GeoMACH: Geometry-Centric MDAO of Aircraft Configurations with High Fidelity

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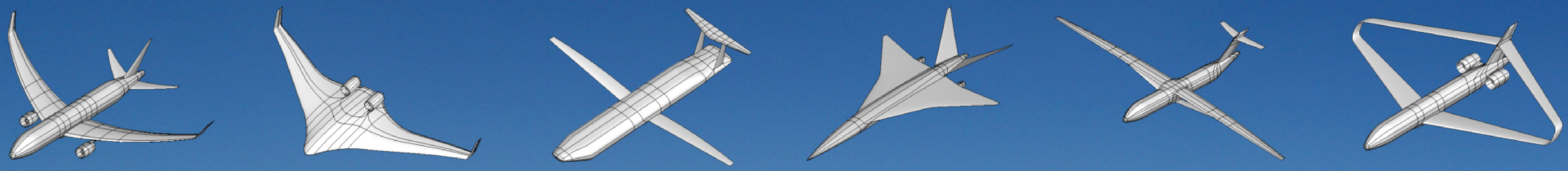
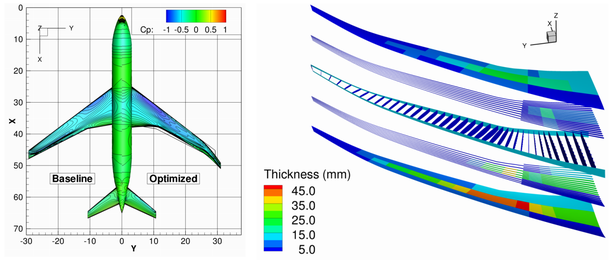


Motivation

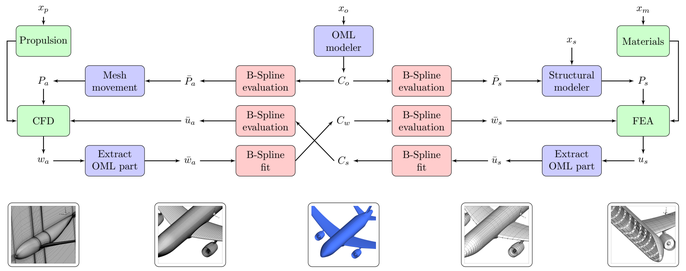
- High fidelity aerostructural optimization with hundreds of variables is now possible using CFD and FEA
- Want to use these tools earlier in the design process
- GeoMACH: geometry-centric approach to MDAO



(Kenway, Kennedy, and Martins, AIAA-2012-1922)

Framework

- Efficient B-spline engine for geometry modeling and data transfer between disciplines
- Integrated with NASA's OpenMDAO framework
- Modular approach with mappings from shape variables to CFD and FEA meshes



Derivatives

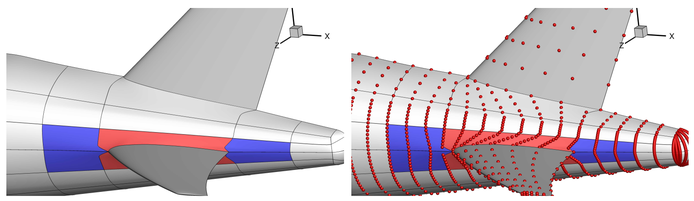
- Smooth mappings; efficient derivative computation
- Supports hybrid coupled adjoint-based derivatives

$$\begin{bmatrix} I & -\frac{\partial R_o}{\partial y_o} & 0 & -\frac{\partial Y_f}{\partial y_o} & 0 & \frac{df}{dy_o} \\ 0 & -\frac{\partial R_c}{\partial y_c} & -\frac{\partial R_a}{\partial y_c} & 0 & 0 & \frac{df}{dr_c} \\ 0 & 0 & -\frac{\partial R_a}{\partial y_a} & 0 & -\frac{\partial R_s}{\partial y_a} & \frac{df}{dr_a} \\ 0 & 0 & 0 & I & -\frac{\partial R_s}{\partial y_f} & \frac{df}{dy_f} \\ 0 & -\frac{\partial R_c}{\partial y_s} & 0 & 0 & -\frac{\partial R_s}{\partial y_s} & \frac{df}{dr_s} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ \frac{\partial F}{\partial y_a} \\ 0 \\ \frac{\partial F}{\partial y_s} \end{bmatrix}$$

(Martins and Hwang, AIAA-2012-1589)

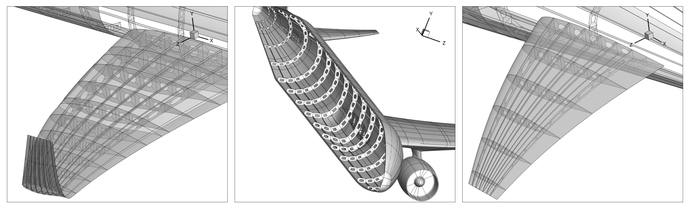
OML modeler

- Watertight union of 4-sided B-spline patches
- Smooth, elegant, and versatile parametrization
- Interpolation-based junctions avoid the need to compute intersections



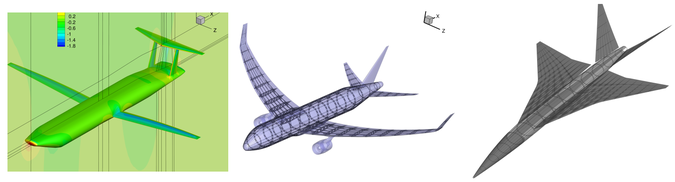
Structural modeler

- Parametric structure driven by OML
- Automatically generated with a simple interface
- Model skin, ribs, spars, stringers, frames, longerons, various types of holes in elements



Significance

- Contributions: B-spline based data transfer; smooth parametric modeler for unconventional configurations; OML-driven structural modeler
- Desired result: enable state-of-the-art MDO tools to make an impact on the aircraft design process



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