

e=MSC^x

ENGINEERING. EDUCATION. ENTERPRISE.
2009 VPD
VIRTUAL
PRODUCT
DEVELOPMENT
CONFERENCE

“Integrating MSC’s CAx Tools Into a Senior Capstone Design Curriculum”

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Integration of MSC's CAx tools Into a Senior Capstone Design Curriculum

- Current Curriculum Integration
- Existing Tools and Resources
- Recommendations
- Current Applications on BYU Campus
 - PACE F1 Global Collaboration Project
 - Structural Analysis using MSC Nastran
 - Motion Analysis using MSC ADAMS
 - Multi-Disciplinary Optimization of Stator Vane

Curriculum Integration

- Courses currently using CAx tools
 - ME 172 – “Engineering Graphics”
 - ME 282 – “Manufacturing Processes”
 - ME 372 – “Mechanical System Design Fundamentals”
 - ME 412 – “Applications of Fluid Dynamics”
 - ME 437 – “Kinematics”
 - ME 471 – “Computer-Aided Engineering Applications”

- Capstone
 - Taken Fall/Winter Senior year
 - Industry sponsored projects

Existing Tools and Resources

- PACE Tutorials

Piston-Pendulum

Constraints

If the new icon is difficult to see it can be helpful to change the icon size. (Pick an appropriate size using the Current Default as a basis of comparison.)
 > Settings > Icons

Enter a value in the box next to New Size.
 > OK

A revolute joint needs to be added to the pendulum.

From the Main Toolbox, MB3 the Joint tool stack and then MB1 the Revolute Joint tool.
 > Joint > Revolute Joint

Select 2 Bod-1 Loc and Normal to Grid.
 > 2 Bod-1 Loc > Normal to Grid

For the first body select block.
 For the second body select long_member.
 For the location select block.cm.

The revolute joint should now appear as shown in the picture to the right.



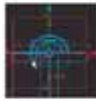

We will now add a revolute joint between the long member and the sphere.

From the Main Toolbox, MB3 the Joint tool stack and then MB1 the Revolute Joint tool.
 > Joint > Revolute Joint

Select 2 Bod-1 Loc and Normal to Grid.
 > 2 Bod-1 Loc > Normal to Grid

For the first body select sphere.
 For the second body select long_member.
 For the location select long_member.MARKER_3. (Should be near the center of the sphere)

The picture to the right shows all of the constraints in place.

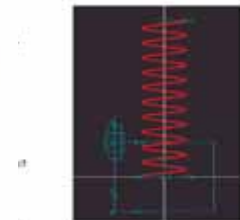
Cylinder

Constraints

with Force

the Model

Unit	Value
Force	1000
Distance	100
Angle	90
Mass	1
Stiffness	10000
Damping	100



16

size"

and type:

1.0

37

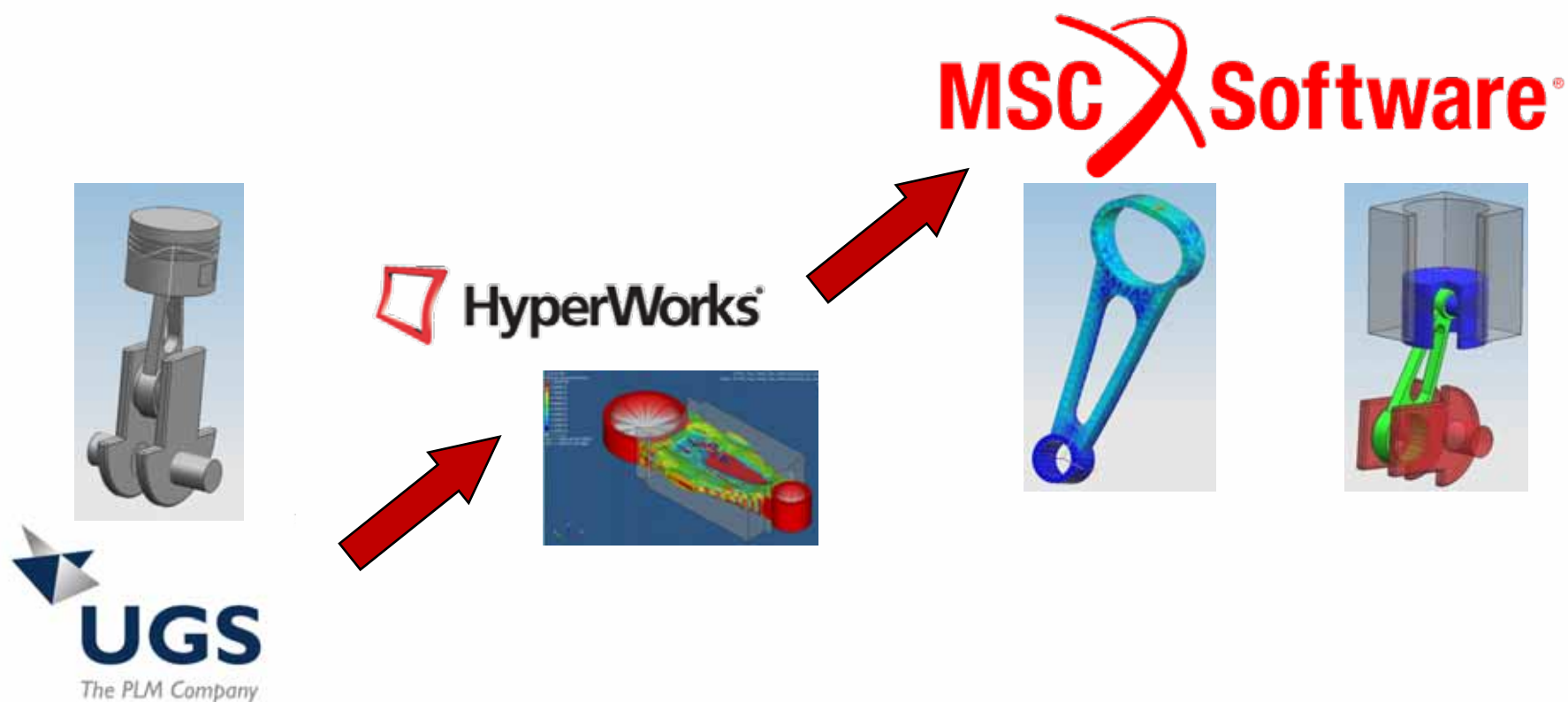
Moving:
 > Body Moving

PACE

Partners for the Advancement of Collaborative Engineering Education.

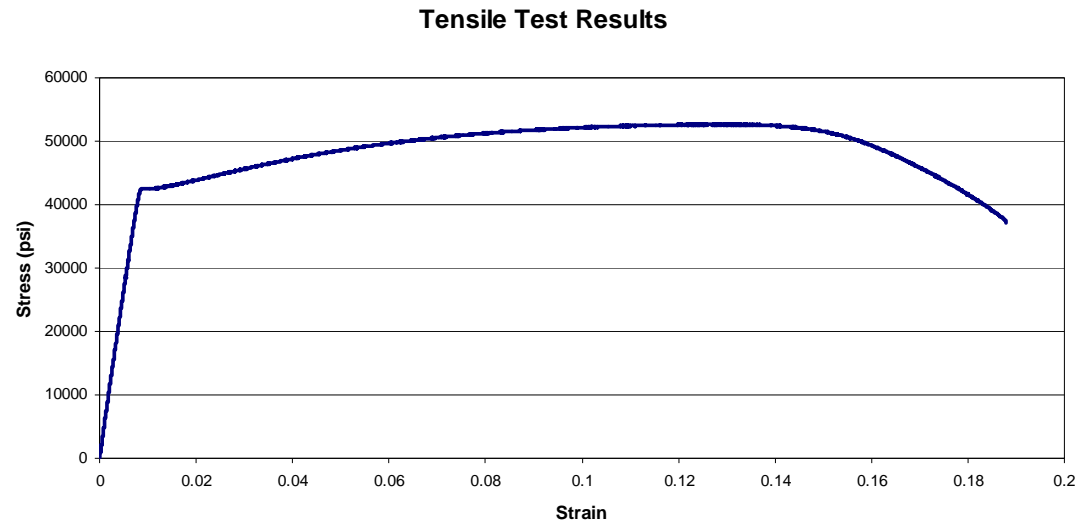
Existing Tools and Resources

- “Best-In-Class” Design Method



Recommendations

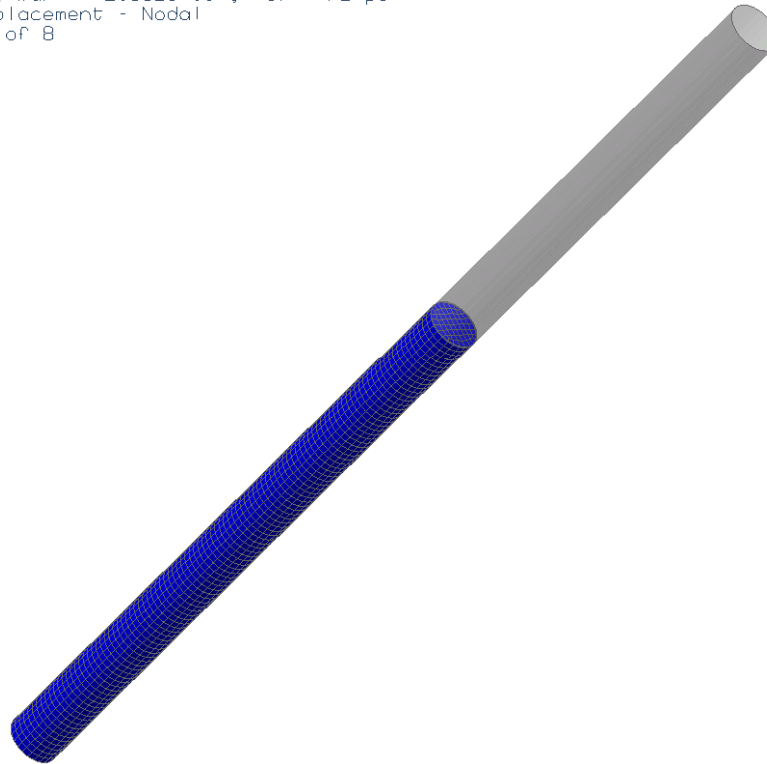
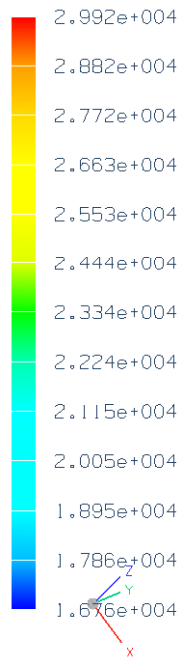
- Conduct simple physical tests
- Generate stress results



Recommendations

- Conduct equivalent virtual test

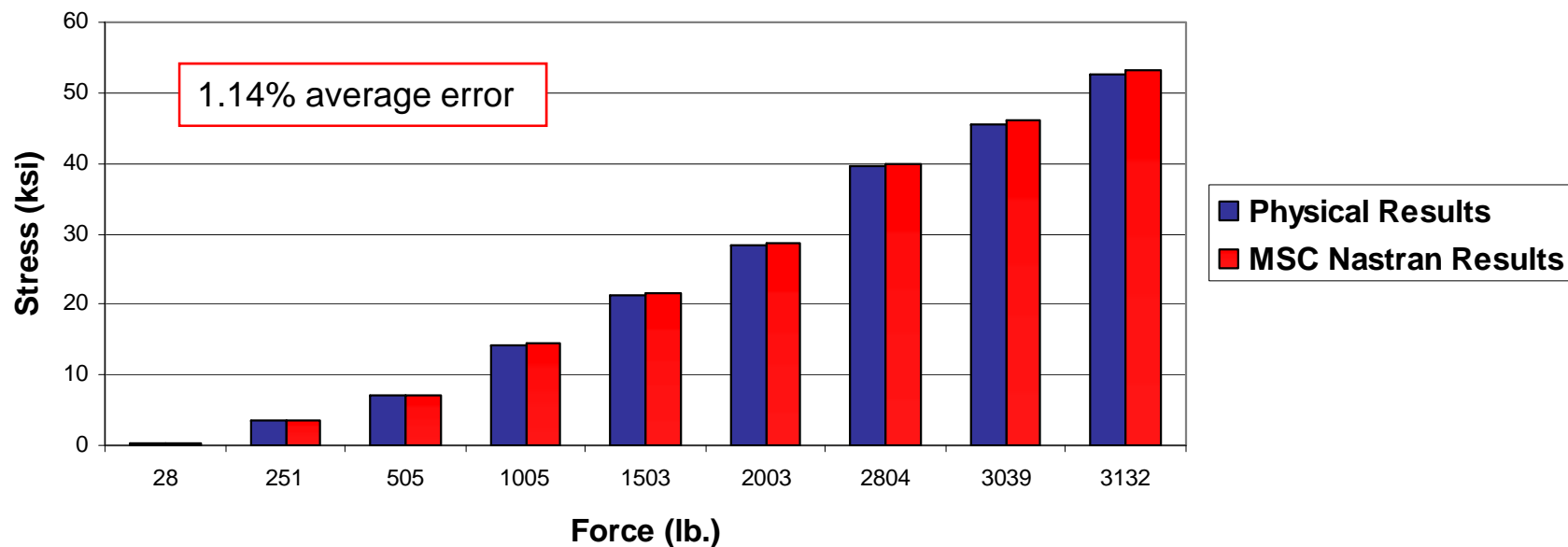
tensile_test_sim2 : Solution 2 Result
Load Case 1, Static Step 1
Stress - Elemental, Von-Mises
Min : 1.676e+004, Max : 2.992e+004, lbf/in²(psi)
Deformation : Displacement - Nodal
Animation Frame 1 of 8



Recommendations

- Compare virtual results to physical results

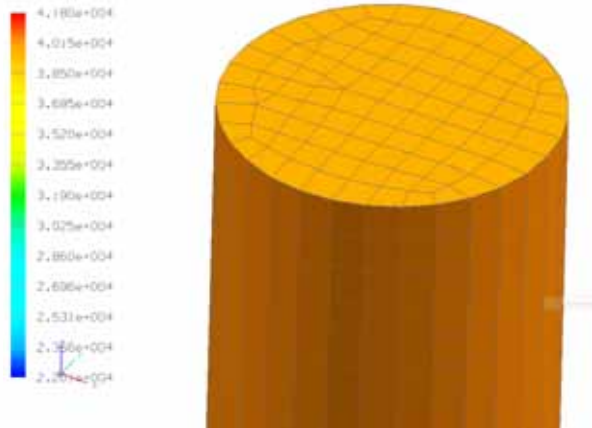
Aluminum Tensile Test



Recommendations

- Teach importance of good technique

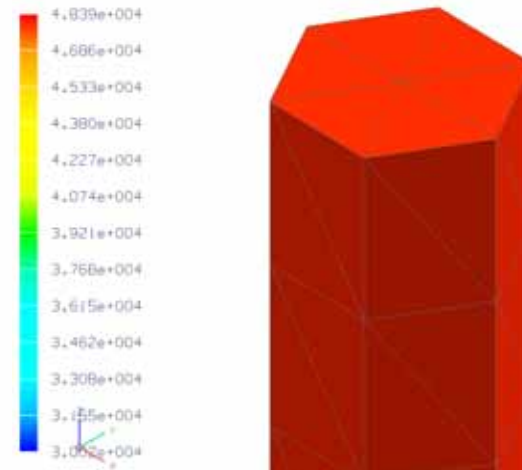
```
tensile_test_sia2:1 Solution 1 Result
Load Case 1, Static Step 1
Stress - Elemental, Von-Mises
Min: 2.201e+004, Max: 4.186e+004, (lb/in^2)(psi)
Deformation 1 Displacement - Nodal
```



Good Mesh

.7% Error

```
tensile_test_sia2:1 Solution 2 Result
Load Case 1, Static Step 1
Stress - Elemental, Von-Mises
Min: 3.002e+004, Max: 4.839e+004, (lb/in^2)(psi)
Deformation 1 Displacement - Nodal
```



Default Mesh

22% Error

Recommendations Summary



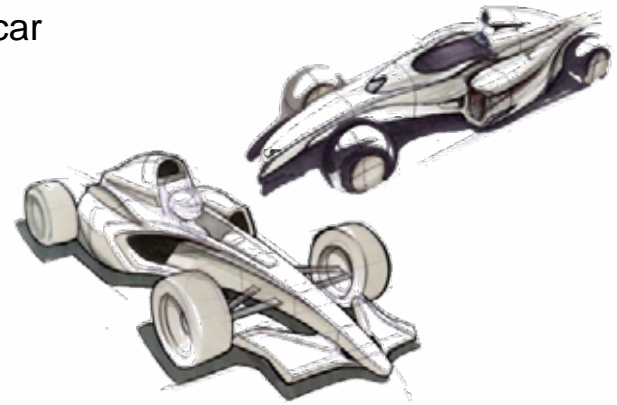
- Integrate PACE tutorials into course syllabi prior to Capstone
- Teach Capstone students how to use “Best-In-Class” design method on their projects
- Conduct simple physical tests to build confidence

PACE F1 Global Collaboration Project



• Grand Challenge:

- 2006-2007 :
 - Conceive, design, build a sporty open-wheeled supercar
 - Small displacement power train
 - 2-4 seats, street licensable
- 2007-2008 :
 - Conceive, design, build a formula 1 style race car
 - True to formula 1 dimensional standards
 - 2.2L longitudinal EcoTec engine (Ethanol)
- 2008-2009 :
 - Analyze, modify, remanufacture trouble areas on 2008 vehicle
 - Subject car to physical testing at GM Cheong-Na proving grounds
 - Ensure safety and race worthiness of vehicle



PACE Global Vehicle Collaboration Project



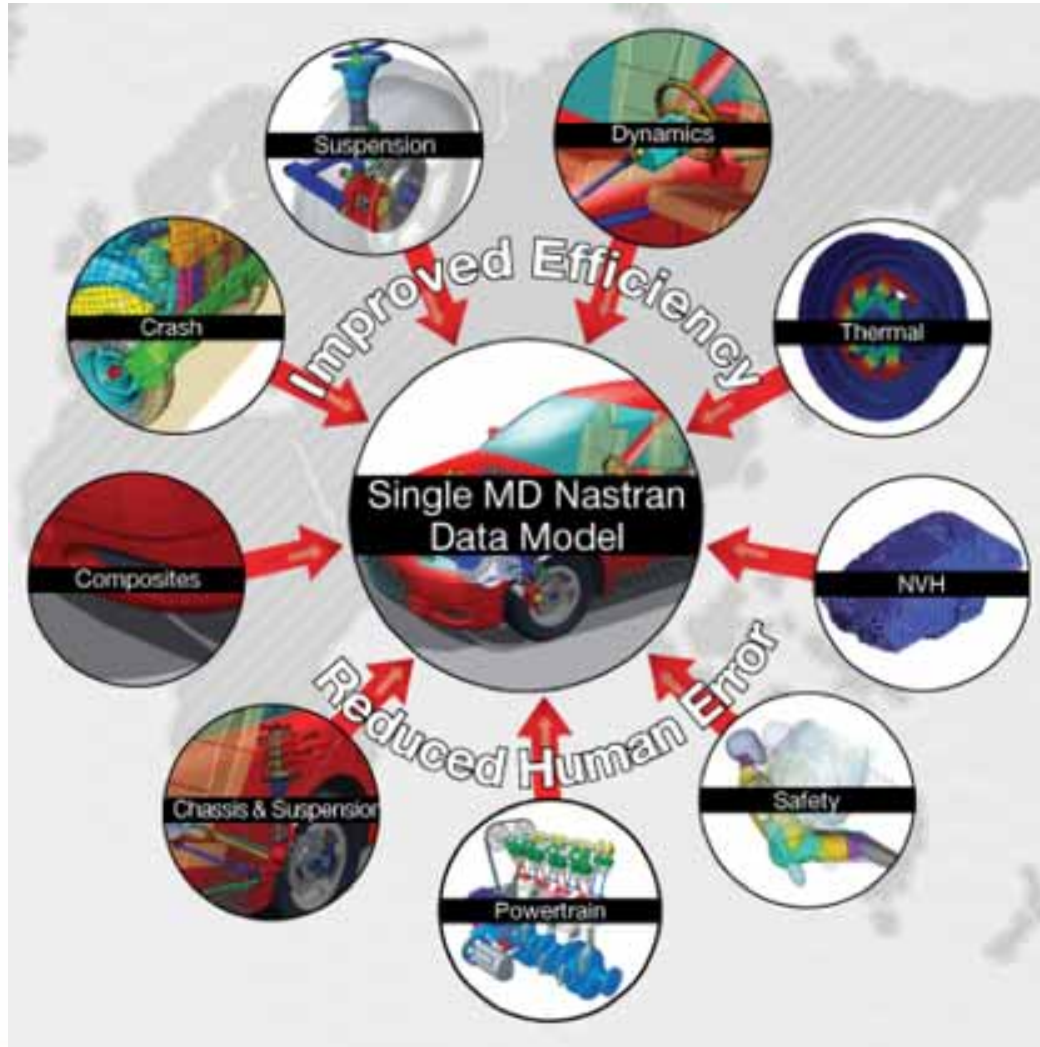
19 Schools on 4 Continents



Languages

- English
- Spanish
- Portuguese
- Swedish
- German
- Mandarin
- Korean

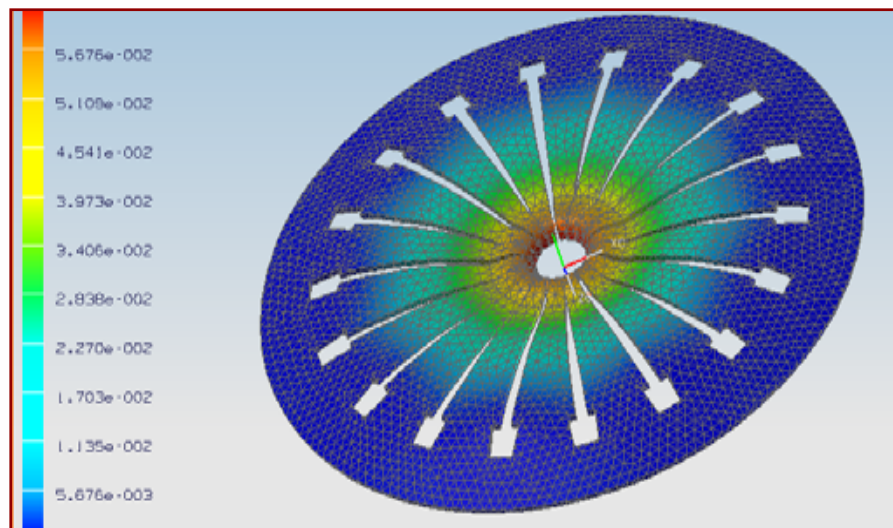
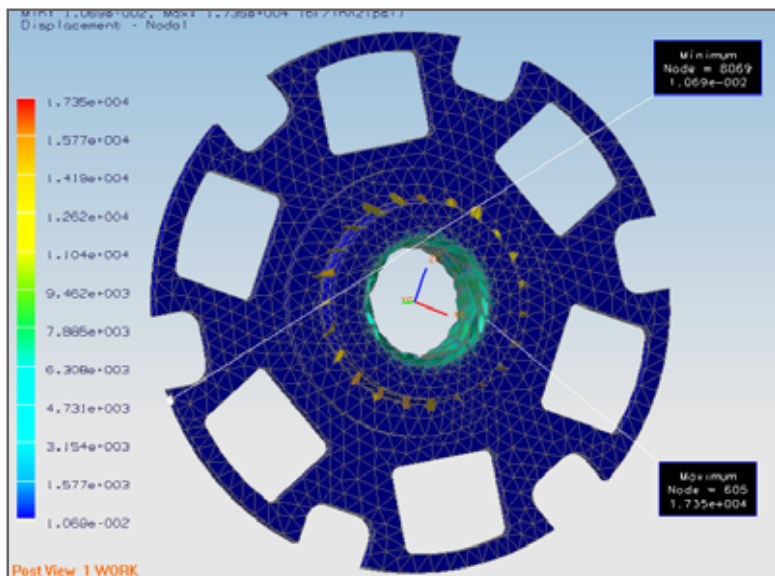
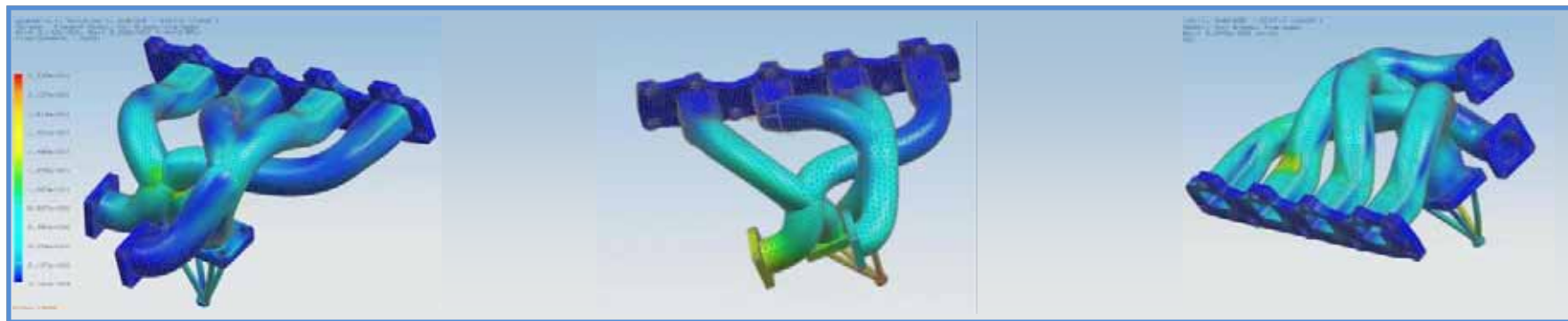
PACE F1 Global Collaboration Project



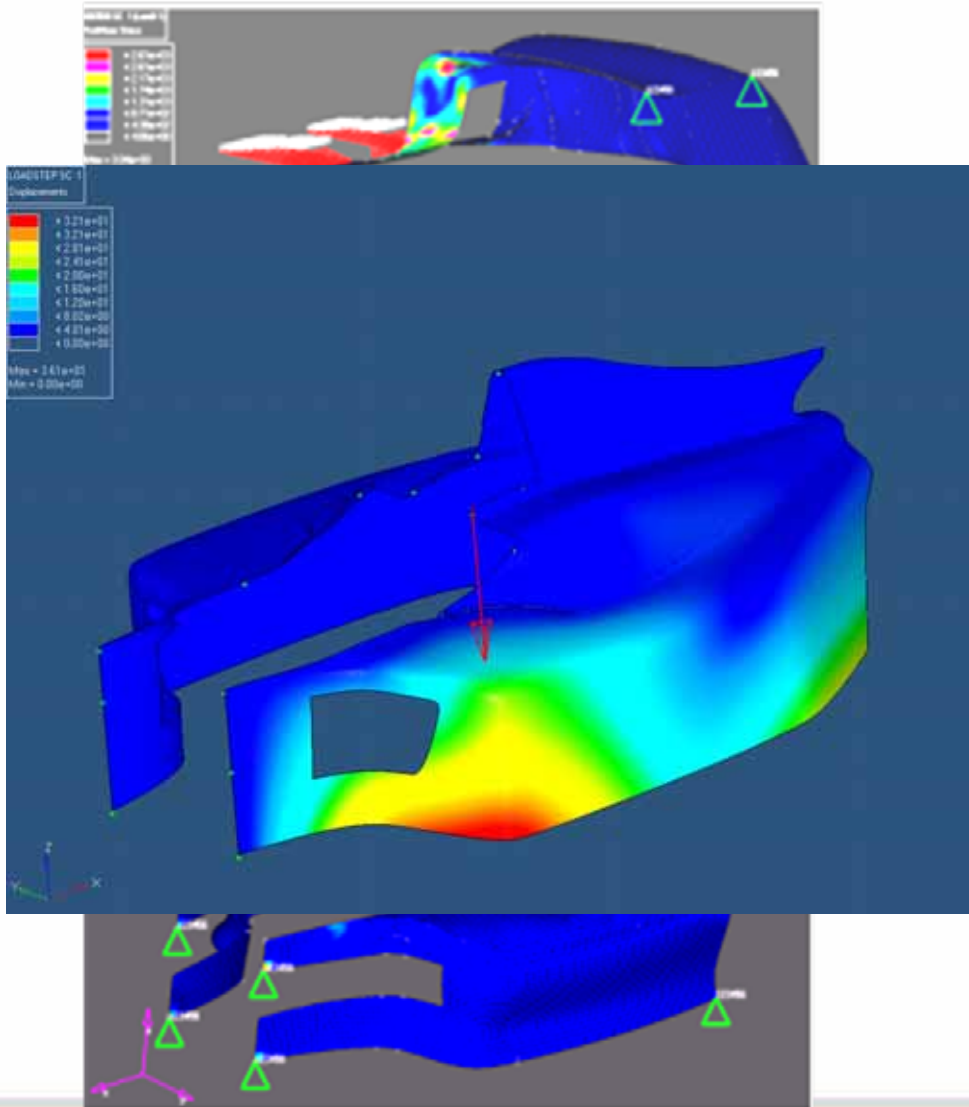
PACE F1 Global Collaboration Project



Structural Analysis – MSC Nastran



Structural Analysis – MSC Nastran



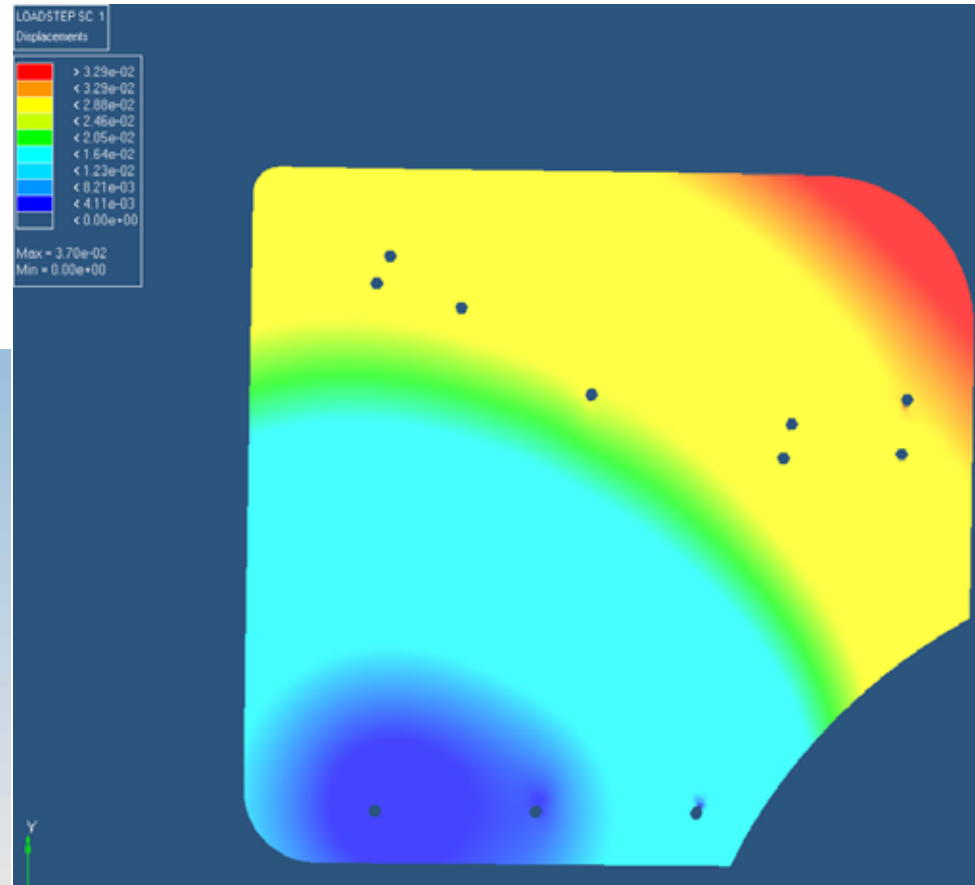
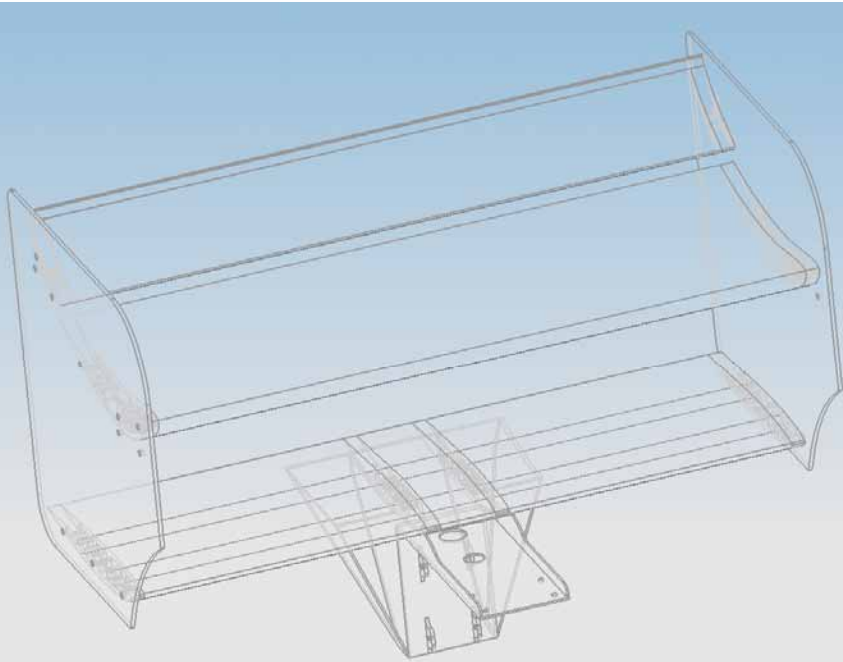
Carbon Fiber	
E_1	160 GPa
E_2	12 GPa
G_{12}	4.4 GPa
ρ	1.8 g/cm ³

Composite Material	
MAT Collector	PCOMPG
Ply Thickness	0.3 mm
Stacking Sequence	[45/-45/0/90]s
Total Thickness	T = 2.4mm

Structural Analysis – MSC Nastran



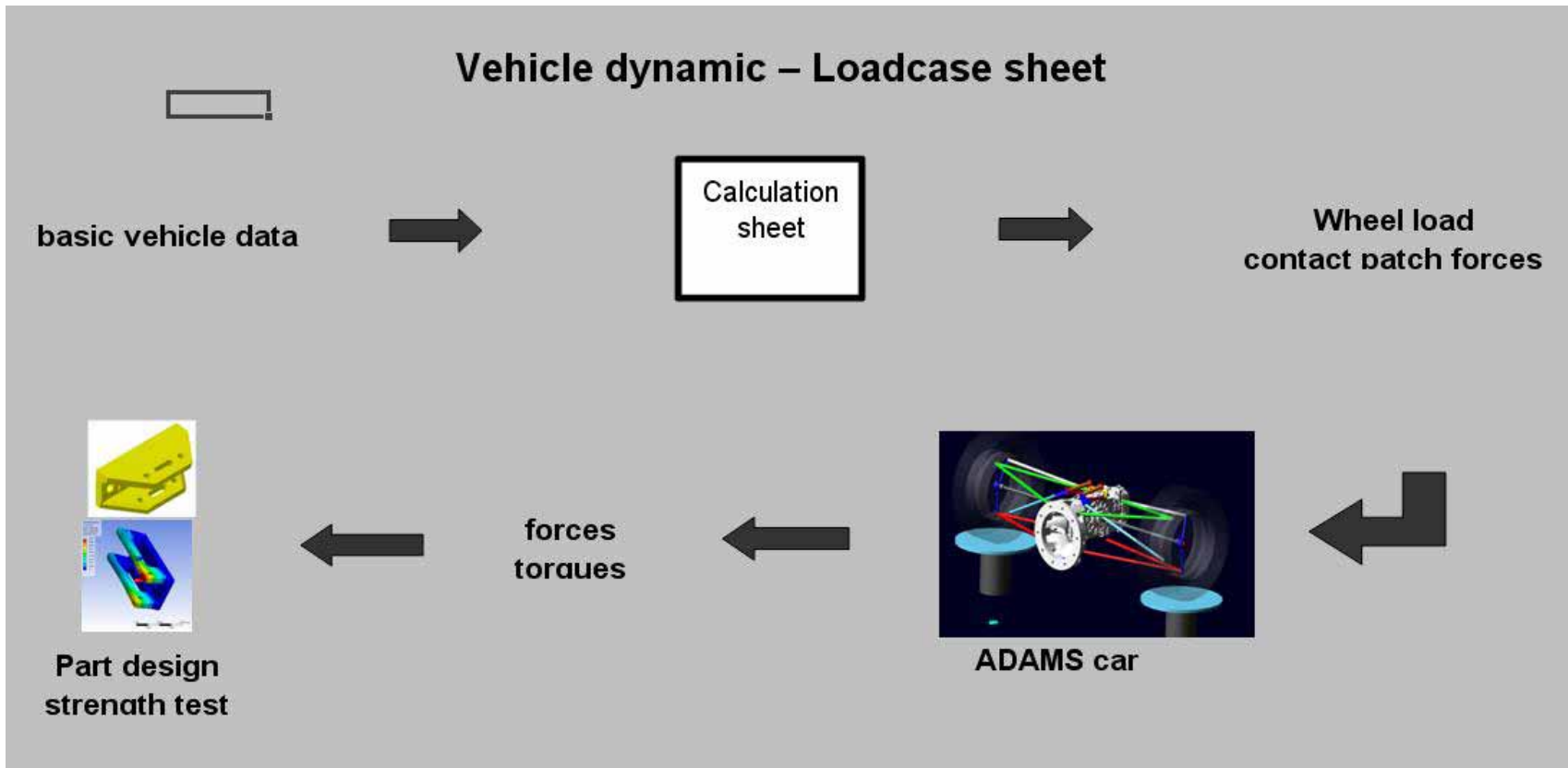
- Ongoing processes and goals
 - Complete rear wing assembly



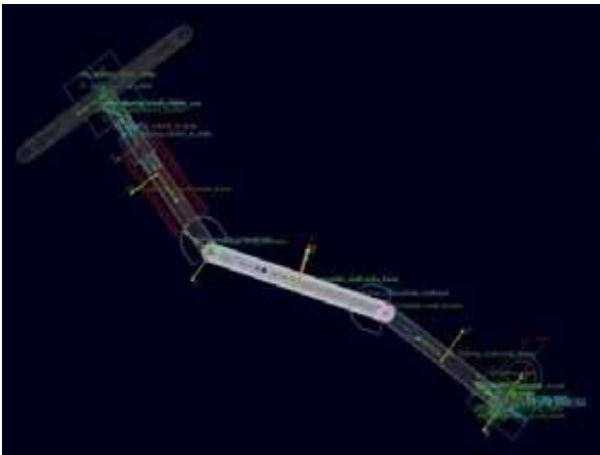
PACE F1 Global Collaboration Project



- ADAMS Car

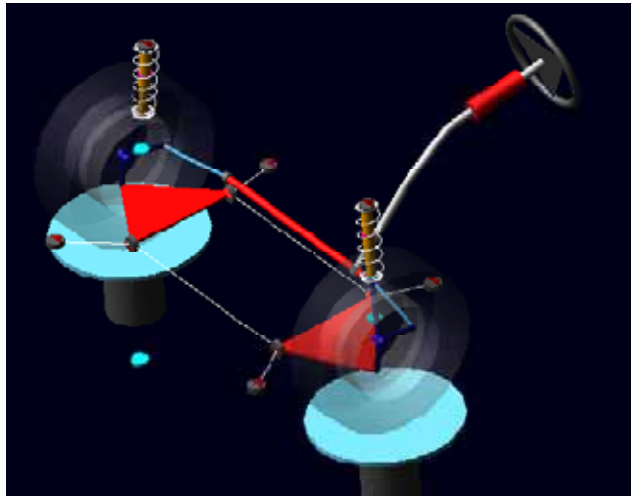


PACE F1 Global Collaboration Project



Create geometry, joints,
mounts, templates

Create Subsystems

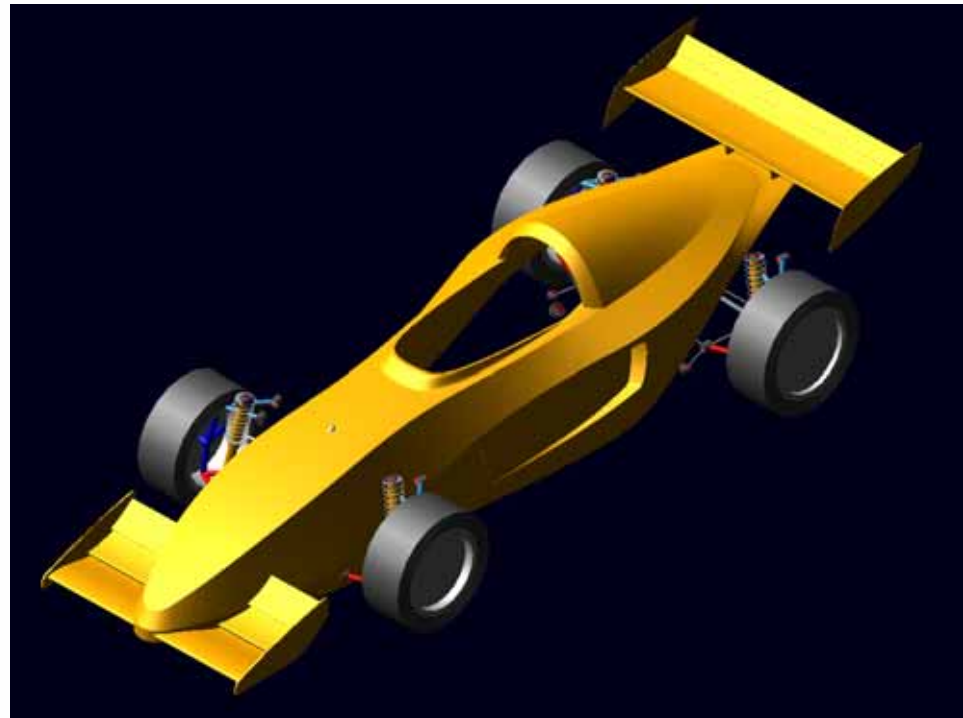
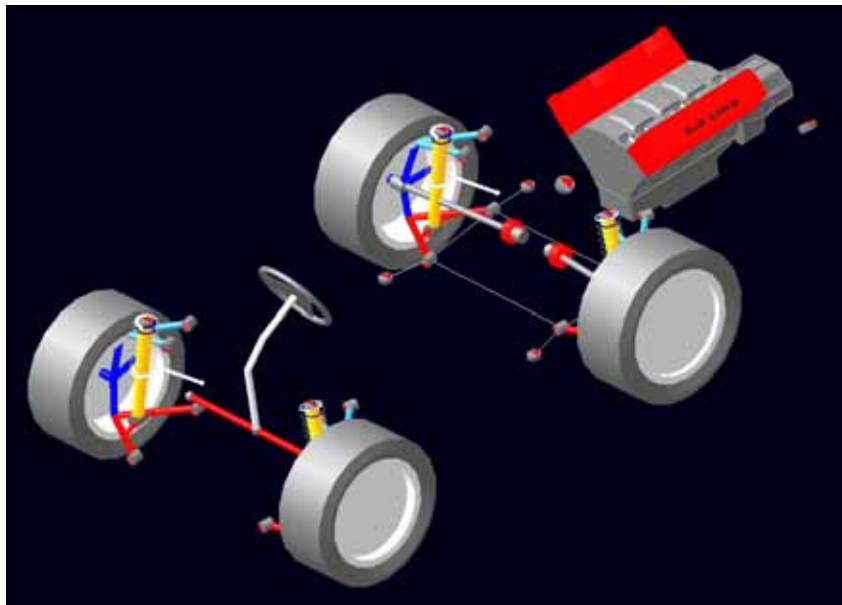


Build, Analyze Assemblies

PACE F1 Global Collaboration Project



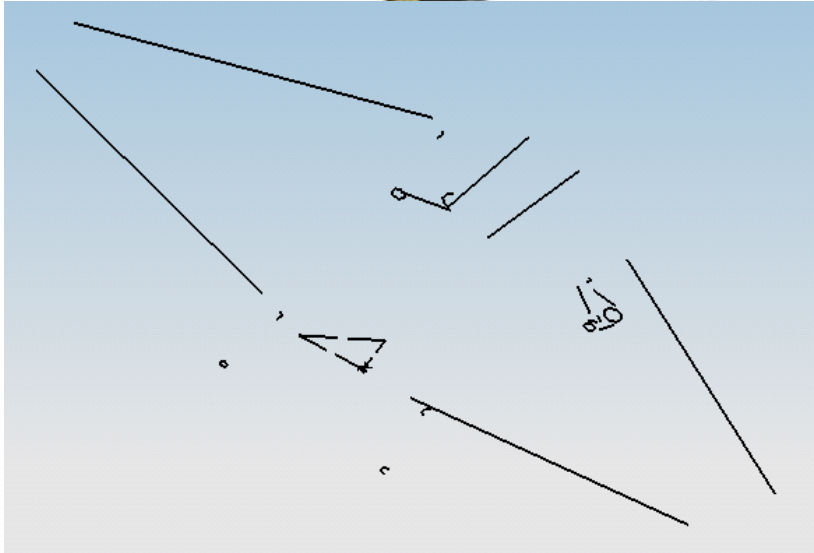
ADAMS Car Model (2007)



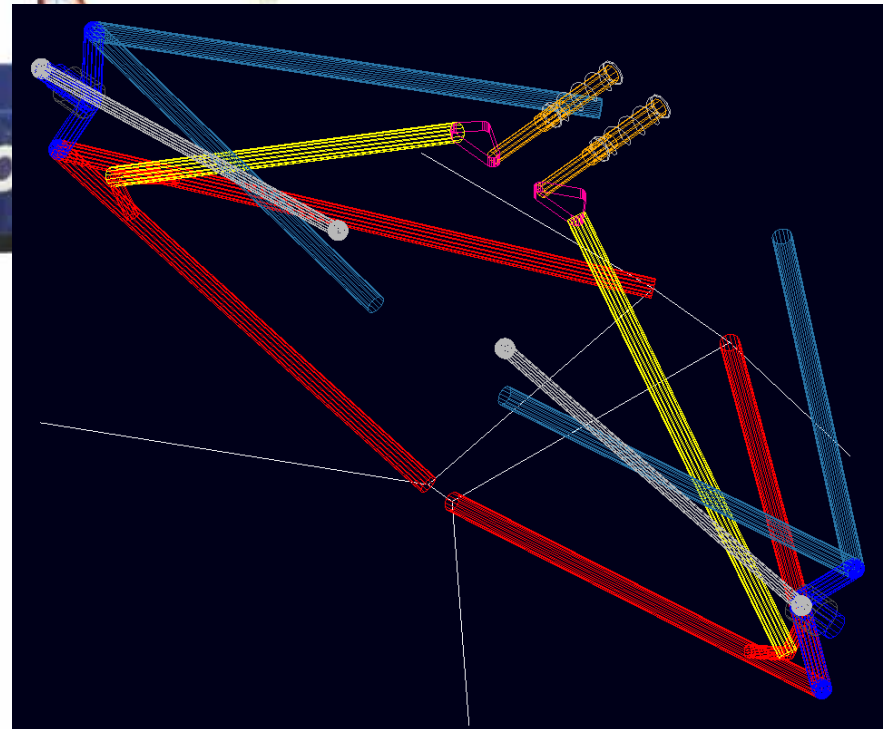
PACE F1 Global Collaboration Project



Current Work



3-dimensional coordinates from vehicle



Creation of suspension subsystems

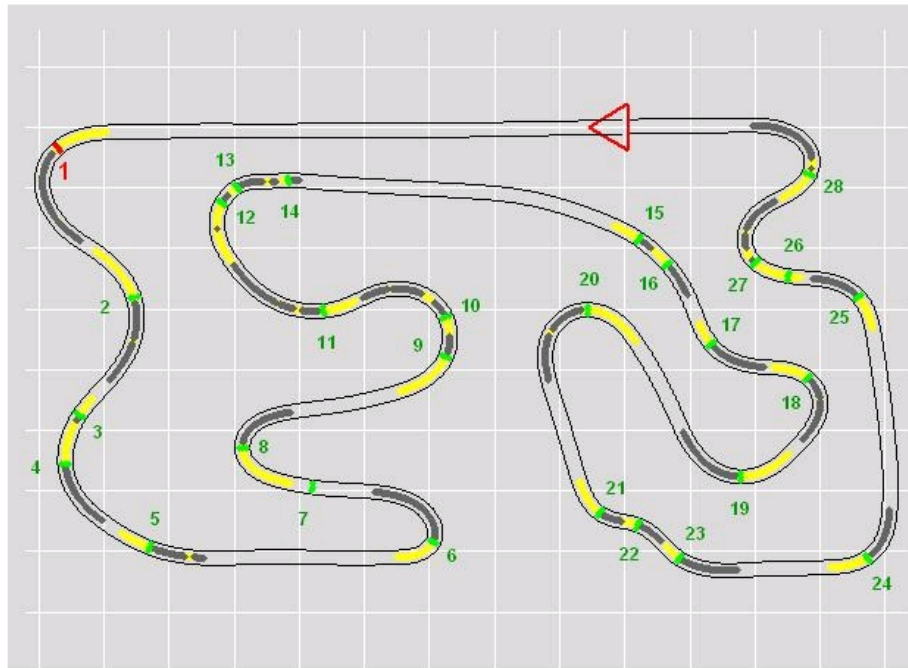
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Current Work

Miller Motorsports Park

Corner Key



Build a virtual track from data and analyze the vehicle's performance on an actual track

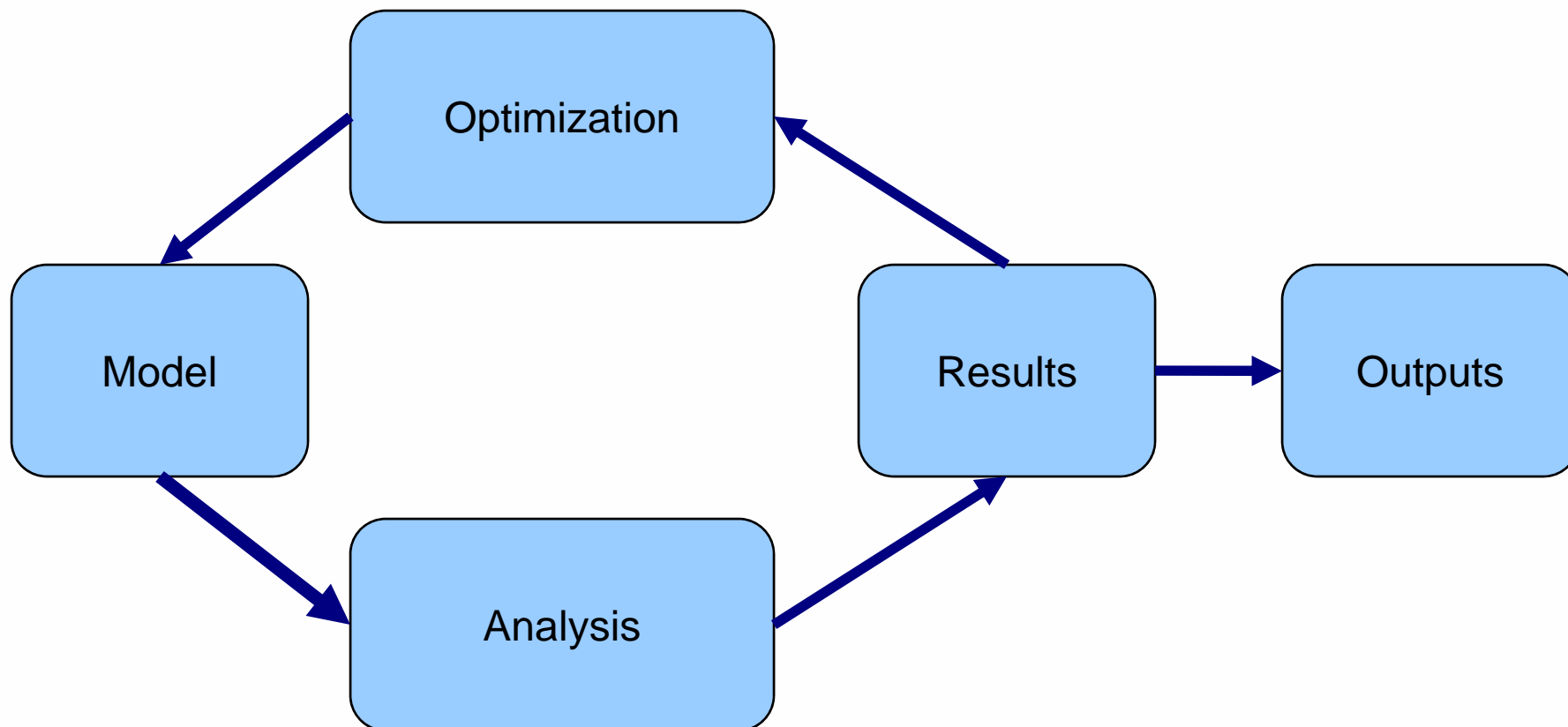
PACE F1 Global Collaboration Project



- **Advantages :**
 - **Multi-purpose solver**
 - **Dynamic analysis without physical testing**
 - **Virtual model**

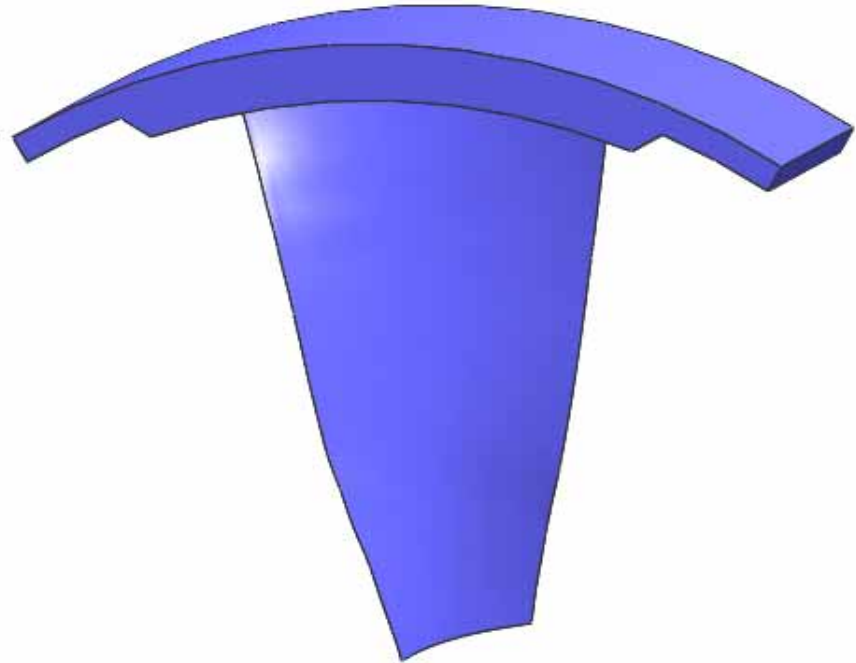
- **Disadvantages :**
 - **Steep learning curve**

Multi-Disciplinary Optimization of Stator Vane



Multi-Disciplinary Optimization of Stator Vane

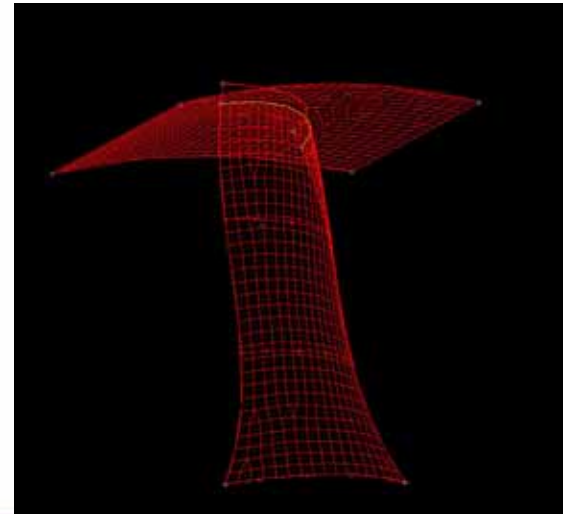
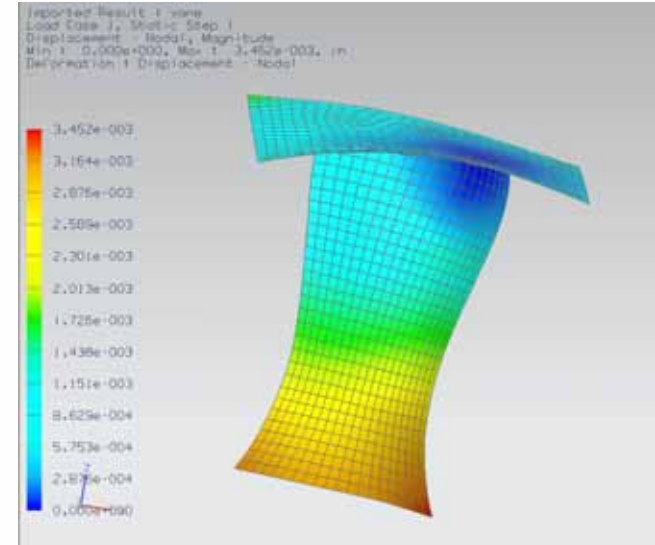
- Parameters
 - Stator Dimensions
 - Ply Angles
- Analysis
 - Residual Stress
 - Max Stress
 - Vibration
 - Fluid Flow
 - Impact



Multi-Disciplinary Optimization of Stator Vane

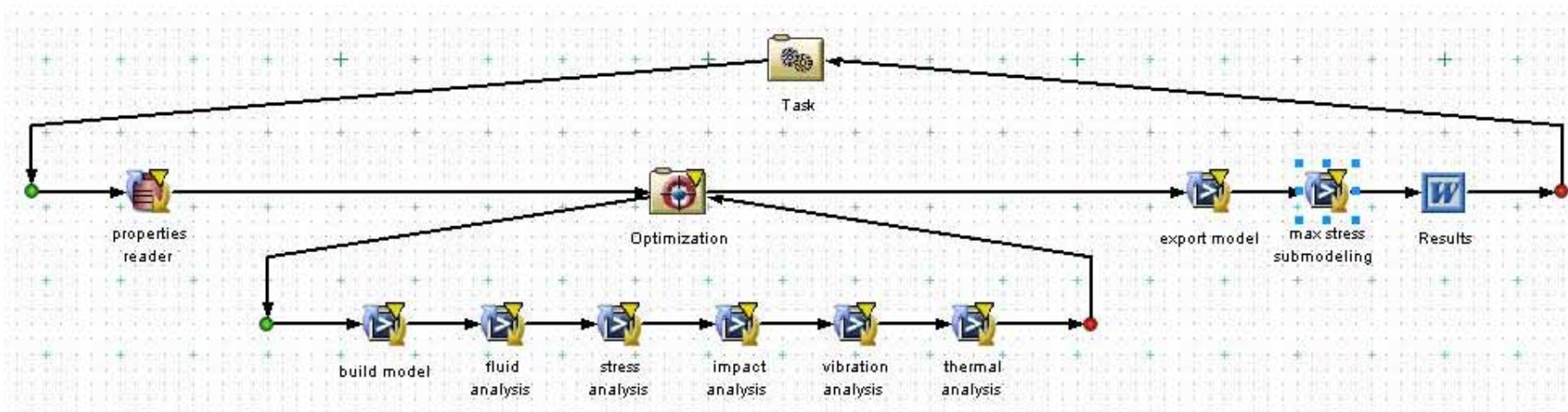
- **Nastran**
 - Thermal Analysis
 - Took nodes and elements from model
 - Created bulk data files from C++ exe
 - Exported residual stress on stator

- **Adams**
 - Vibration analysis
 - Model built from iges of original model
 - Vibration response exported



Multi-Disciplinary Optimization of Stator Vane

- Optimizes dimensions and ply angles



Multi-Disciplinary Optimization of Stator Vane

- Able to build geometry and run analysis in minutes
- Able to perform many iterations on updated geometry
- Optimal stator vane can be obtained given the set constraints
- Potential to save months of work on updating parts

Contact Details :

- For further information please contact

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