POINTWISE®
THE CHOICE FOR CFD MESHING

CAD-Based Design Optimization of a Race Car Front Wing

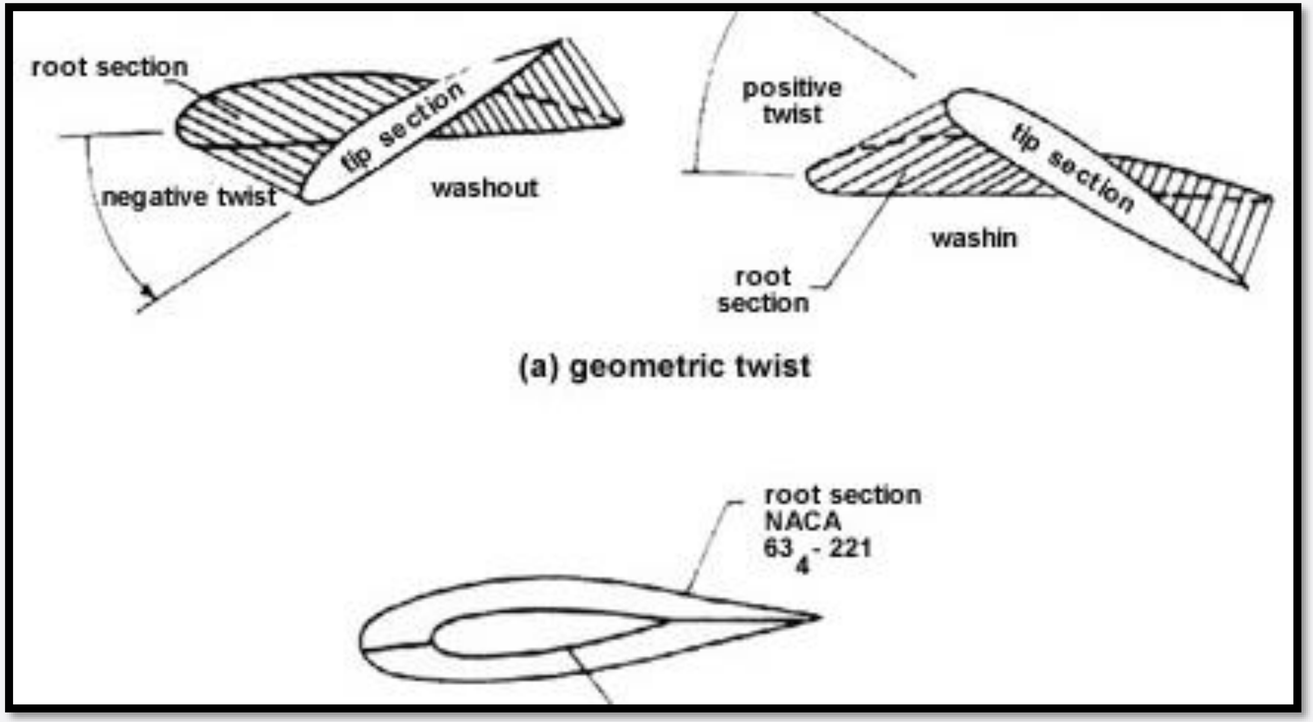
PHOENIX® INTEGRATION

No consensus in Formula 1 on a good front wing design

- Aerodynamics are critical to the performance
- The front wing is responsible for about a third of the downforce of the car
- Complex designs but no consensus
- Optimal design has not yet been identified!

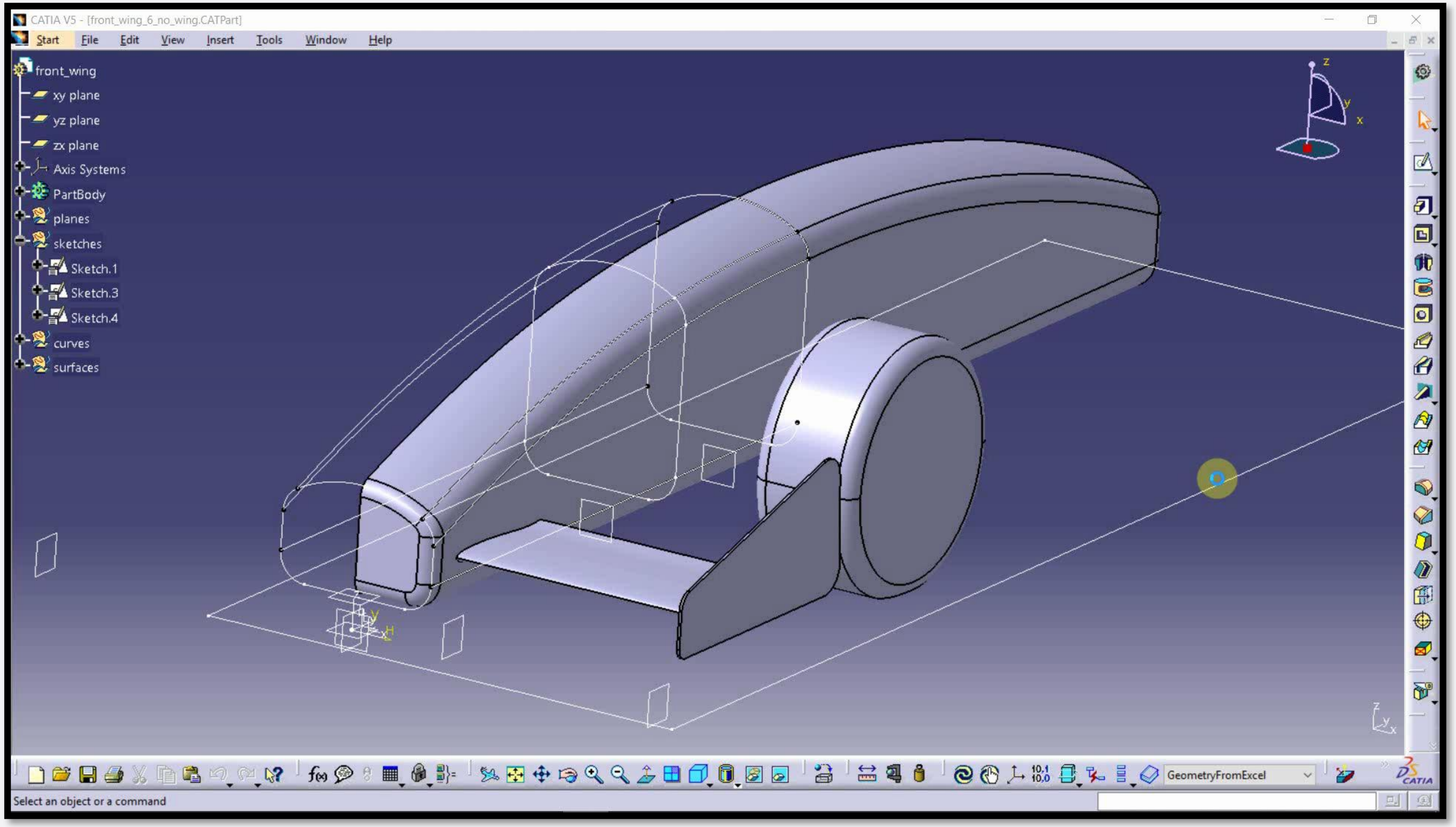
Simplifying the design problem

- Wing twist is a variable with great impact on performance
- Can be used to control which part of the wing generates downforce
- Enables answering a fundamental question about the design of a front wing - Is it better to have a larger angle of attack at the root or tip?
- Let's find out using ModelCenter®!



Virtual test rig

- Simplified Formula 1 Car with a two-section front wing
- Only elements sufficient to model the effect of twist are included
- Root and tip angles of attack of the rear section are exposed as variables

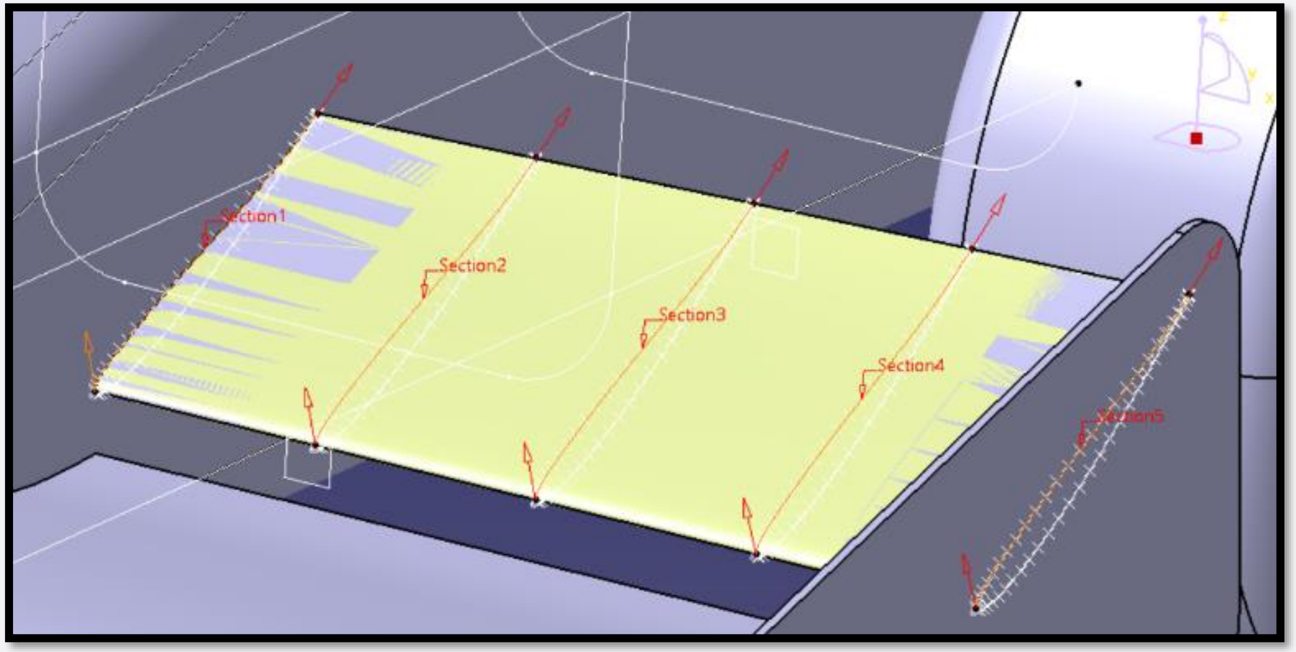


PHOENIX INTEGRATION

POINTWISE

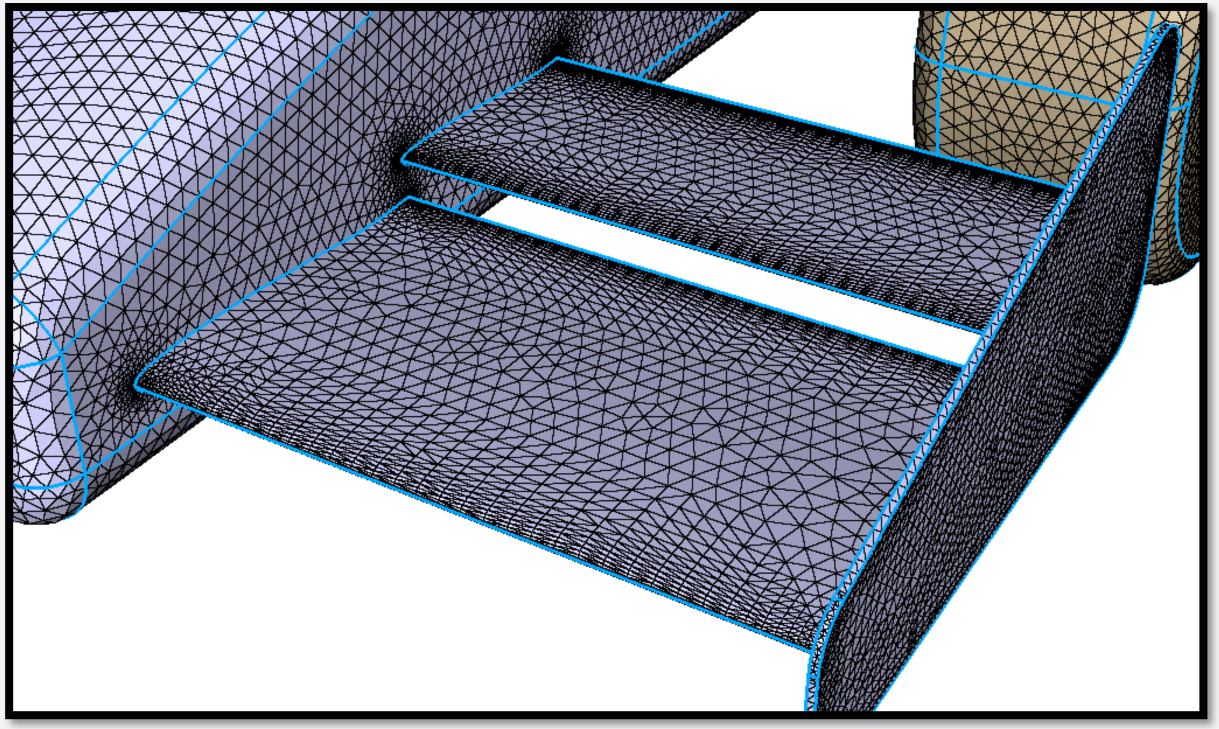
Generic method for lofting a 3d shape

- Cross section data is specified in Excel®
- A macro lofts the cross sections in Catia®
- Can be re-used for any 3d shape that can be specified as a set of cross sections



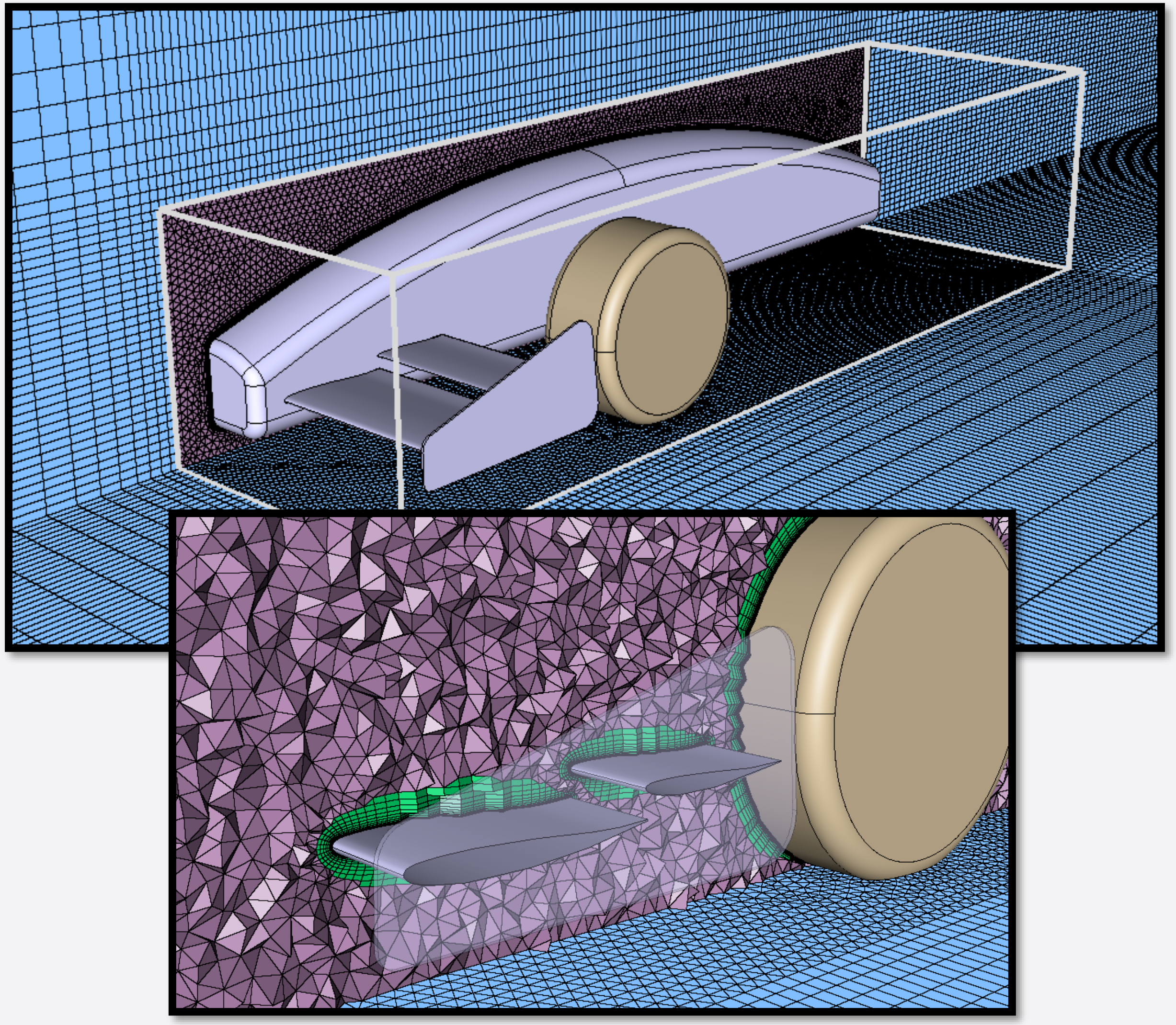
Mesh Generation: Anisotropic Surface Meshing

- Pointwise® used to generate surface and volume meshes
- Boundary-conforming, advancing front surface mesh consisting of all triangular elements
- Anisotropically stretched, right-angled triangular elements used to accurately resolve areas of high curvature



Mesh Generation: Hybrid Viscous Volume Meshing

- Vehicle isolated in a hybrid prism-tet region to minimize mesh-solution variability during optimization
- Static farfield consisted of all hexahedral elements
- Anisotropic tetrahedral extrusion (T-Rex) algorithm used to automatically generate prismatic boundary layer region and transition to an isotropic tetrahedral core

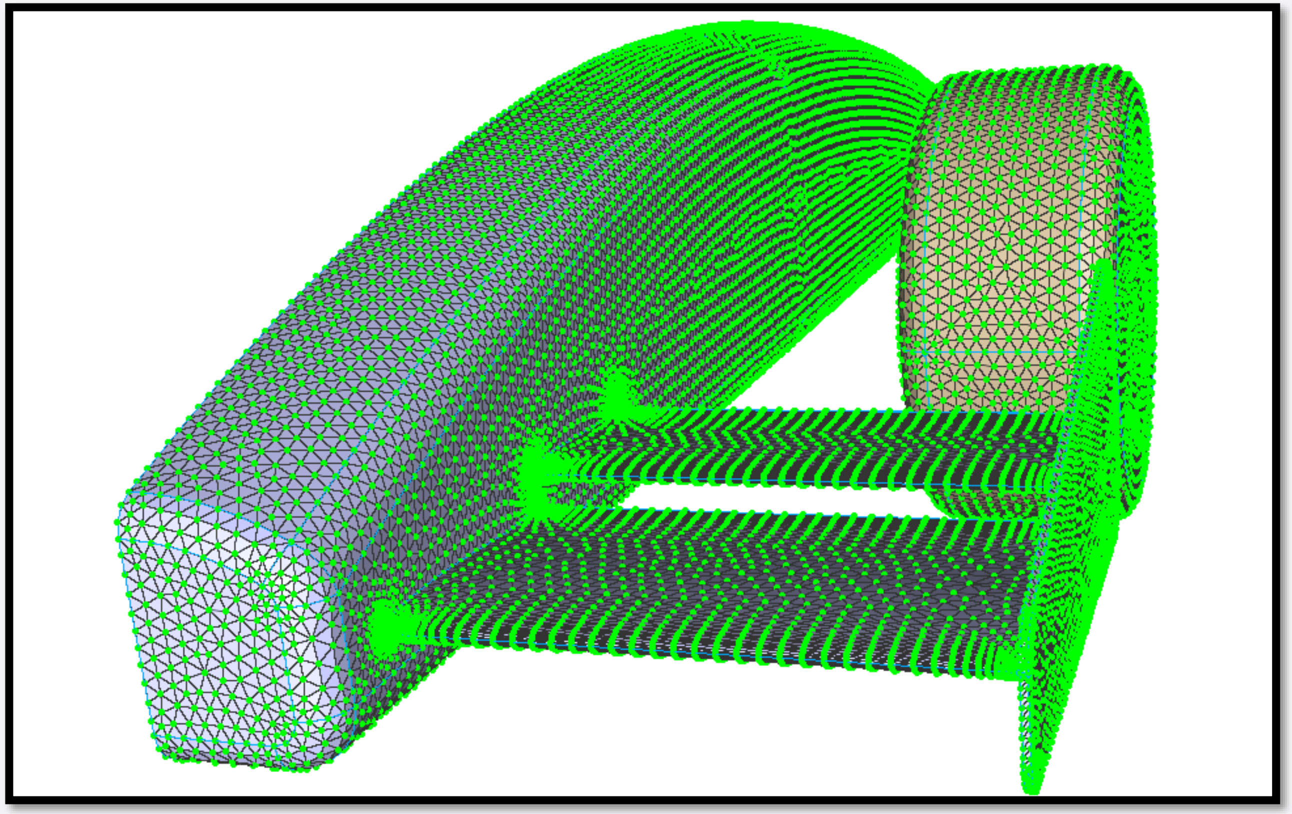


PHOENIX INTEGRATION

POINTWISE

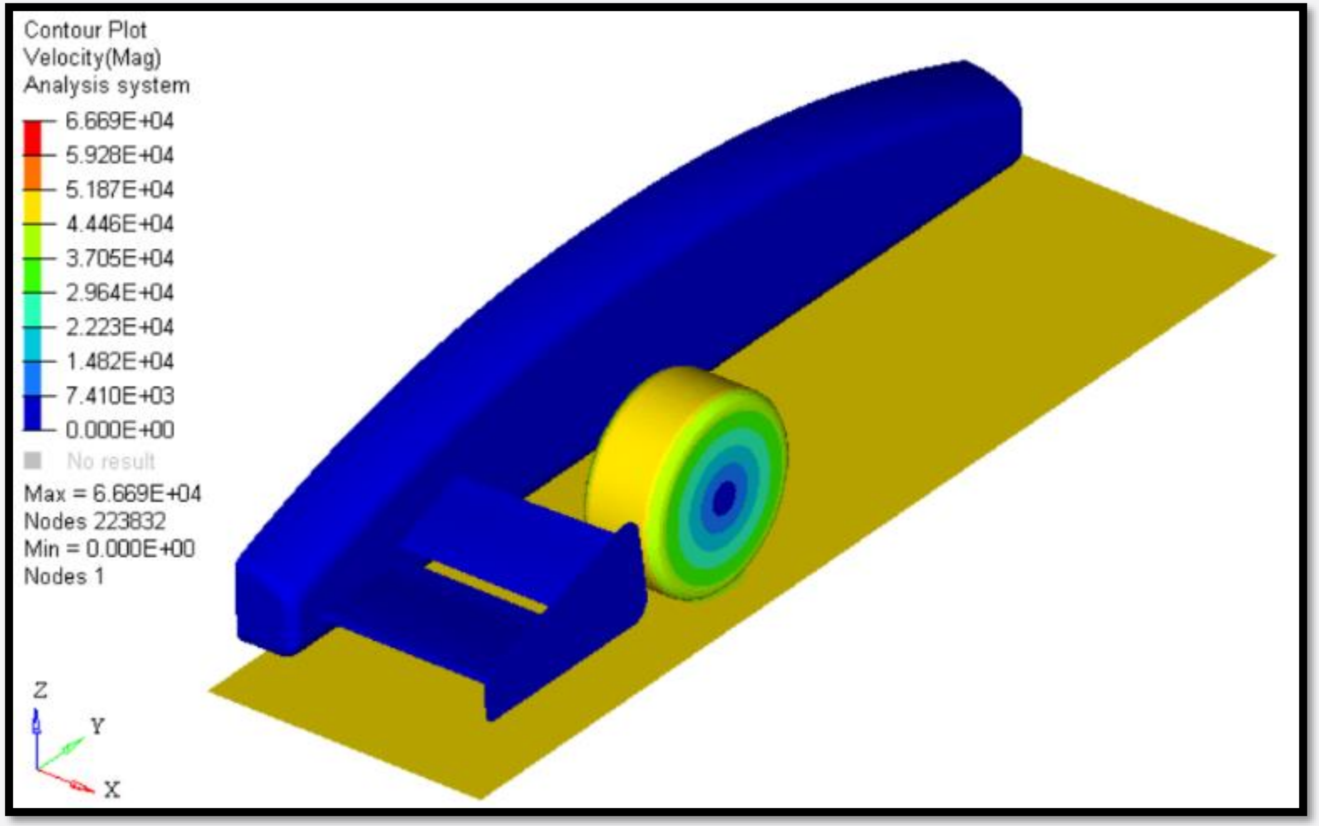
Mesh Generation: Automated Remeshing

- Analytic geometry (NURBS) and surface mesh share identical topologies
- UV parameter mapping of baseline mesh to geometry
- Pointwise's Glyph scripting language used geometry and mesh associativity to automate remeshing for each design iteration



CFD setup

- Evaluated at 100 mpg
- Moving floor and spinning wheel
- Computed using AcuSolve®
- 6-8 hours computation time on a high spec laptop

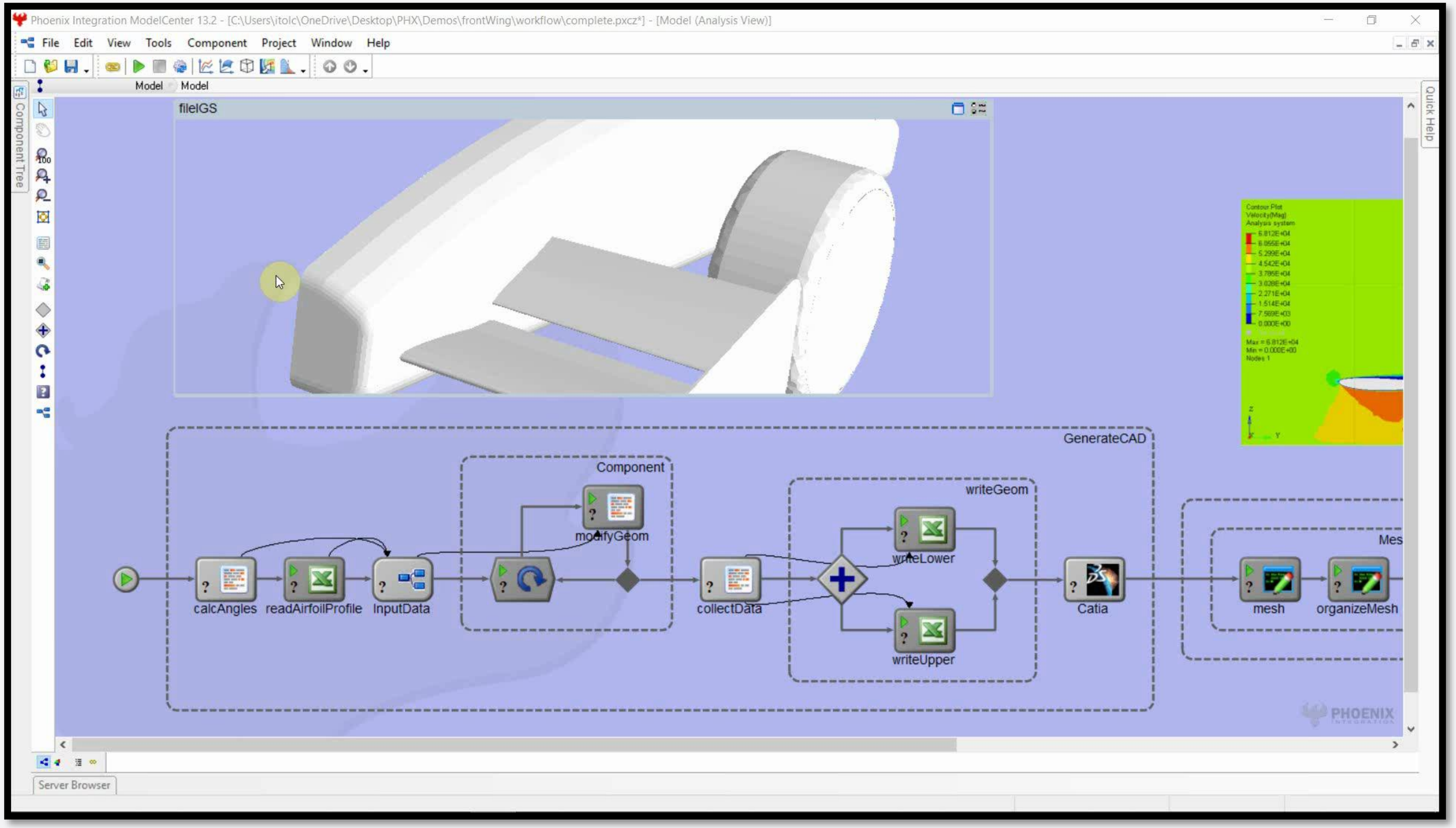


PHOENIX INTEGRATION

POINTWISE

Integrated Workflow

- All the tools are integrated into a fully automated workflow using ModelCenter®
- Enables design exploration
  - Trade studies
  - Optimization

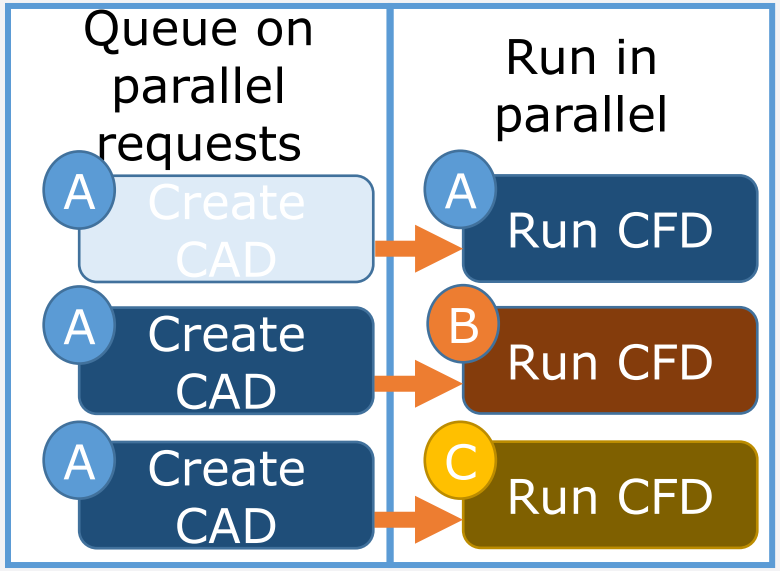


PHOENIX INTEGRATION

POINTWISE®

Distributed Execution

- Studies were performed on an adhoc cluster using available laptops
- Only one Catia® license required waiting for concurrent requests

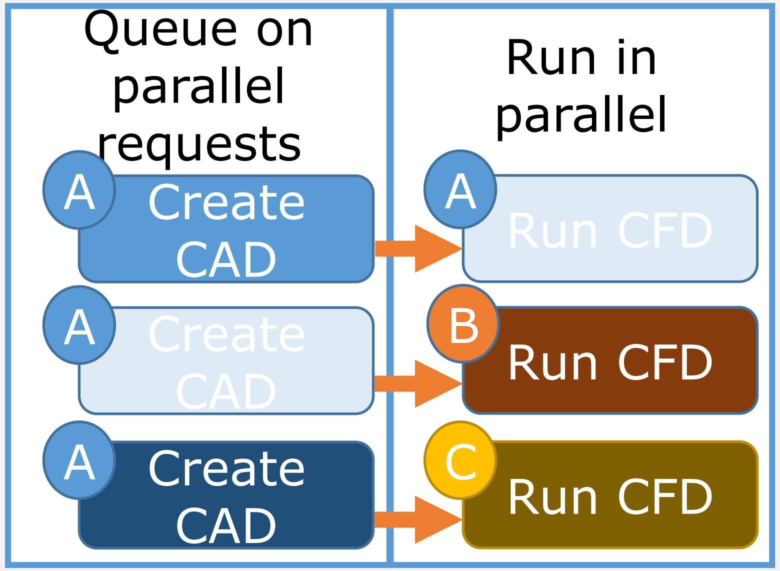


PHOENIX INTEGRATION

POINTWISE®

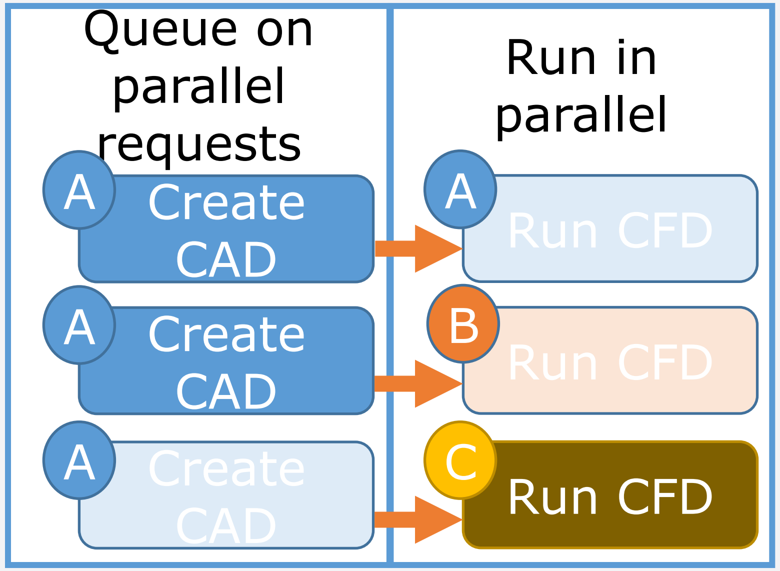
Distributed Execution

- Studies were performed on an adhoc cluster using available laptops
- Only one Catia® license required waiting for concurrent requests



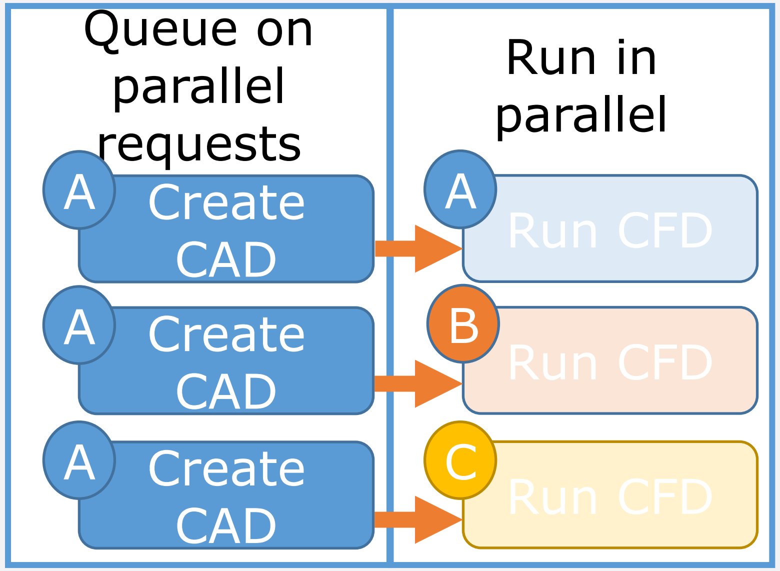
Distributed Execution

- Studies were performed on an adhoc cluster using available laptops
- Only one Catia® license required waiting for concurrent requests



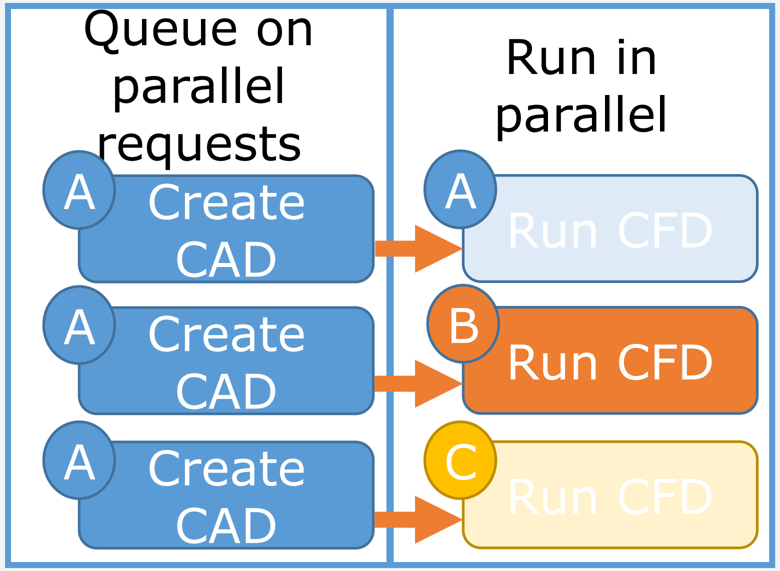
Distributed Execution

- Studies were performed on an adhoc cluster using available laptops
- Only one Catia® license required waiting for concurrent requests



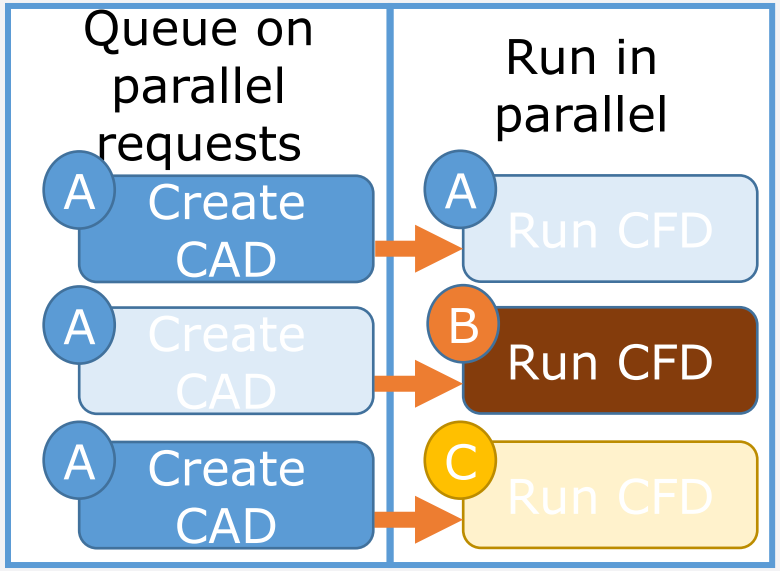
Distributed Execution

- Studies were performed on an adhoc cluster using available laptops
- Only one Catia® license required waiting for concurrent requests



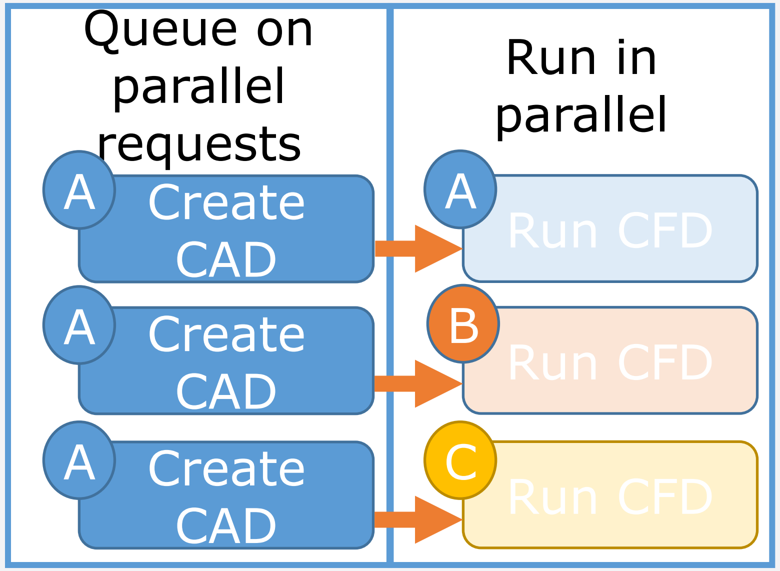
Distributed Execution

- Studies were performed on an adhoc cluster using available laptops
- Only one Catia® license required waiting for concurrent requests



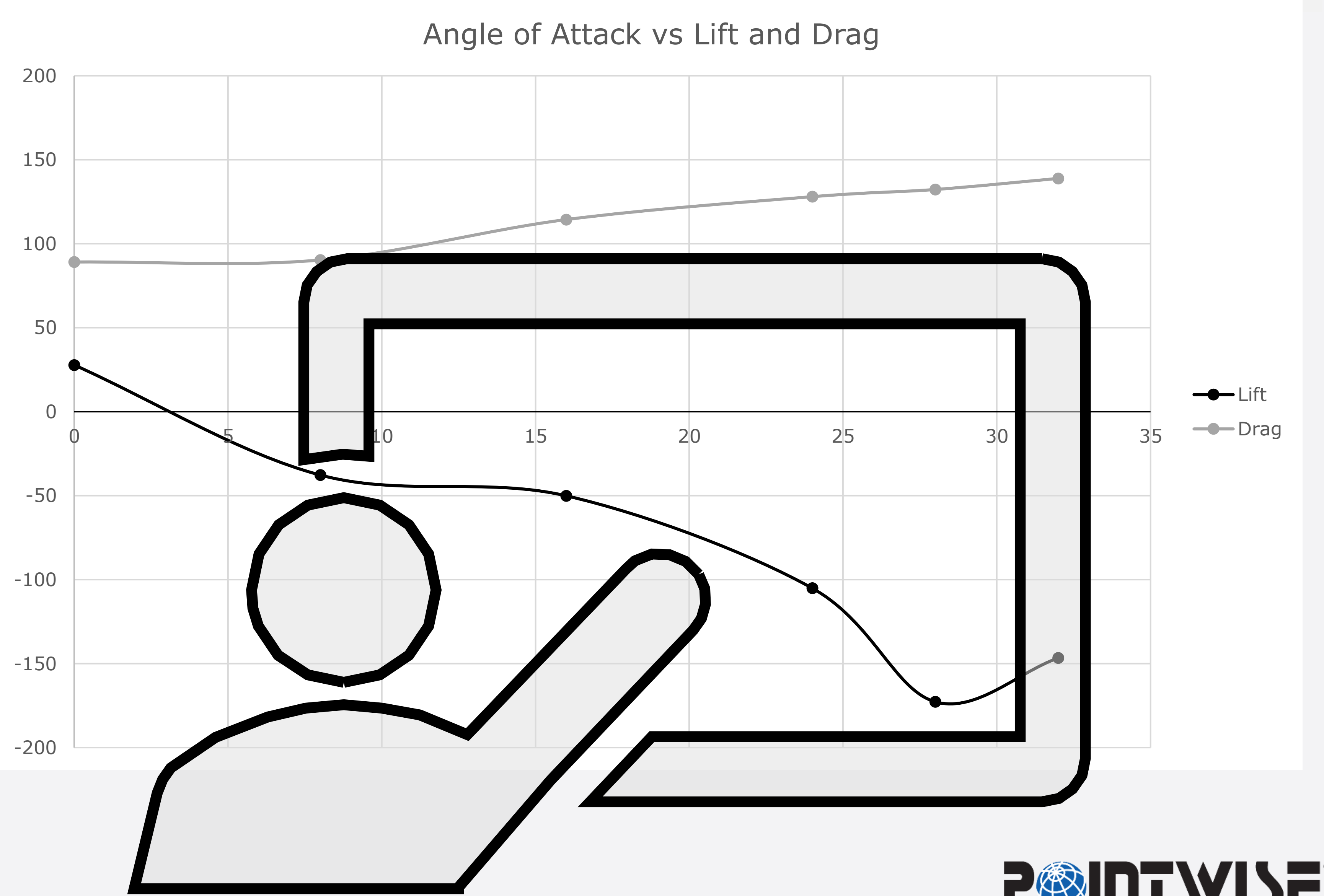
Distributed Execution

- Studies were performed on an adhoc cluster using available laptops
- Only one Catia® license required waiting for concurrent requests



Identifying a region of interest

- Initial parametric study varied the angle of attack on an untwisted wing
- A region of interest was identified and used to define the bounds for the next study

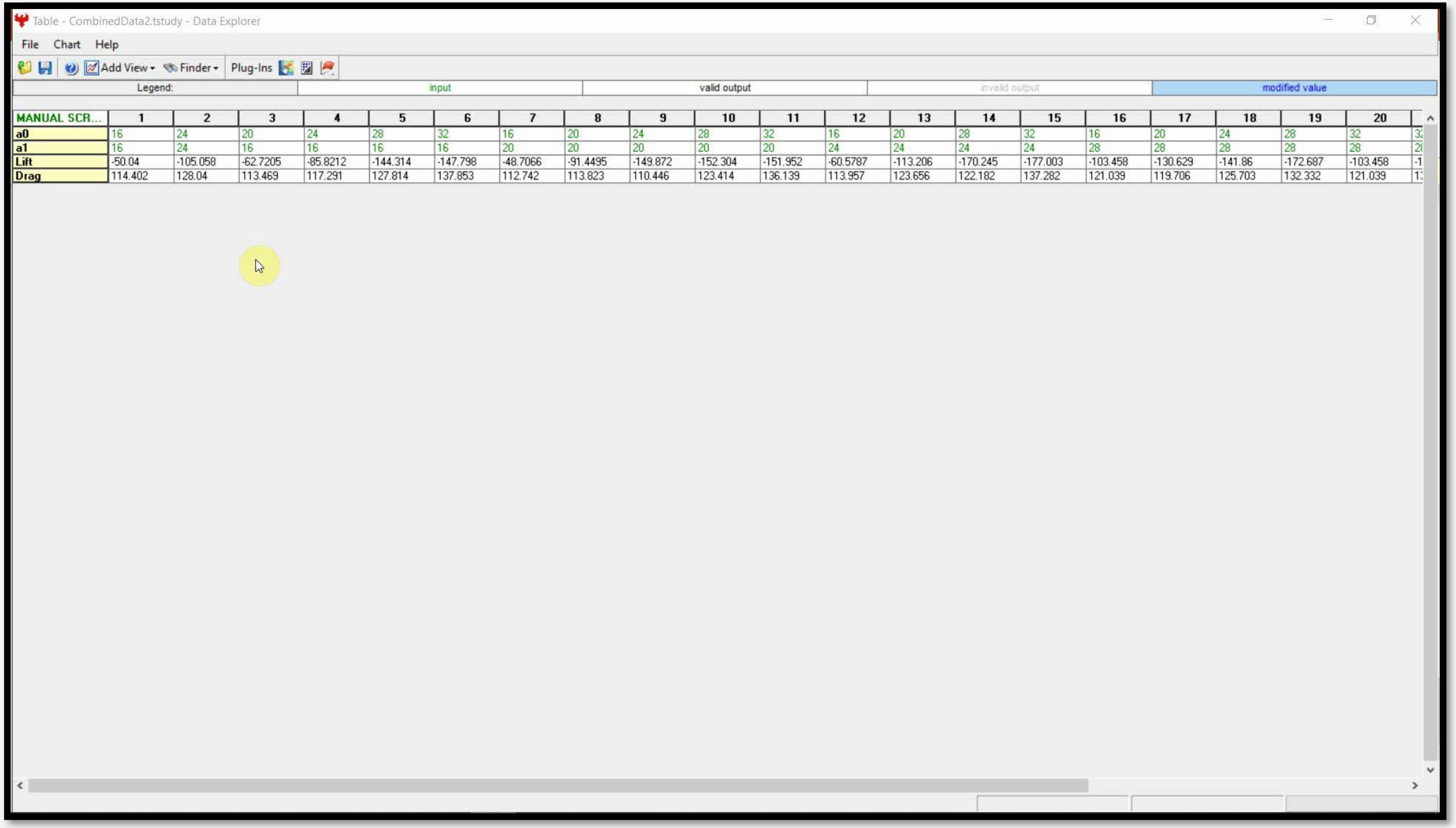


PHOENIX INTEGRATION

POINTWISE

Understanding the results

- ModelCenter® was used to visualize the results



MANUAL SCR...	1	2	3	4	5	6	7	8	9	10
a0	16	24	20	24	28	32	16	20	24	28
a1	16	24	16	16	16	16	20	20	20	20
Lift	-50.04	-105.058	-62.7205	-85.8212	-144.314	-147.798	-48.7066	-91.4495	-149.872	-152.304
Drag	114.402	128.04	113.469	117.291	127.814	137.853	112.742	113.823	110.446	123.414

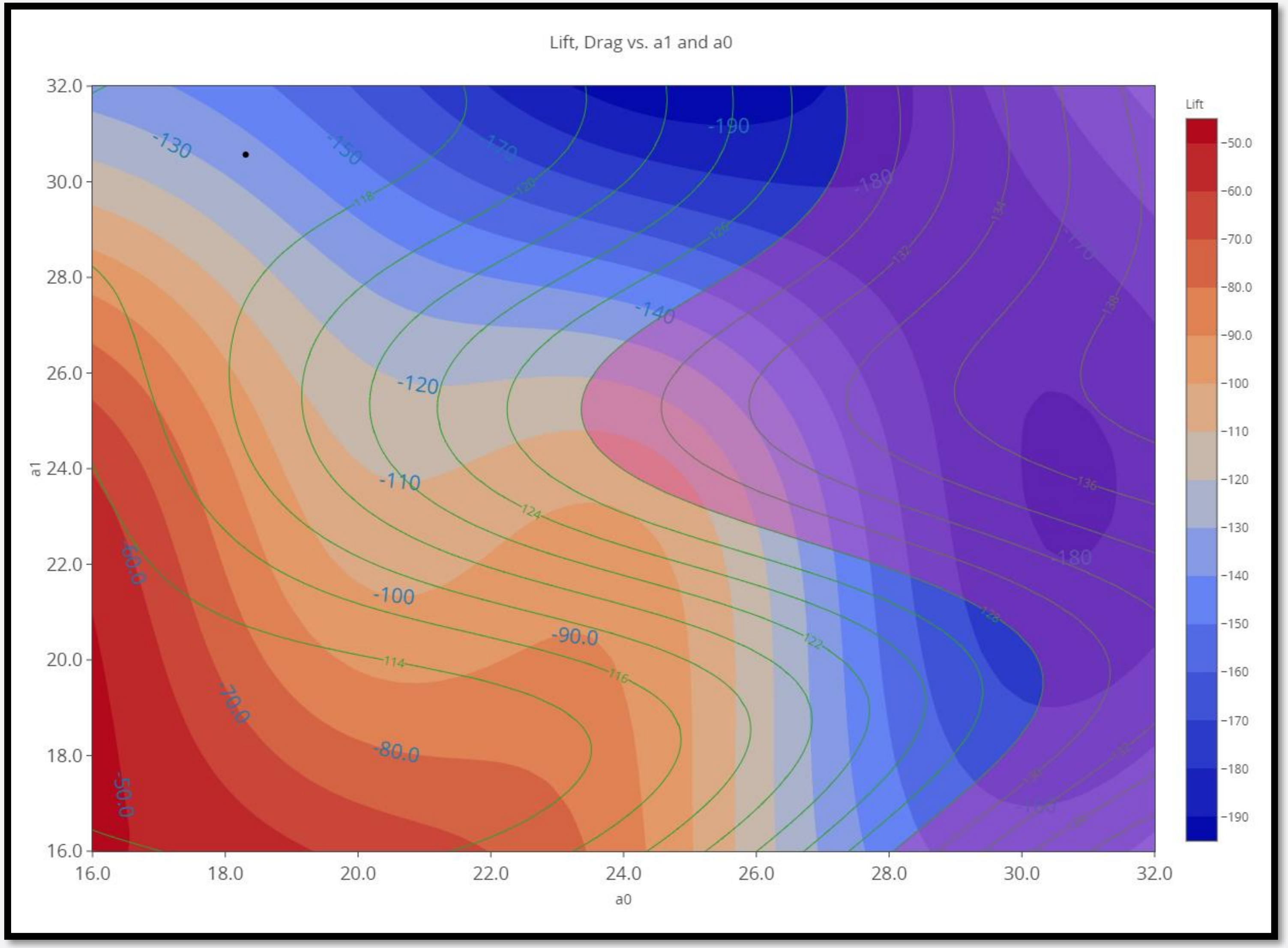
MANUAL SCR...	11	12	13	14	15	16	17	18	19	20
a0	32	16	20	28	32	16	20	24	28	32
a1	20	24	24	24	24	28	28	28	28	28
Lift	-151.952	-60.5787	-113.206	-170.245	-177.003	-103.458	-130.629	-141.86	-172.687	-103.458
Drag	136.139	113.957	123.656	122.182	137.282	121.039	119.706	125.703	132.332	121.039

PHOENIX® INTEGRATION

POINTWISE®

Understanding the results

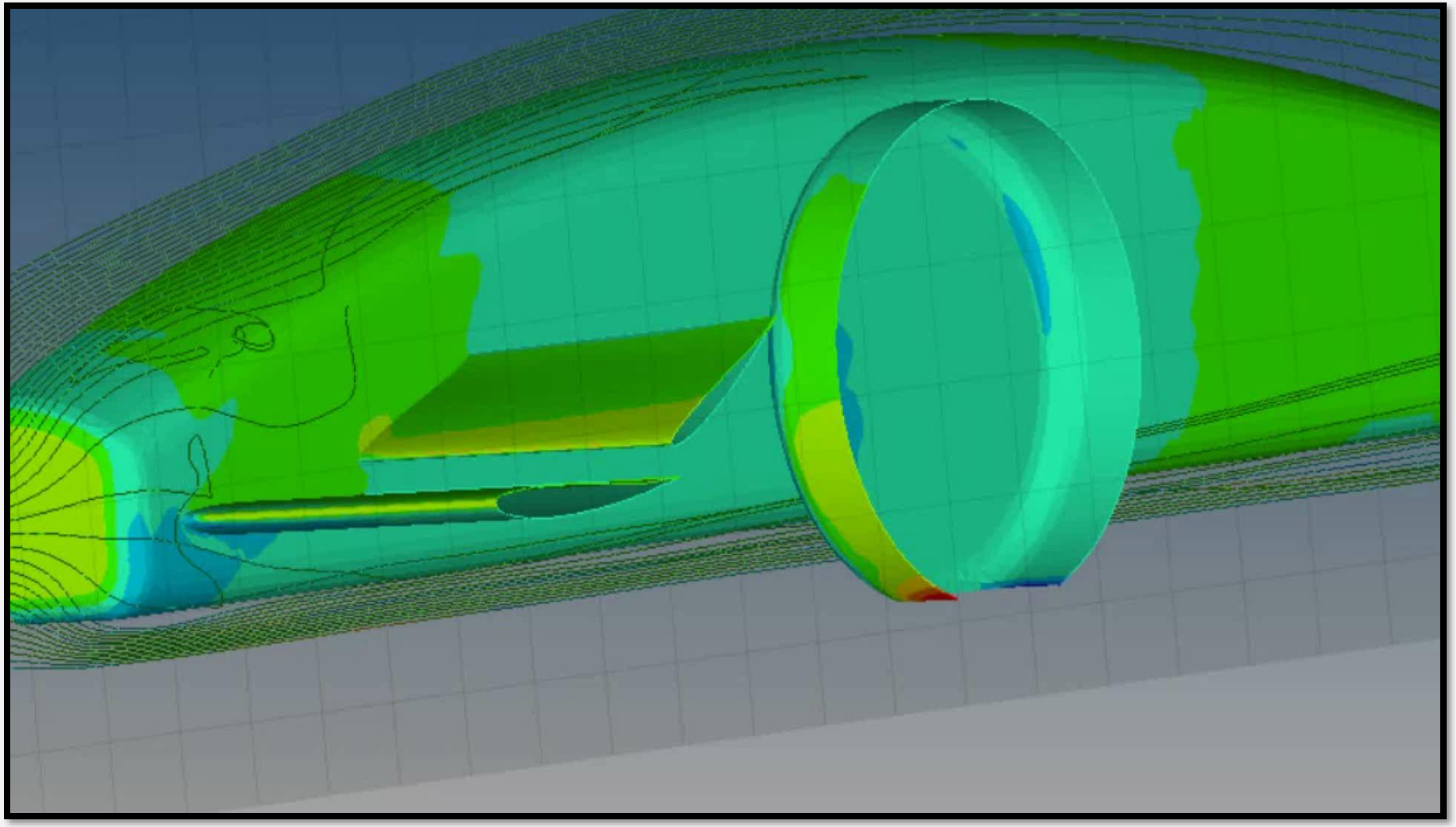
- Trade study shows higher values of downforce are generated with a higher angle of attack at the tip of the wing



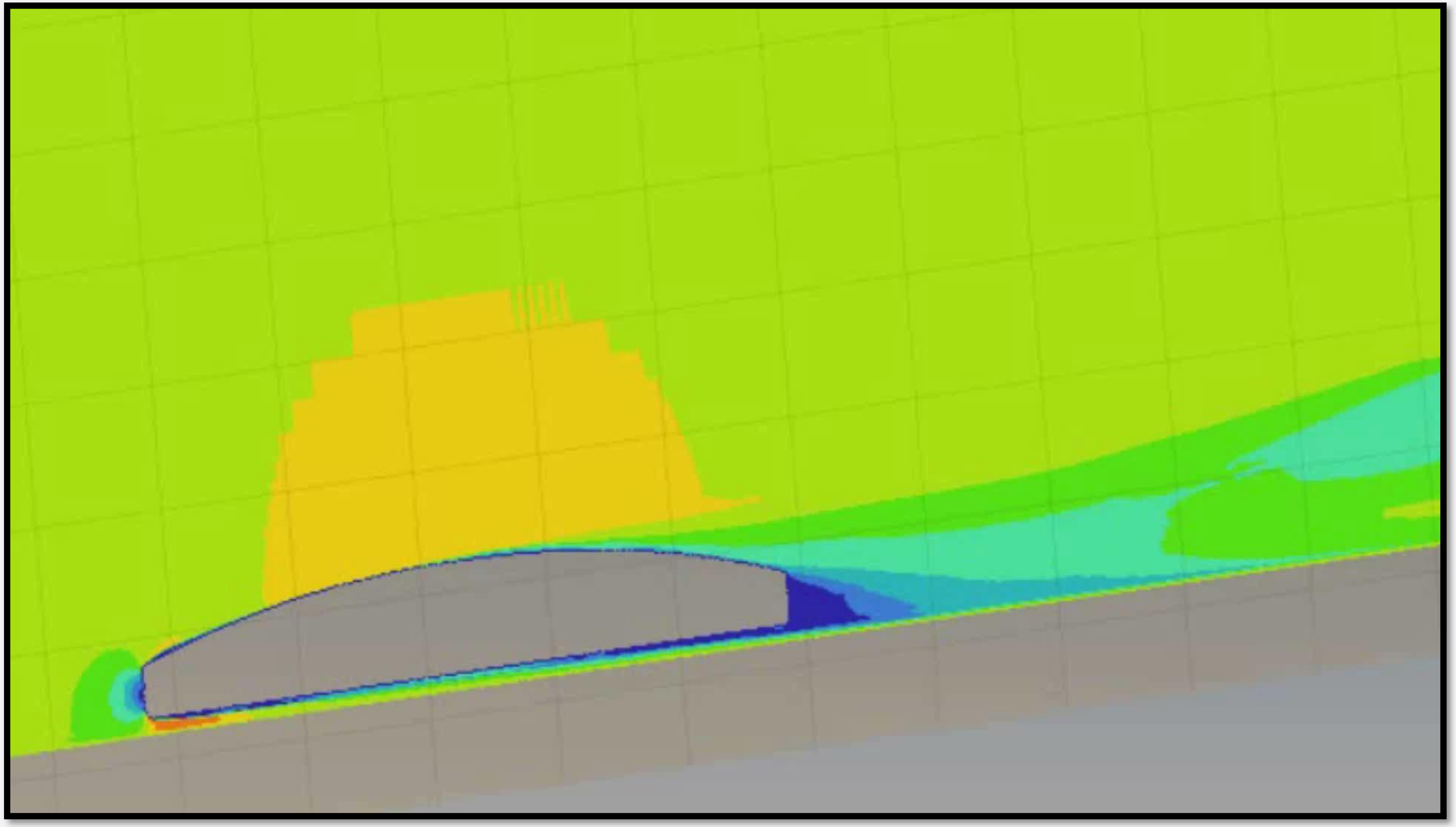
PHOENIX INTEGRATION

POINTWISE

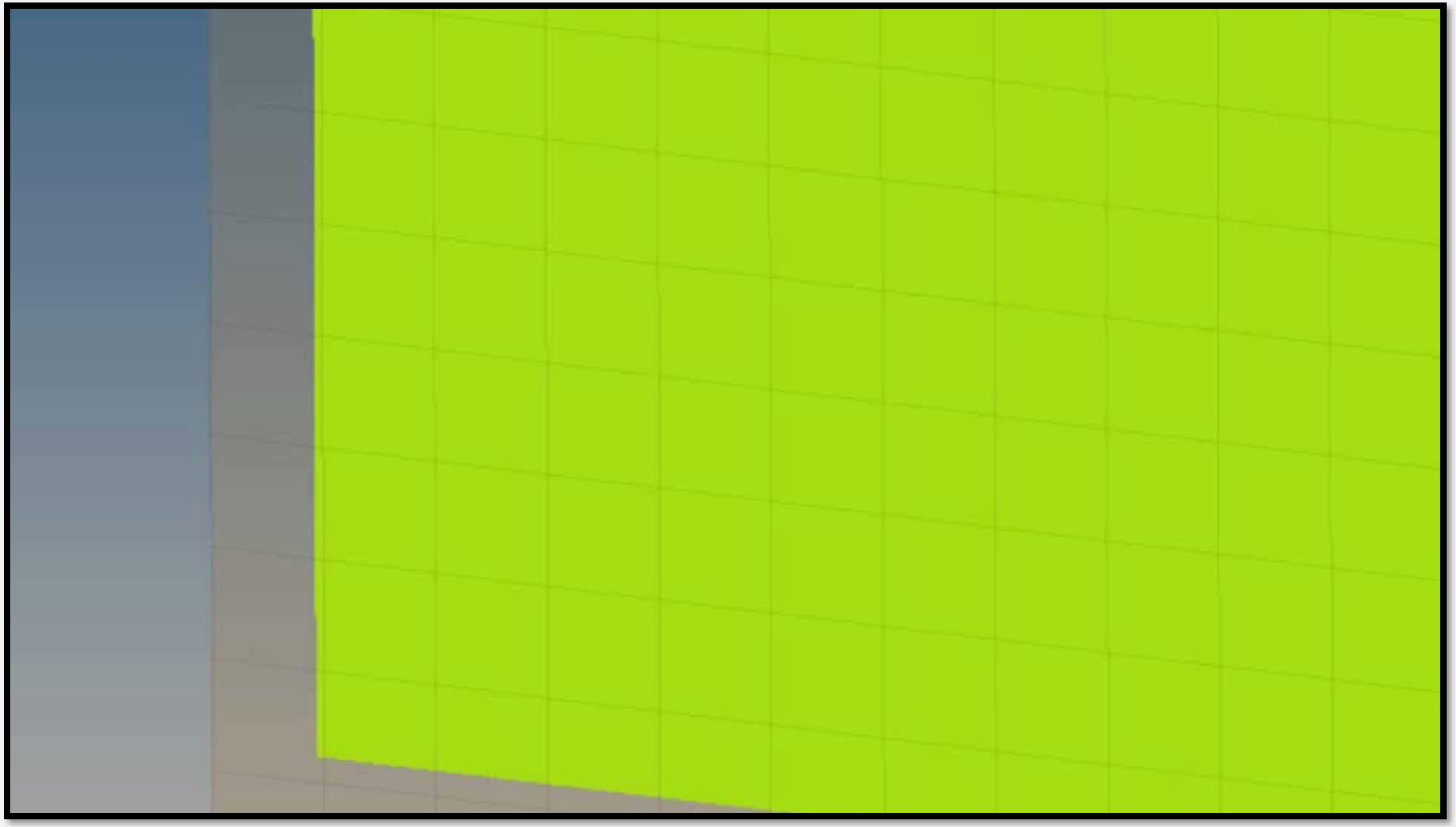
Streamlines from best design



Velocity profile from best design



Velocity profile from best design



Next Steps

- Continue with more complex geometry
- Consider the effects of the aerodynamics of the whole car
- Integrate with other engineering disciplines
  - Structures
  - Propulsion
  - Dynamics