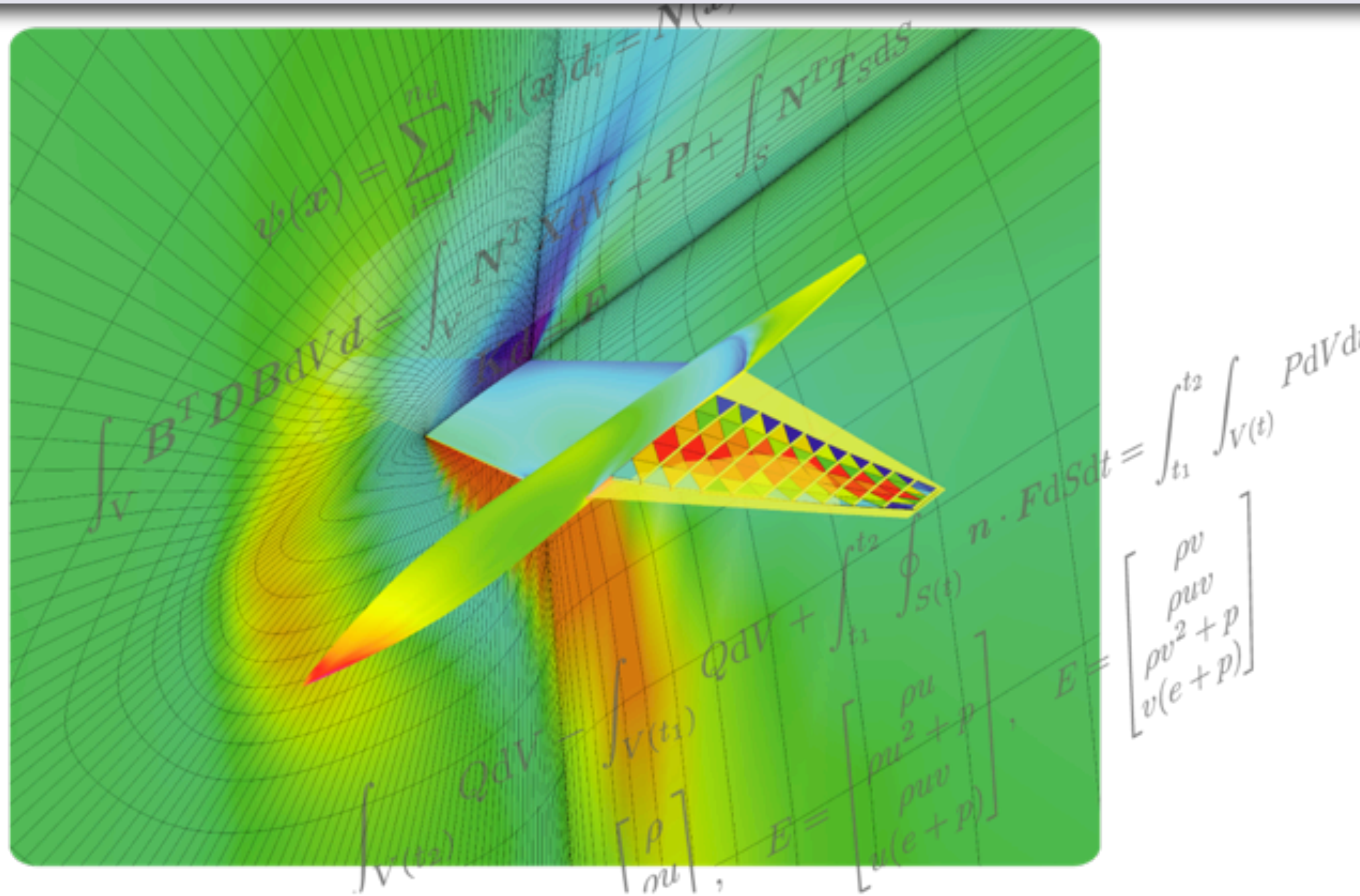
# High-Fidelity MDO for Future Aircraft Configurations

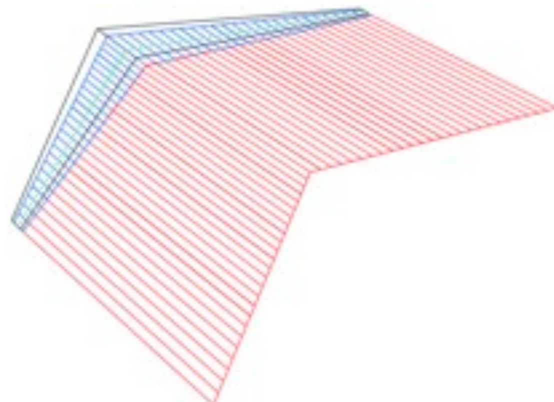


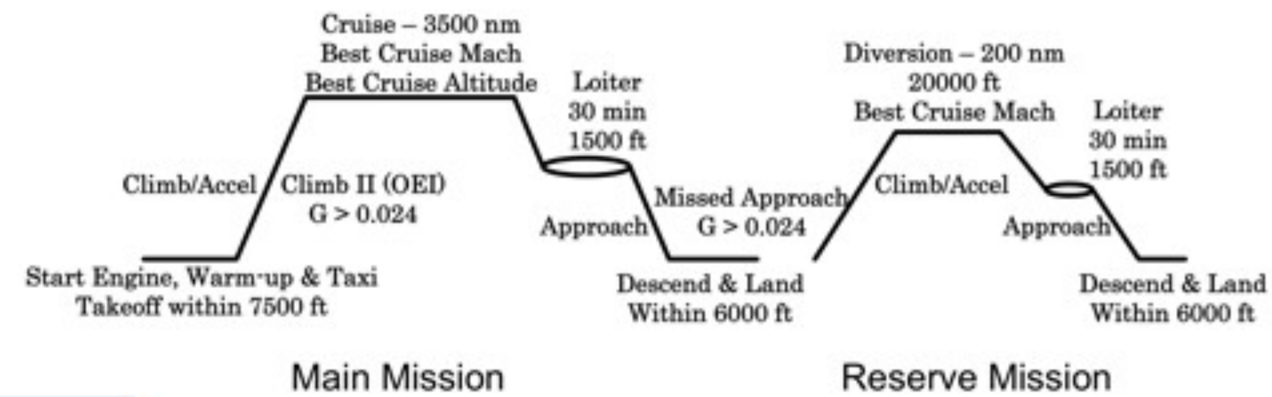
Joaquim R. R. A. Martins
Aerospace Multidisciplinary Design Optimization Laboratory
University of Michigan

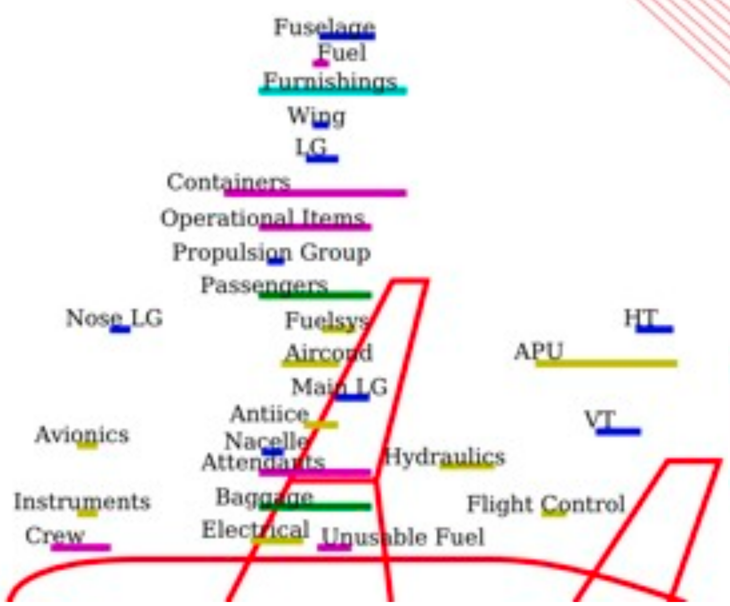
2nd UTIAS-MITACS International Workshop on Aviation and Climate Change
Toronto, May 2010

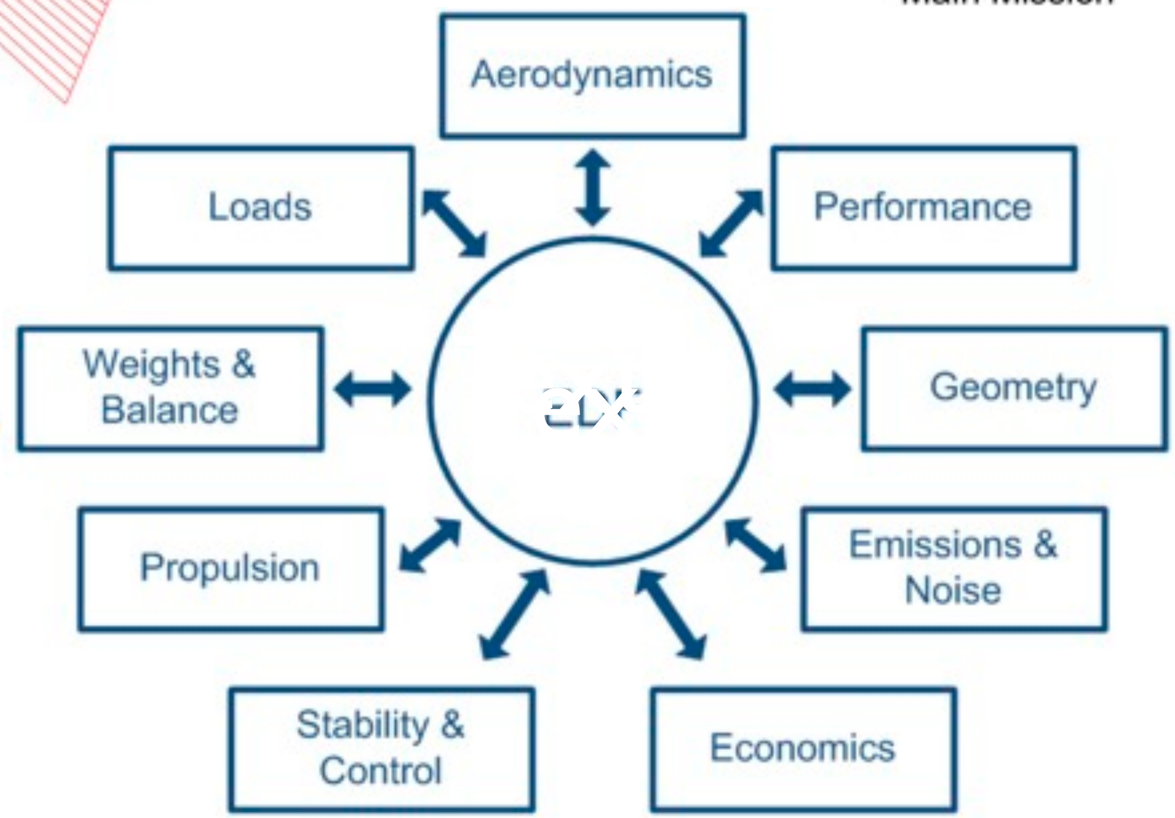
# Aircraft Design for Minimum Environmental Impact

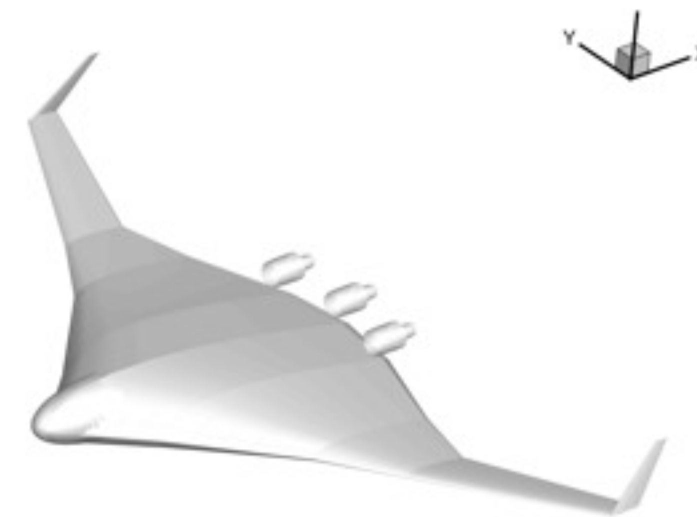
(Henderson, Perez, Martins, 2009)

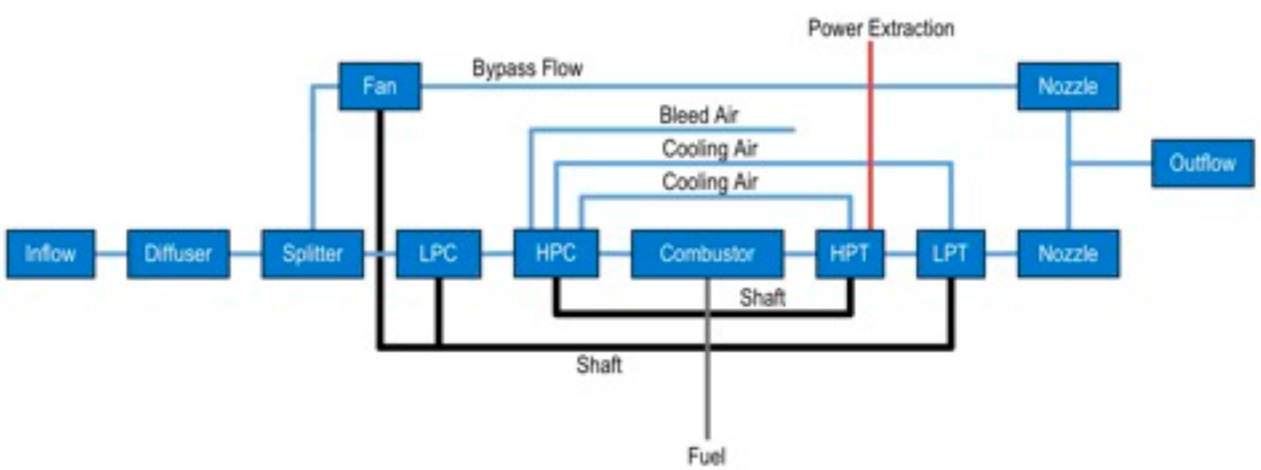


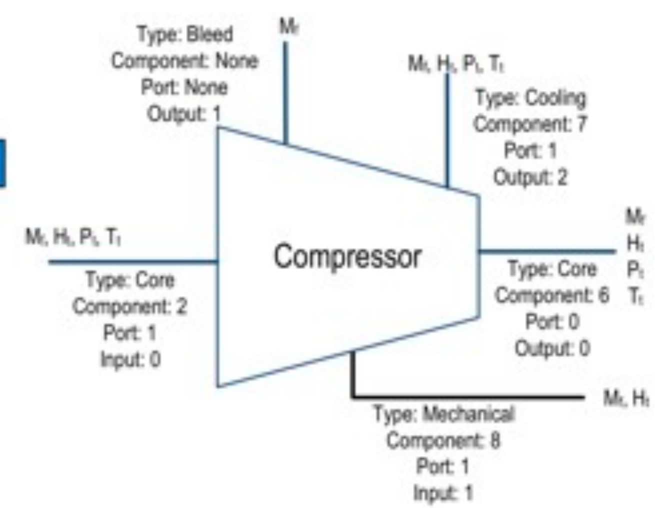


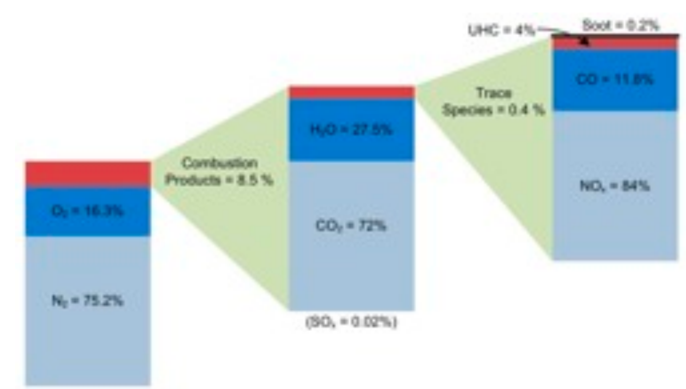



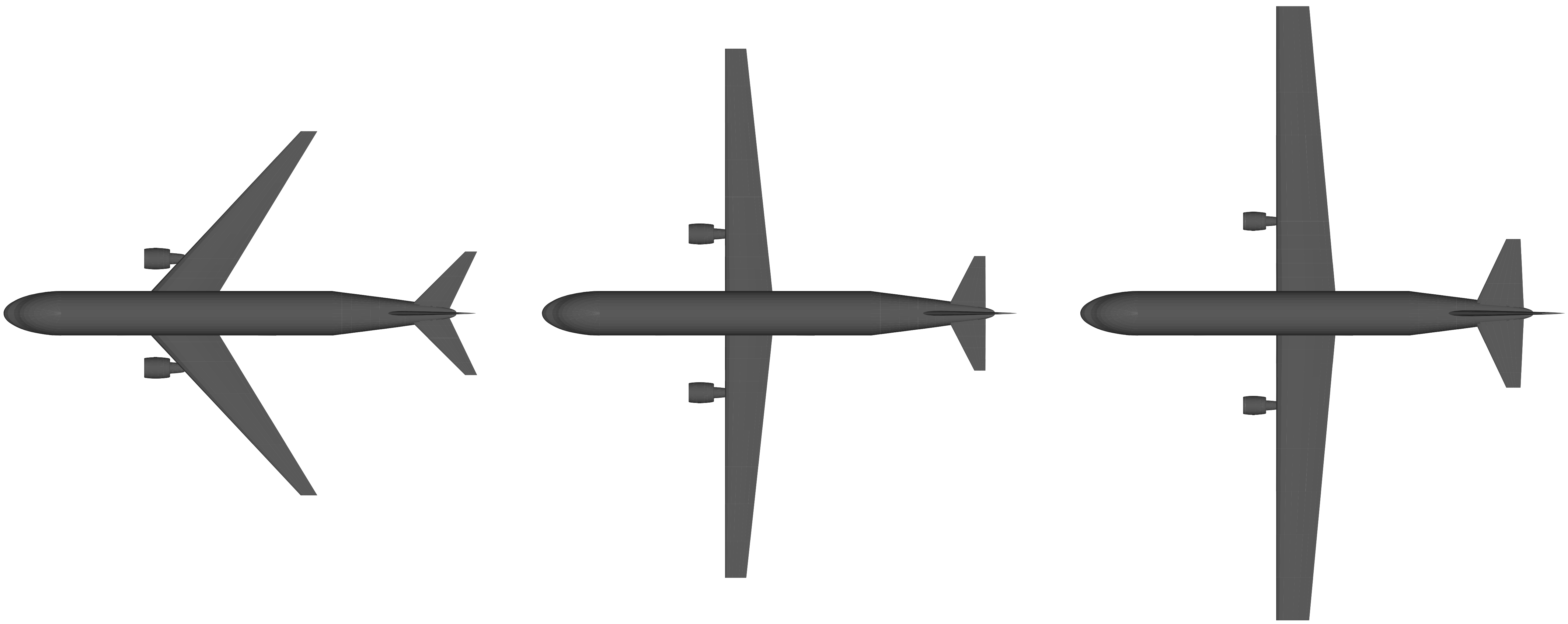



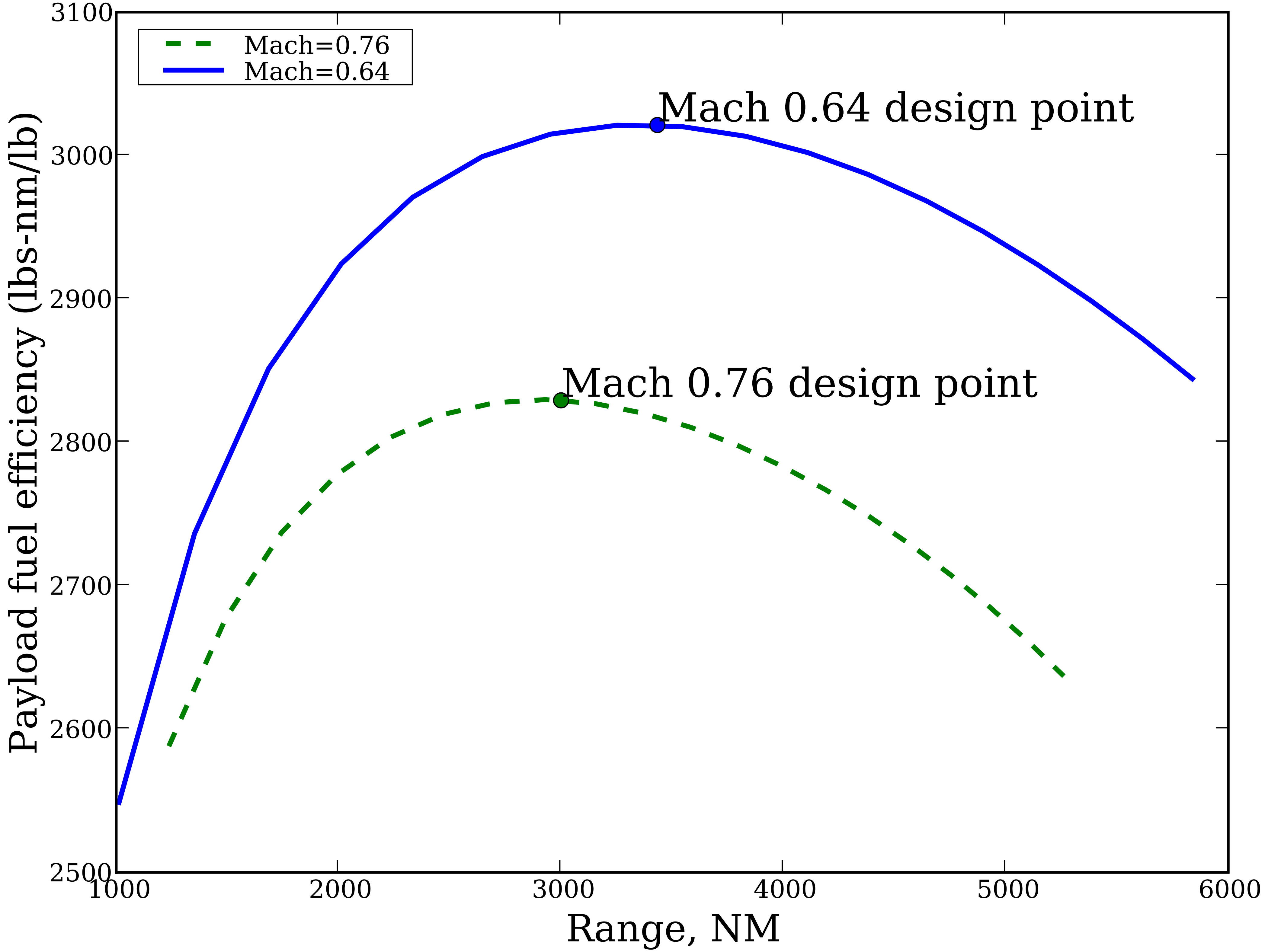



# Single Objective Optimization

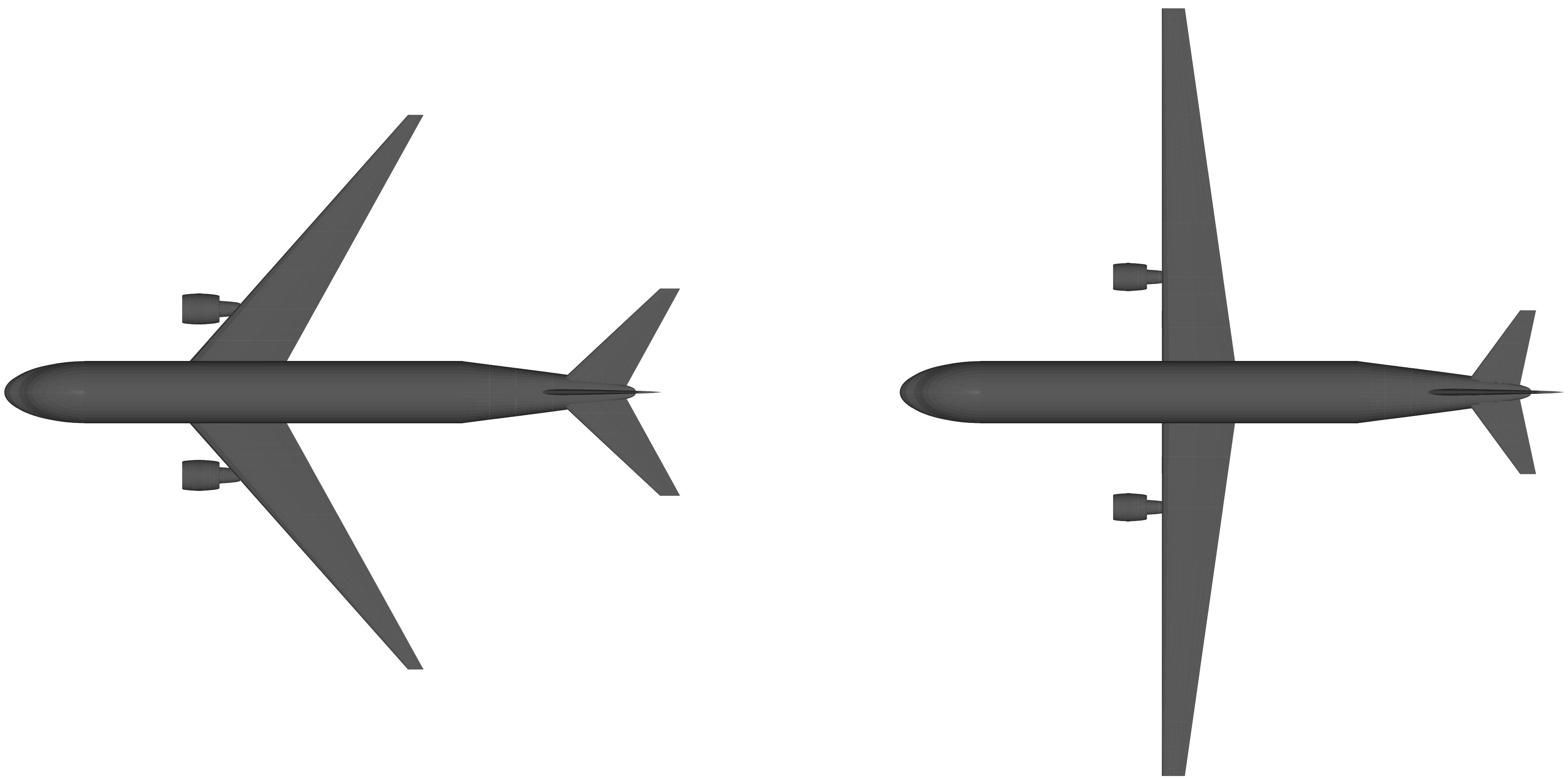


Cost　　Fuel Burn　　LTO NOx

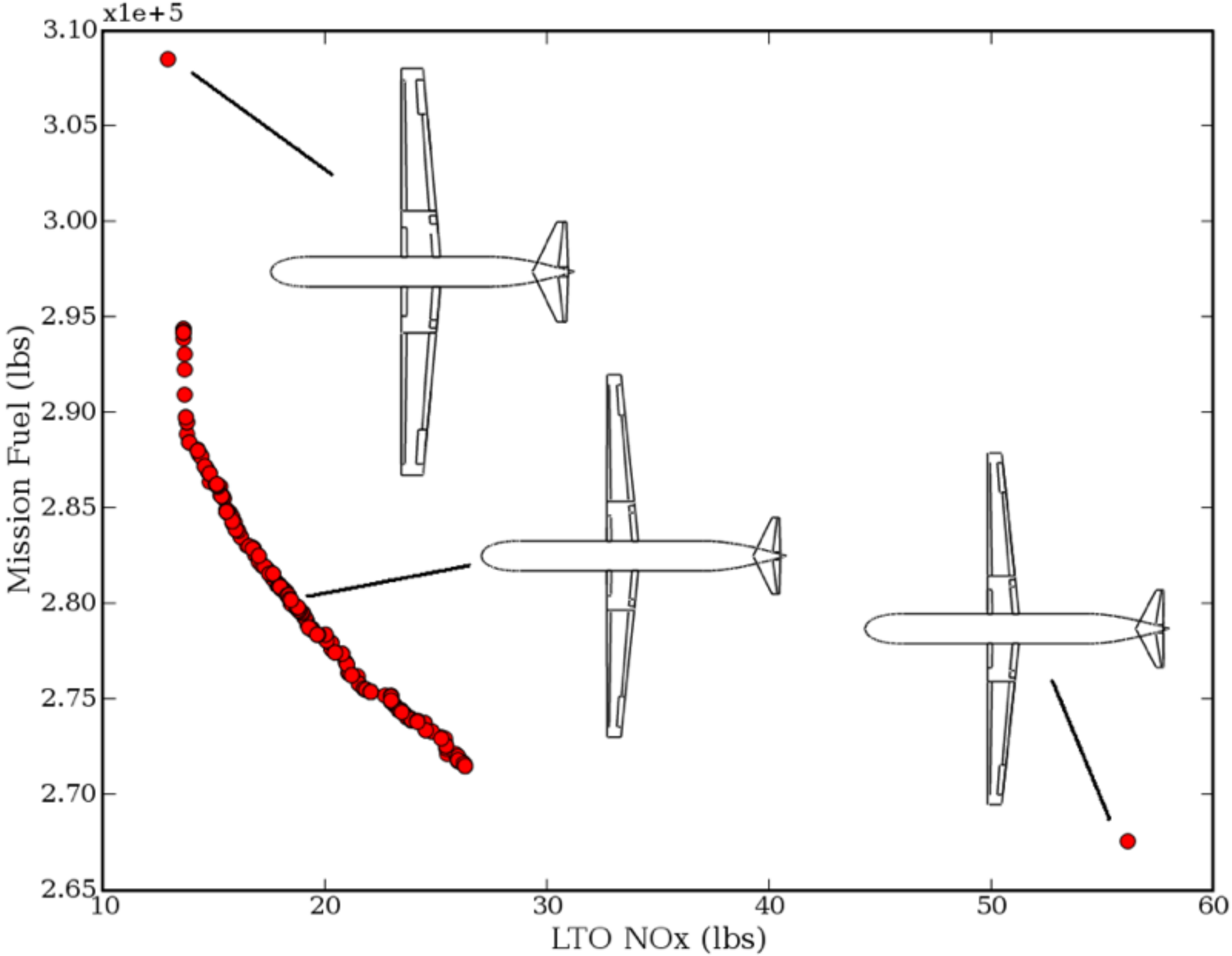
# Minimization of Fuel Burn per Distance Flown



# Minimization of Fuel Burn per Distance Flown

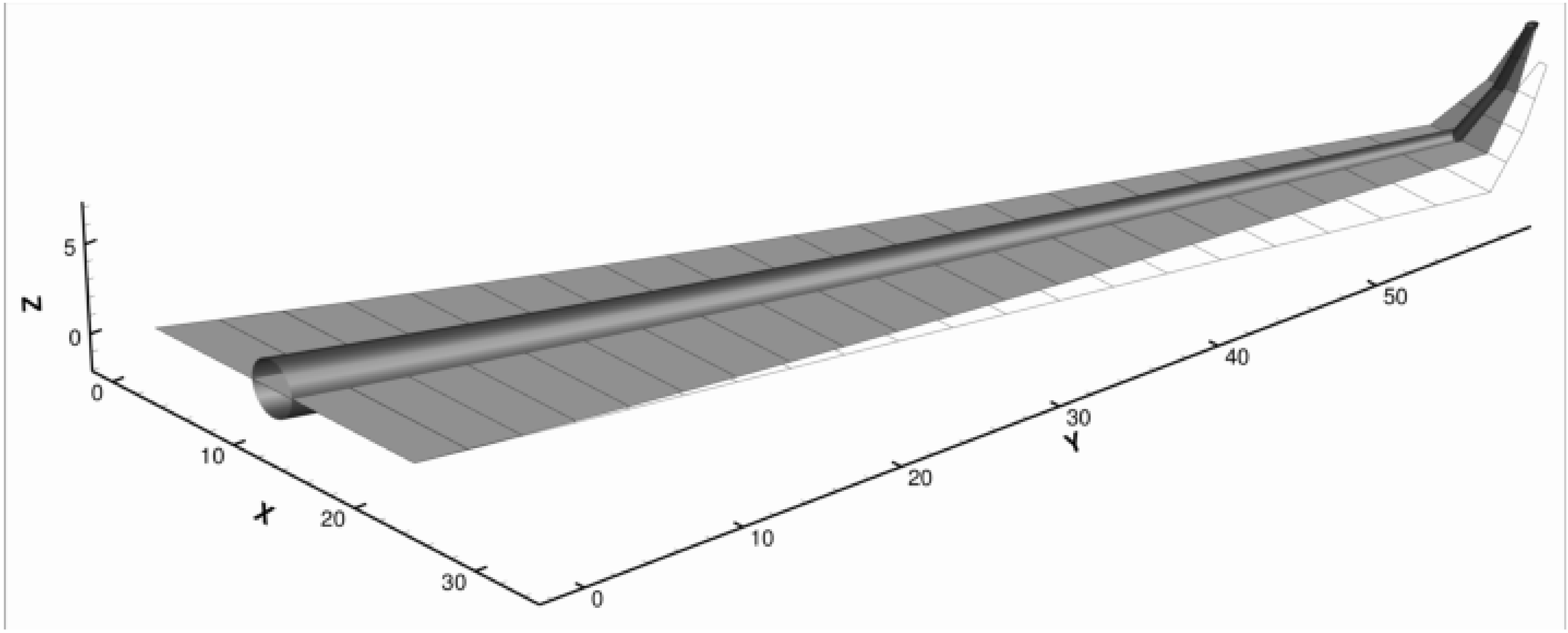


# Multi-Objective Optimization



# Aerostructural Optimization of Nonplanar Configurations

(Jansen, Perez and Martins, 2010)



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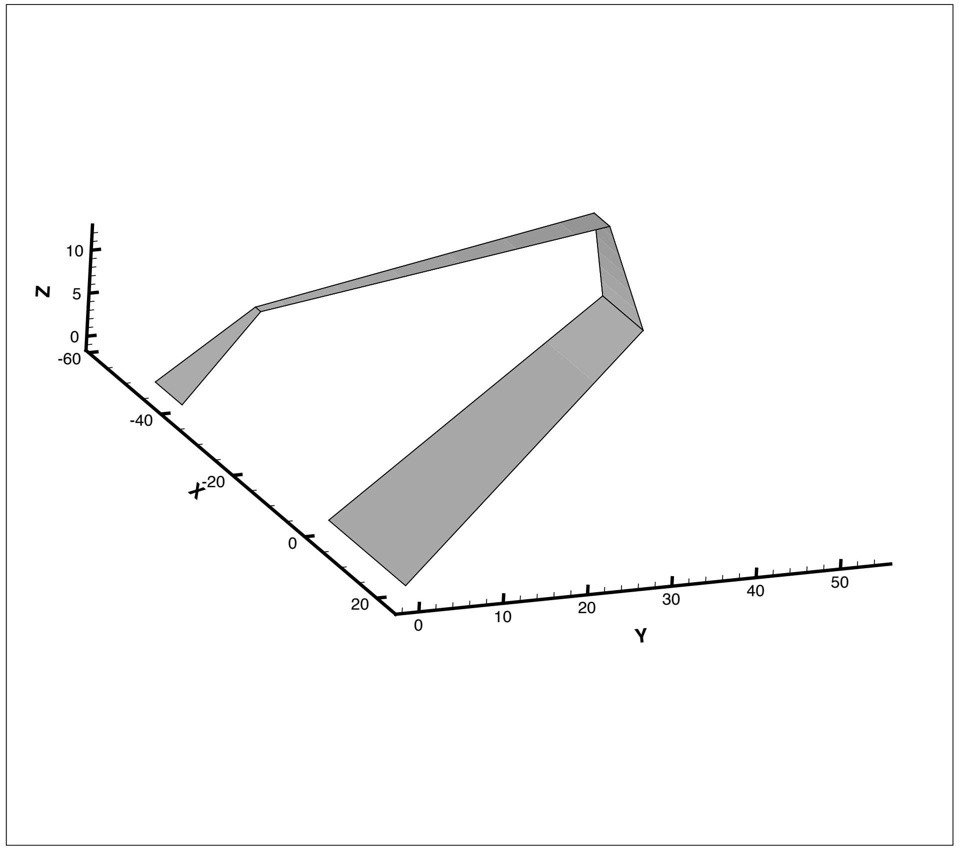


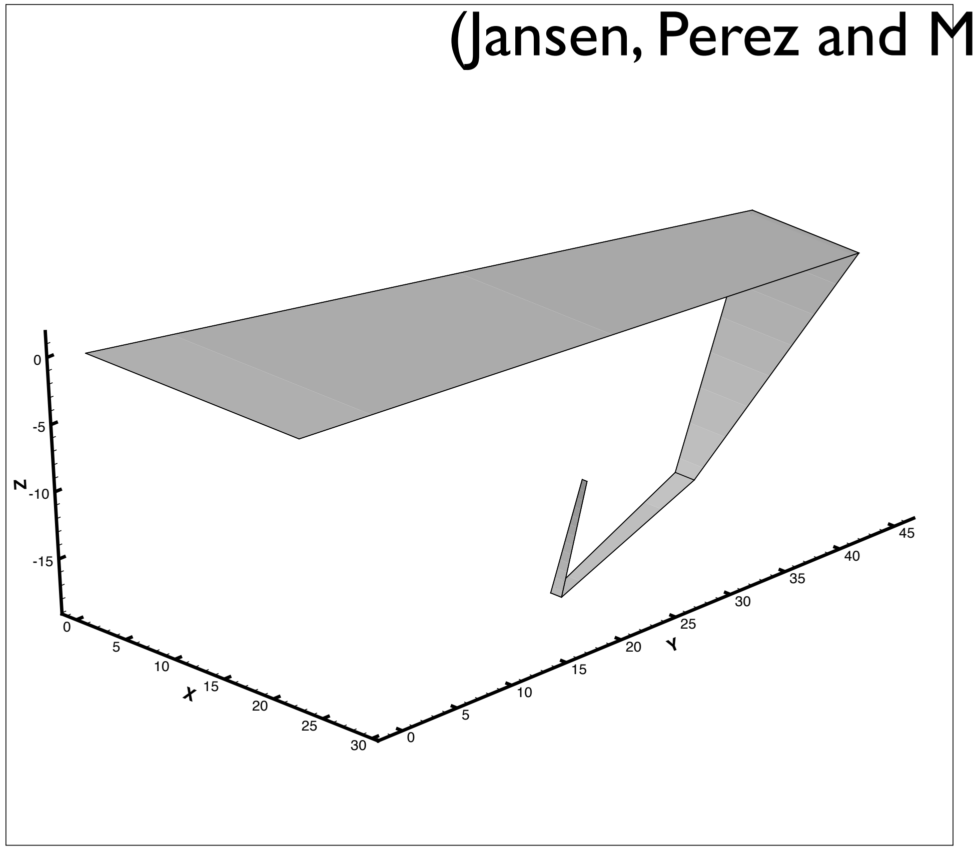


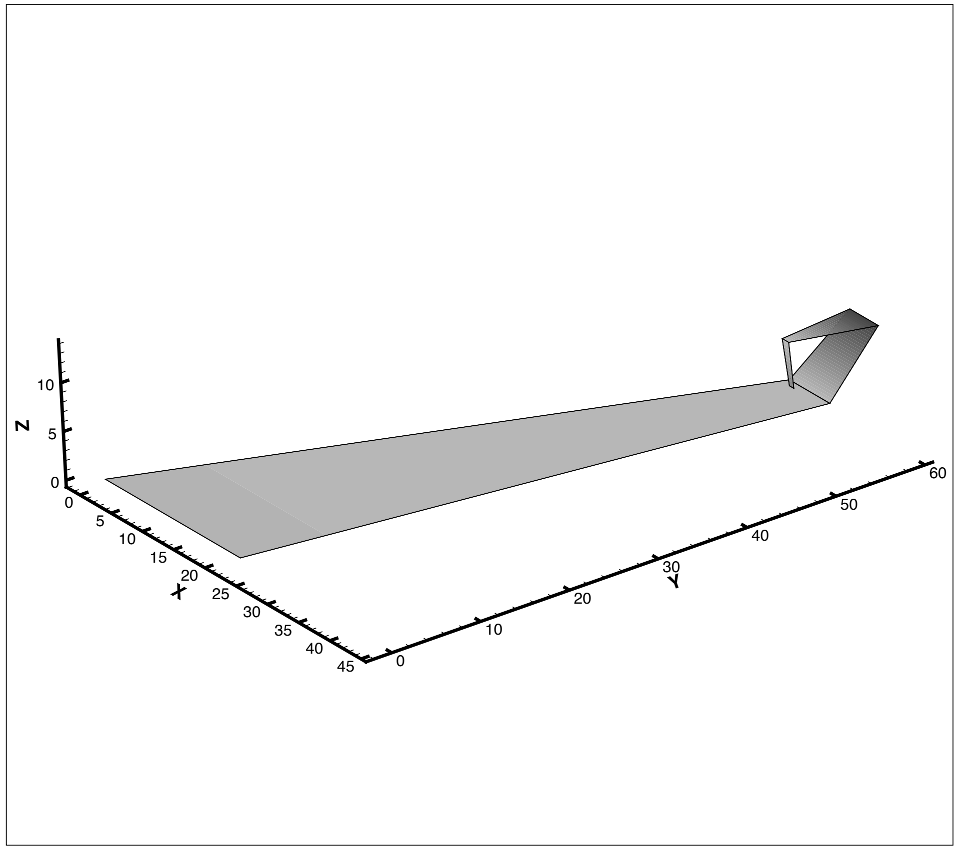


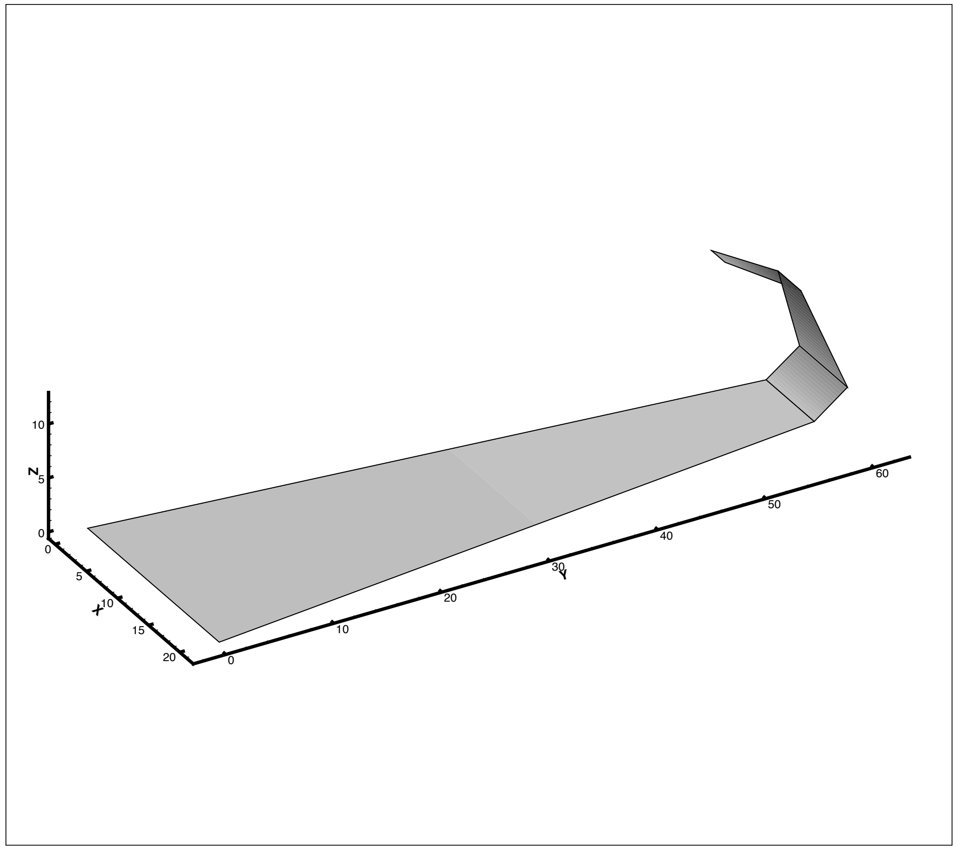

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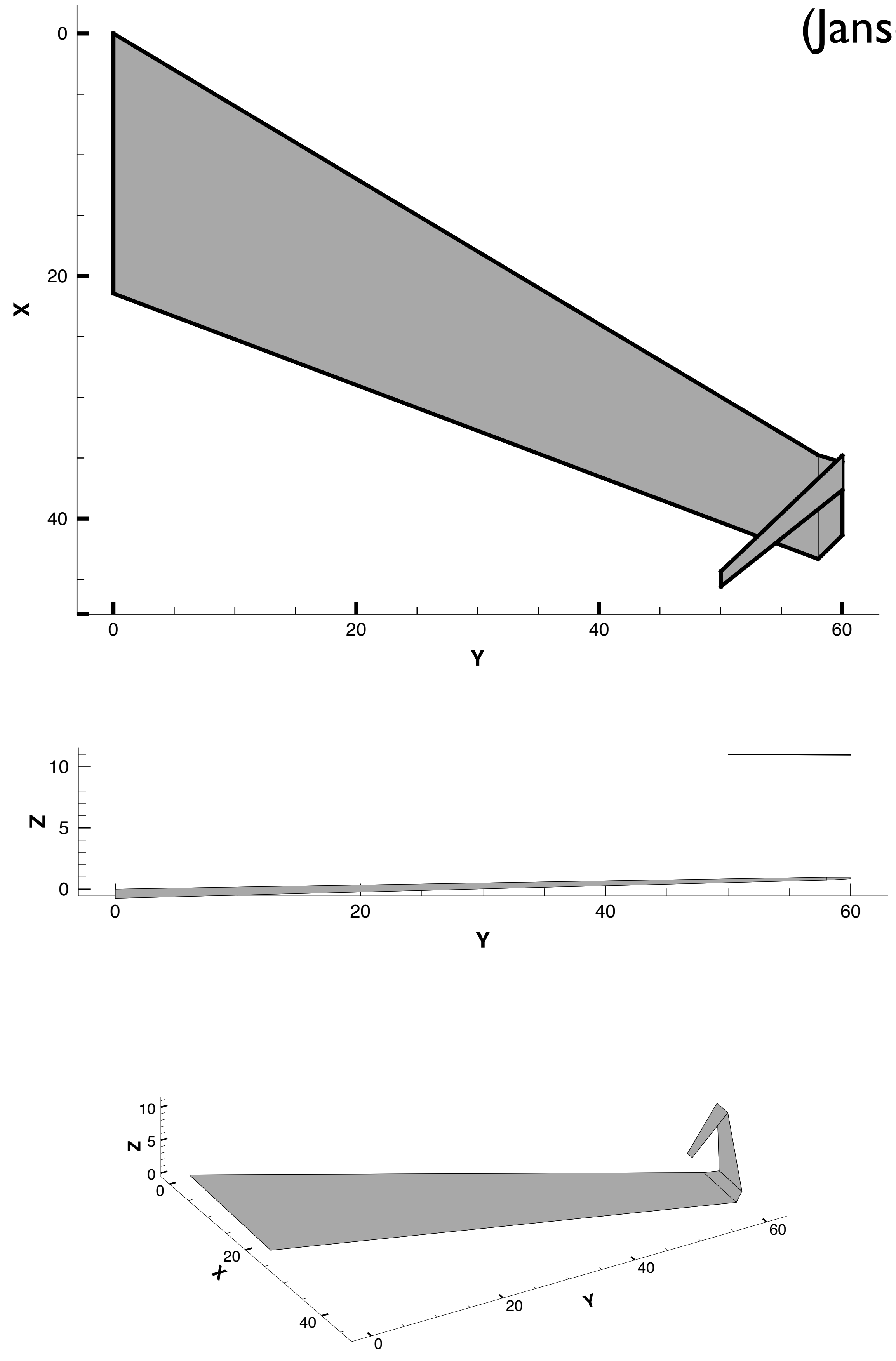

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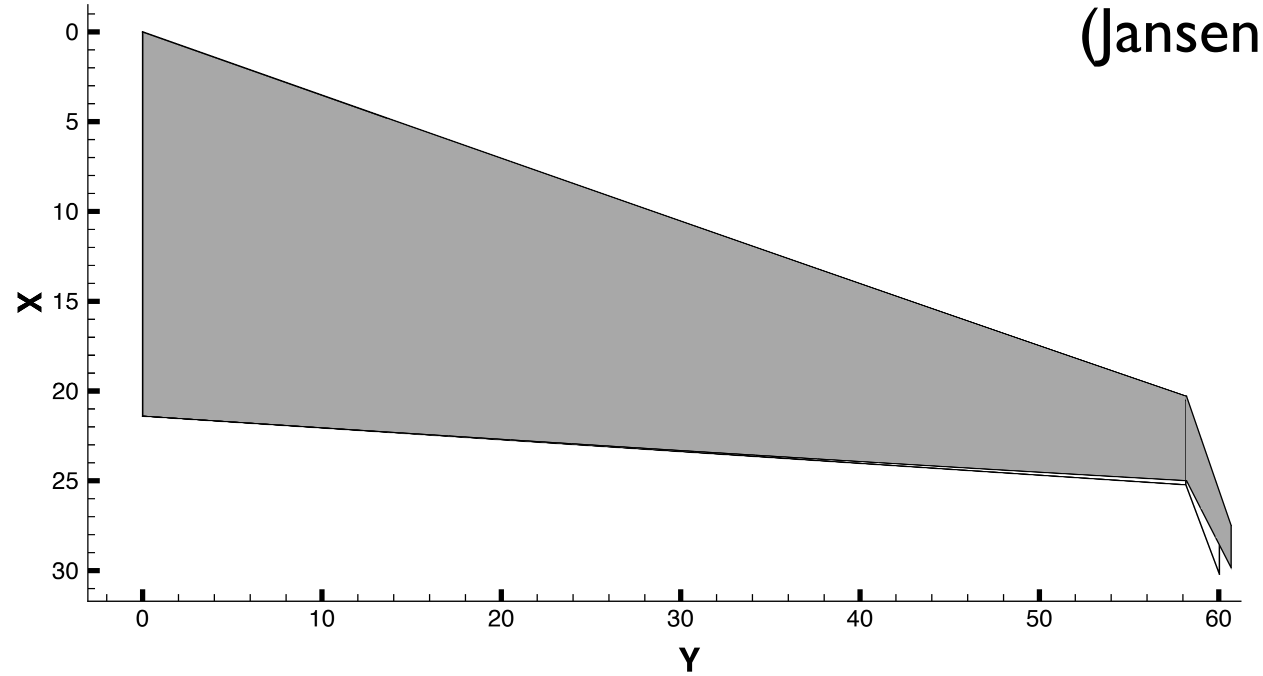
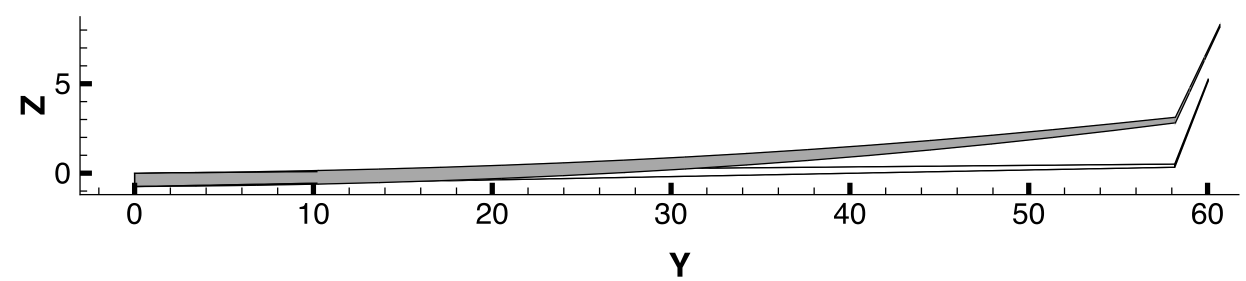
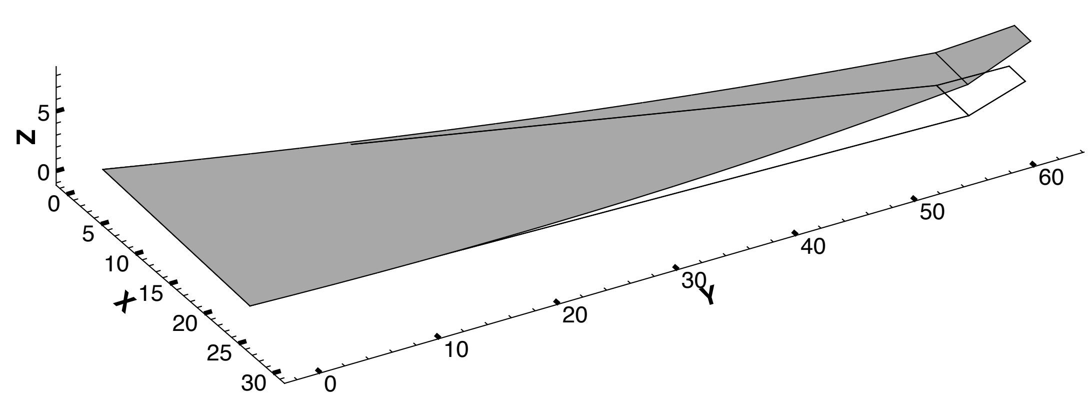



(a)




(b)



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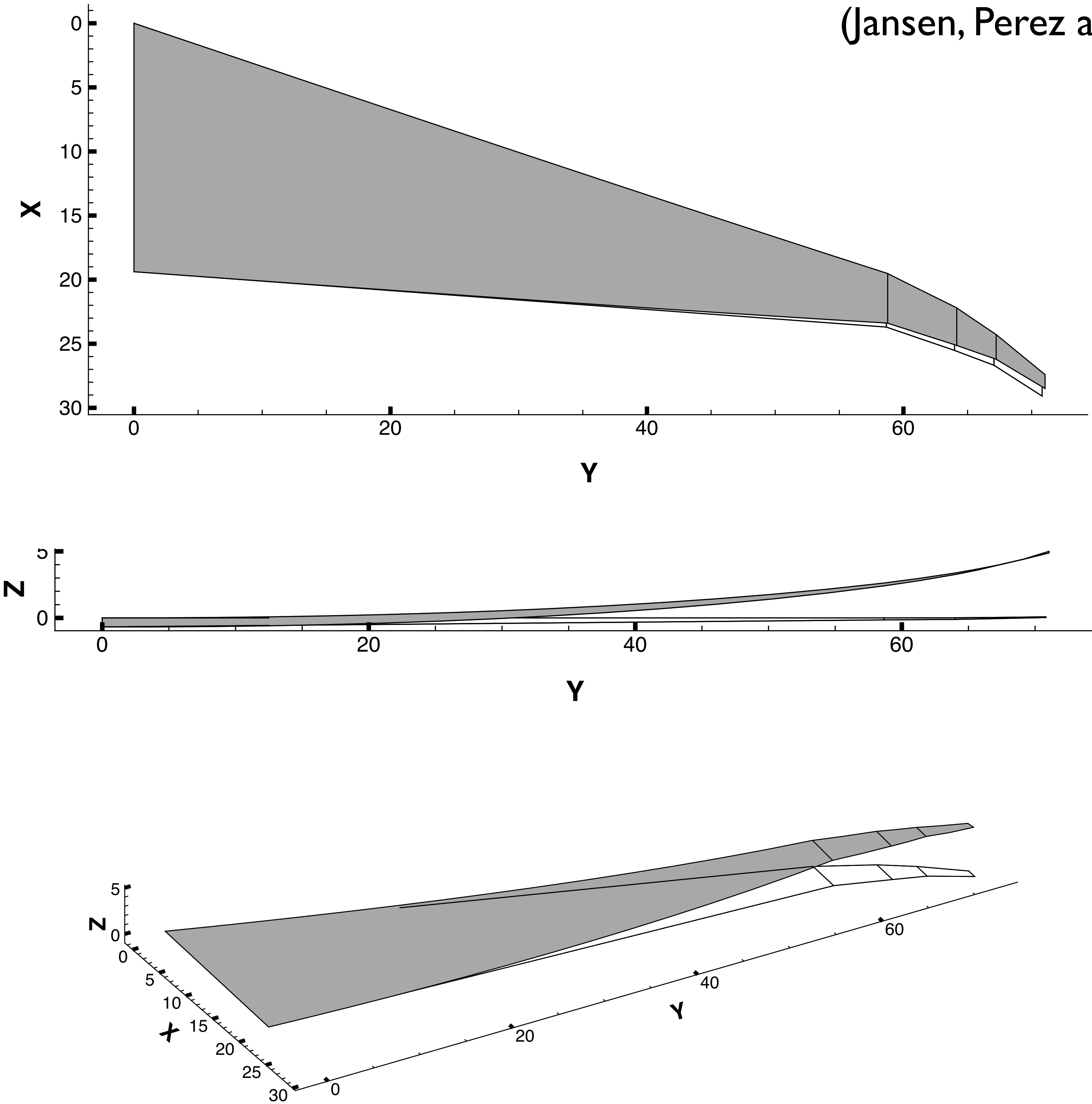
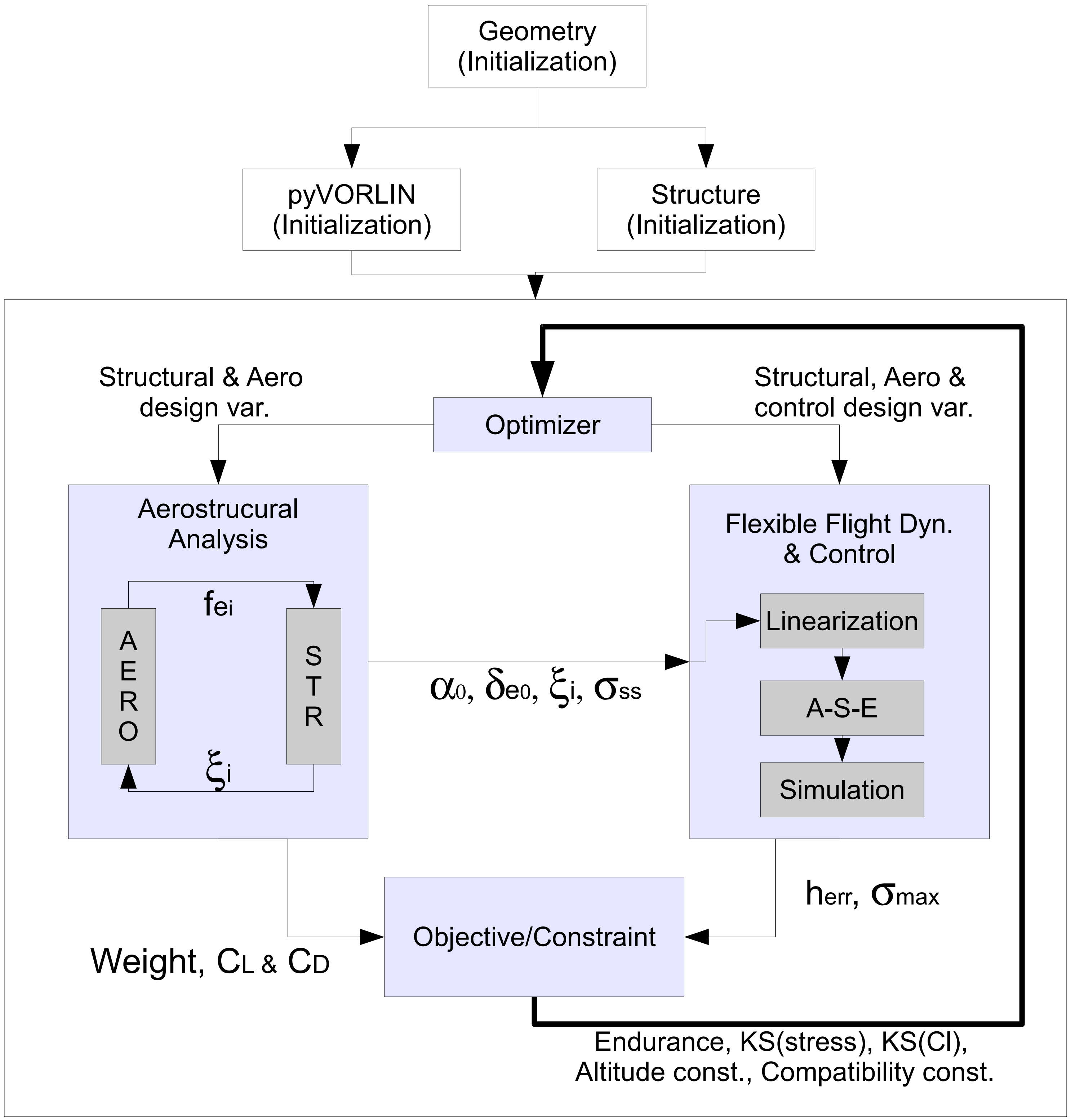
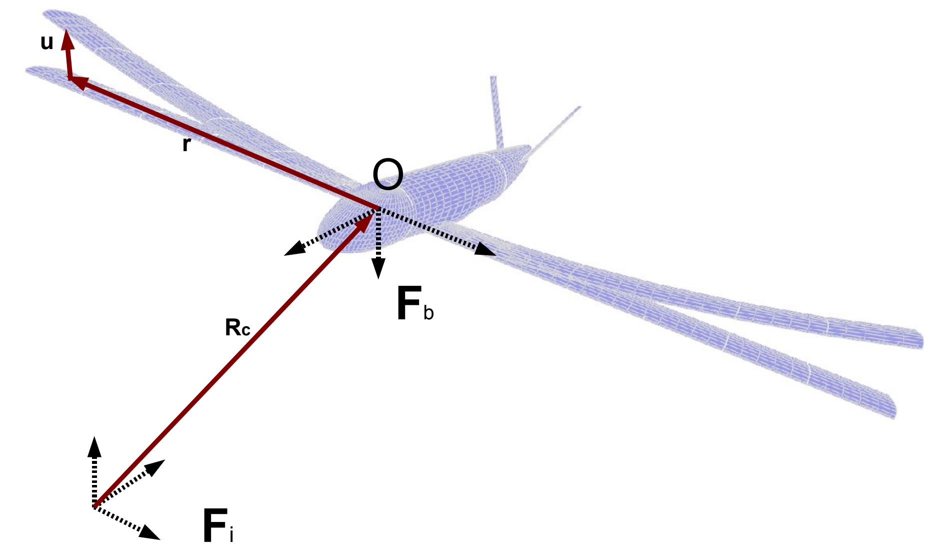
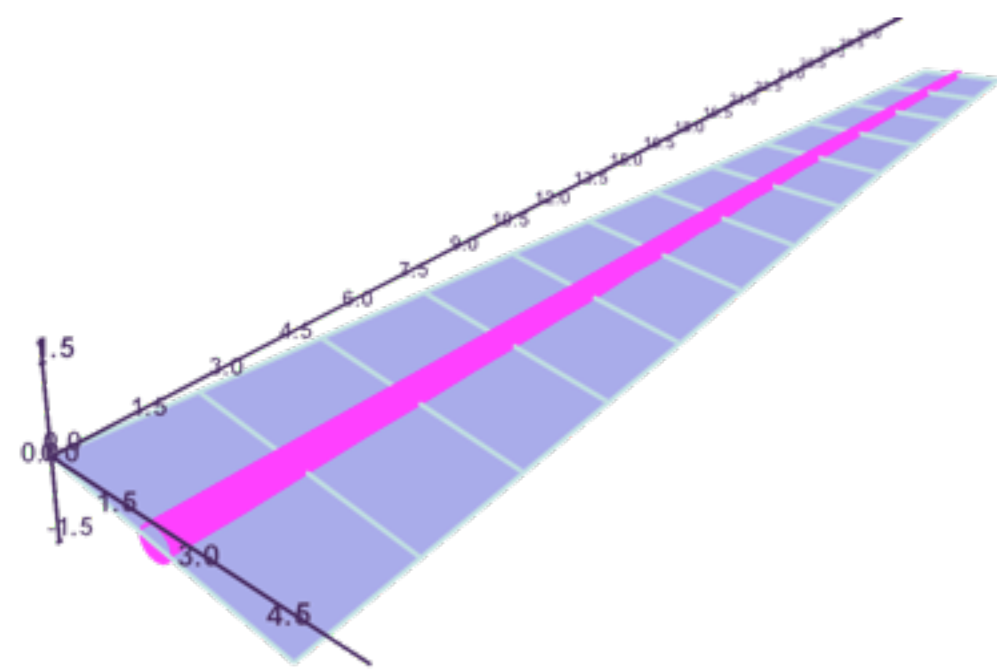


# MDO of Very Flexible Aeroservoelastic Wings

(Haghighat, Martins and Liu, 2009)



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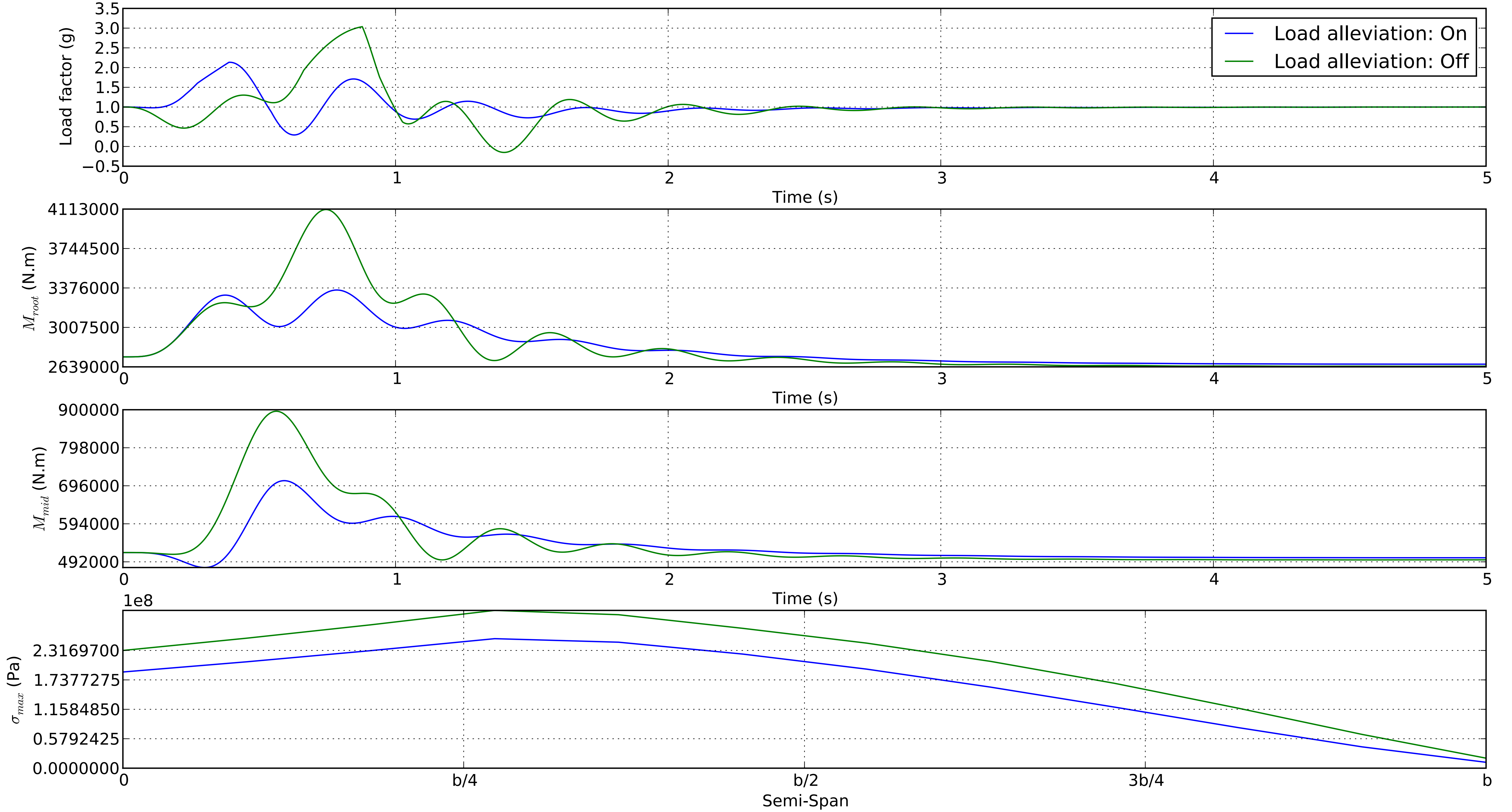
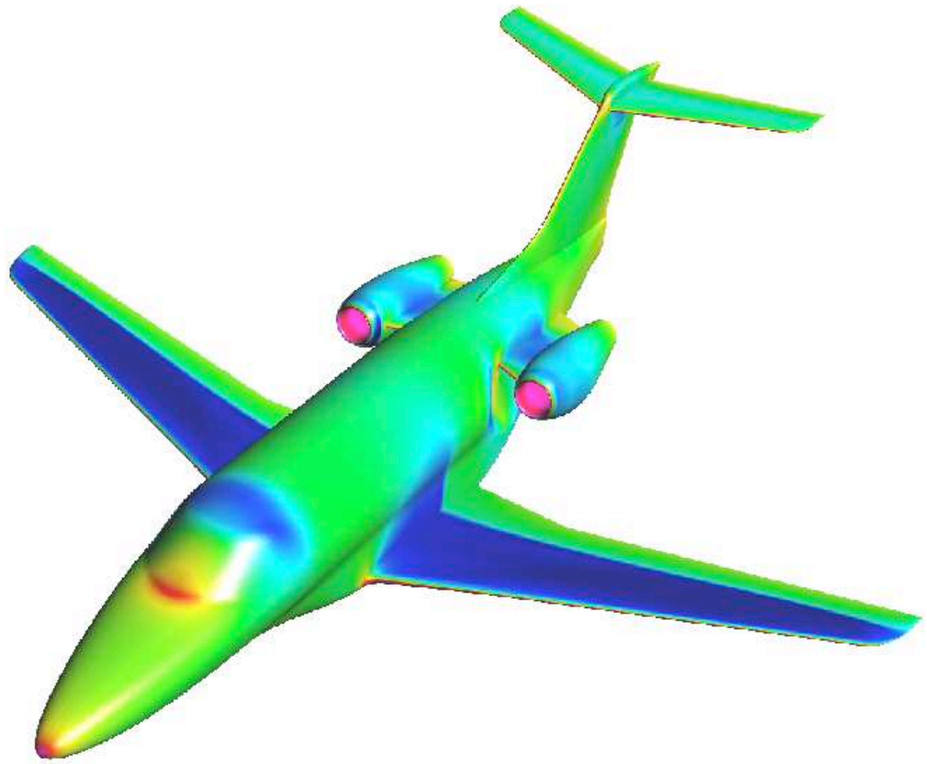
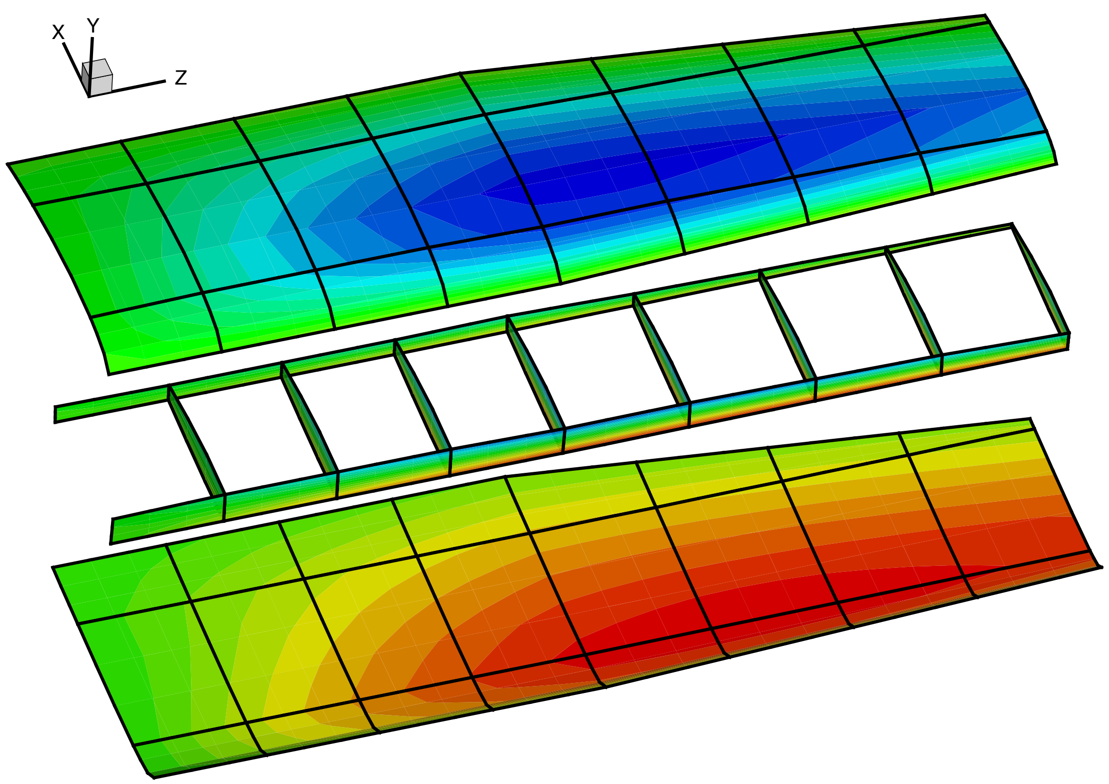


# High-Fidelity Analysis and Optimization





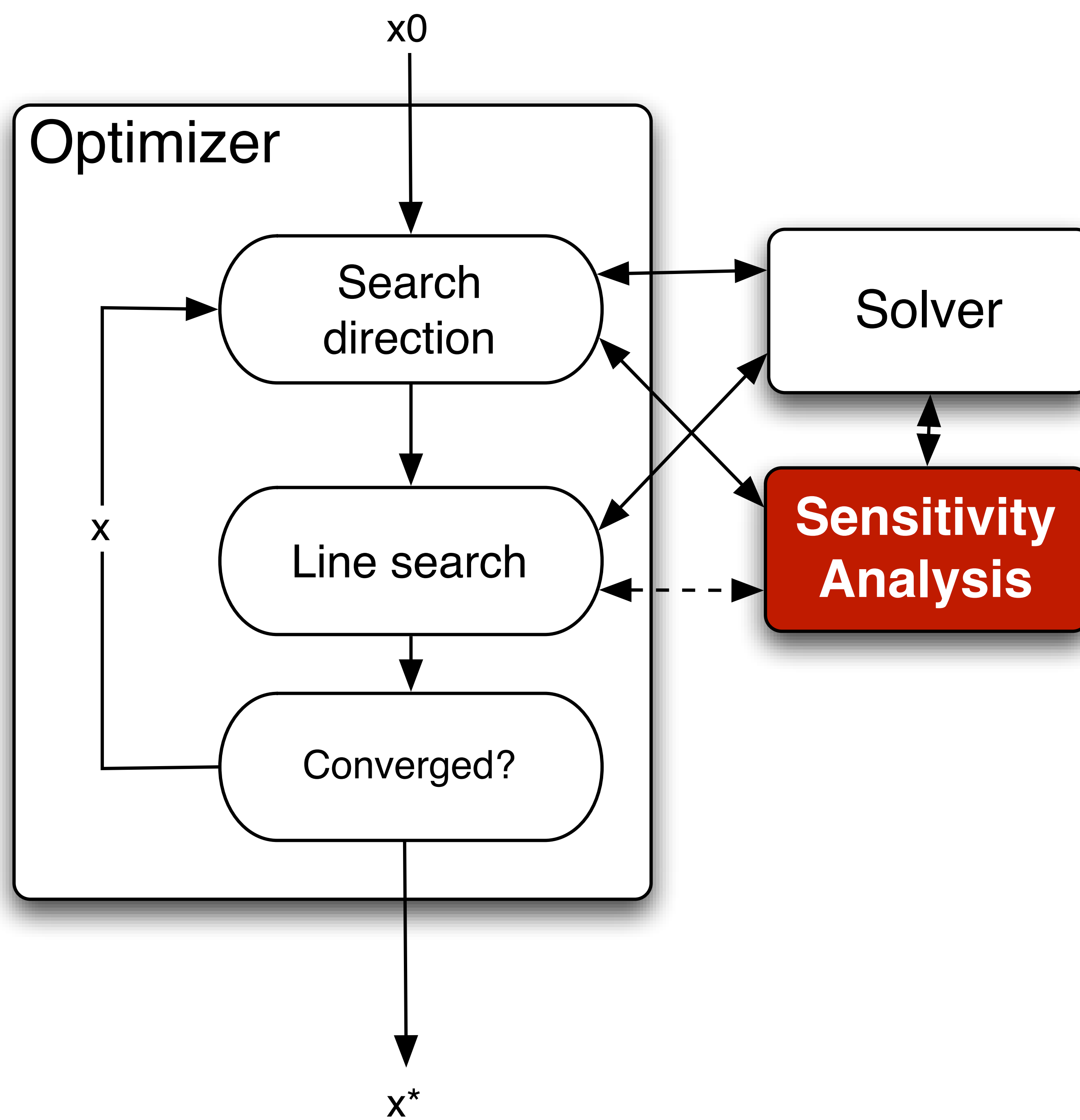

- As high-fidelity models mature, the questions becomes: How do we use these models to design a system?
- Multidisciplinary design optimization provides an approach

**Challenges**

- Cost of function evaluations
- Large number of design variables

# The Case for Efficient Sensitivity Analysis

- Use gradient-based optimizer when possible
- By default, most gradient-based optimizers use finite differences
- When using finite differences with large numbers of design variables, sensitivity analysis is the bottleneck
- Accurate sensitivities needed for convergence

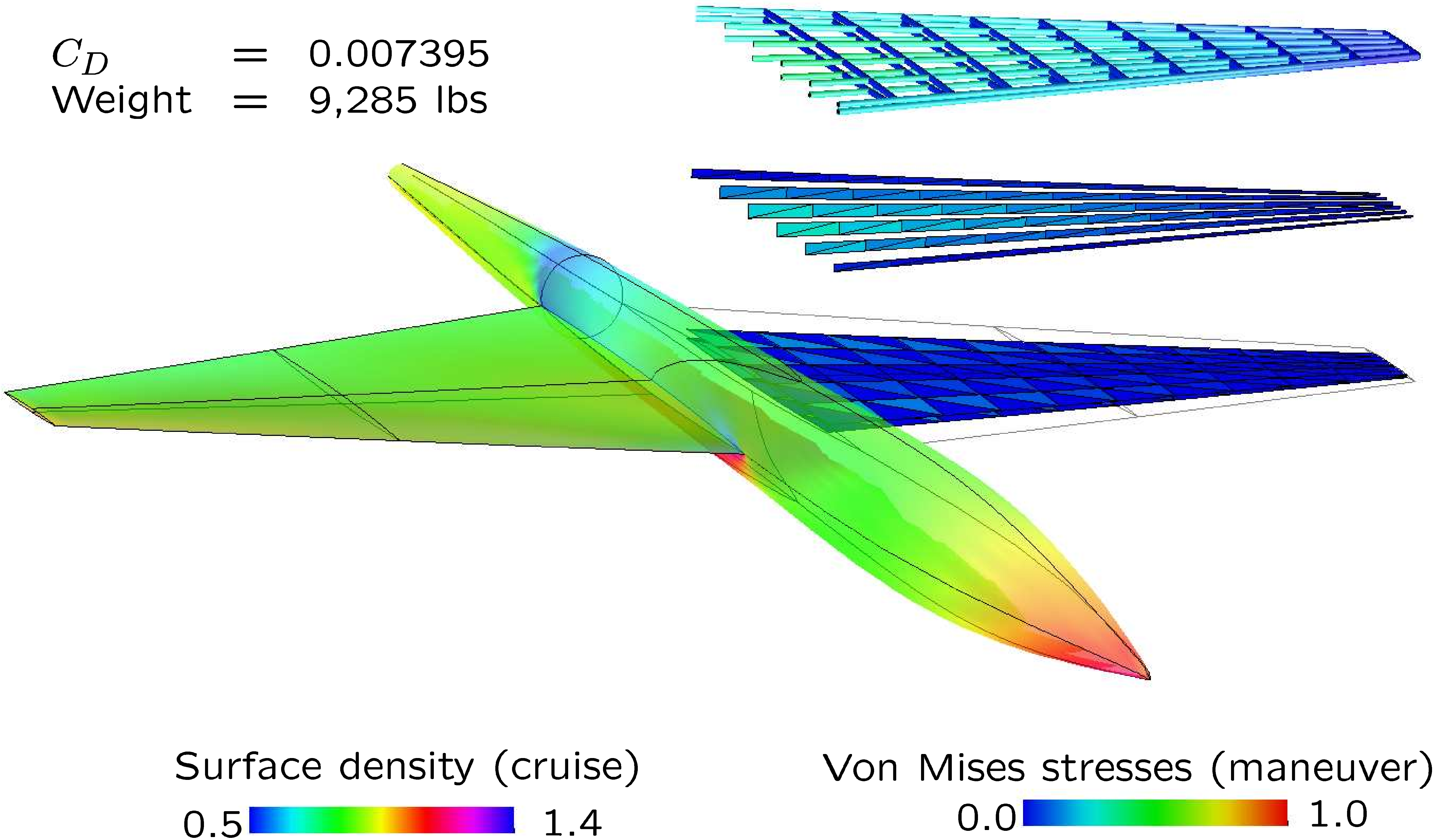


# Aerostructural Optimization

(Martins, Alonso and Reuther, 2004)

$C_D = 0.007395$

Weight = 9,285 lbs

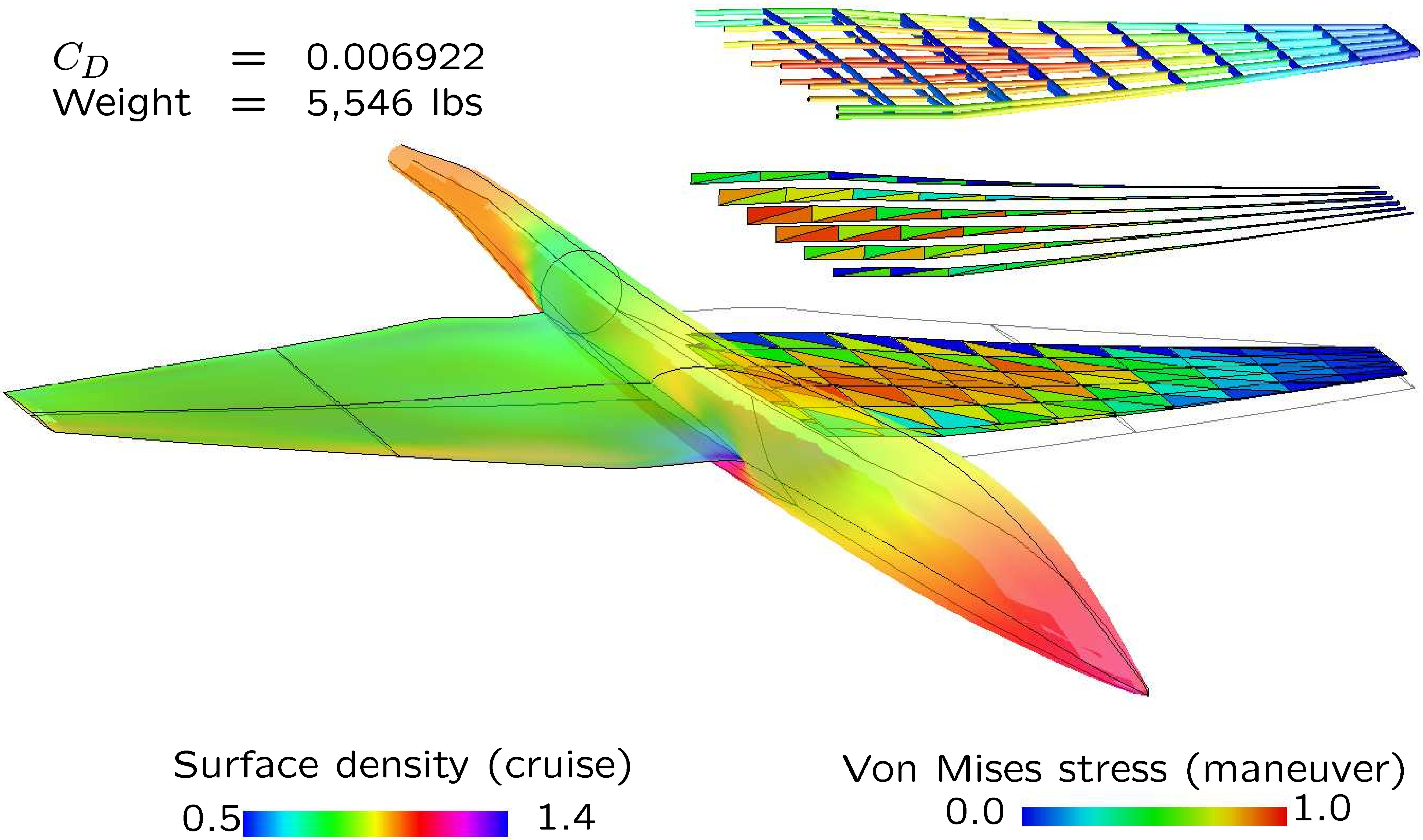


# Aerostructural Optimization

(Martins, Alonso and Reuther, 2004)

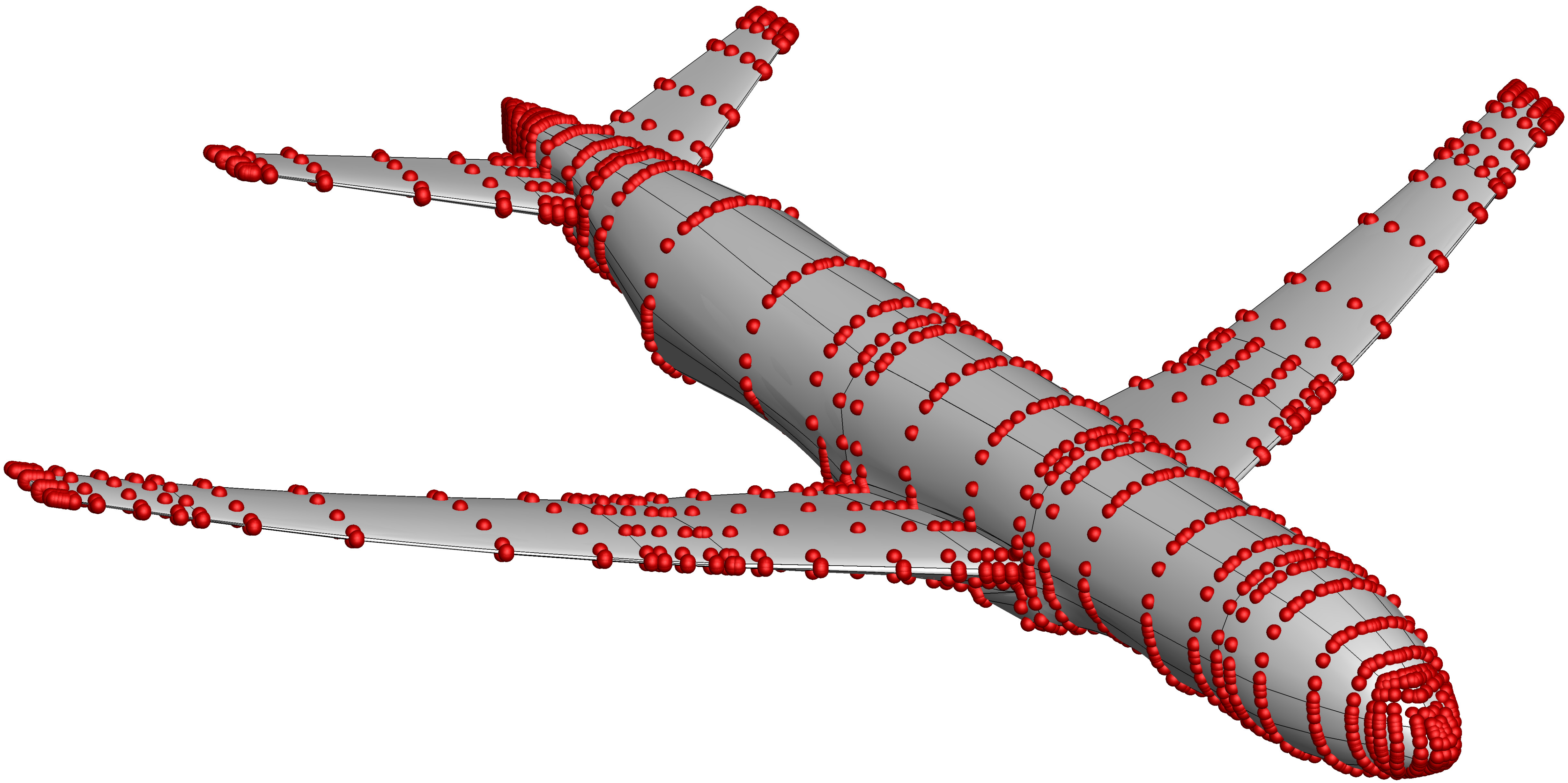
$C_D$ = 0.006922

Weight = 5,546 lbs



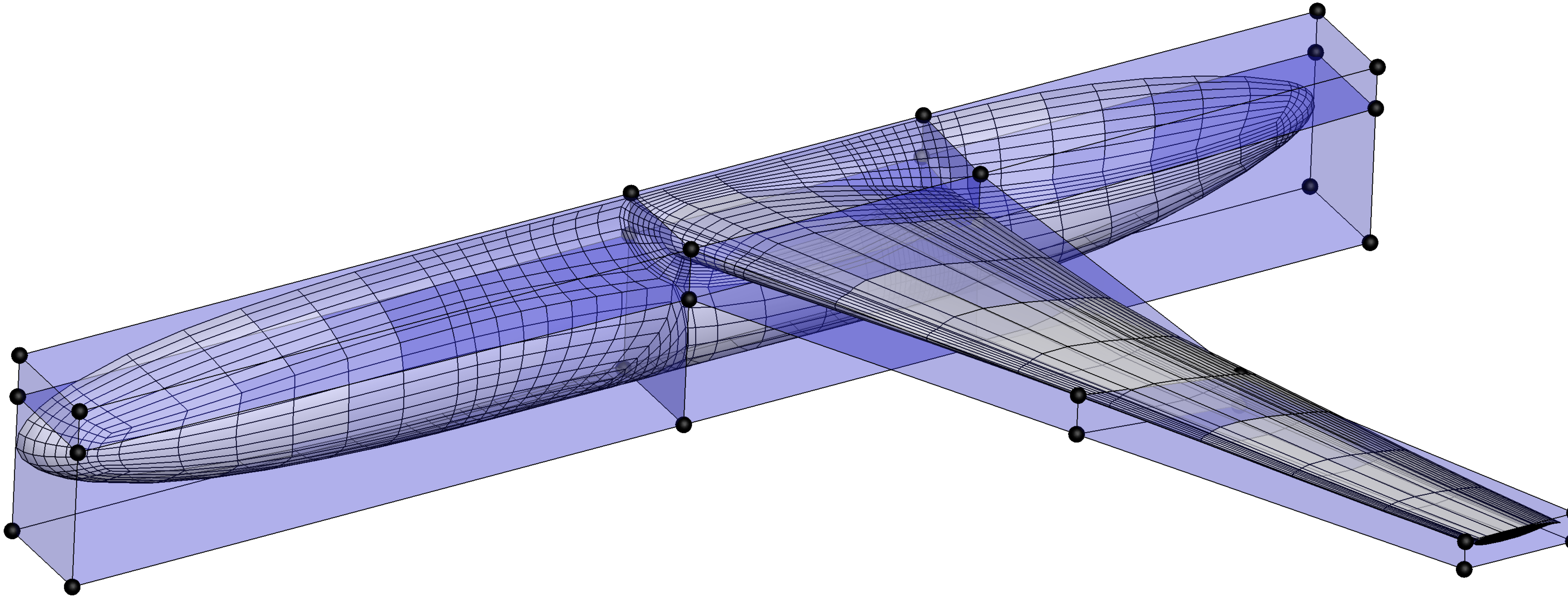
# Geometry: B-Spline Surfaces

(Kenway and Martins, 2010)



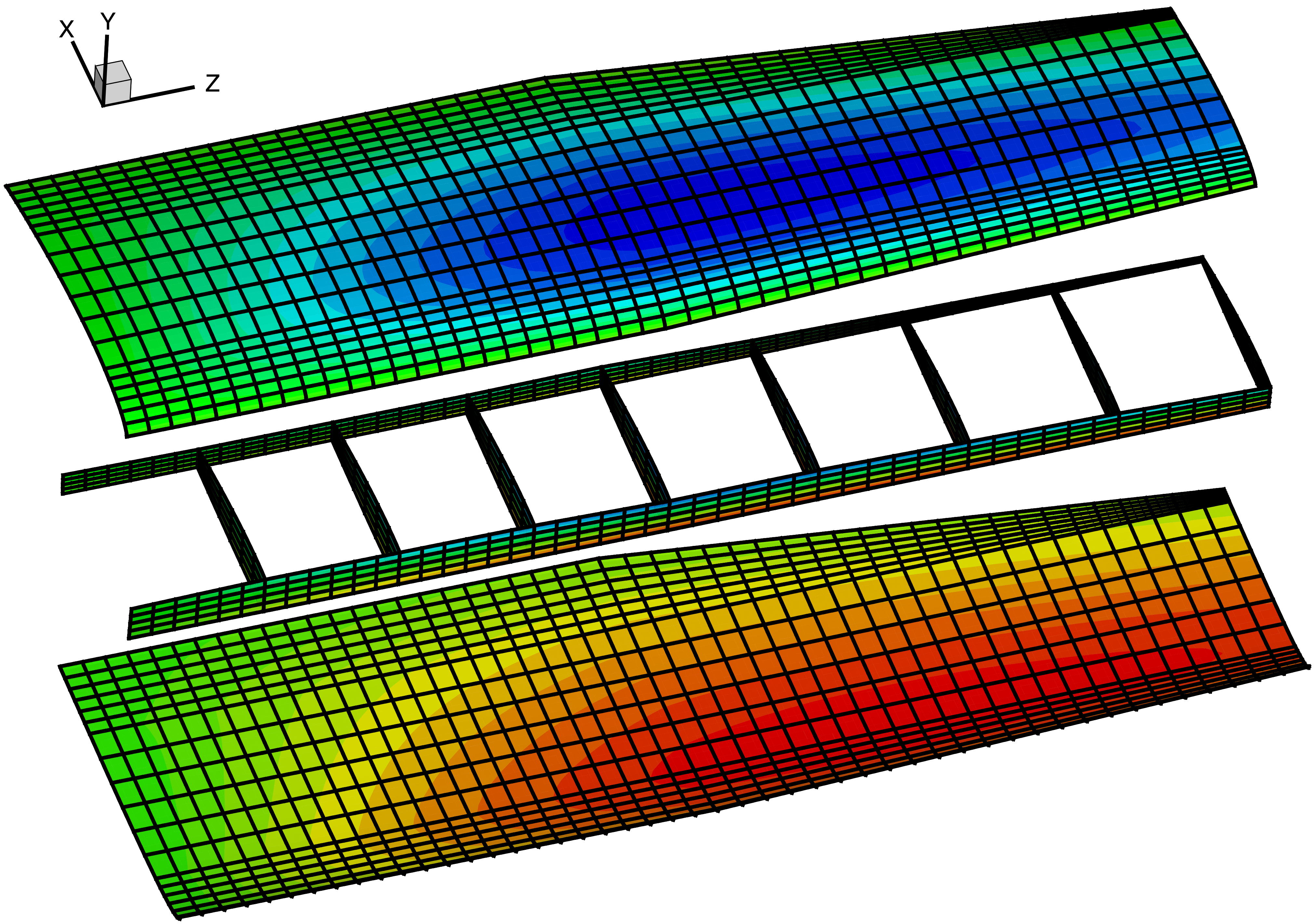
# Geometry: Free-Form Deformation

(Kenway and Martins, 2010)



# Finite-Element Structural Analysis

(Kennedy and Martins, 2010)



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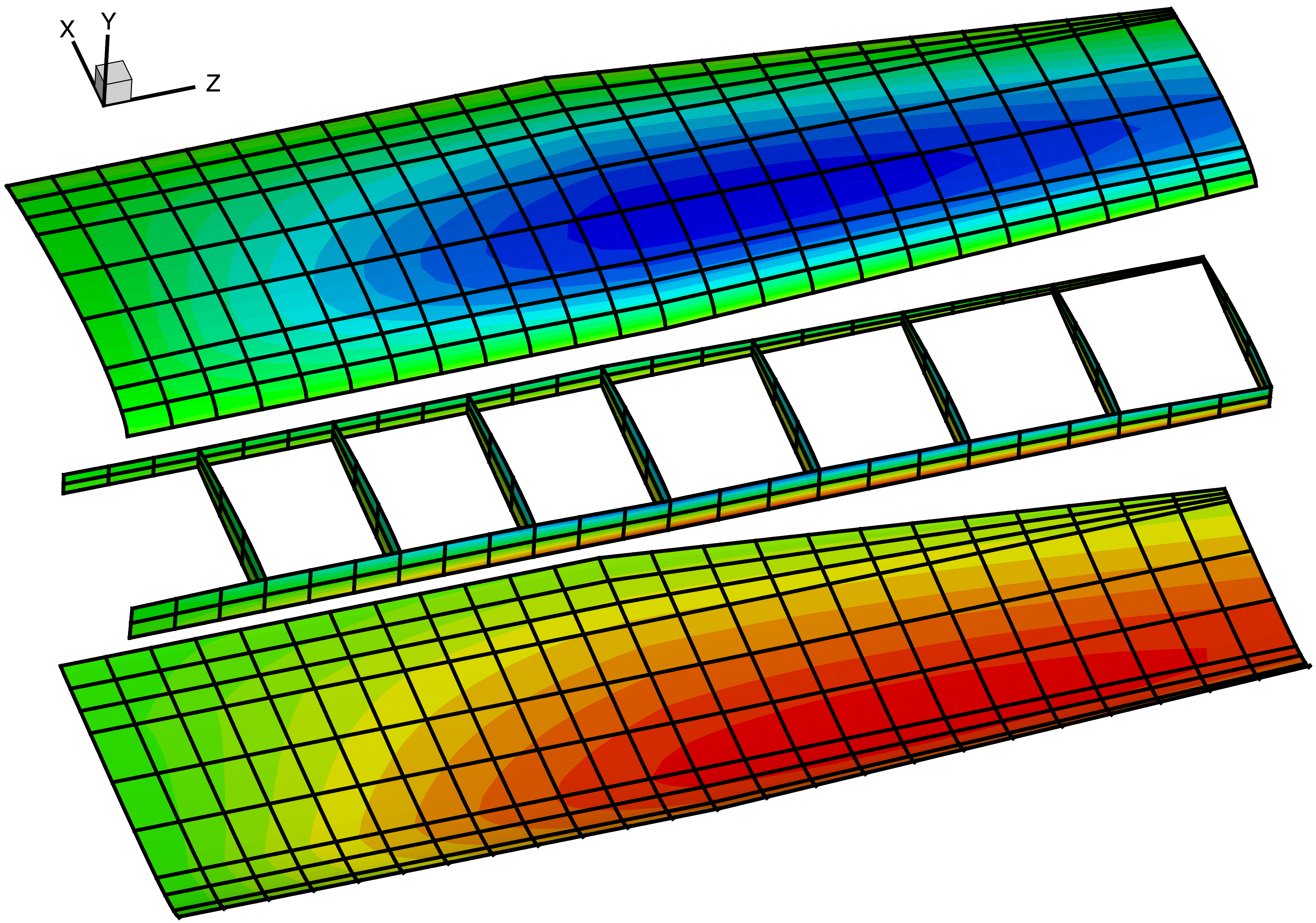

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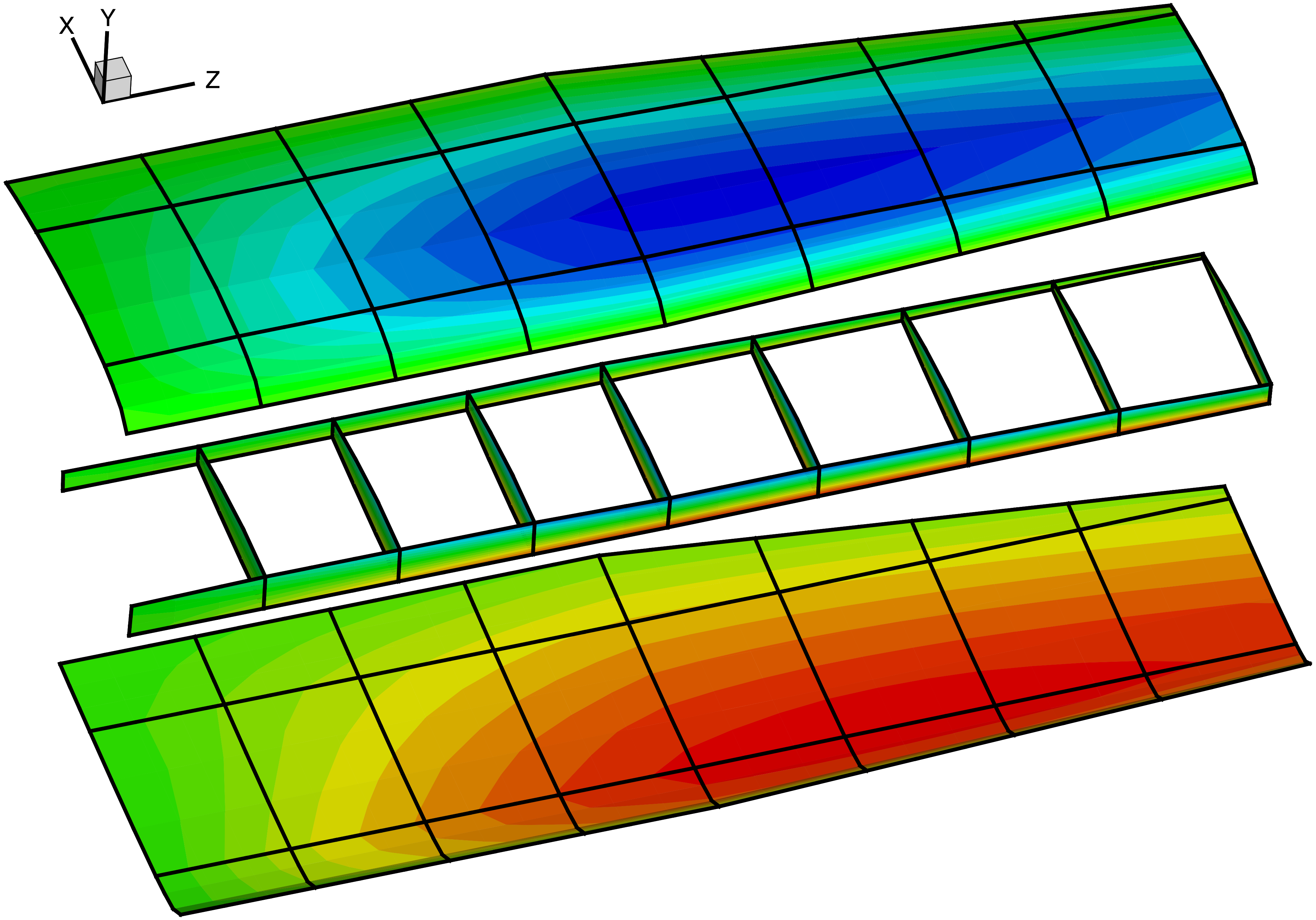
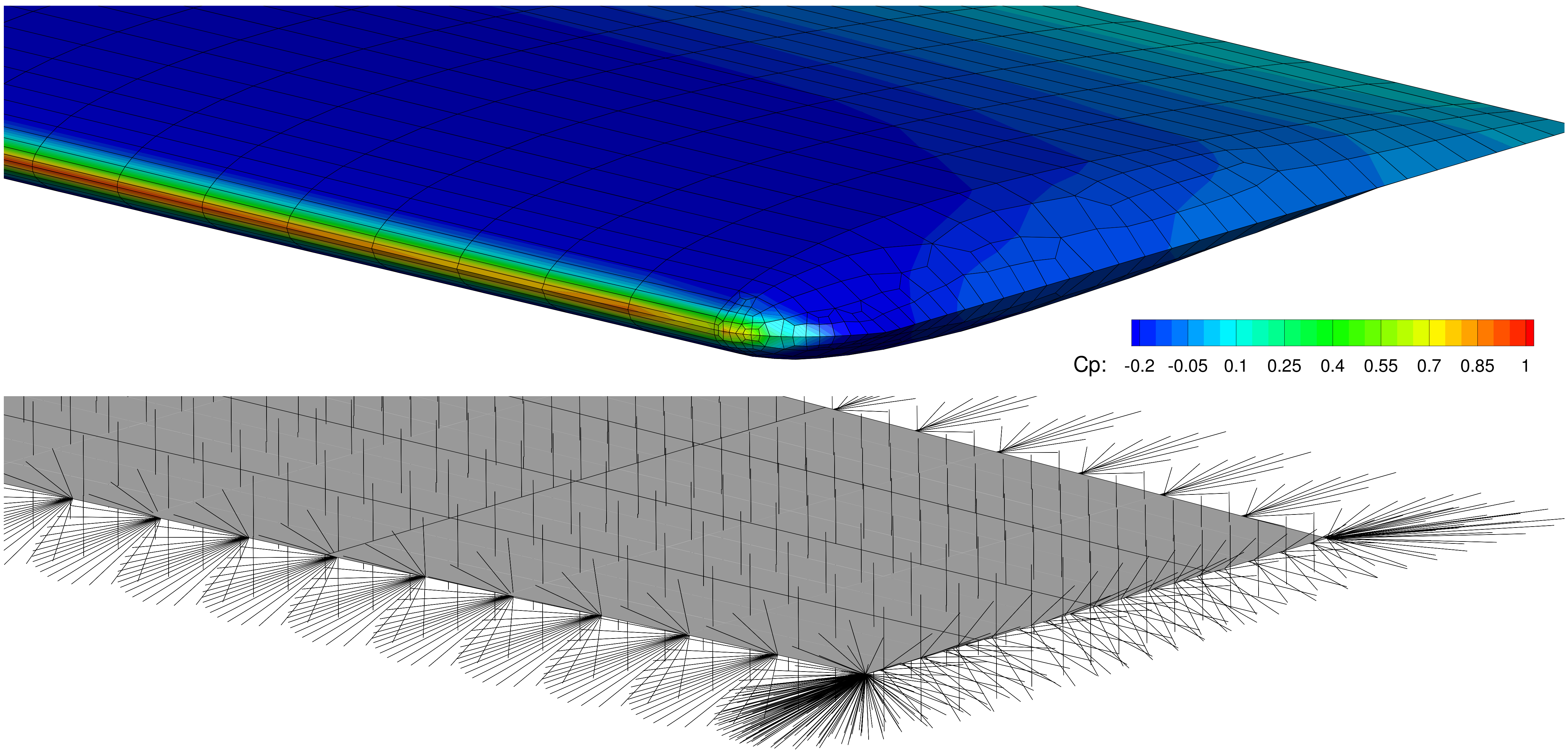


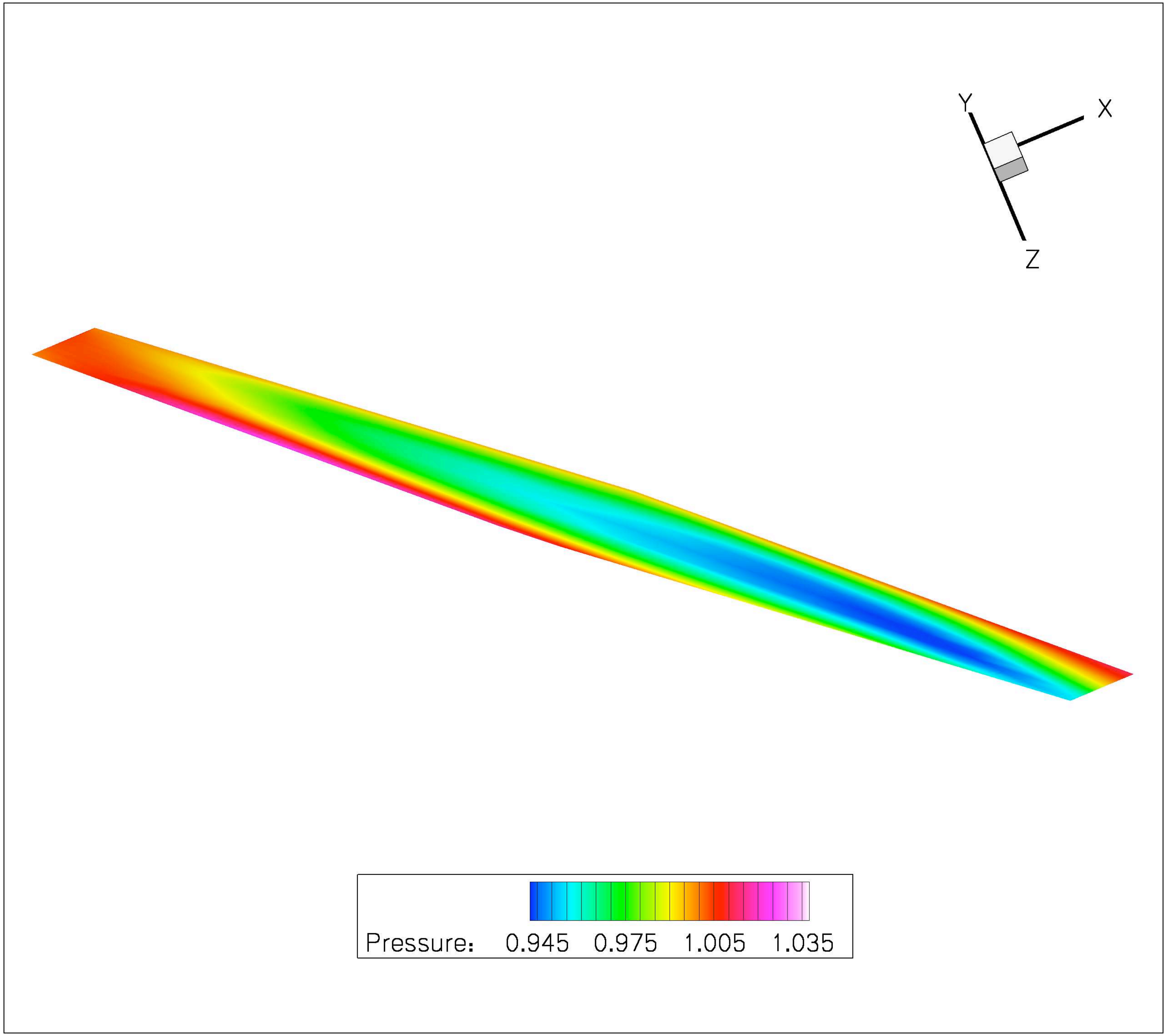
# Aerostructural Coupling

(Kennedy, Kenway, and Martins, 2010)



# Aerodynamic Shape Optimization with Stability Constraints

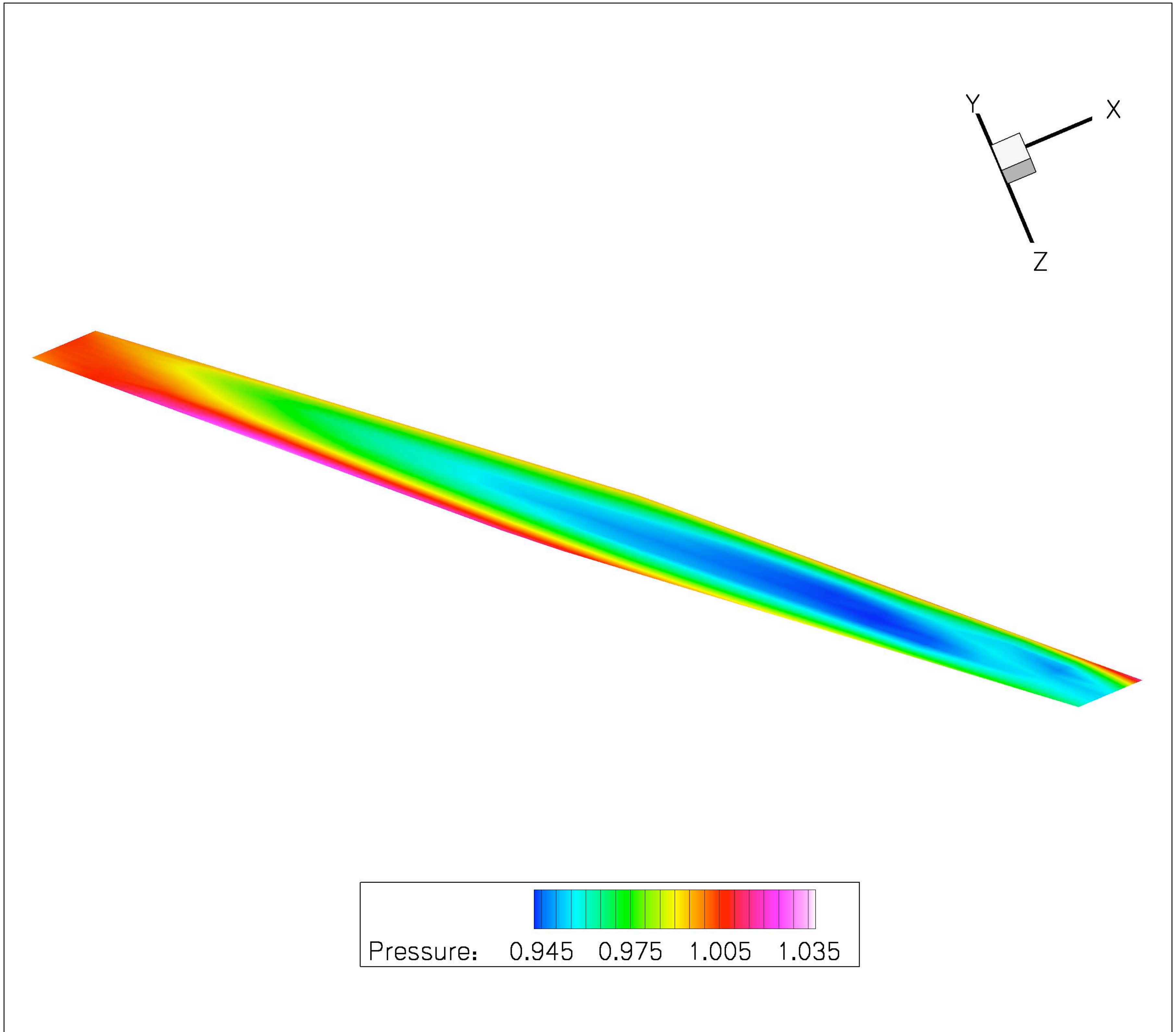
(Mader, Martins, 2010)




Baseline

# Aerodynamic Shape Optimization with Stability Constraints

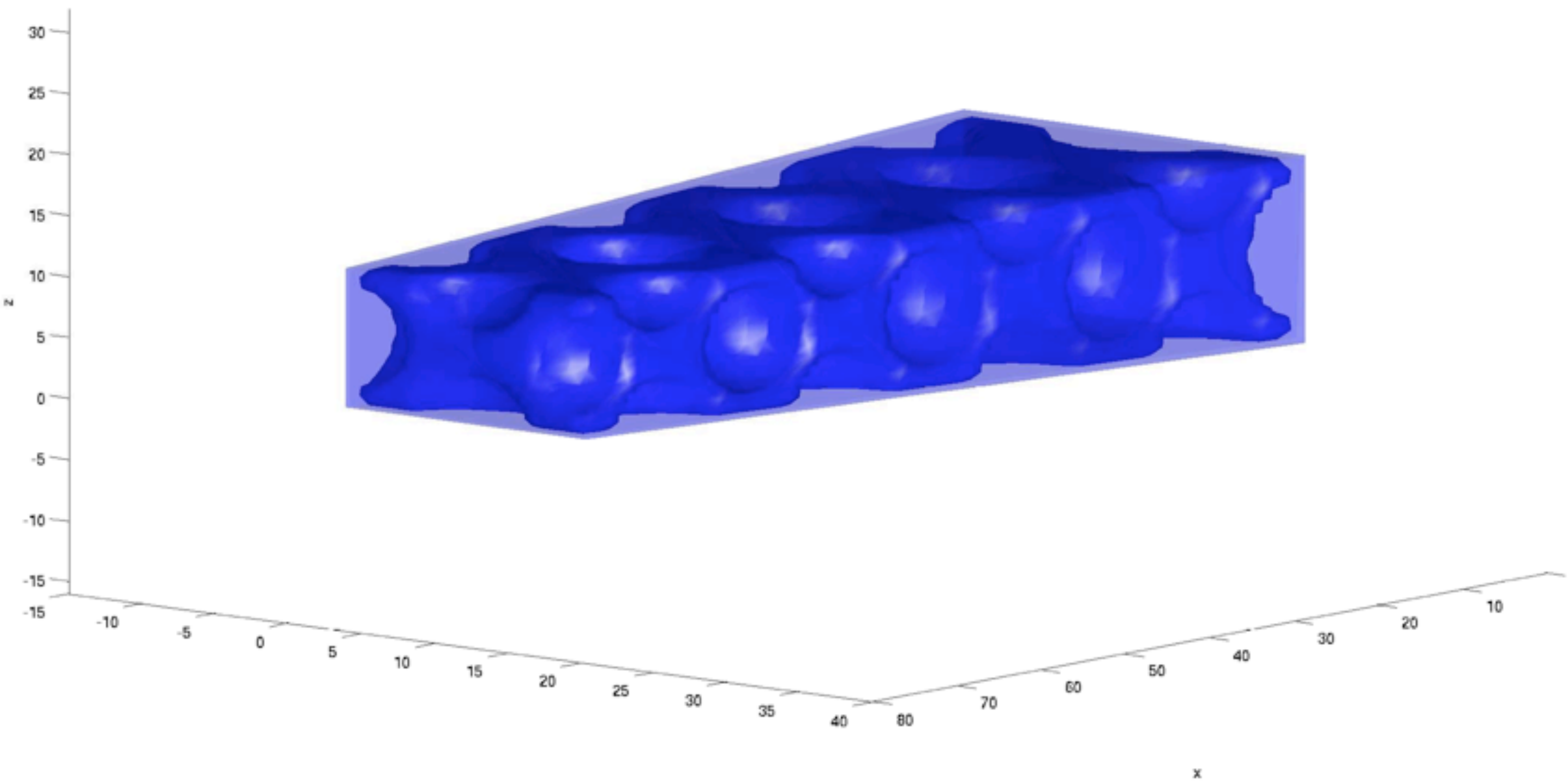
(Mader, Martins, 2010)




Optimized

# Wing Box Structural Topology Optimization

(James and Martins, 2008)



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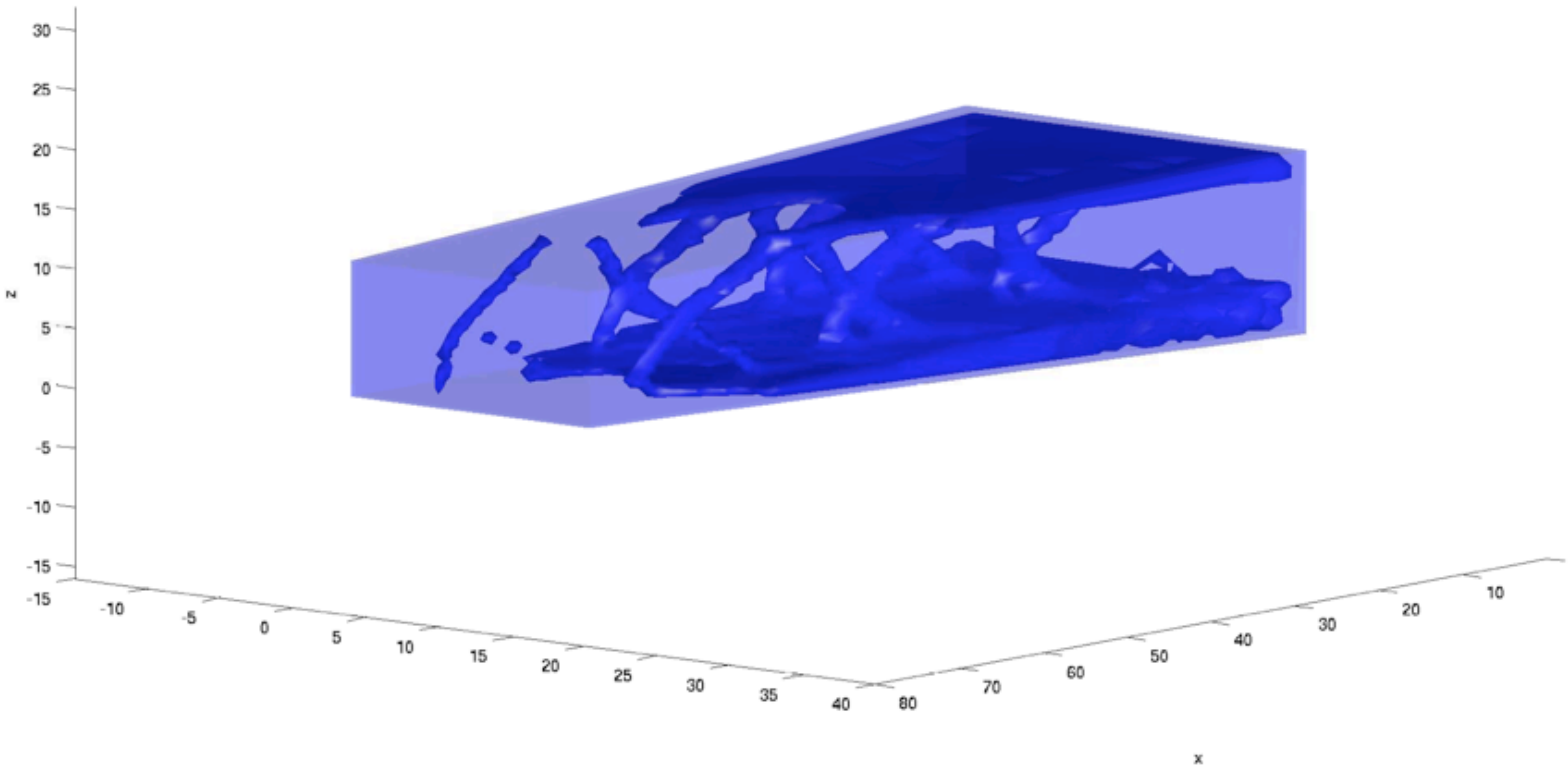
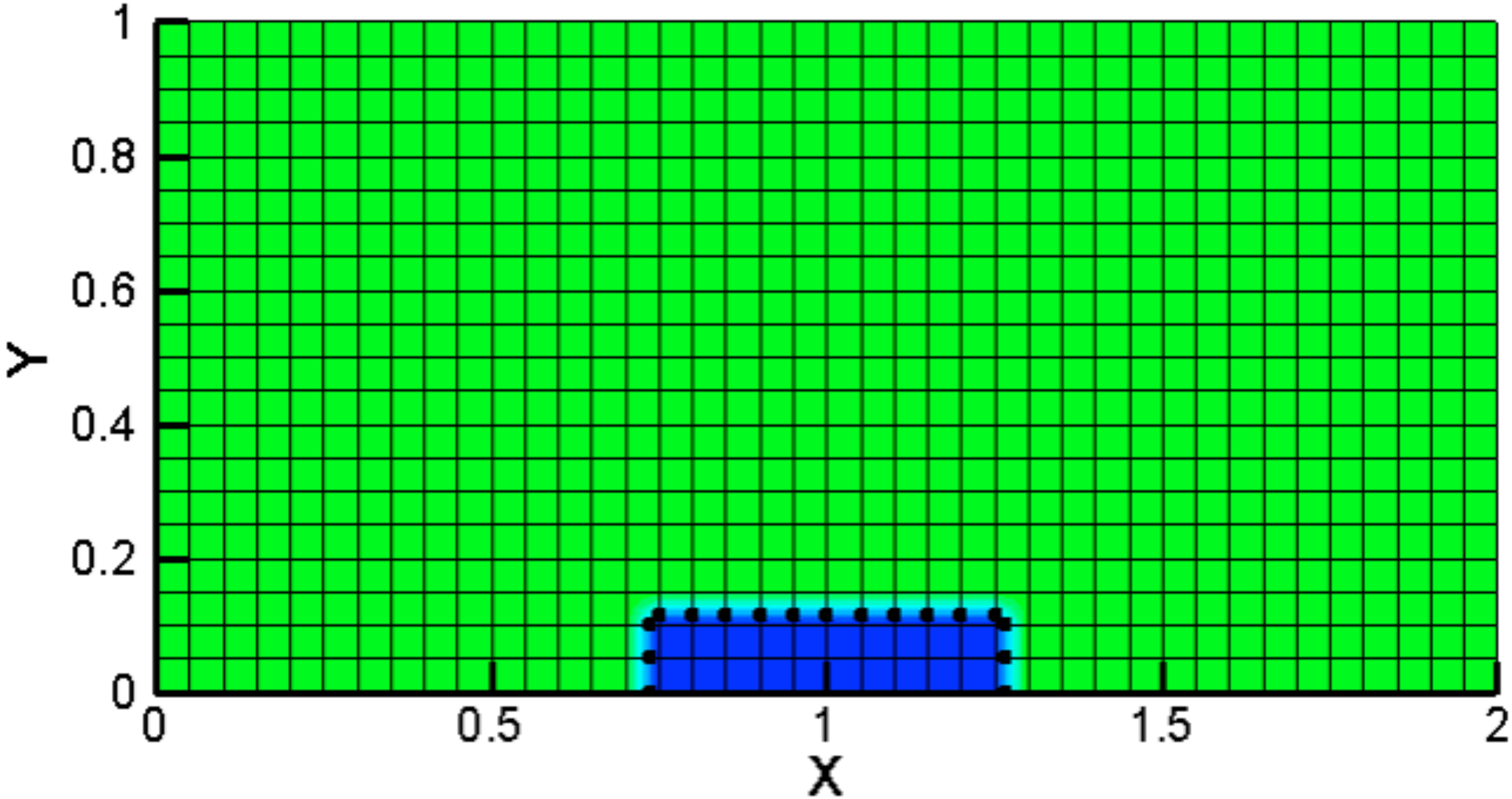


# Aerostructural Topology Optimization with Pressurization Loads

(Lee and Martins, 2011?)



# Acknowledgements: Students

# Thank You!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