Discrete Data Transfer Between Dissimilar Meshes (DDTBDM)

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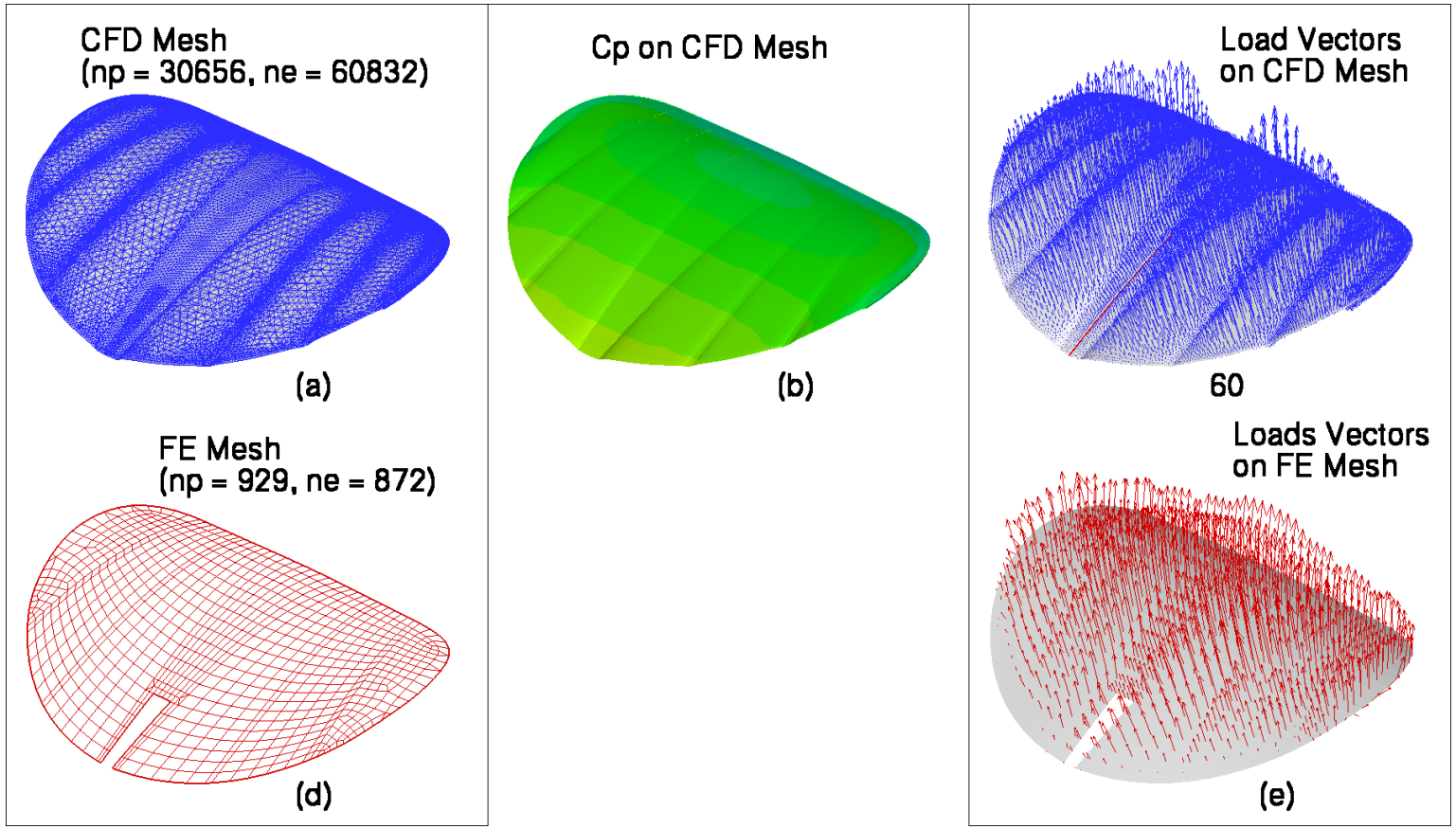
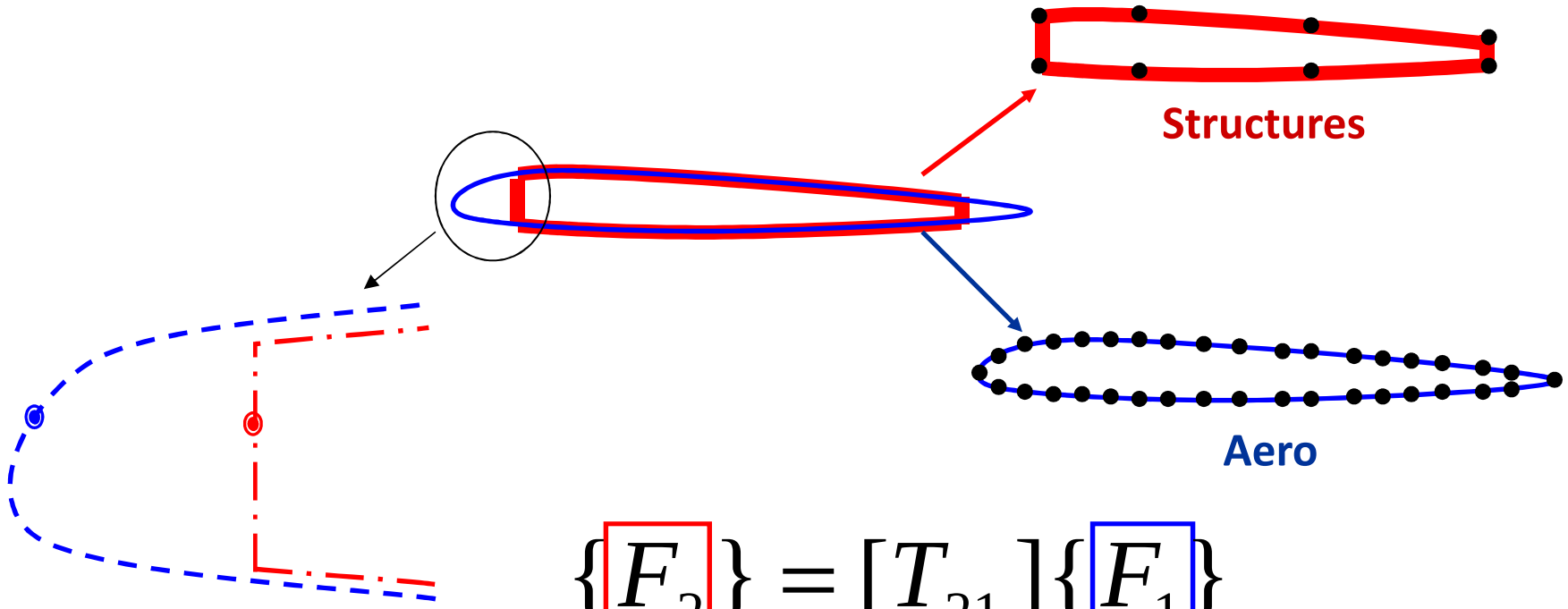
Objective

Transfer Scalar or Vector Quantities Between Dissimilar Meshes



Algorithm Characteristics

- **Transfers scalar, vector, or integrated quantities.**
- **Handles surface meshes from two different disciplines with dissimilar meshes (mesh density and different levels of geometry details).**
- **Enforces constraints (e.g., conservation forces and moments)**



$$\{\boxed{F_2}\} = [T_{21}]\{\boxed{F_1}\}$$

Transformation Matrix (Aeroelastic)

$$\{\overline{F}_F\} = \{\text{Flow Solution}\,(\overline{G}_F + \overline{\delta}_F)\}$$

$$\{\overline{F}_S\} = [T_{SF}]\{\overline{F}_F\}$$

$$[K]\{\overline{\delta}_S\} = \{\overline{F}_S\}$$

$$\{\overline{\delta}_F\} = [T_{FS}]\{\overline{\delta}_S\}$$

Transformation Matrix (Sensitivity Analysis)

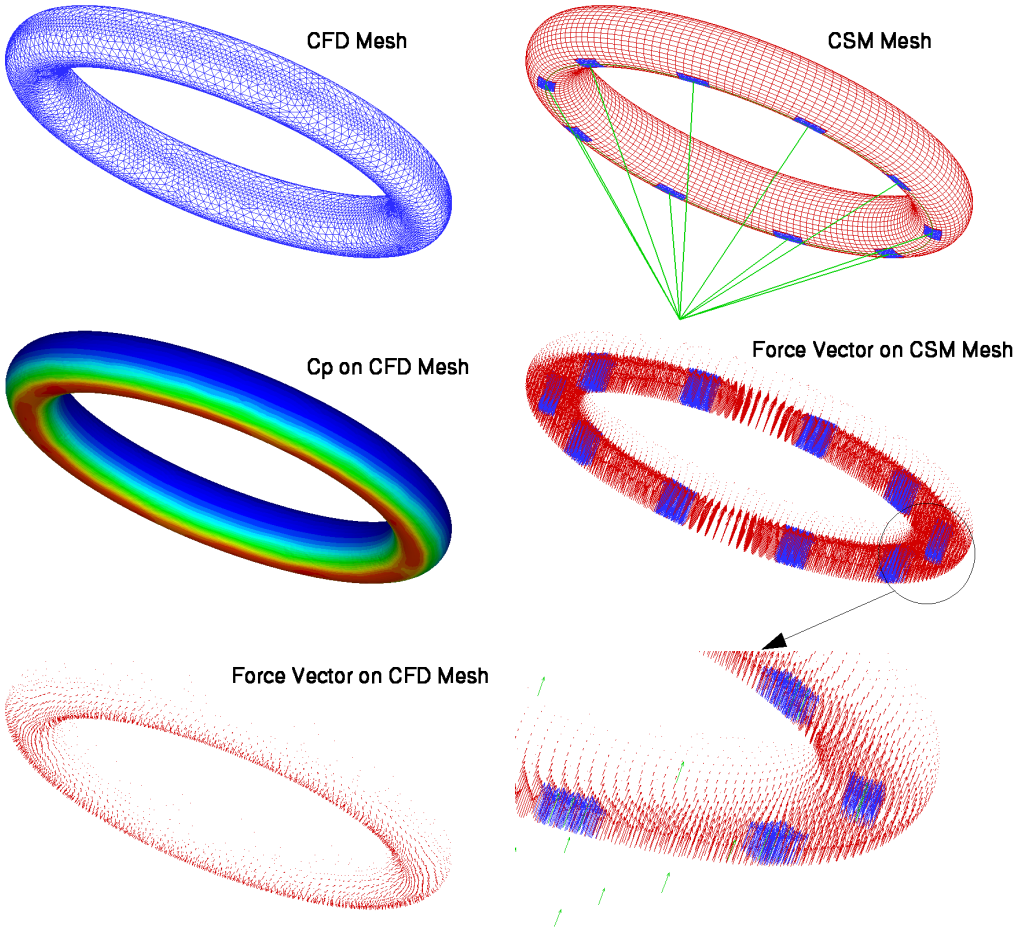
design variables

$$\{\overline{F}_S(V_i)\} = [T_{SF}]\{\overline{F}_F(V_i)\}$$

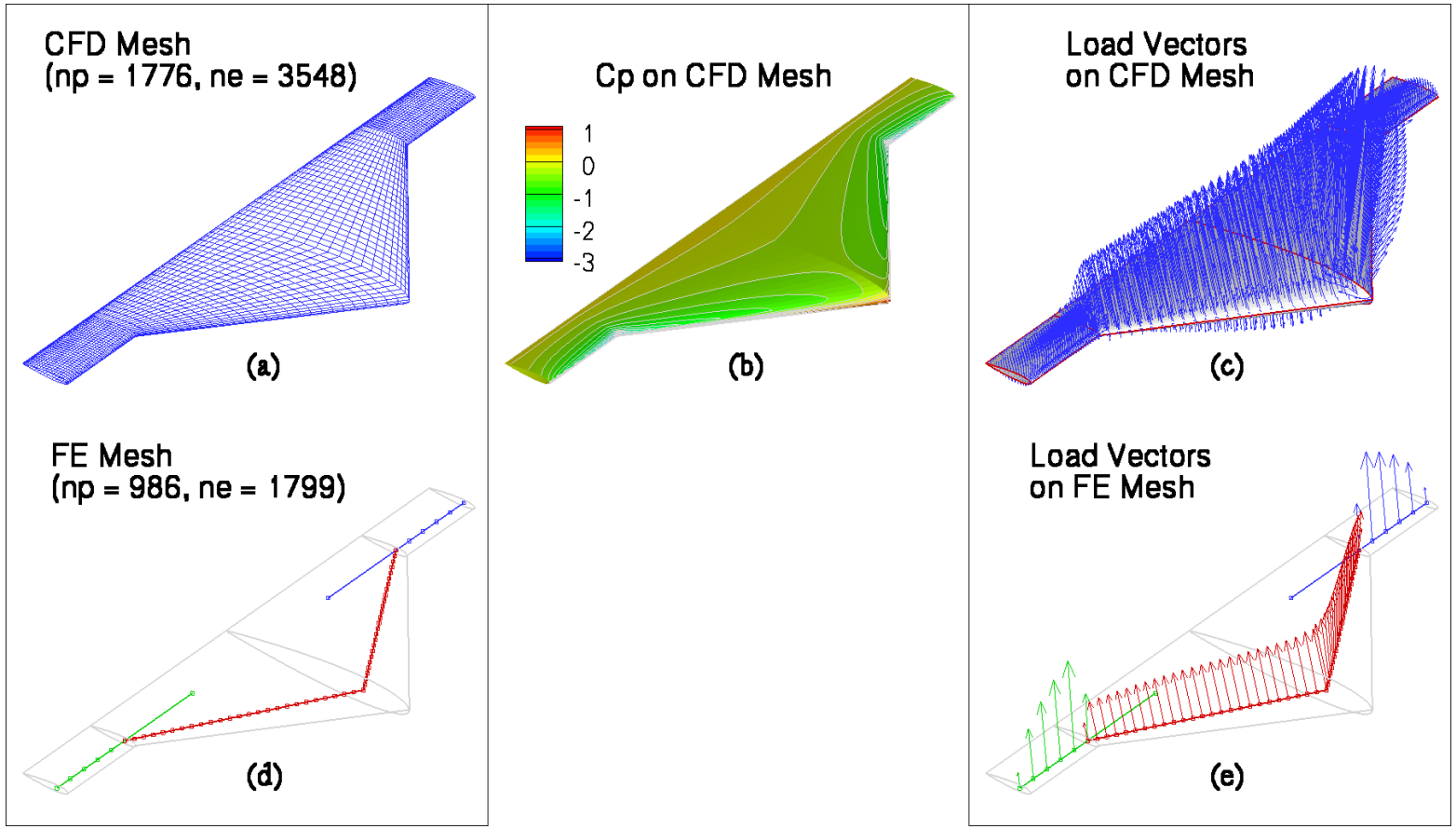
$[T_{SF}]$ is independent of V_i

$$\left\{\frac{\partial \overline{F}_S}{\partial V_i}\right\} = [T_{SF}]\left\{\frac{\partial \overline{F}_F}{\partial V_i}\right\}$$

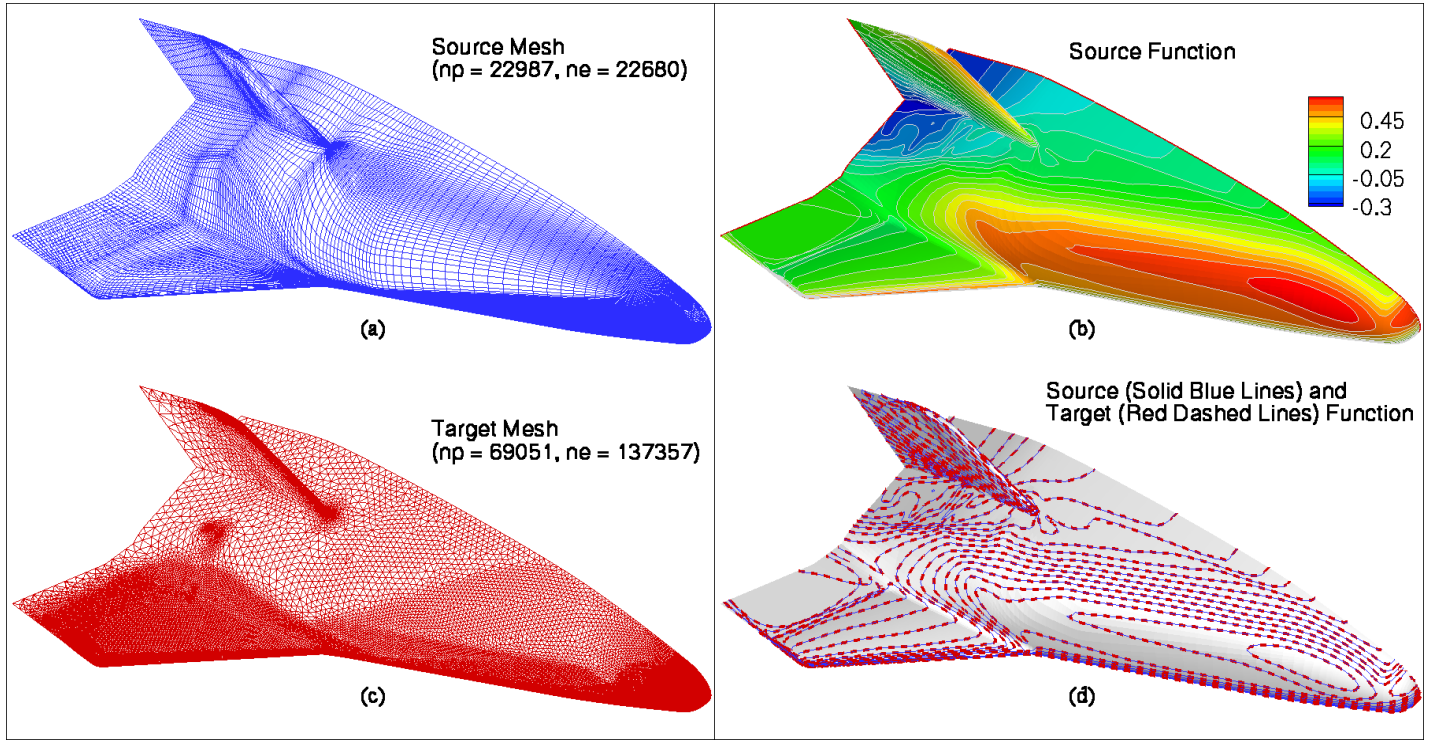
Sample Results (IAD)



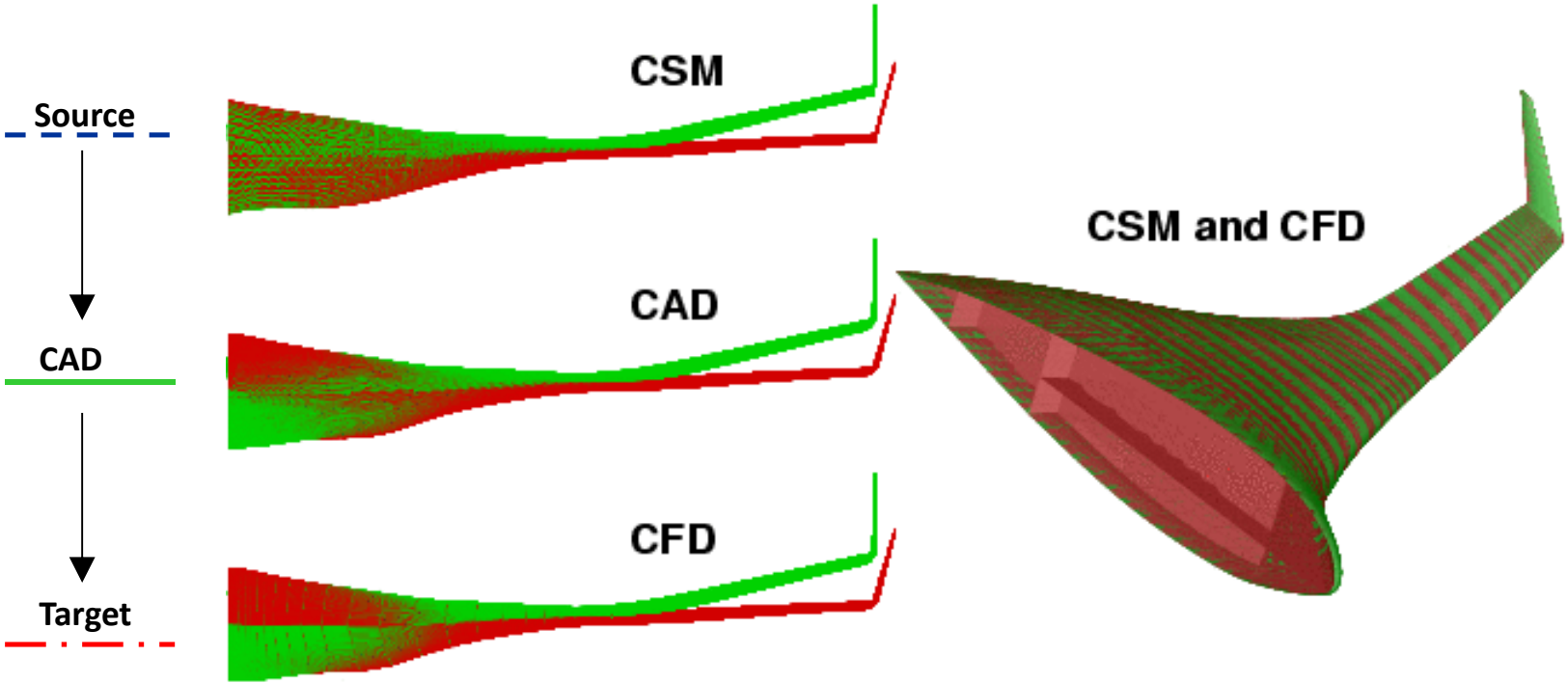
Sample Results (Morphing Wing)



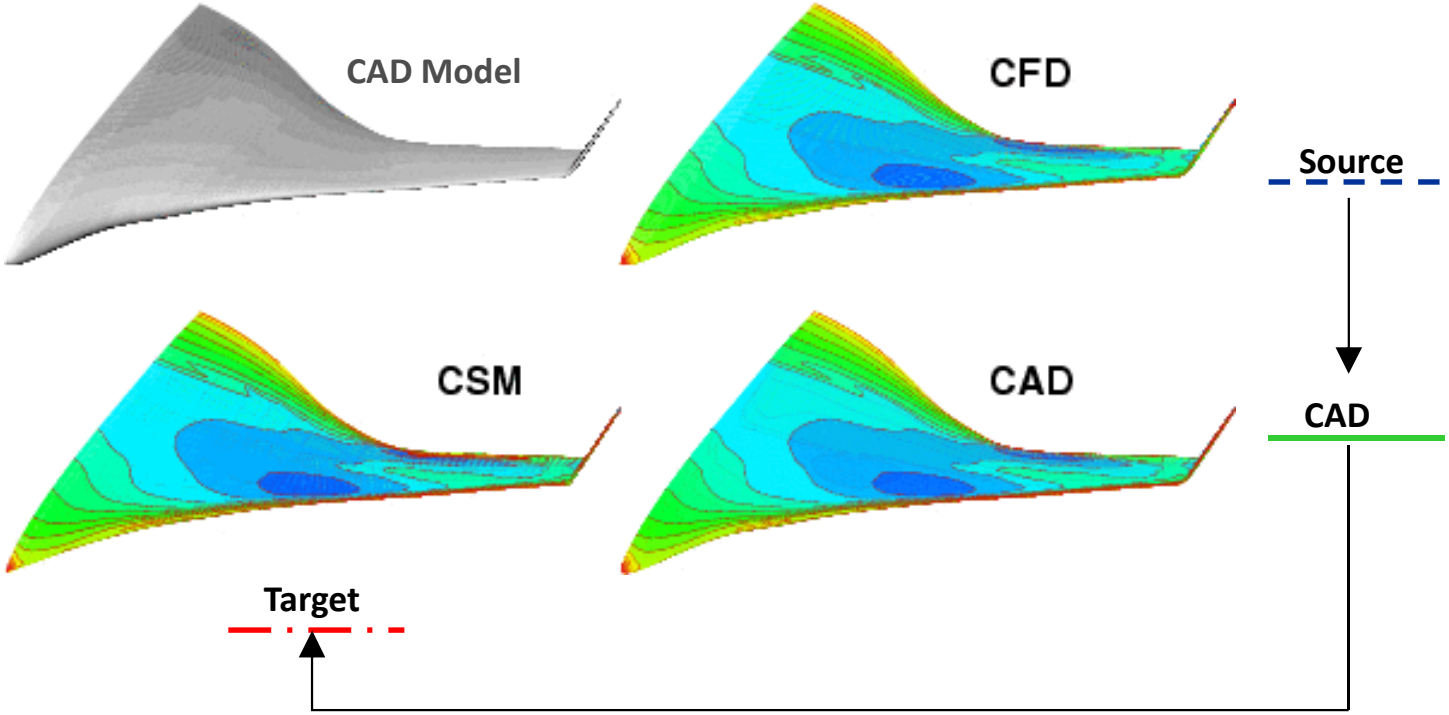
Sample Results (Spacecraft)



Sample Results (BWB Deflections)

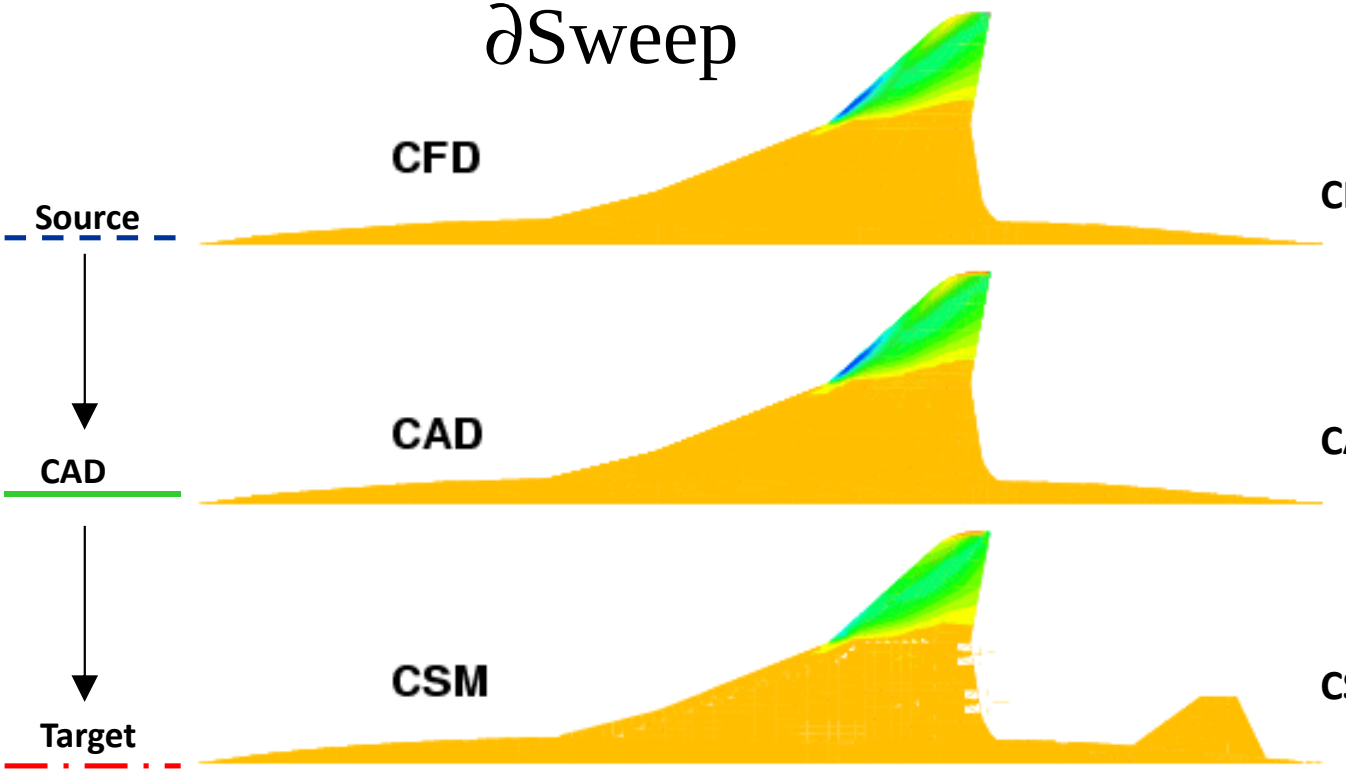


Sample Results (BWB Pressures)



Sample Results (HSCT Sensitivity Derivative)

$$\frac{\partial P}{\partial \text{Sweep}}$$



CFD (600,000 field pts, 1100 surface pts)

CAD

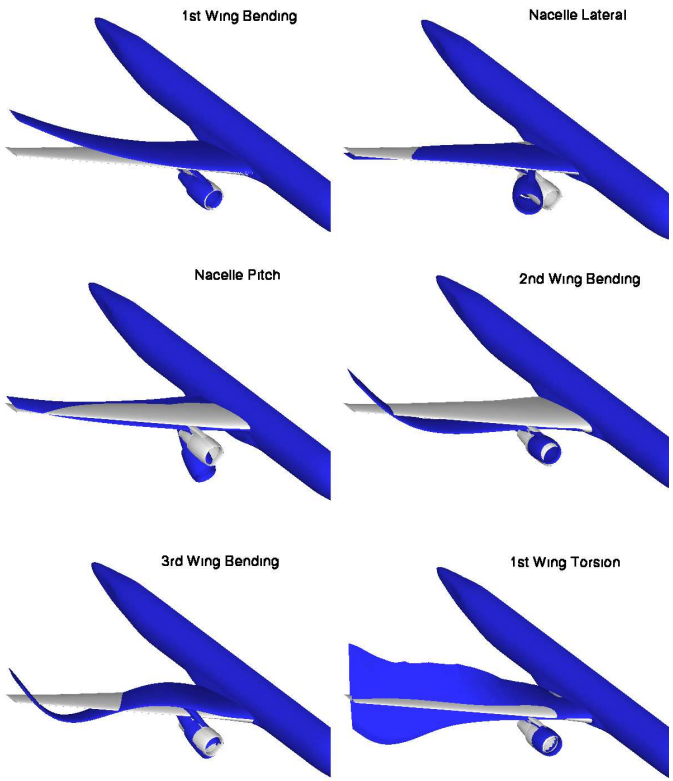
CSM (40,000 DOF)

Sample Results (Flutter Model)

Courtesy of Hong & Bhatia, The Boeing Company

Mode Number	Freq. (Hz)	Mesh DISCRETE TRANSFORM Diag. MAC
1	7.512	1
2	15.084	0.999
3	18.462	1
4	22.718	0.999
5	27.233	0.995
6	29.97	1
7	40.673	0.999
8	53.115	0.998
9	59.662	0.997
10	65.812	0.997
11	78.773	0.998
12	85.749	0.998
13	94.322	0.997
14	106.247	0.997
15	118.263	0.996
16	126.16	0.996
17	139.972	0.995
18	159.465	0.992
19	175.465	0.993
20	179.79	0.998

Modal Assurance Criterion (MAC)

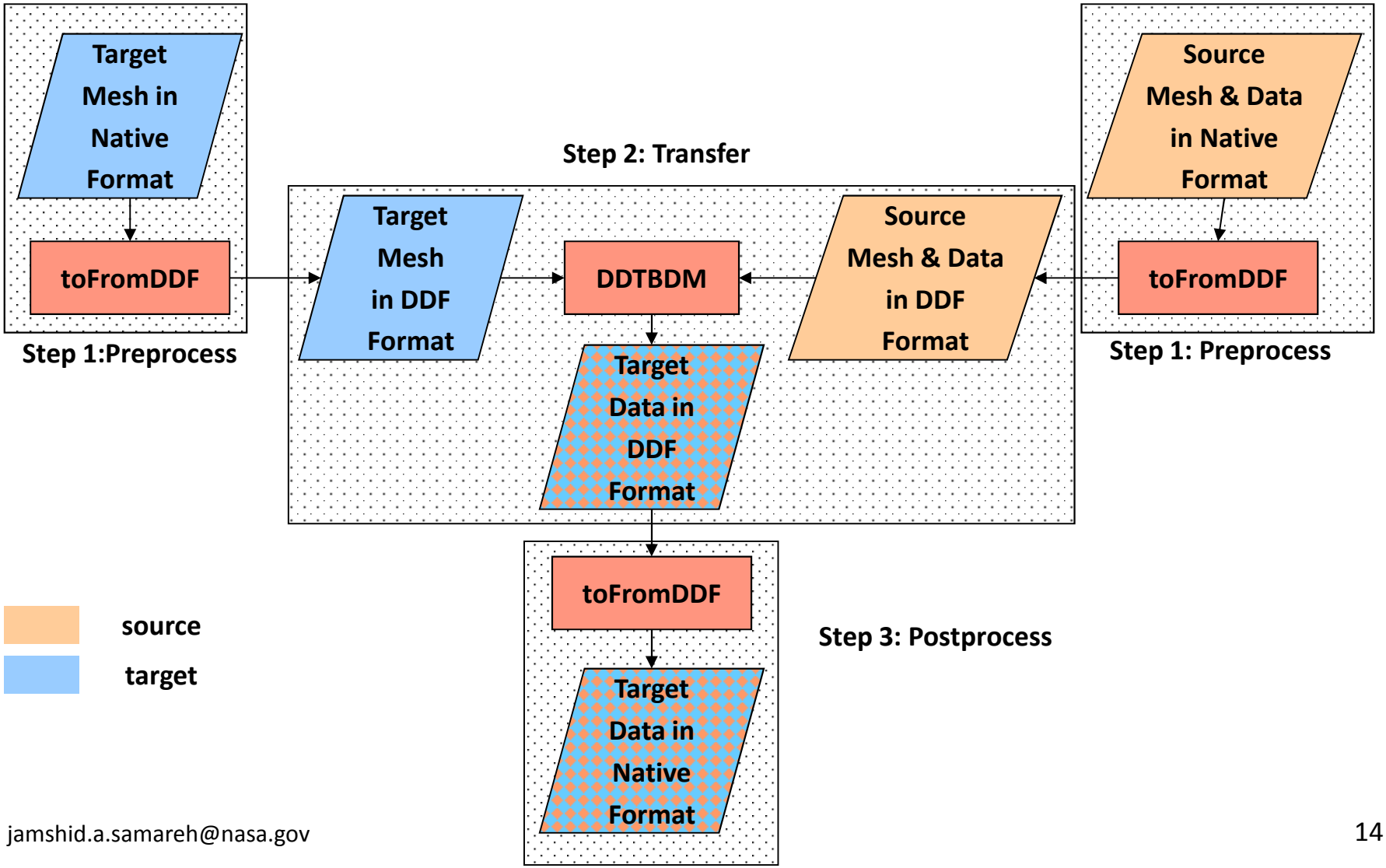


Structural Modes on CFD Model

Implementation

- C++/g++ gnu implementation (Linux, Windows, Mac, SGI, …)
- General data structure (structured quads & unstructured beams, triangles, and quads)
- Data formats (DDF, tecplot, plot3d, FAST, NASTRAN, LS-Dyna, Marc, Abaqus, STL, …)
- Pre- and post-processors
- Possible uses:
  - Direct: re-compute mapping between source and target for every iteration
  - Restart: compute the mapping once and save a restart file. This restart file will be used during the subsequent iterations
  - Matrix: compute the mapping once and save the result in a spare matrix form. This matrix will be used during subsequent iterations.

Overall Process: Direct



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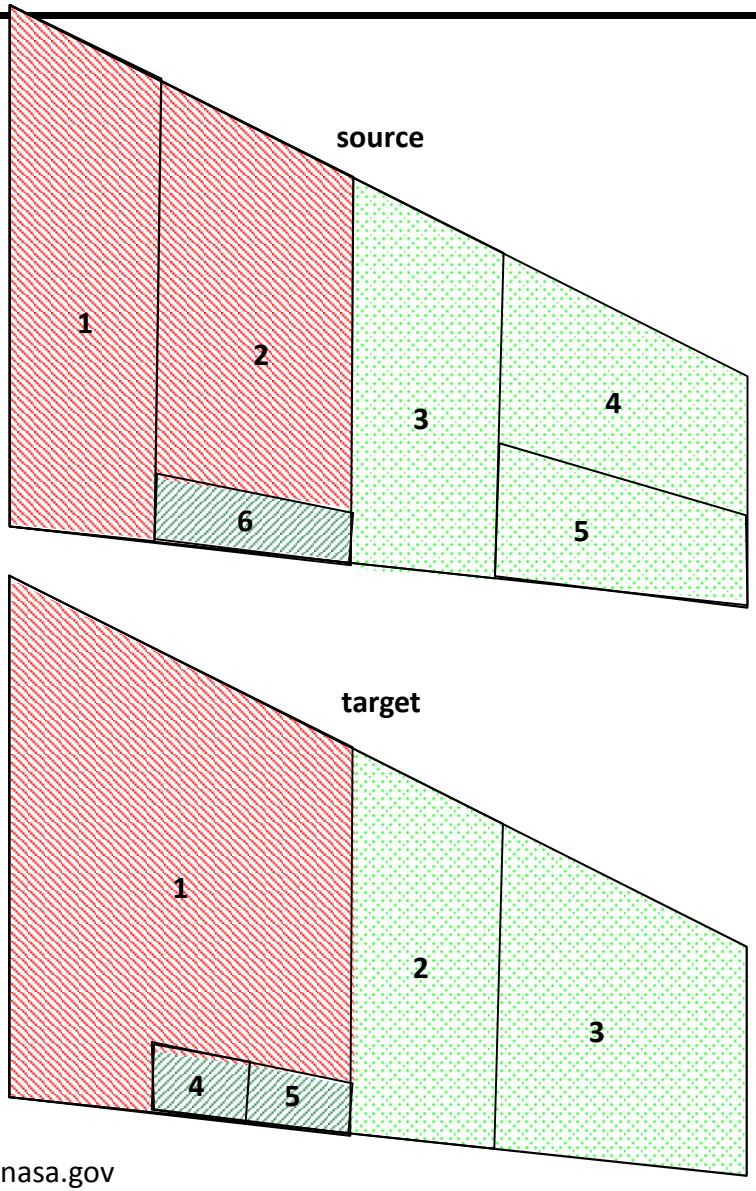
Targeted Mapping



Sample ddfDrive.inputFile

```
-21 250.27 250.27 250.27
Aero2FEM4.Restart m14a1.4.ddf -ddf 0 1 2
artemis_surf_bhm.bdf dum -nastran1 0 1 2
restart 0 1 2
0 matrixTest
3
2
1
2
1
1
1
6
2
4
5
3
3
4
5
2
2
3
```

Mapping #1
Source: 2 zones (zones #1 & 2)
Target: 1 zone (zone # 1)

Mapping #2
Source: 1 zone (zones #6)
Target: 2 zones (zones # 4 & 5)

Mapping #3
Source: 3 zones (zones #3, 4, & 5)
Target: 2 zones (zones # 2 & 3)

Caveat

- Models in different spaces (e.g., units & orientations)
- Inadequate model definitions (e.g., holes only in one model)
- Mismatch in model geometries (e.g., wings with different dihedrals)
- Non-smooth source data (e.g., very coarse FEM)
- Dissimilar dimensions (e.g., mapping 1D FEM displacements to a 3D CFD model)
- Solid elements (e.g., FEM tet & hex elements)
- Large disparity in mesh resolutions (e.g., very coarse FE and very fine CFD meshes)
- Inconsistent gaps (e.g., control surfaces with gaps in one model and without in another)
- Higher order elements (e.g., p-elements)
- New Format (e.g., new CFD solver)
- ....