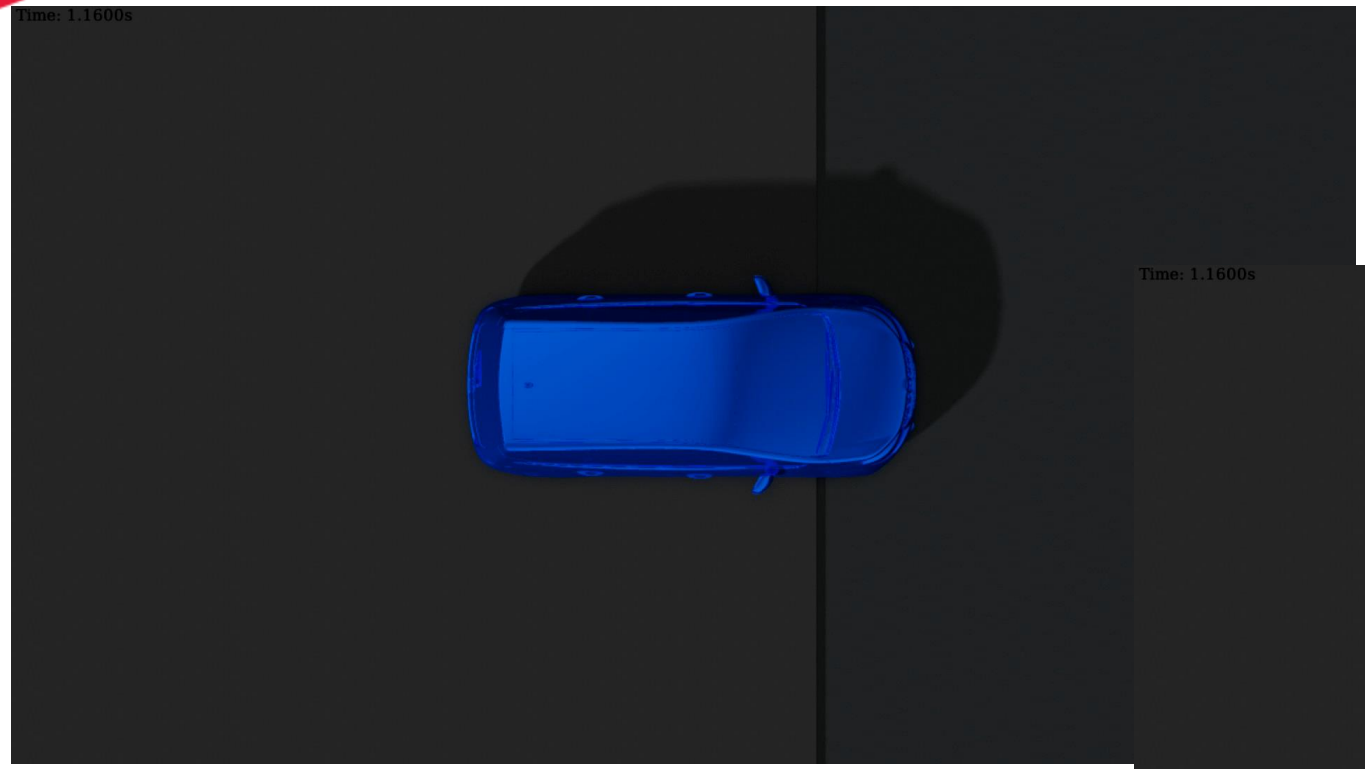

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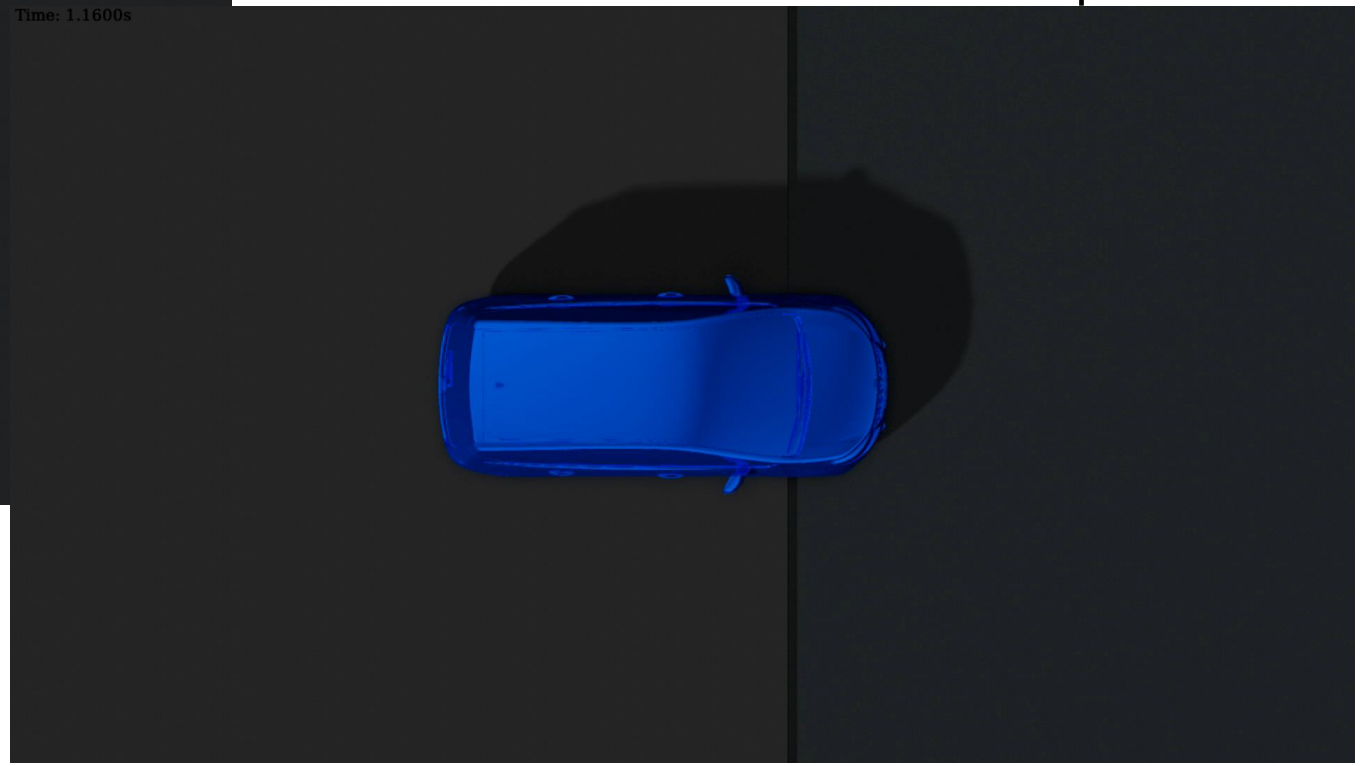


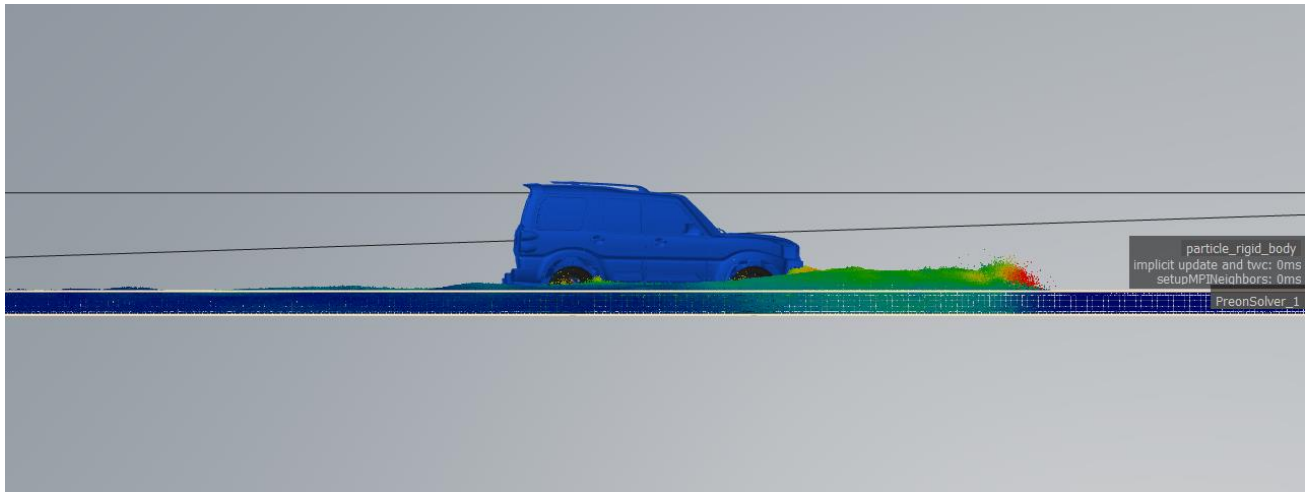
Water Wading

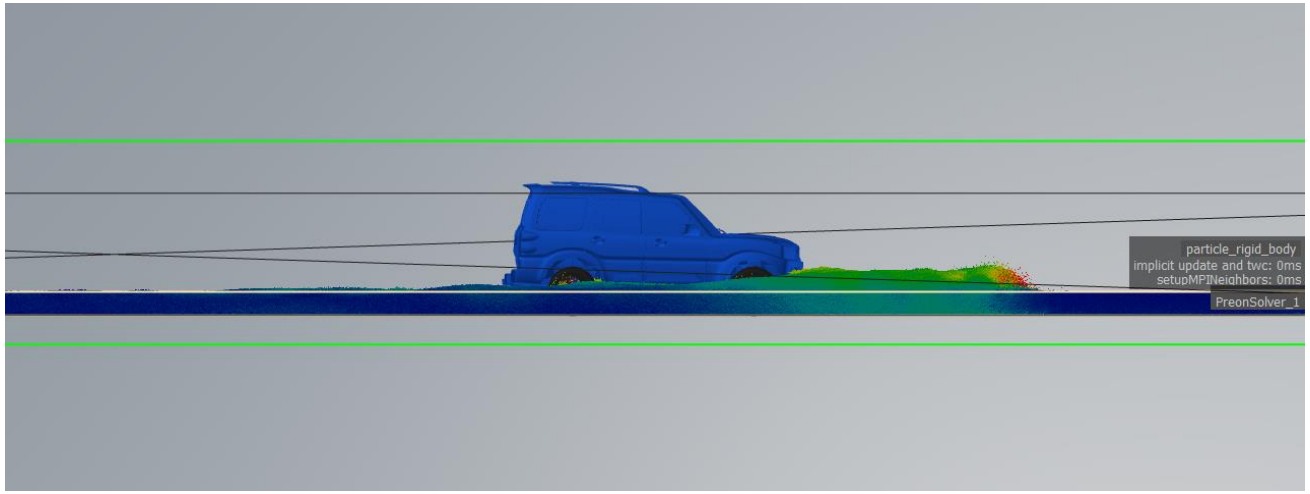
- Mahindra test at a range of vehicle speeds and water depths to evaluate wading performance
- The particular case I'm presenting was run at 10kph and water depth of 350mm
- Initial particle size chosen was 20mm in order to quickly assess the behavior
- This was run on 224 cores on MANA's cluster without a BoxDomain (stopped) and then with a BoxDomain (2h 06m)
- A final run was conducted with a particle size of 12mm to check for convergence
- We expected this to take (20/12)^4 times longer to run – i.e. 7.7 times longer or approximately 16 hours but it actually only took 14 hours and 26 minutes

SCORPIO

Water Wading – effect of BoxDomain

- This was run on 224 cores on MANA's cluster without a BoxDomain (stopped) and then with a BoxDomain (2h 06m)
- For the frames that were completed for the run without a BoxDomain they were taking approximately 12 minutes to calculate
- Each frame with the BoxDomain was only taking approximately 15s to calculate at the same point in the simulation
- Overall to get to the same point the run without the BoxDomain took 20 hours and 29 minutes, the run with a BoxDomain only took 1 hour and 1 minute





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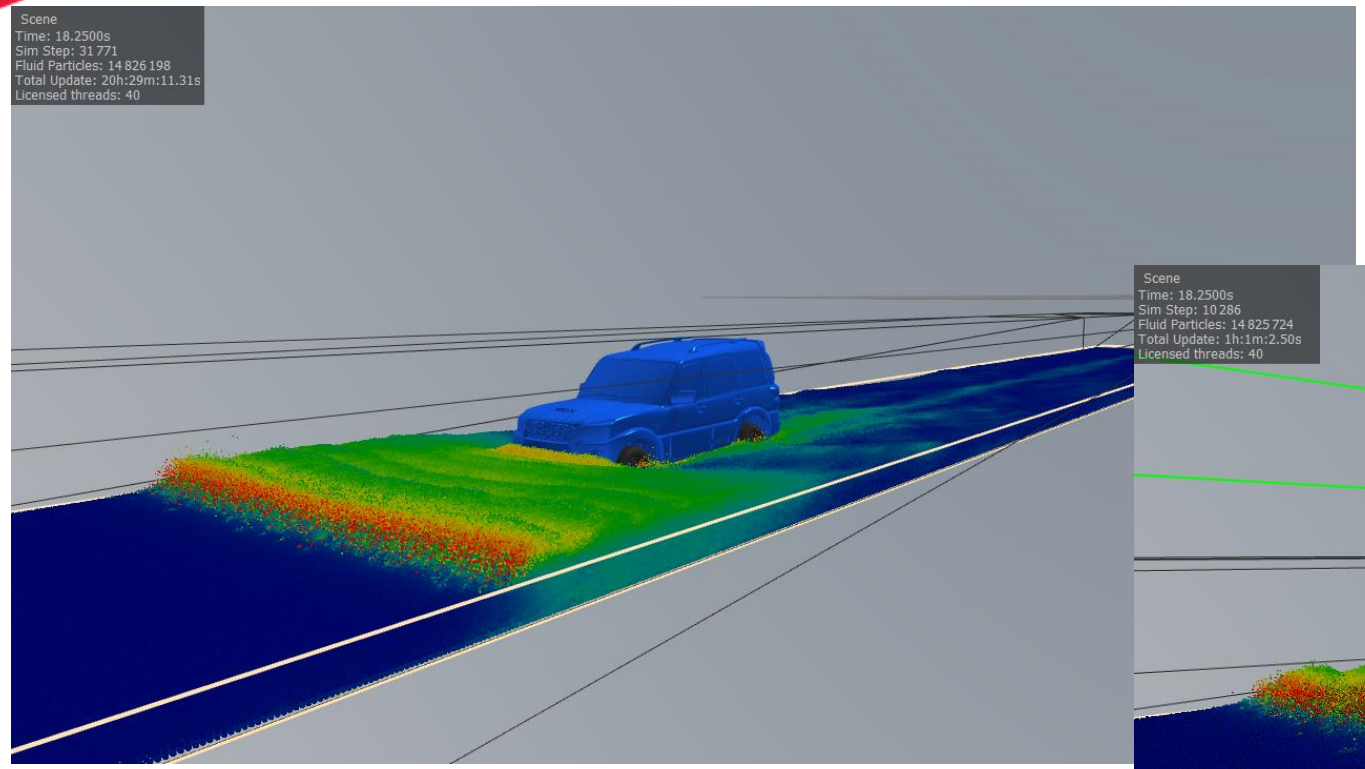
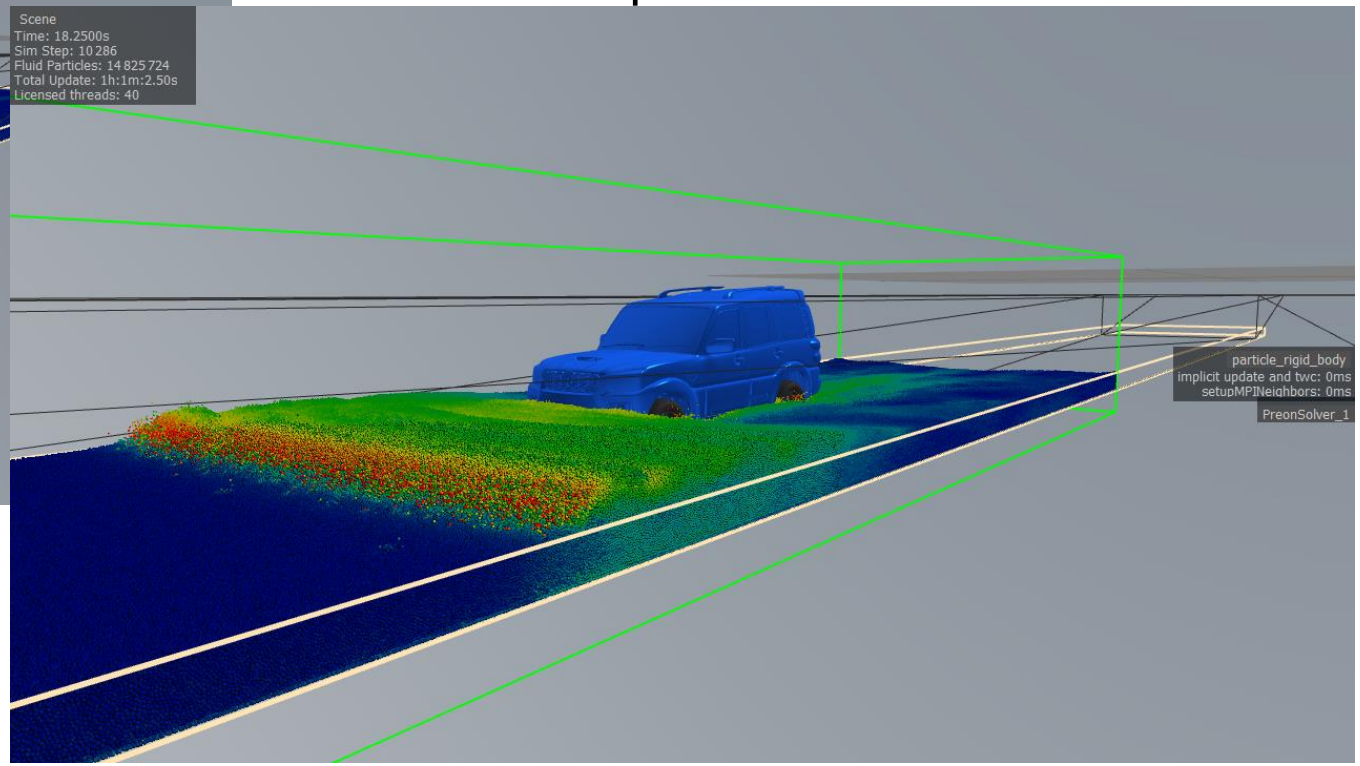


20mm particle size – no BoxDomain

20mm particle size – with BoxDomain



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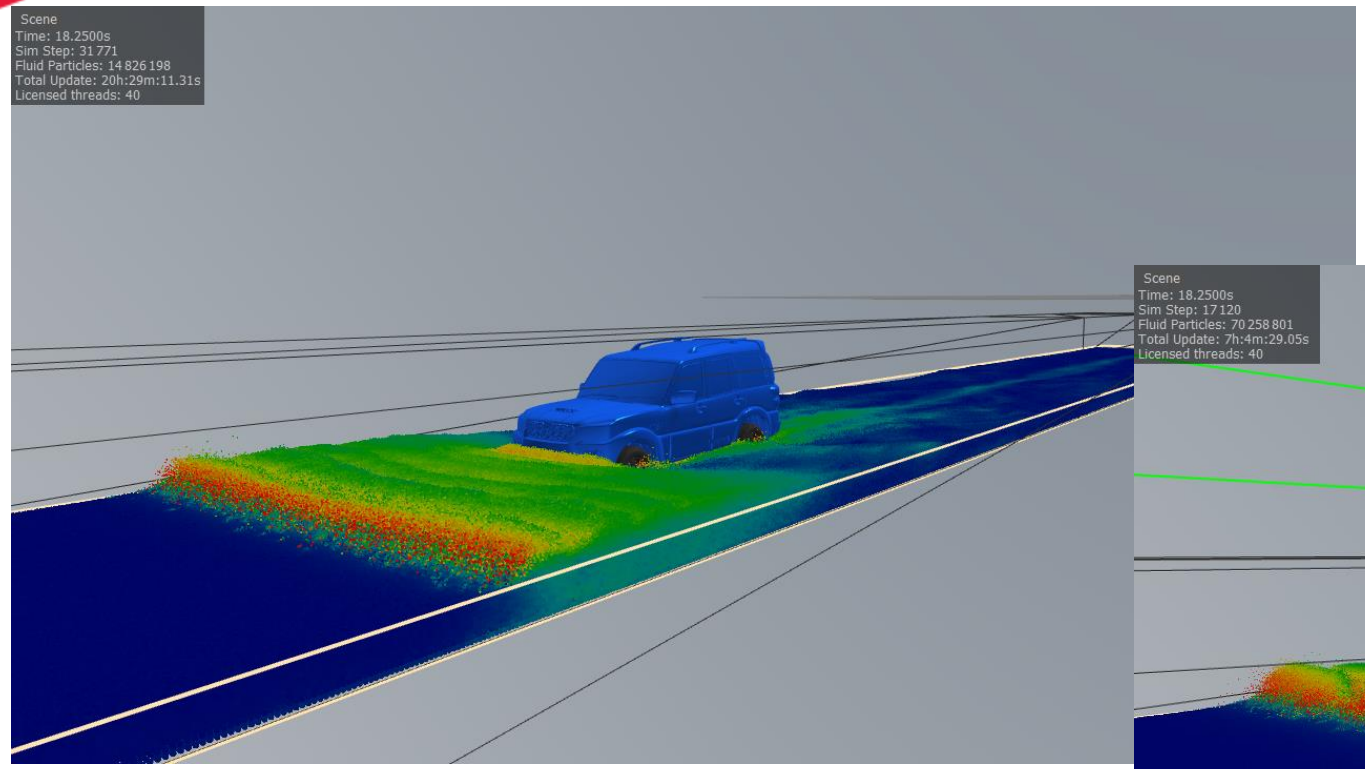

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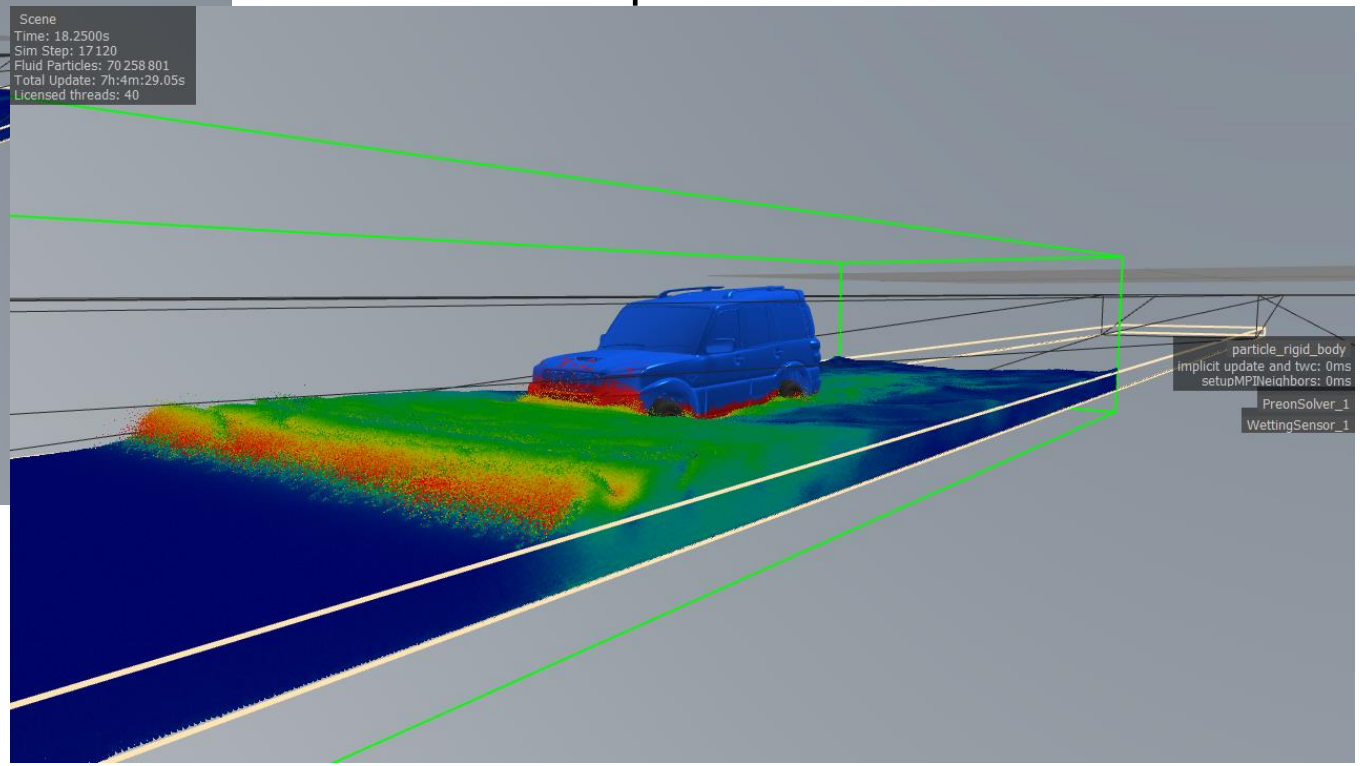
12mm particle size – with BoxDomain



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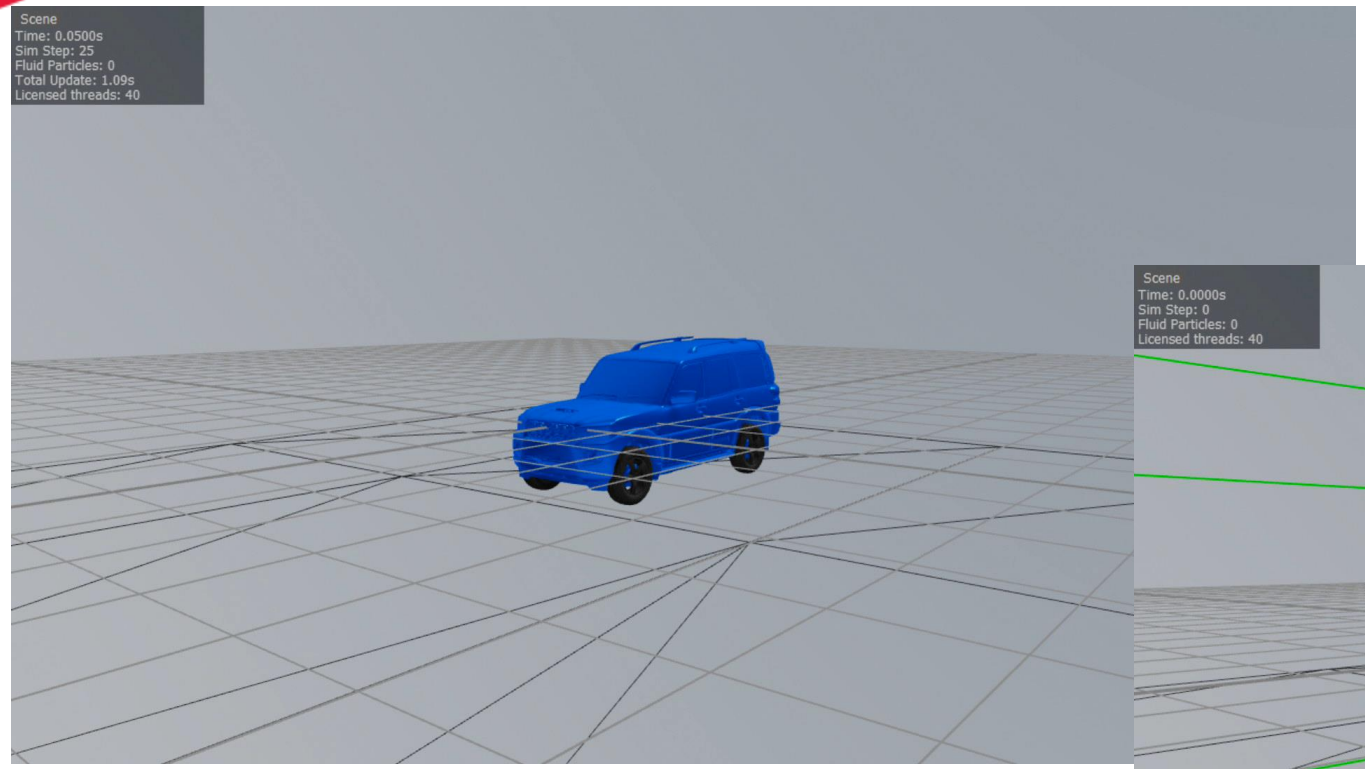

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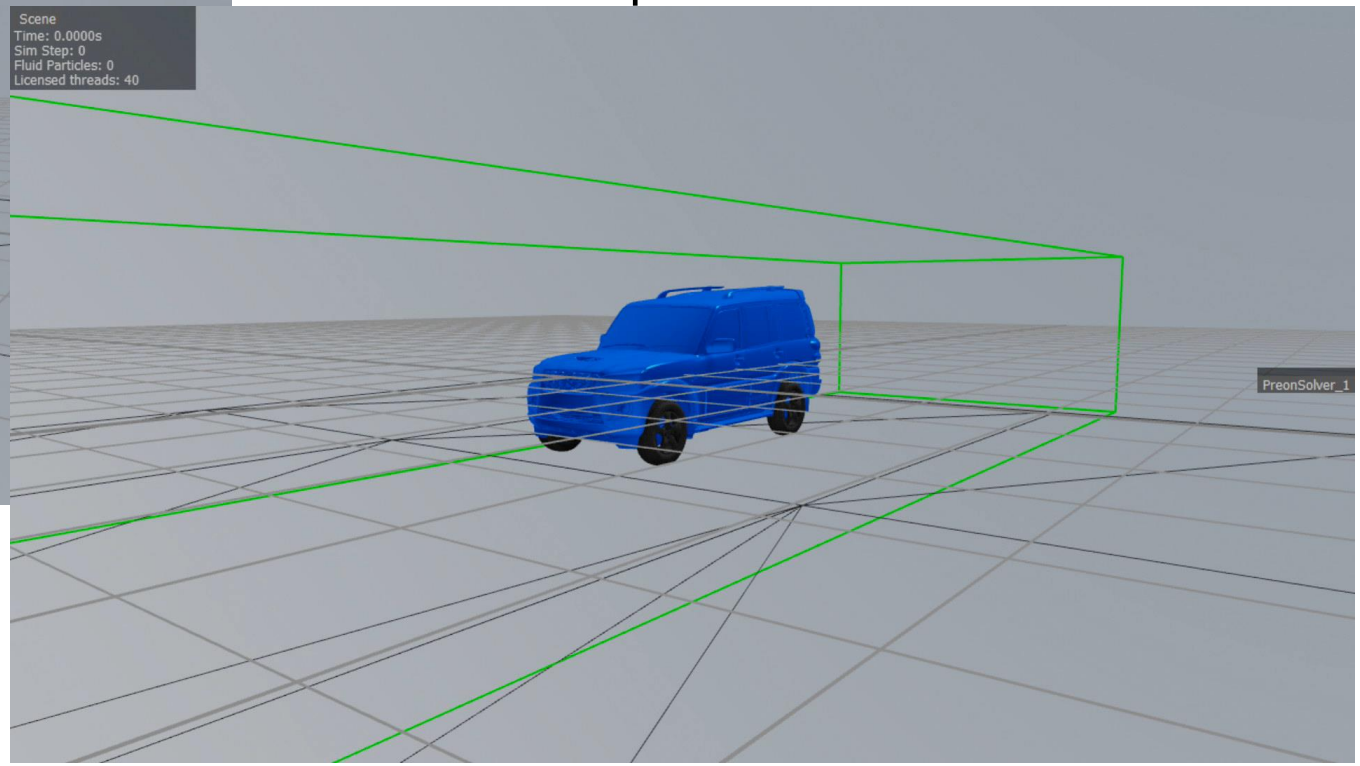
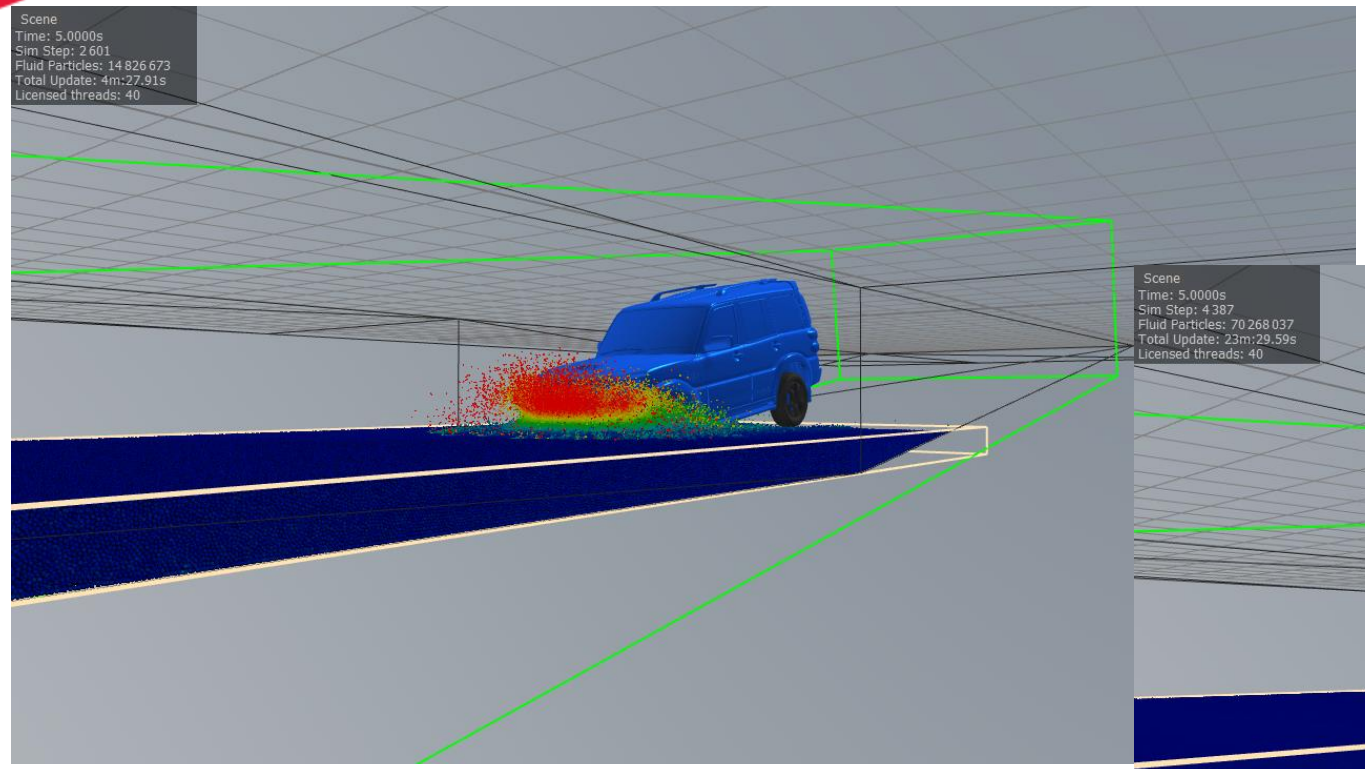


Water Wading – Resolution Dependence



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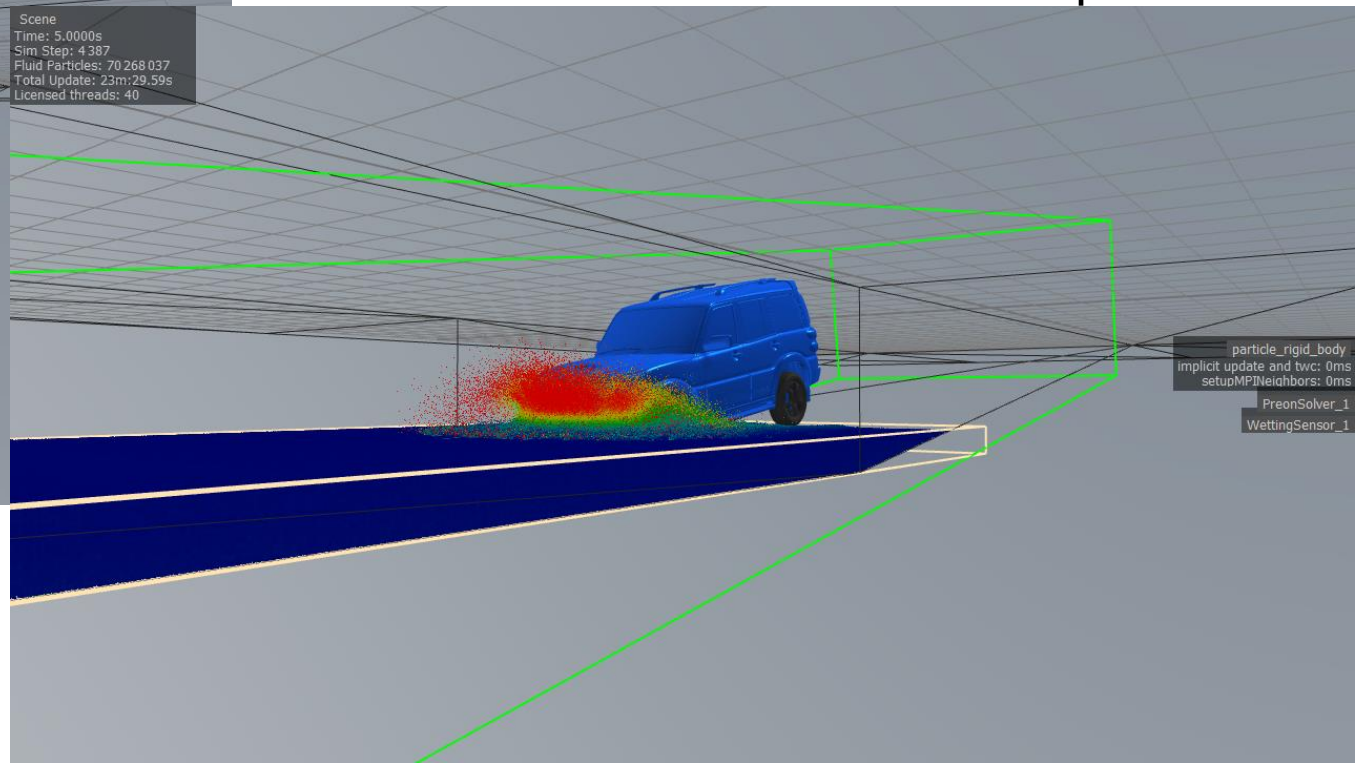

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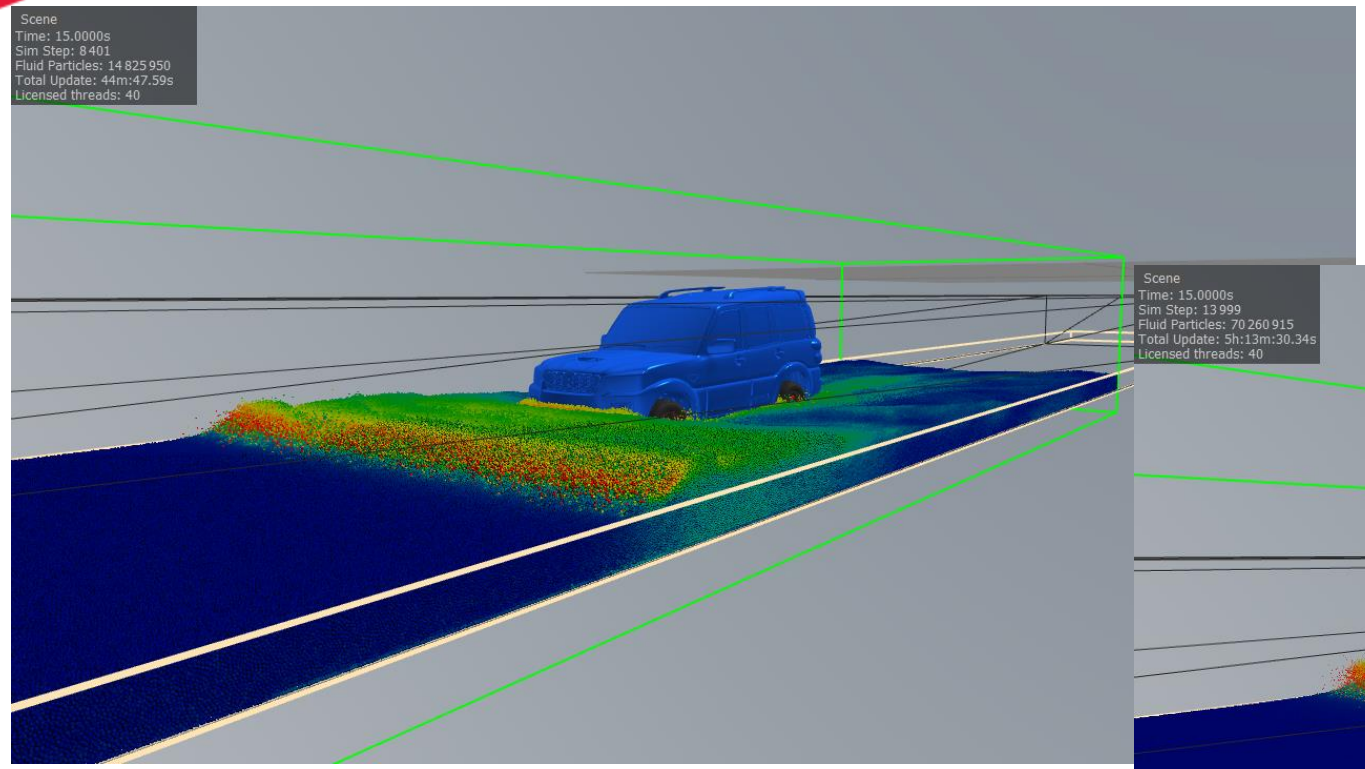

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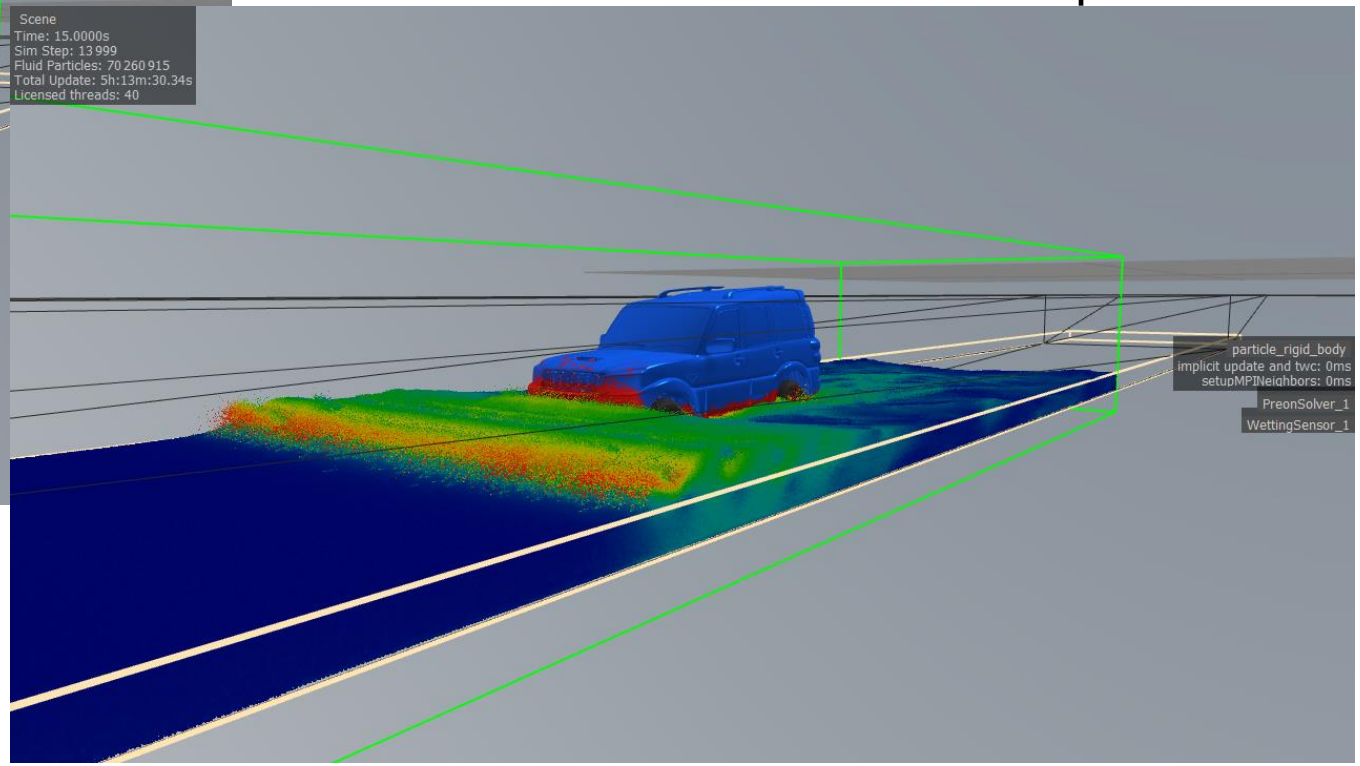

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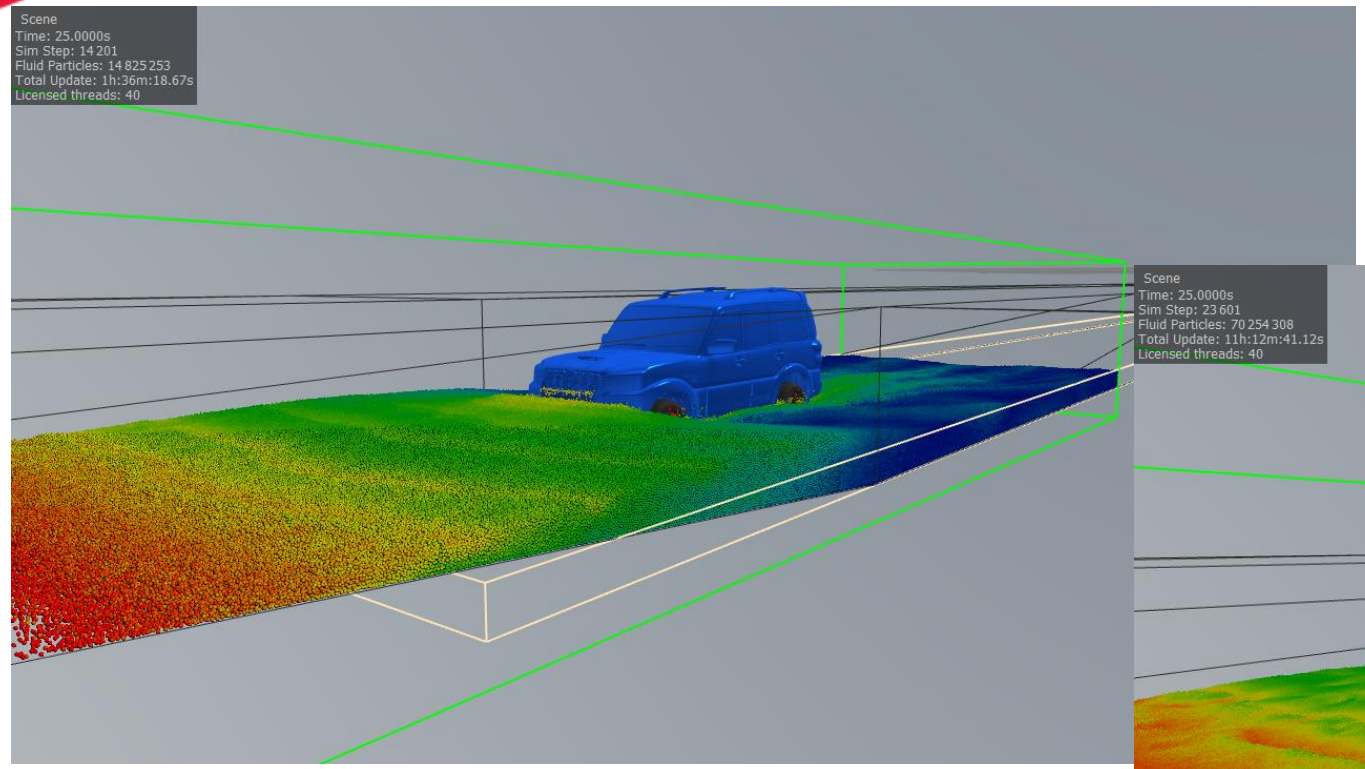

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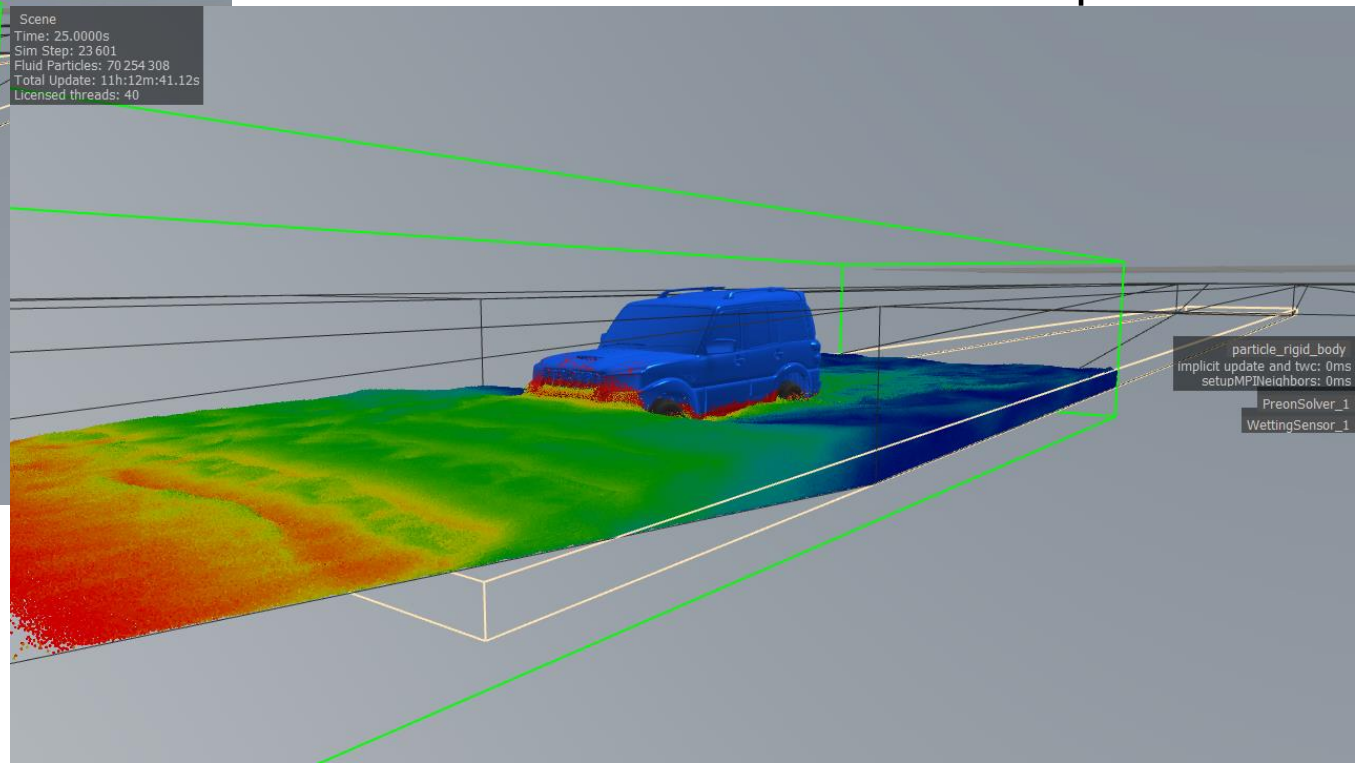

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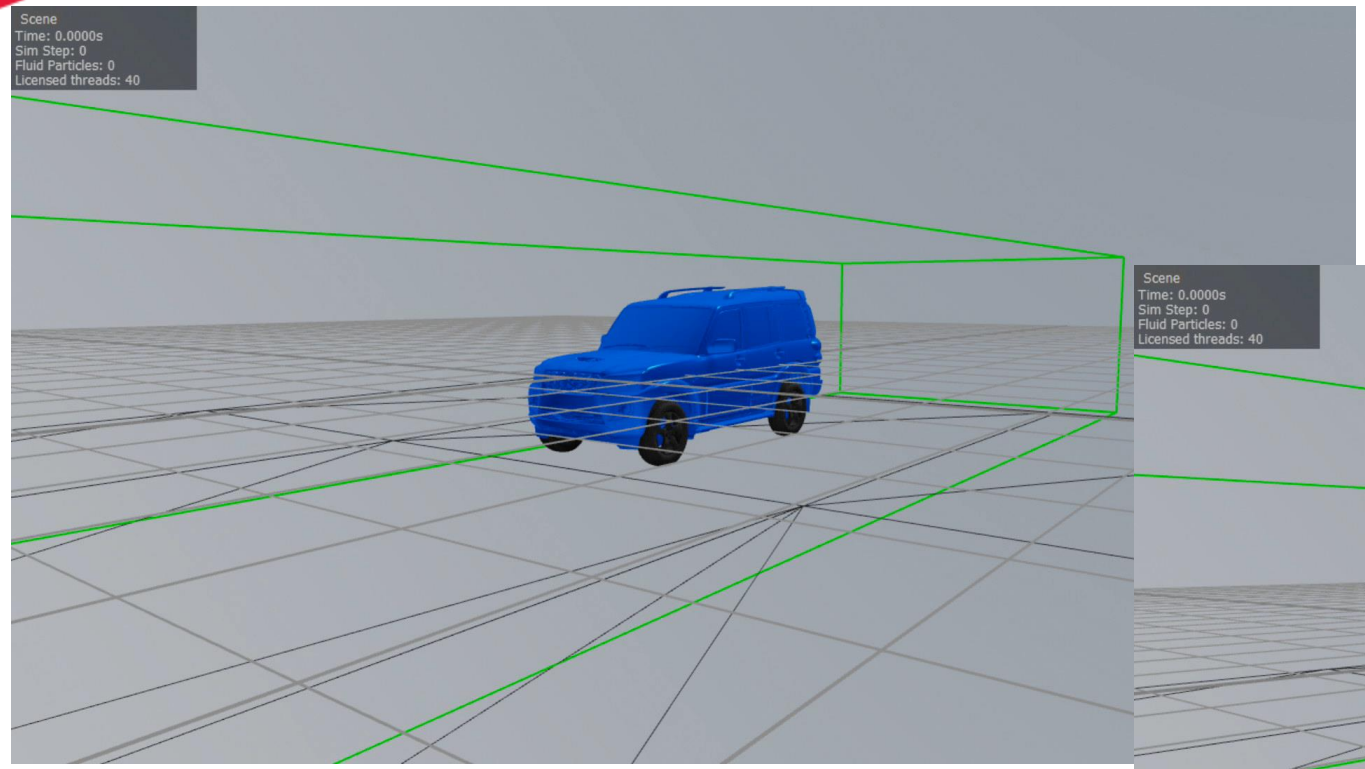

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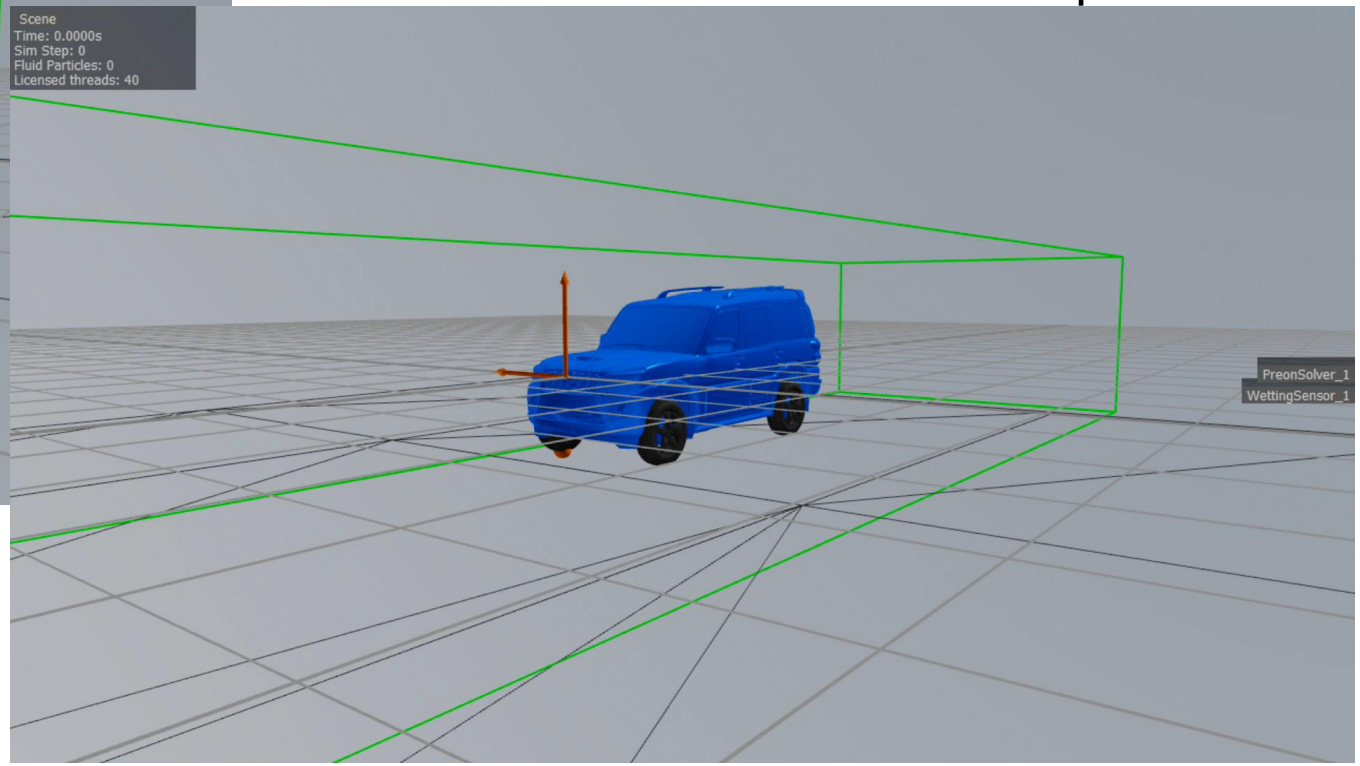

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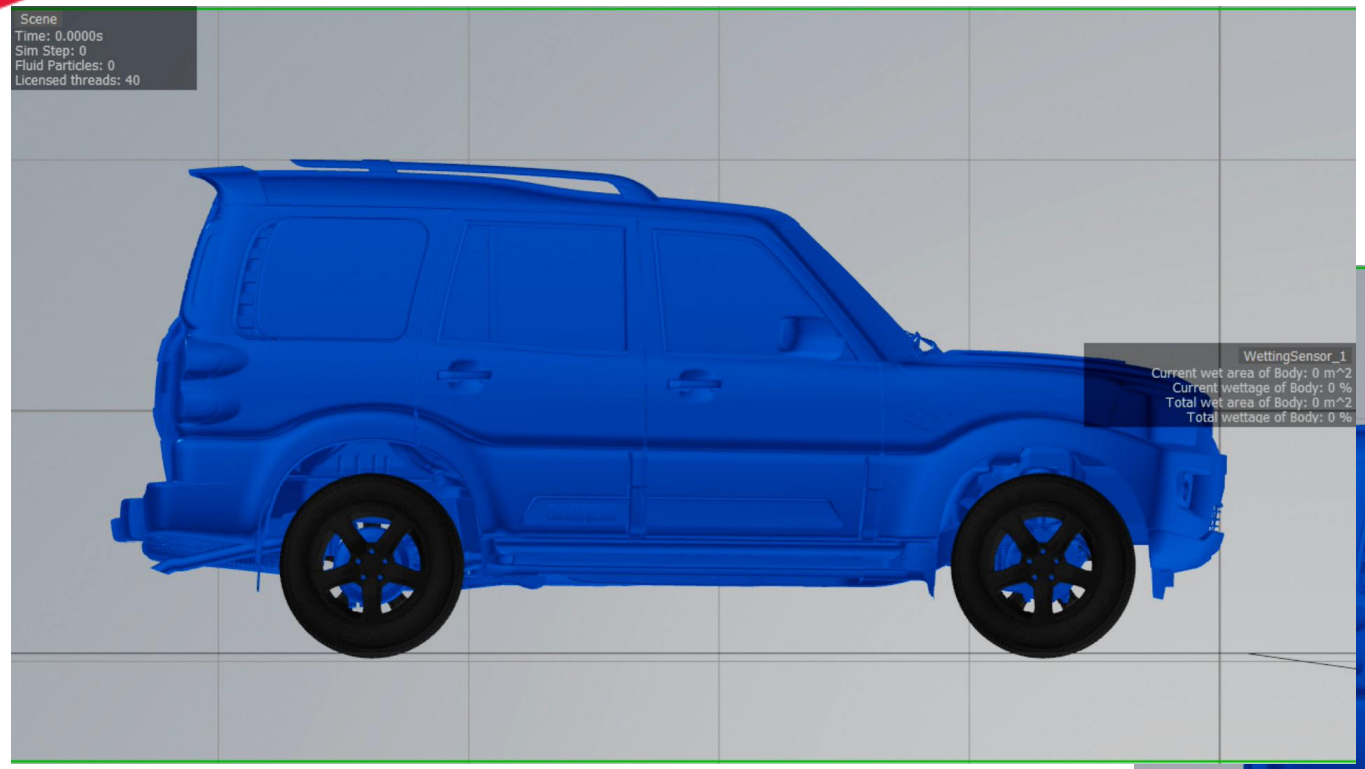

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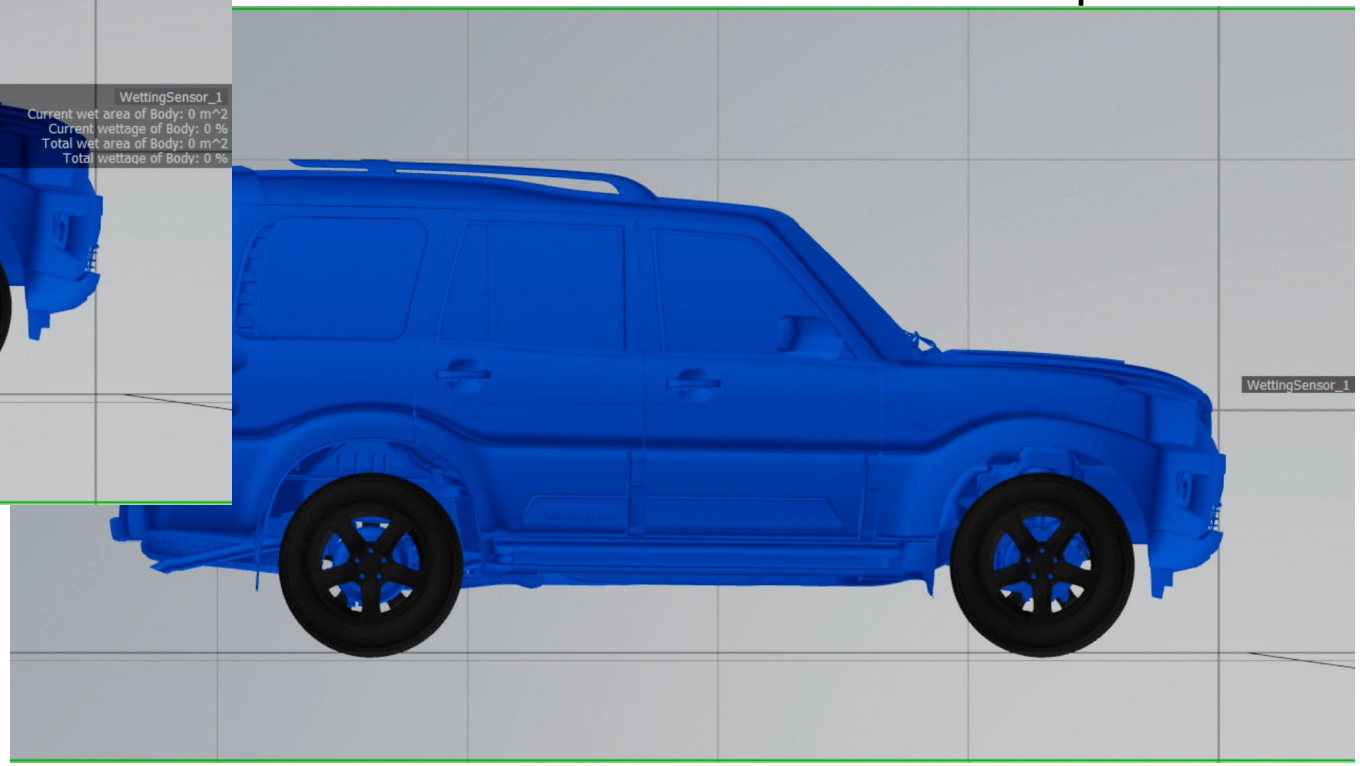
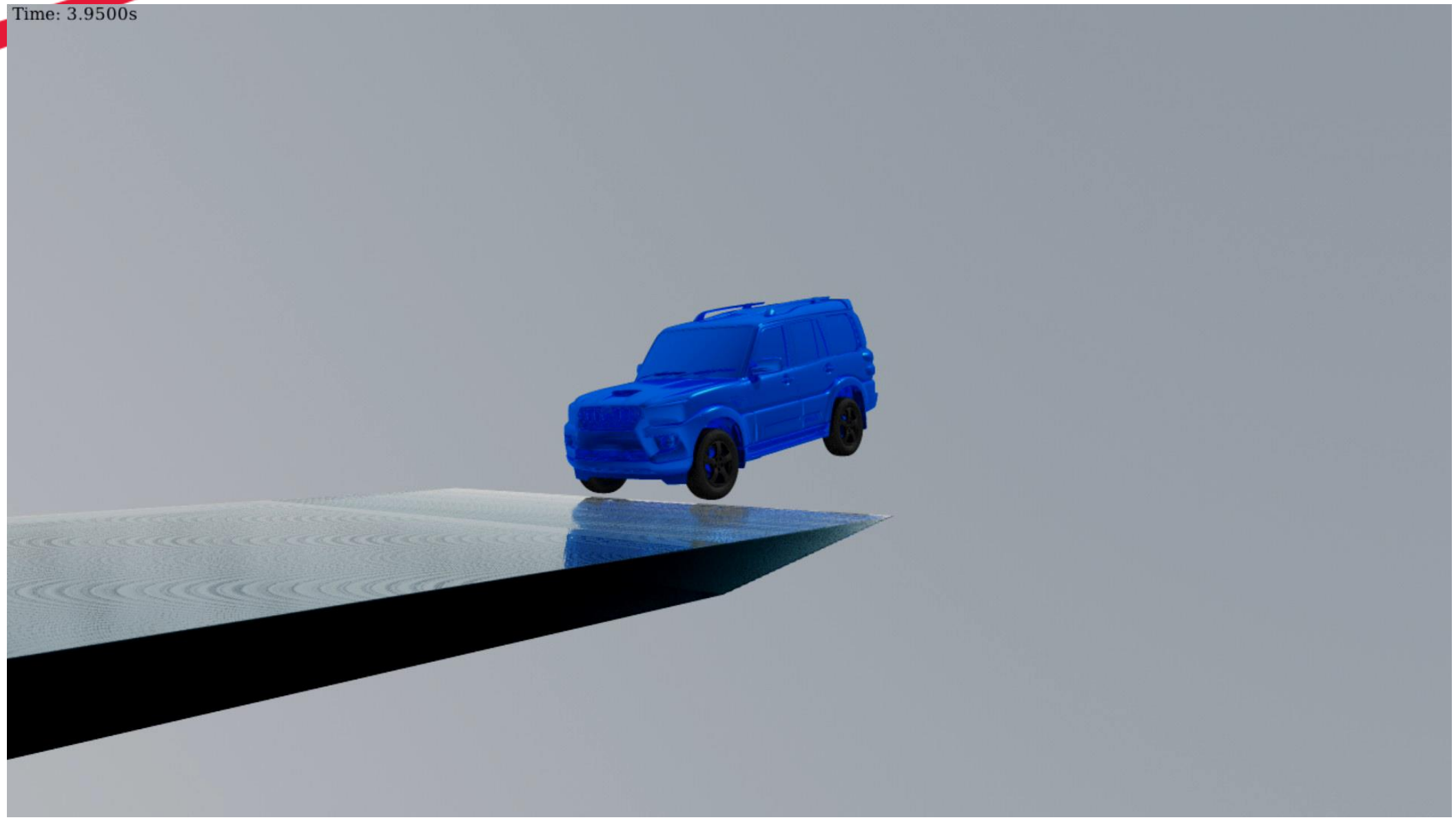


Water Wading – Final Render



Summary & Conclusions

- Mahindra Automotive North America are now using PreonLab for both water wading and splash simulations in our standard development process
- The finer resolution for both wading and splash resolutions gave very similar water behaviour but better surface wetting fidelity, so will be the best practice for production simulations. We will also evaluate the new local refinement feature
- Further work to optimize the size of the box domain will take place, to balance improved capture of flow features with increase in run time
- Both porous solids (to represent heat exchangers) and suspension will be used for all simulations in the future
- We will also evaluate the effect of an air flow force field on the splash simulations using data from our external aerodynamics CFD simulations
- Finally we are currently running physical tests on a vehicle we couldn't show, so will soon have correlation data to confirm the accuracy of the predictions

Thank you…