

BAND-AID Theory

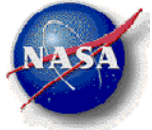
**Aerodynamic Shape Parameterization Based
on Free-Form Deformation
(AIAA-2004-4630)**

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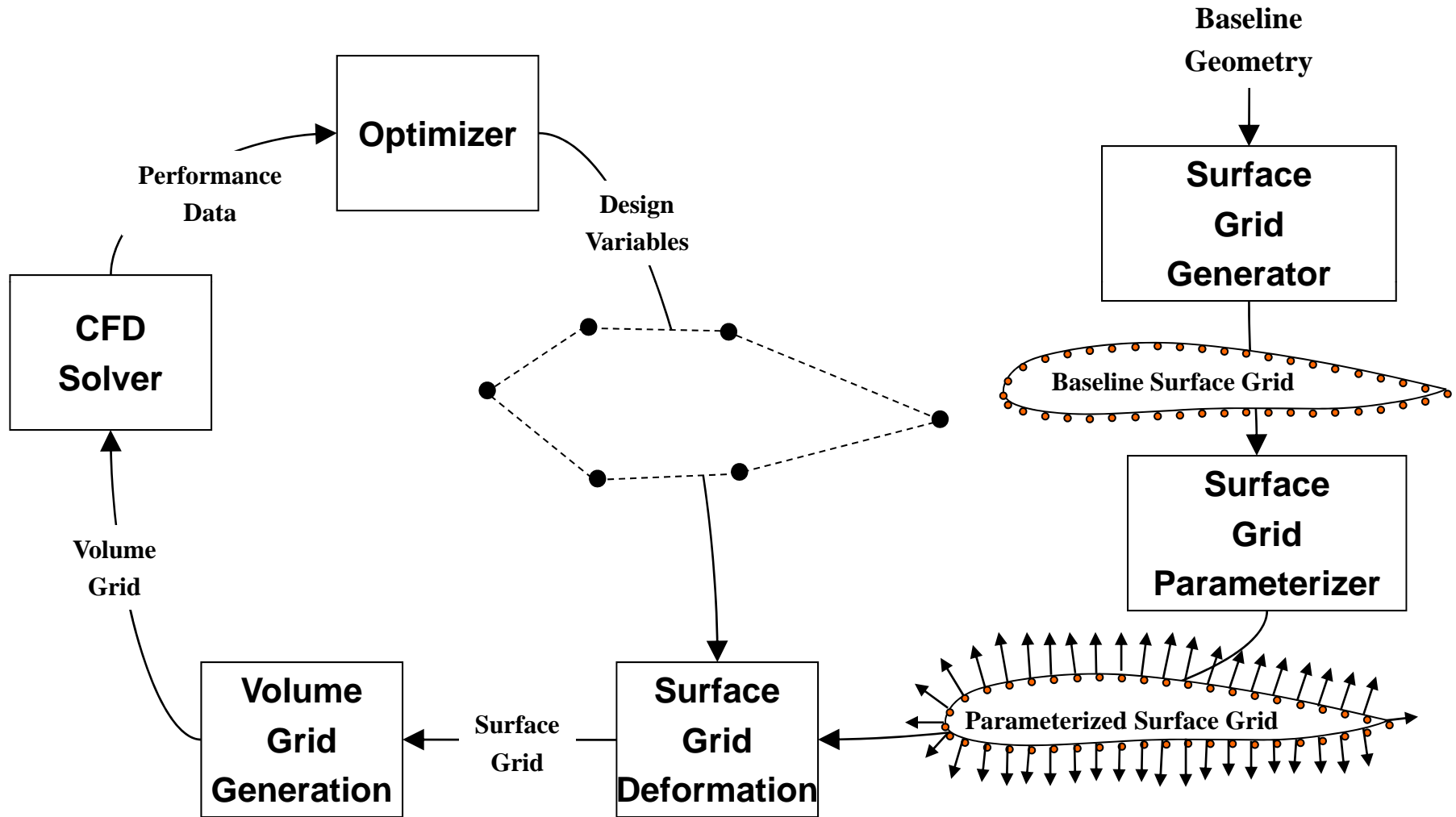
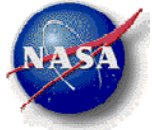
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Three Key Ideas

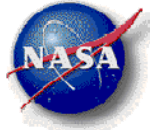


- KI-1 Parameterize surface grid (avoids surface grid regeneration)
- KI-2 Use free-form deformation to represent shape perturbations (automates the surface parameterization)
- KI-3 Parameterize the changes in shape perturbation, not the shape itself (reduces number of design variables)

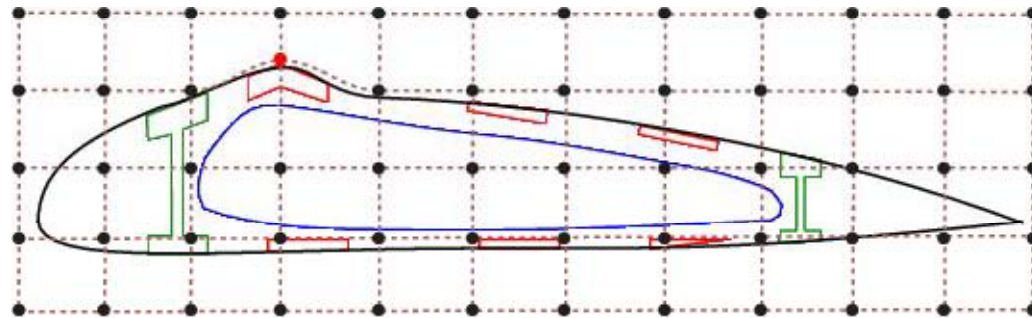
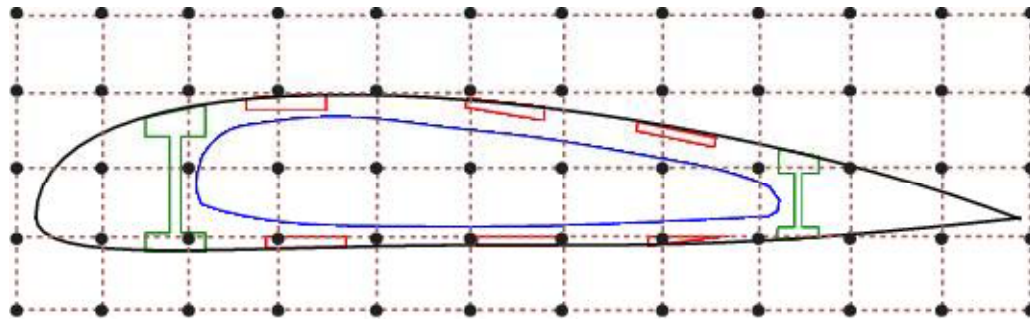
Grid-Based Parameterization (KI-1)



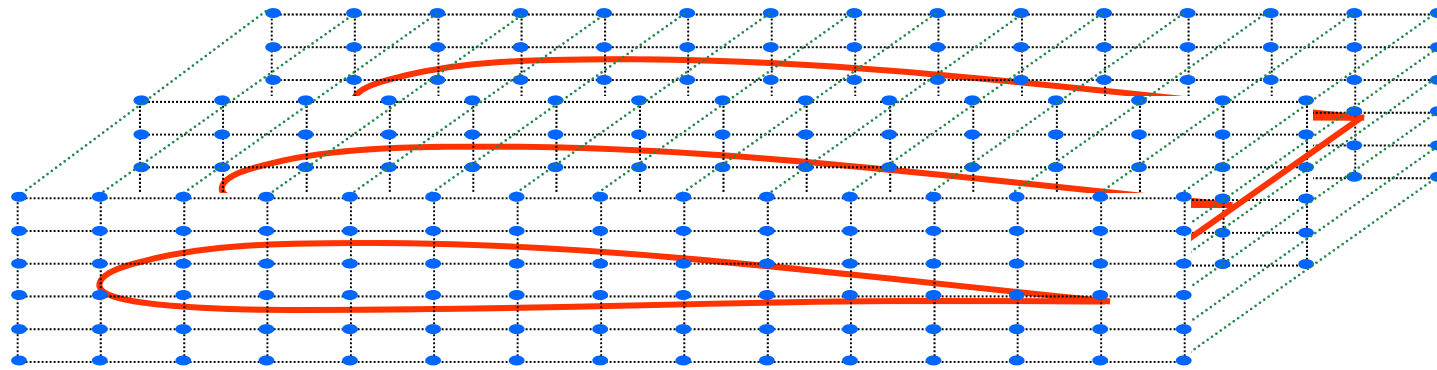
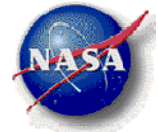
Free-Form Deformation Technique (KI-2)



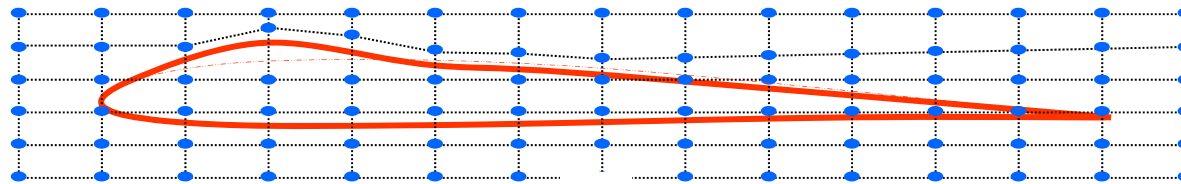
- Based on algorithm used in computer animation
- Avoids grid generation by deforming the baseline grid
- Design variables have no aerodynamic significance



Free-Form Deformation Technique (KI-2) (cont.)

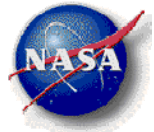


(a)

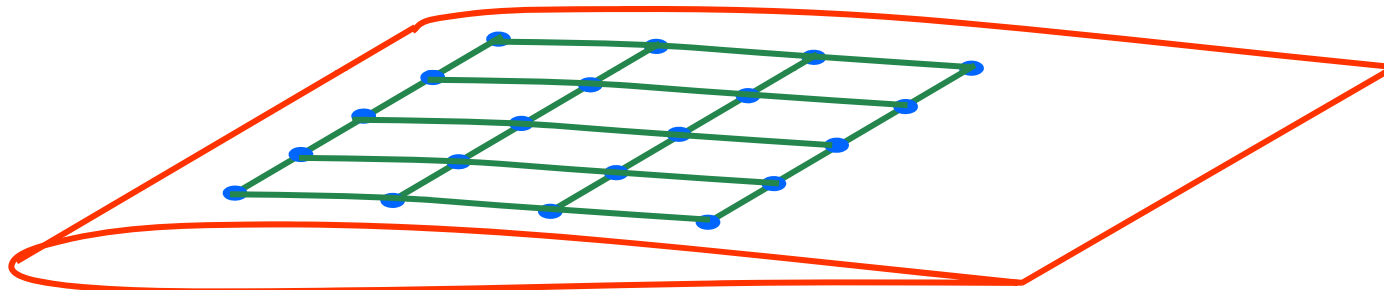


(b)

Free-Form Deformation Technique (KI-2) (cont.)



Number of design variables is reduced from n^3 to n^2

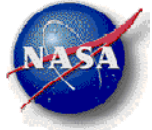


(a)

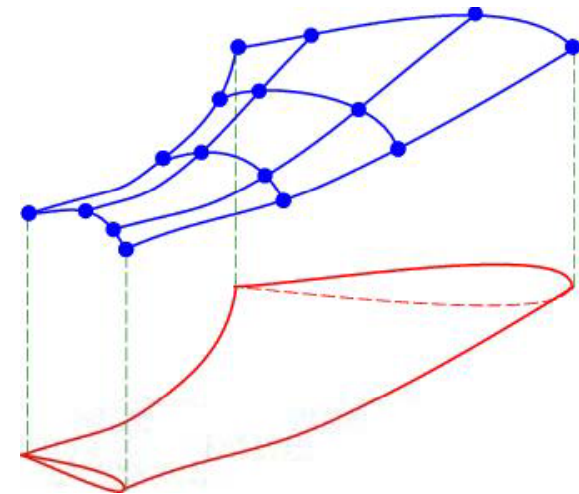


(b)

Parameterize Changes in Shape (KI-3)



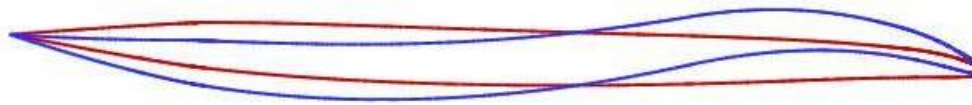
NURBS control points for camber & thickness



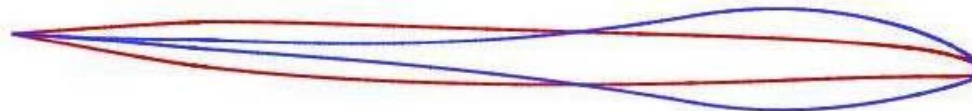
$$r_n(v) = r_n^b + \Delta r_n(v)$$

Surface grid point Design variable vector Baseline surface grid Shape changes

Camber

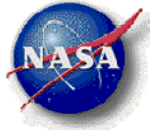


Thickness

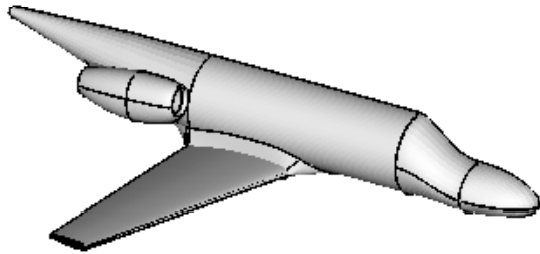


Extreme camber & thickness deformation

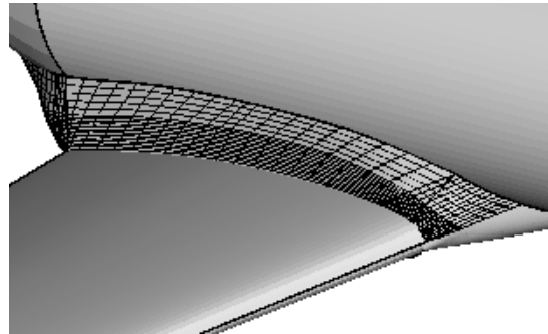
Examples



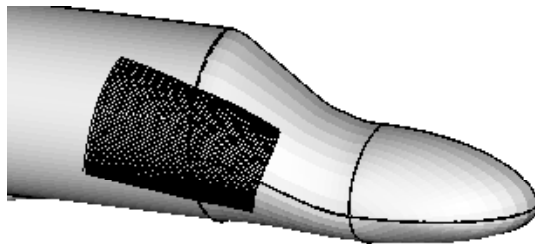
Marking Surfaces (Bivariate Surface)



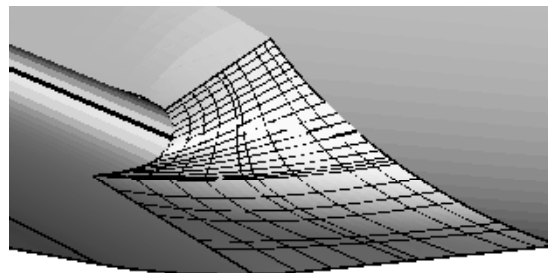
a) Business jet model



b) Marking surface for fillet



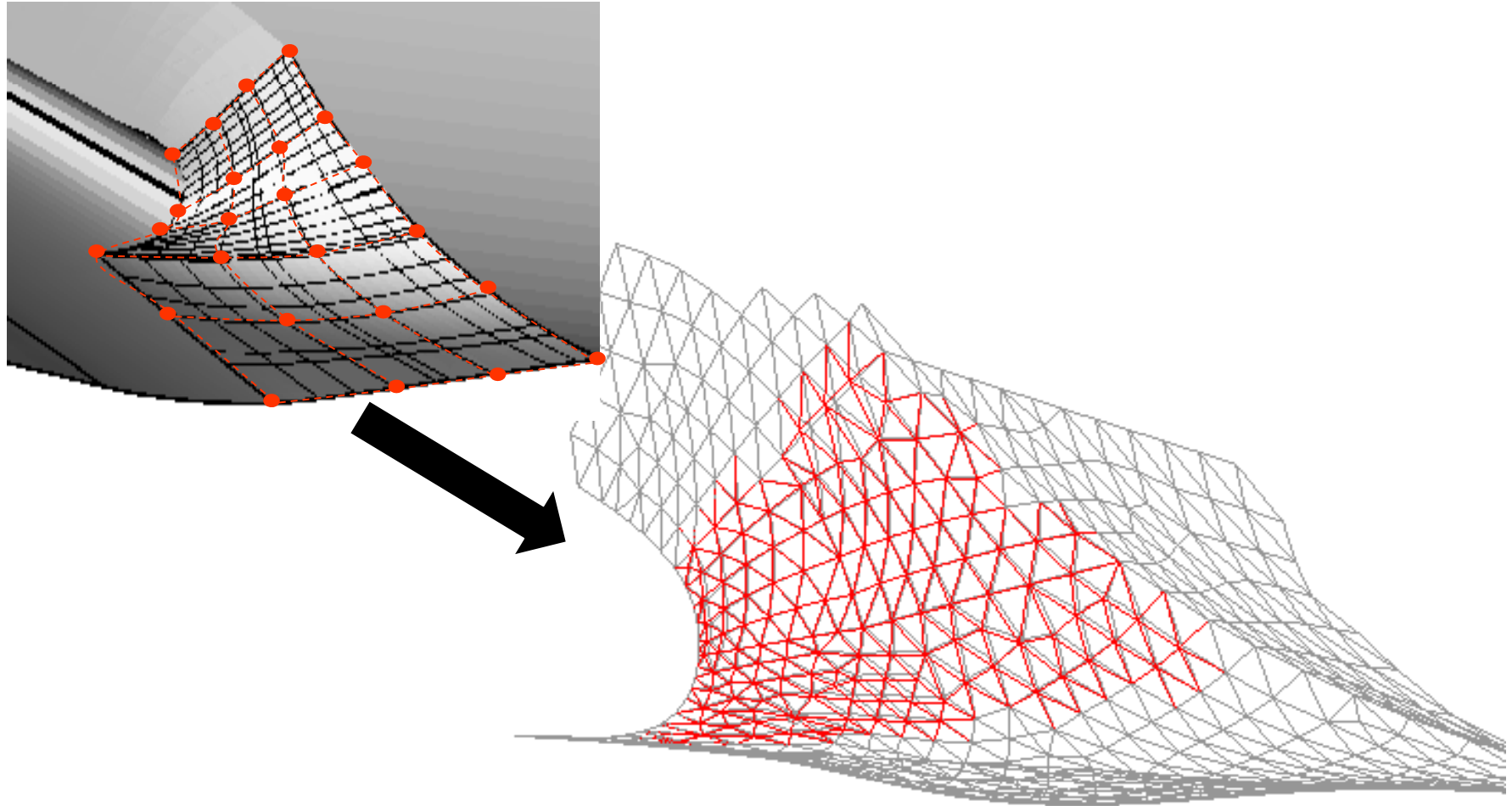
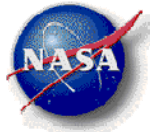
c) Marking surface part of fuselage



d) Marking surface for fillet

Parameterizing wing-fuselage fillet of a business jet

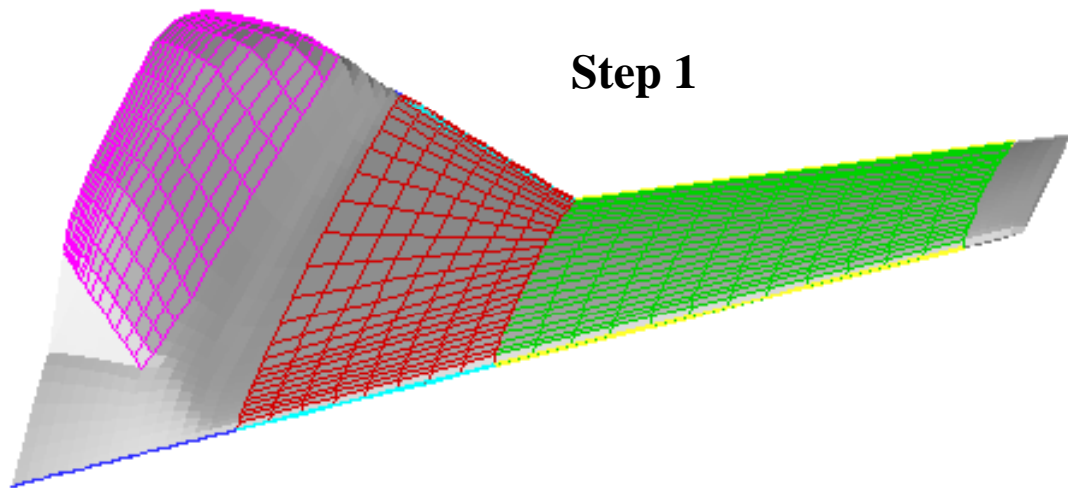
Examples, Cont.



Parameterizing wing-fuselage fillet of a business jet

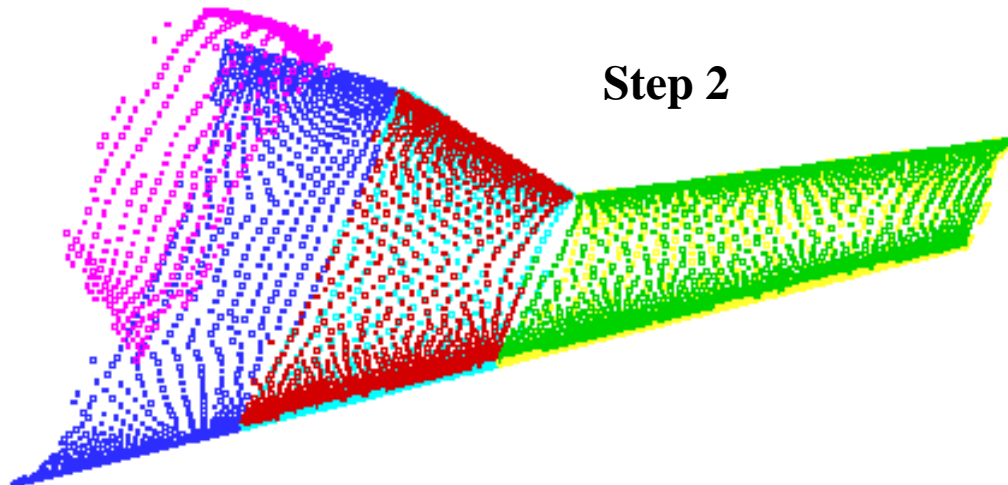
Examples, Cont.

Morphing Aircraft Structures (MAS)



Step 1

Six Marking Surfaces (NURBS)
150 design variables
54 active design variables

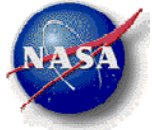


Step 2

Surface Grid Points
identified for Deformation

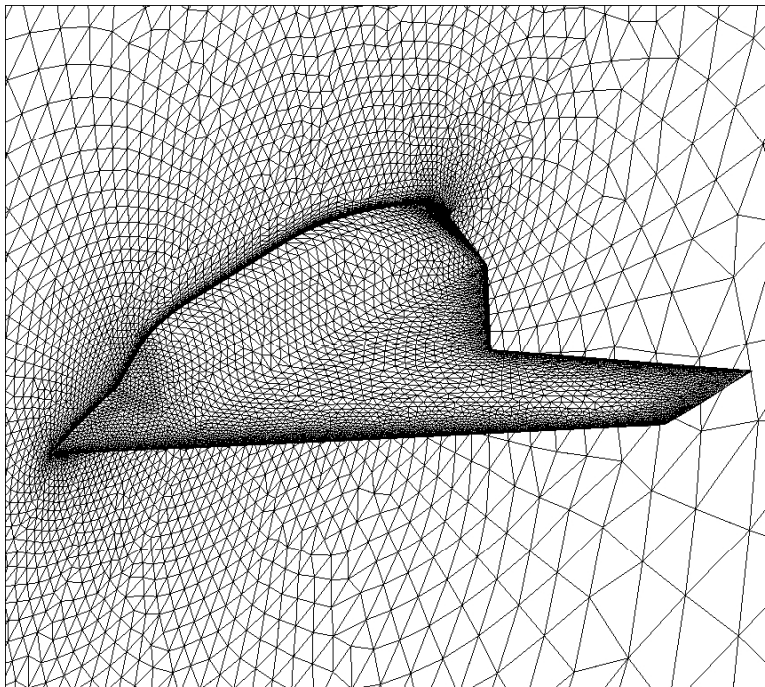
Examples, Cont.

Morphing Aircraft Structures (MAS)



Courtesy of Eric Nielsen

- Mach 0.80, $\alpha=2^\circ$, Re=5 million
- 534,525 Nodes / 3,159,677 Elements
- 54 Active DV's, no thinning allowed



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