# Engineering Overview of a Multidisciplinary HSCT Design Framework Using Medium-Fidelity Analysis Codes

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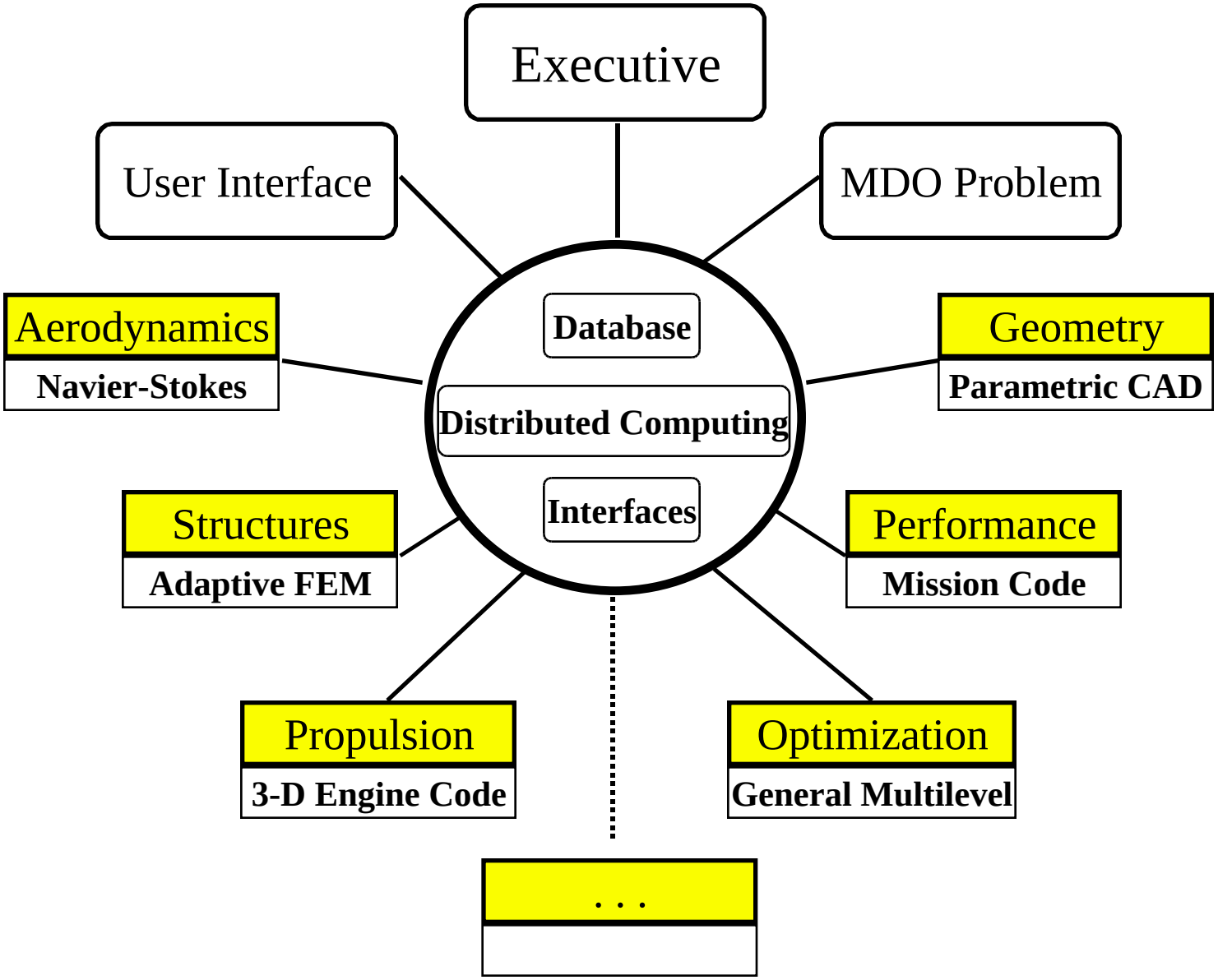
# OUTLINE

- Objective of LaRC HPCCP CAS Application
- Summary of Previous Applications
- Overview of Current Design
  - Discipline Summaries
  - Process Interactions
- Current Status
- Plans

# Objective of LaRC HPCCP CAS Application

- **Demonstrate teraflop computing on a model MDO problem, including:**
  - **Multilevel N-S CFD analysis & sensitivity.**
  - **Adaptive FEM structural analysis & sensitivity.**
  - **Steady 3-D engine simulation.**
  - **Mission performance, including multipoint objective function.**
  - **Other disciplines, including cost, to be included as resources permit.**

# HPCCP HSCT Application Goal



# Application vs Framework Focus

- Application Focus
  - Progressively more complex engineering problems
  - HSCT 2.1
    - Greatly simplified models
    - Fast analysis codes, ~10 min/cycle
  - HSCT 3.5
    - Simplified models
    - Intermediate analysis codes, ~3 hr/cycle
  - HSCT 4.0
    - Realistic models
    - Medium-fidelity analysis codes, ~1 day/cycle
- Framework Focus
  - Computer integration environment with distributed tasks
  - Currently centered at CSC; subject of later talk

# HSCT Applications

| **Application** | **HSCT2.1** | **HSCT3.5** | **HSCT4.0** |
|---|---|---|---|
| **Design Variables** | 5 | 7 | 271 |
| **Constraints** | 6 | 6 | 31868 |
| **Major Codes** | | | |
| Aerodynamics | Wingdes | ISAAC | CFL3D, USSAERO |
| Structures | ELAPS | COMET | GENESIS |
| Performance | Range equation | Range equation | FLOPS |
| Propulsion | Engine deck | Engine deck | ENG10 |
| **Analysis Processes** (without looping) | 10 | 20 | 70 |
| **Analysis Control** | | | |
| Major Loops | Weight Conv., Trim | Weight Conv., Aeroelastic, Trim | Aeroelastic, Trim |
| Load conditions | 2 | 2 | 7 |
| Mission conditions | 1 | 1 | 10 |
| Process (with loops) | O(10) | O(100) | O(1000) |
| Total time | O(minutes) | O(hours) | O(1 day) |
| **Optimization Cycle** | | | |
| (ndv+1) #analysis processes | O(100) | O(1000) | O(100,000) |
| Total time/cyle | O(10 minutes) | O(3 hours) | O(3 days) |

# HSCT 2.1

| | |
|---|---|
| Structures: | Equivalent Plate (ELAPS), ~100 DOF's, |
| | Variables: 2; inboard/outboard skin thicknesses |
| Aero: | Panel (WINGDES), ~1000 gridpoints, |
| | Variables: 3; sweep, root chord, and span at break |
| Framework: | FIDO, Ga Tech IMAGE, iSIGHT, CORBA/Java |
| Status: | Freely distributable, no proprietary software (FIDO) |
| Platform: | single workstation SUN (Solaris), IBM (AIX) *or* |
| | heterogeneous cluster of workstations (FIDO version) |

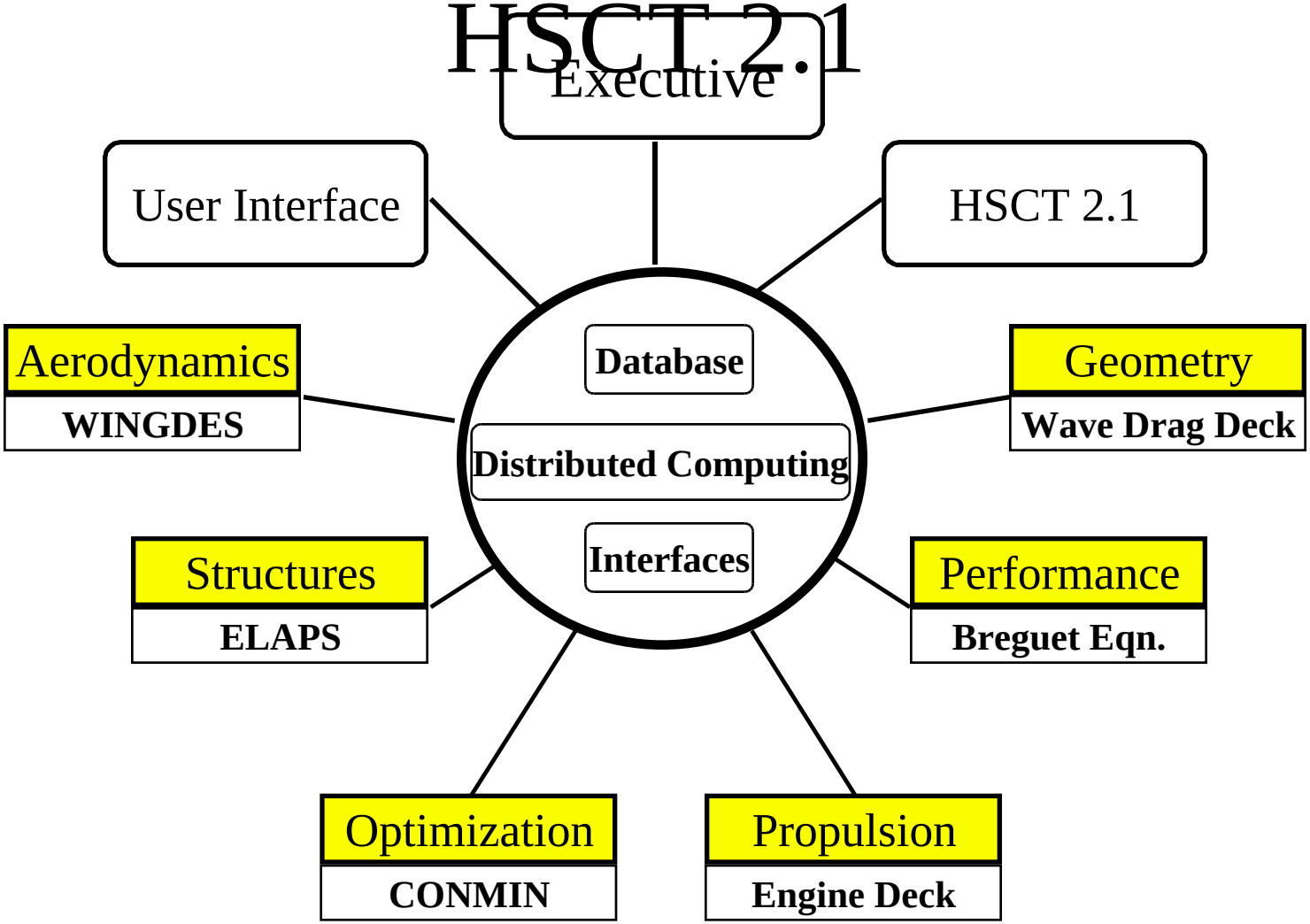
**Pros**

- **turnaround time (~10min/cycle)**
- **robust implementation**
- **repeated use as demo problem**

**Cons**

- **notional wing-only a/c concept**
- **simple design problem**
- **Breguet performance**

# HSCT 2.1


Executive
User Interface
HSCT 2.1
Aerodynamics
WINGDES
Database
Distributed Computing
Interfaces
Geometry
Wave Drag Deck
Structures
ELAPS
Performance
Breguet Eqn.
Optimization
CONMIN
Propulsion
Engine Deck

# HSCT 3.5

| | |
|---|---|
| Structures: | FEM (COMET), ~15000 DOF's, |
| | Variables: 4; inbd/outbd skin thickness distributions |
| Aero: | Marching Euler (ISAAC), ~15000 gridpoints, |
| | Variables: 3; sweep, root chord, and span at break |
| Framework: | FIDO |
| Status: | Freely distributable, no proprietary software |
| Platform: | heterogeneous cluster of workstations (Sun,SGI,IBM) |

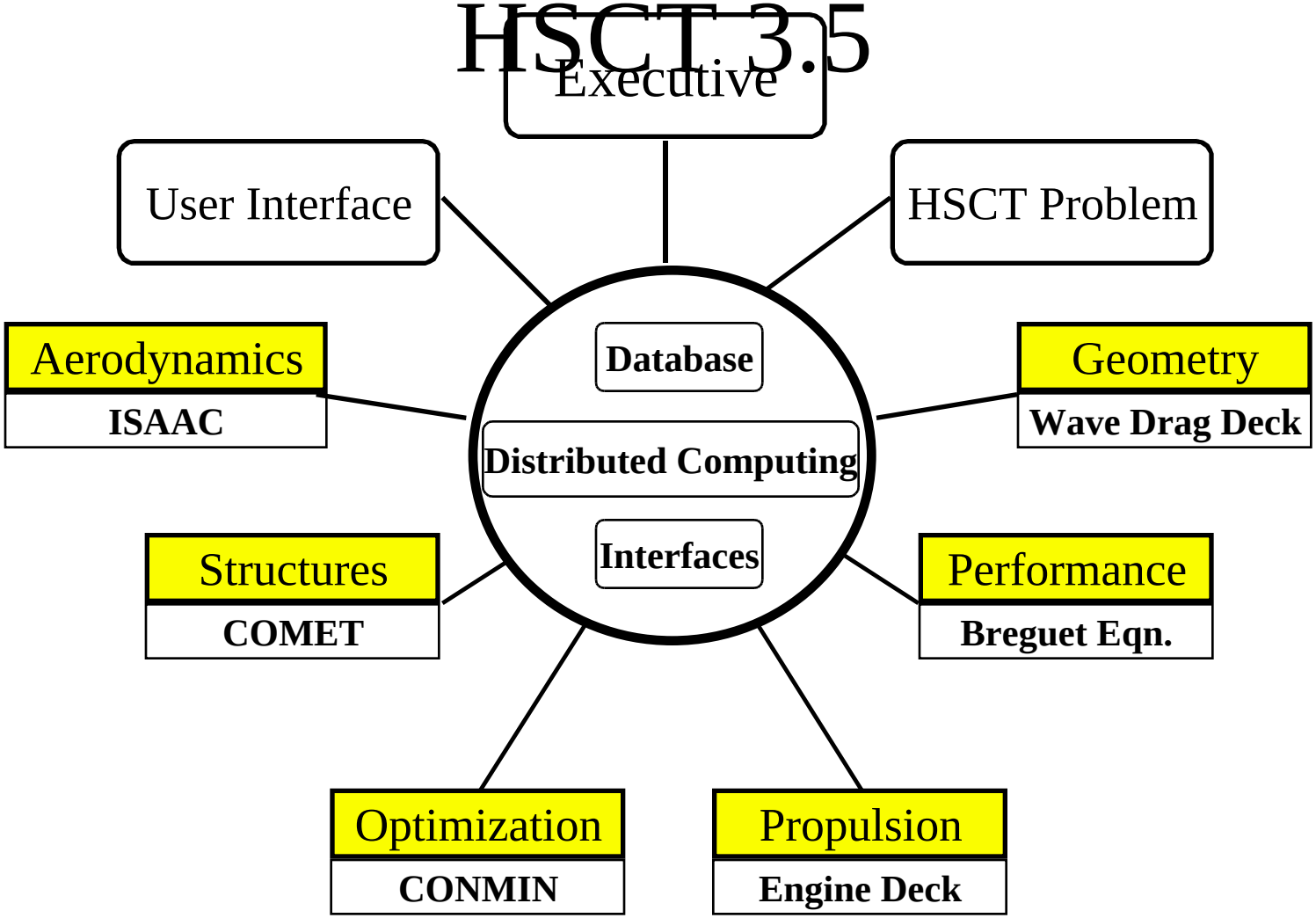
**Pros**

- **turnaround time (~3hrs/cycle)**
- **representative simulations**
- **reasonable model sizes**

**Cons**

- **notional a/c concept**
- **simple design problem**
- **Breguet performance**

# HSCT 3.5


Executive
User Interface
HSCT Problem
Aerodynamics
ISAAC
Database
Distributed Computing
Interfaces
Geometry
Wave Drag Deck
Structures
COMET
Performance
Breguet Eqn.
Optimization
CONMIN
Propulsion
Engine Deck

# HSCT 4.0

| | |
|---|---|
| Structures: | FEM (GENESIS), plate elements, ~40000 DOF's, |
| | Variables: 244 (plies, core thicknesses) |
| Aero: | Linear (USSAERO) + Euler/Navier Stokes (CFL3D), |
| | $10^5$-$10^6$ nodes, Variables: 27, |
| Framework: | CORBA-based during FY 98 |
| Status: | initial analysis capability anticipated 10/98 |
| Platform: | parallel architecture (Origin 2000's) |
| | heterogeneous cluster of large-memory workstations (Sun,SGI, IBM) |

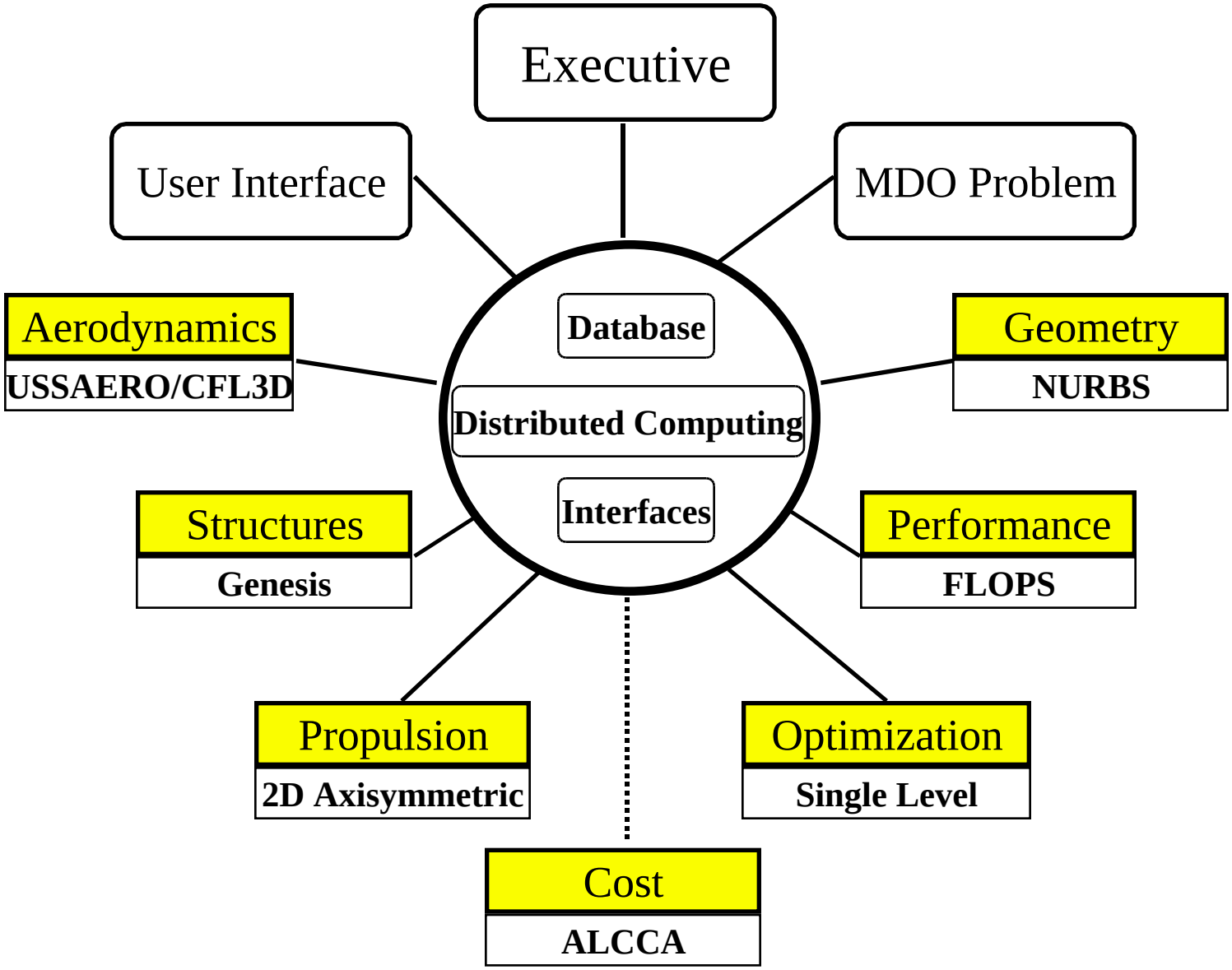
**Pros**

- **representative models**
- **FLOPS performance**
- **propulsion simulation**
- **intermediate complexity design**

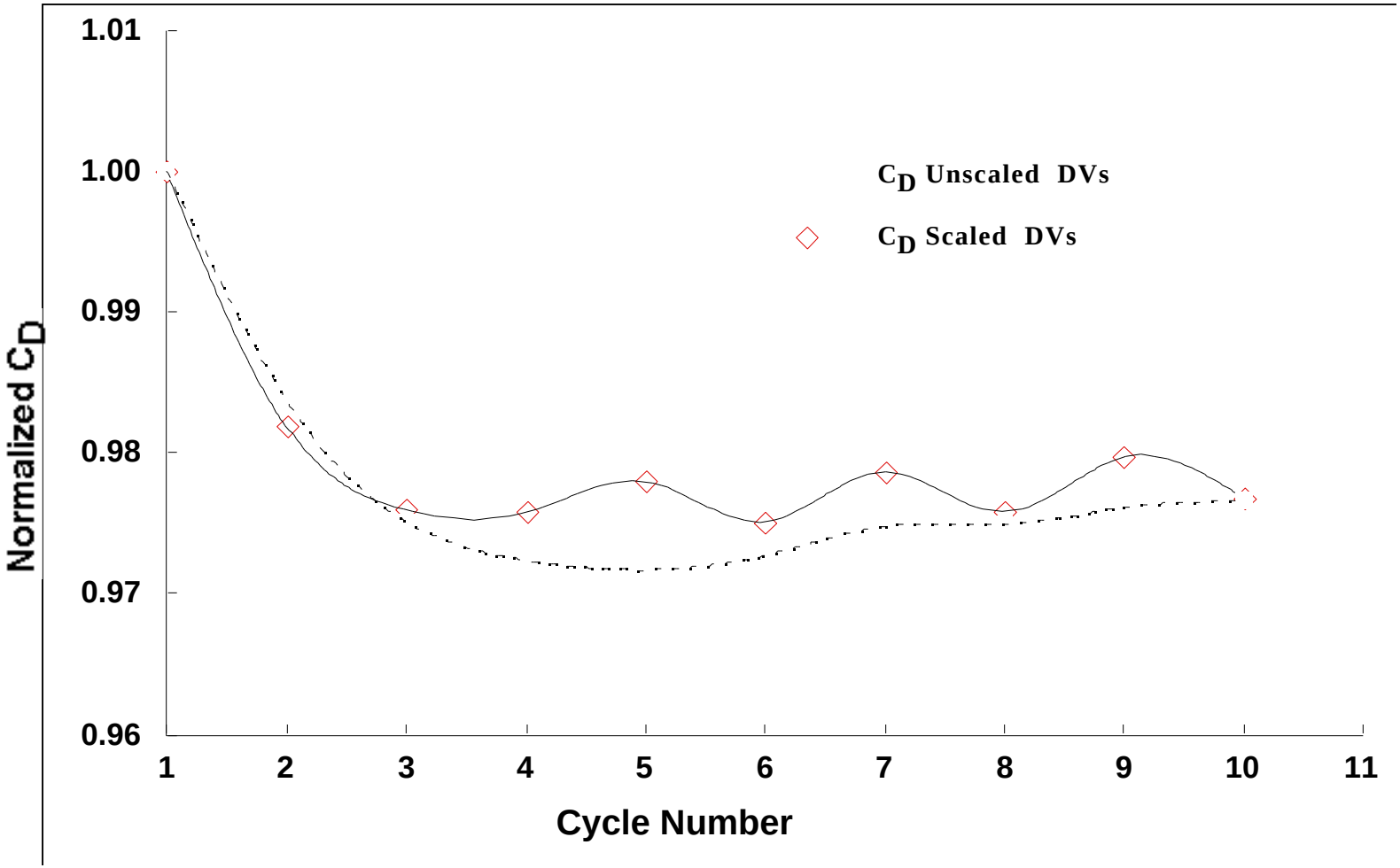
**Cons**

- **not on-line until FY 99**
- **turnaround time (~1day/cycle)**
- **proprietary a/c model**

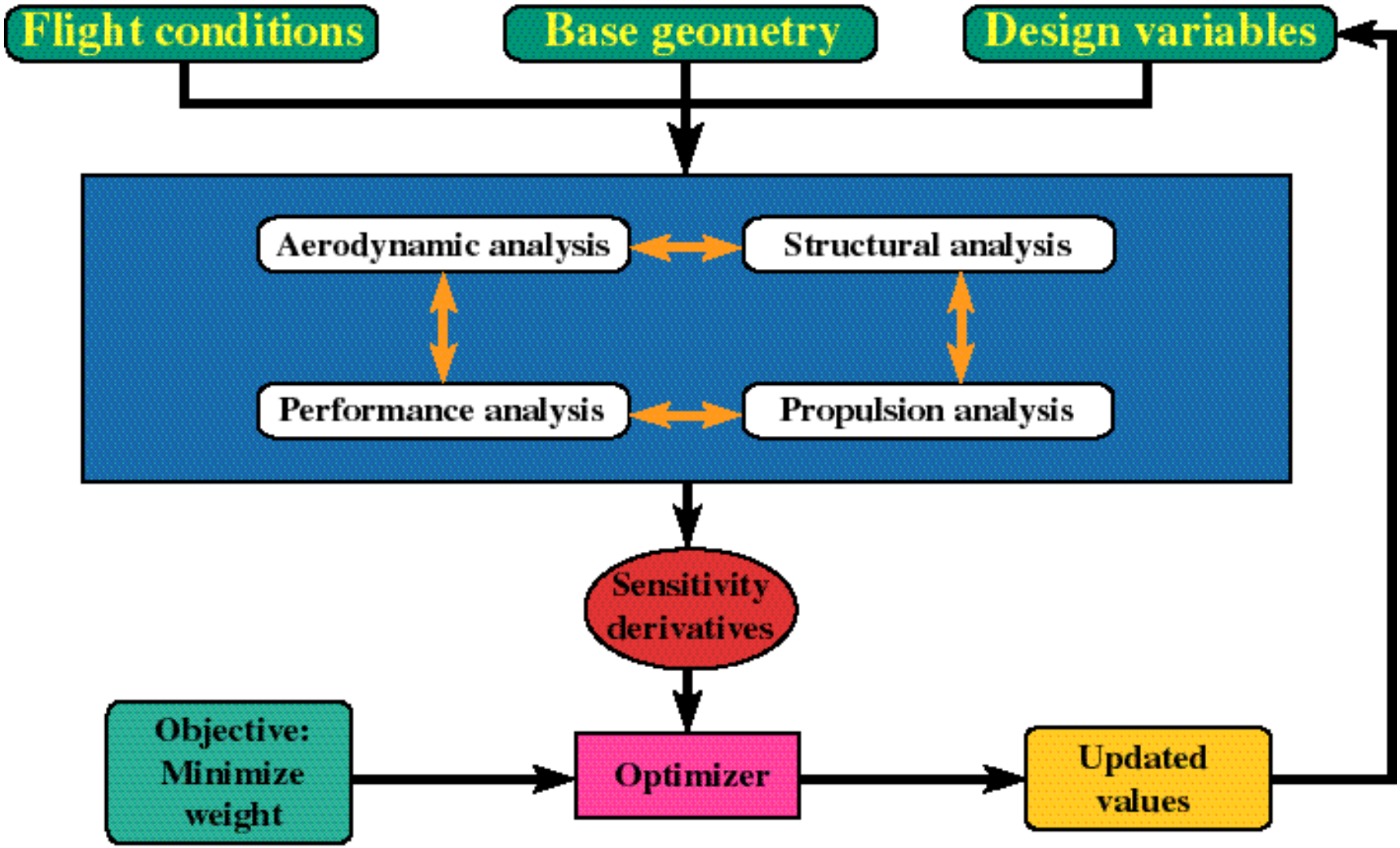
# HSCT 4.0


Executive
User Interface
MDO Problem
Aerodynamics
USSAERO/CFL3D
Database
Distributed Computing
Interfaces
Geometry
NURBS
Structures
Genesis
Performance
FLOPS
Propulsion
2D Axisymmetric
Optimization
Single Level
Cost
ALCCA

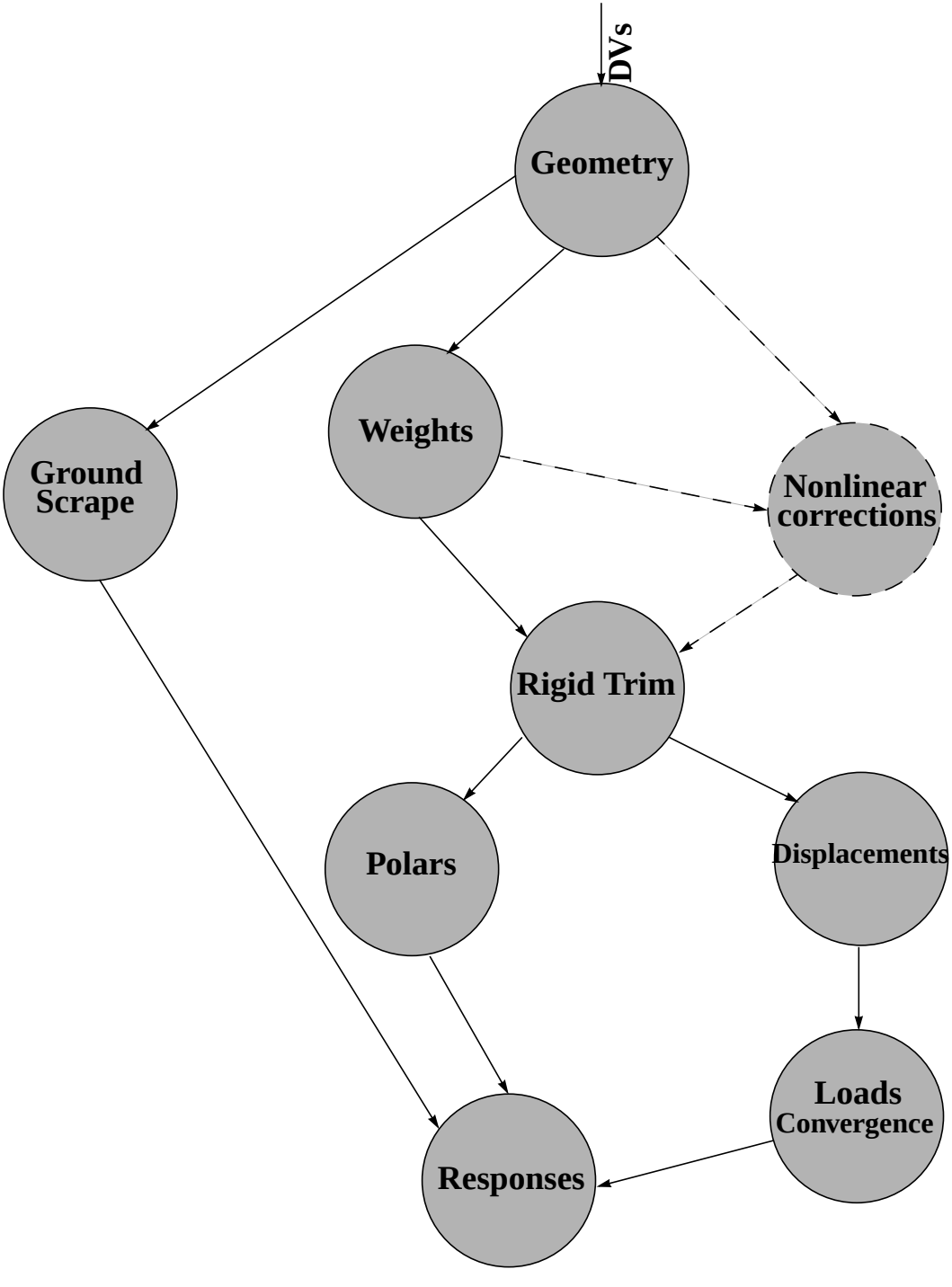
# HSCT Aerodynamic Optimization



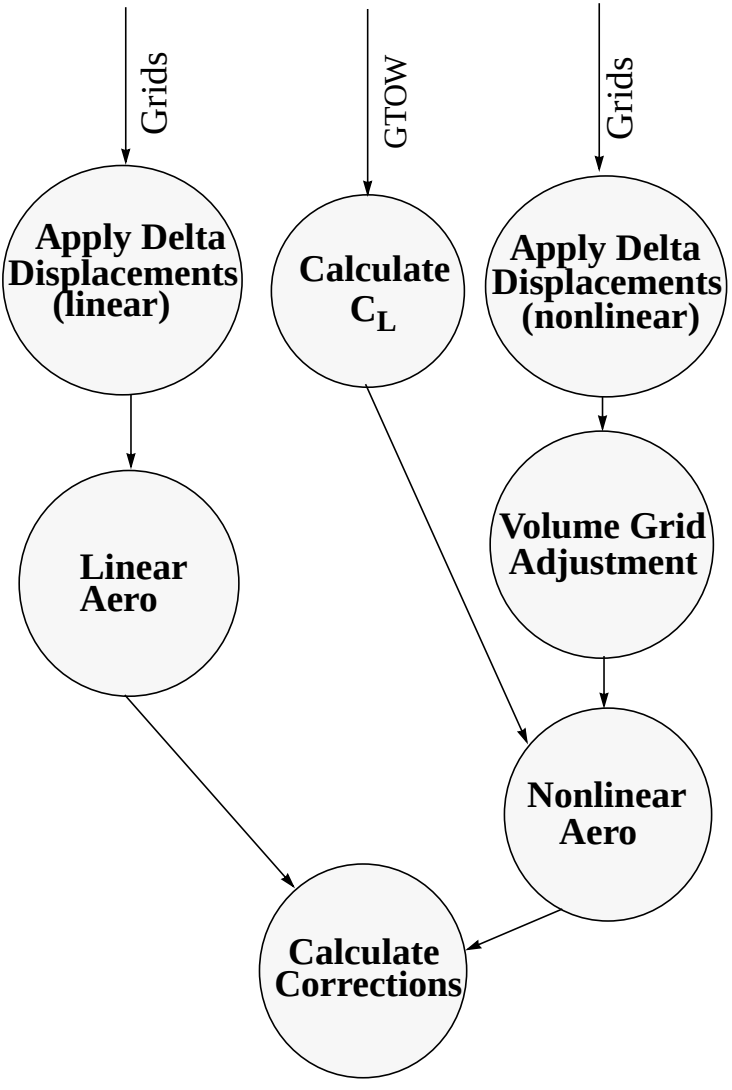
# HSCT Optimization Process



# Analysis

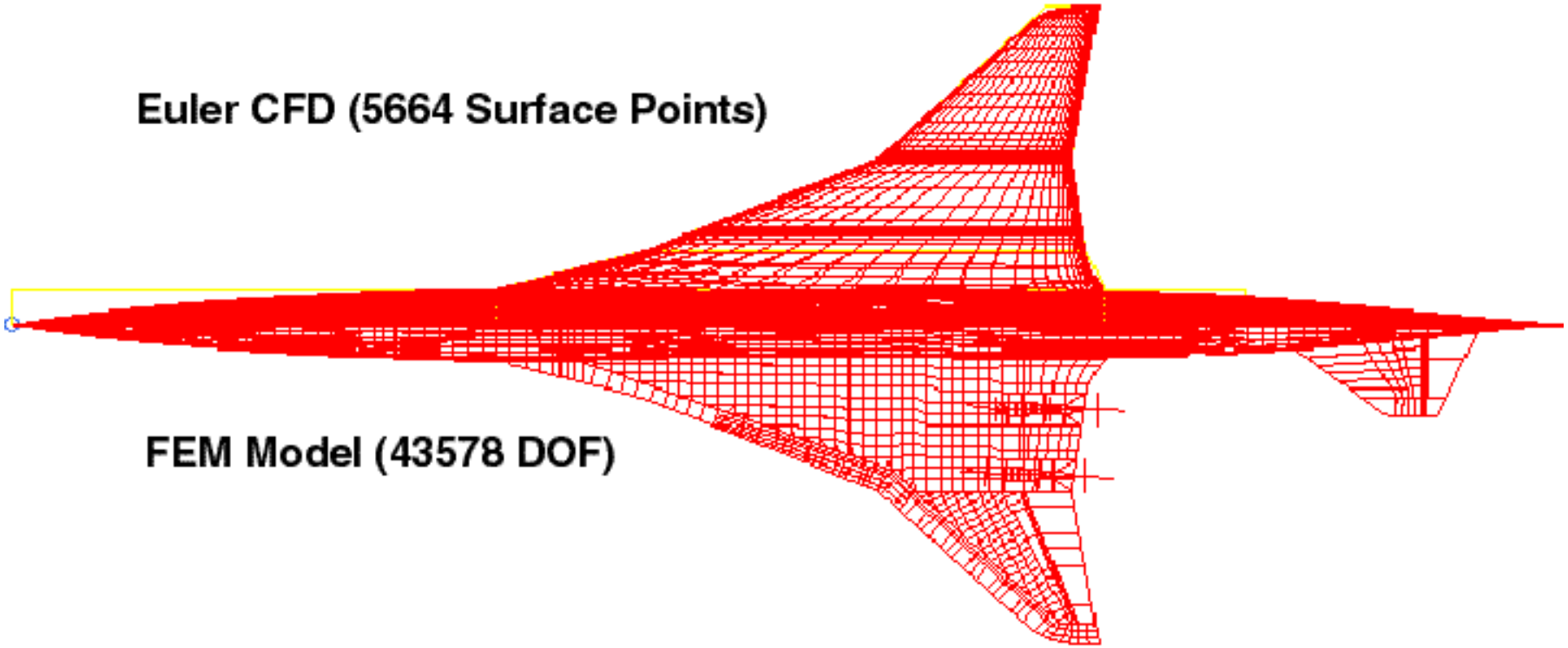

DVs
Geometry
Weights
Ground Scrape
Nonlinear corrections
Rigid Trim
Polars
Displacements
Loads
Convergence
Responses

# Nonlinear Corrections



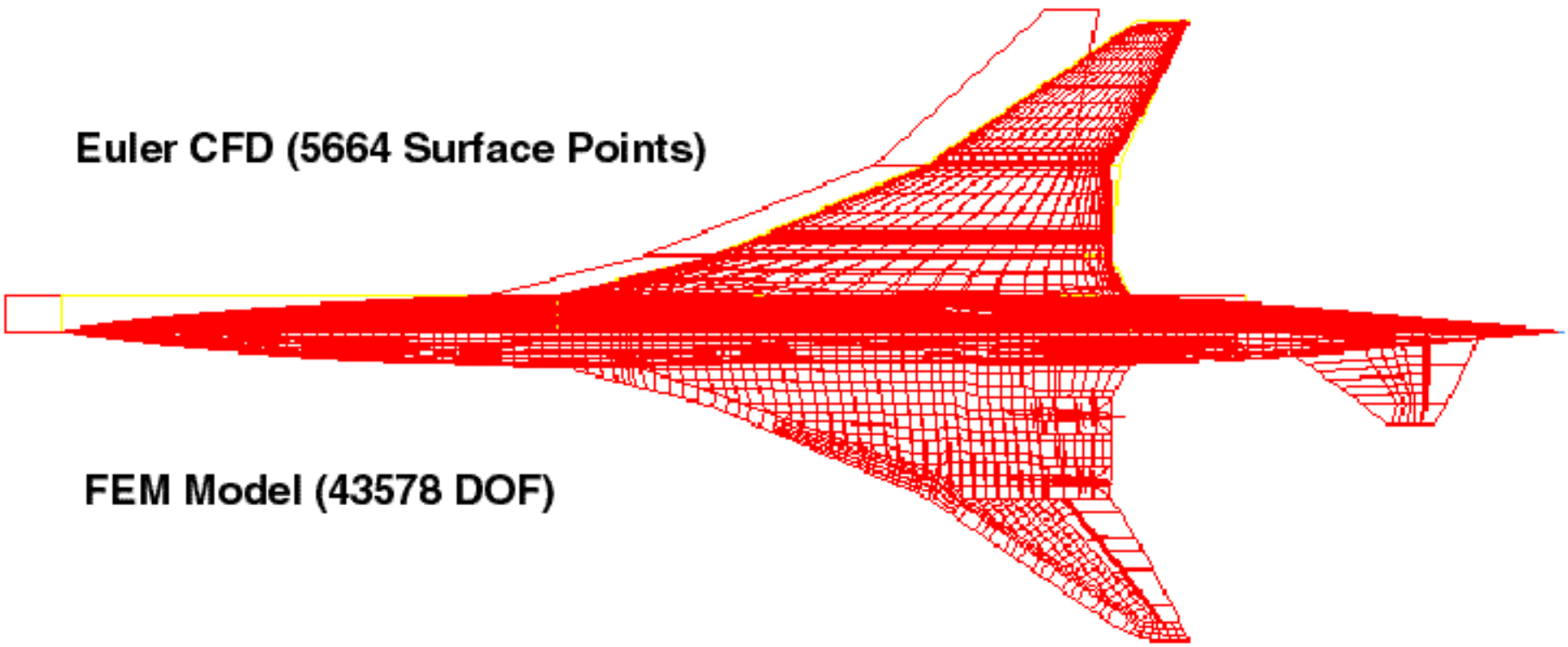
# Parameterized HSCT Model

## (39 DVs)



# Deformed HSCT Model

## (39 DVs)



# HSCT Configuration
## (Preliminary AERO Optimization, 3 cycles)

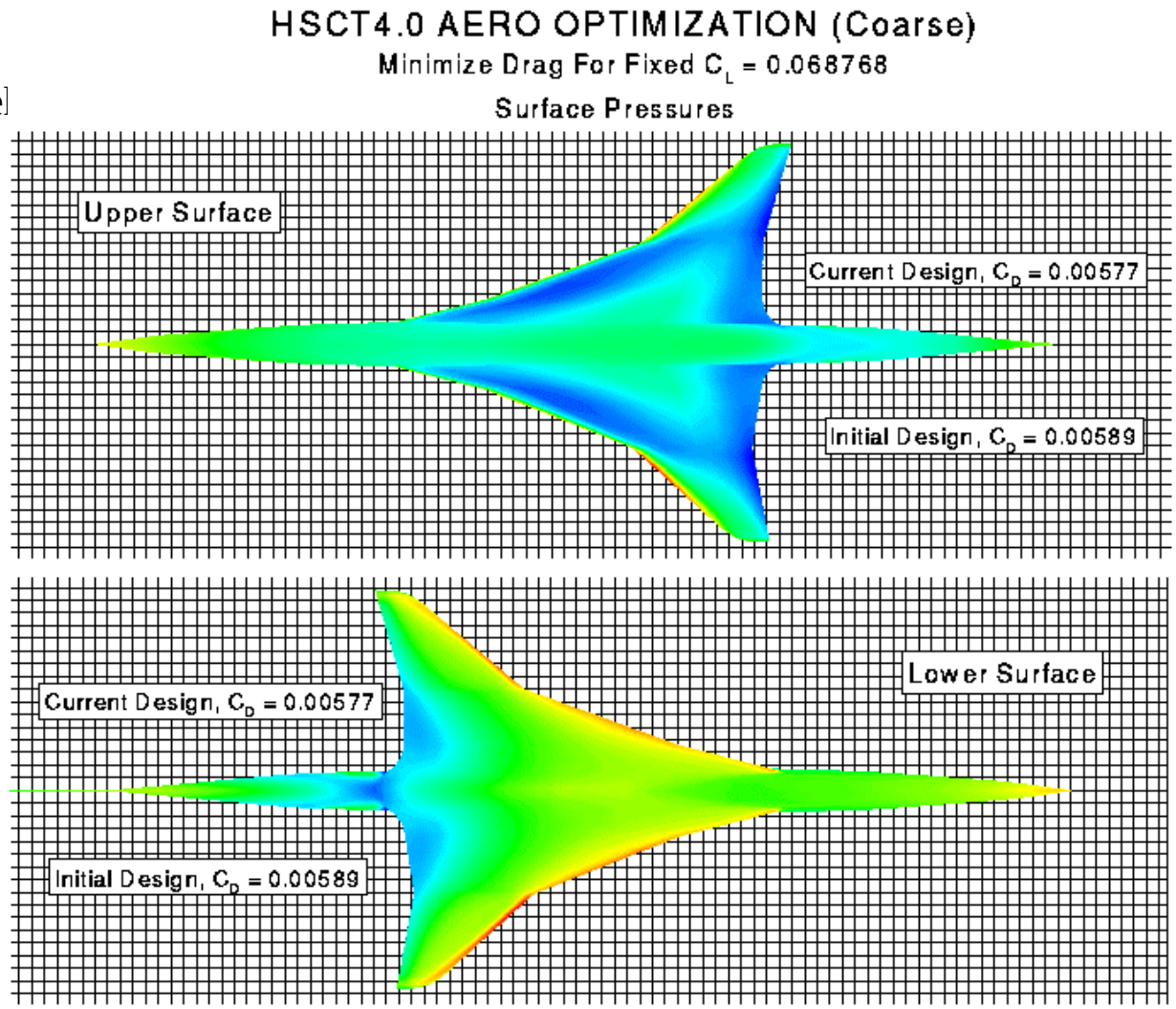
- Geometry/Grid (Samare
- CFD (Biedron)
- Optimization (Green)

**Reduce Drag (~2%)**

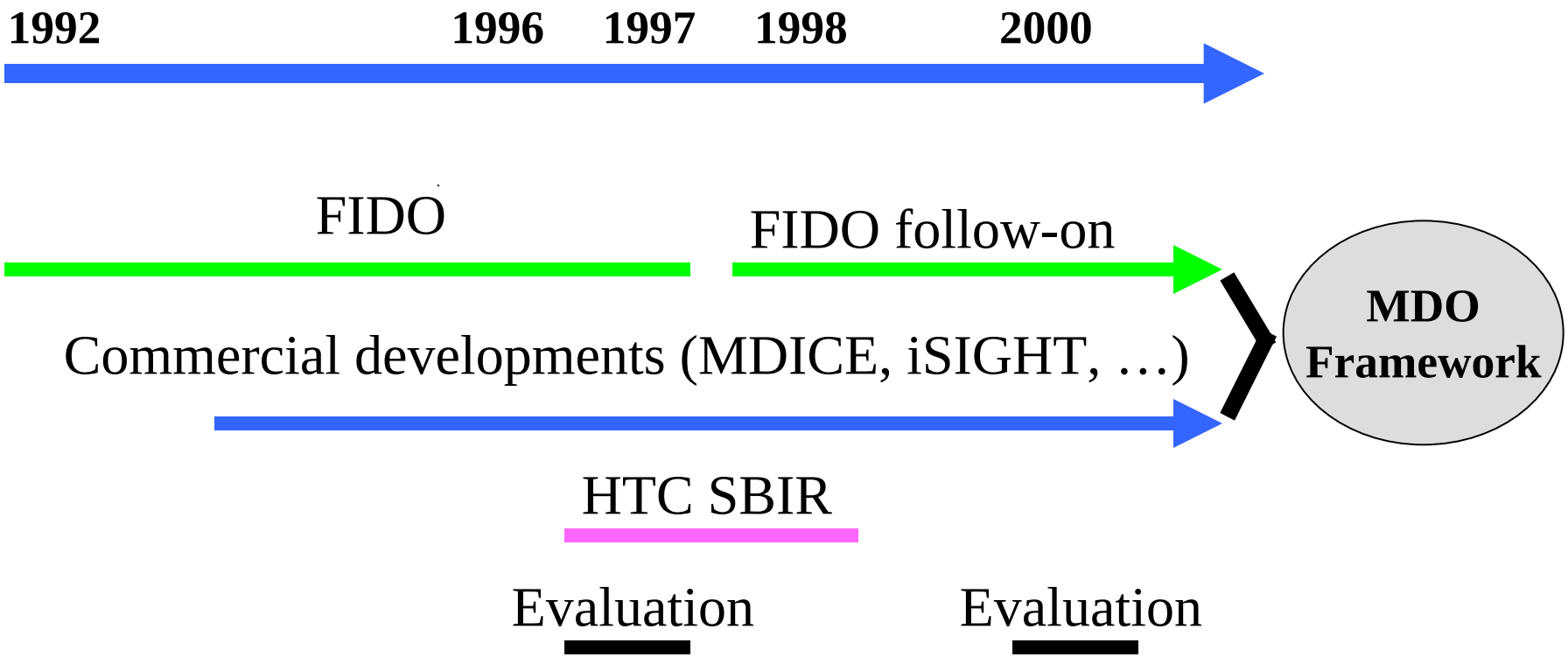
**Increase Sweep**

**Reduce Twist**

**Reduce thickness**



# Summary


1992
1996
1997
1998
2000
FIDO
FIDO follow-on
Commercial developments (MDICE, iSIGHT, …)
MDO Framework
HTC SBIR
Evaluation
Evaluation

# FY 98 Developments

- Derivation of consistent structural/aerodynamic models, with exact geometric derivatives automatically available
- CORBA implementation of most component codes
- Individual analyses with medium-fidelity codes, suitable for incorporation in multidisciplinary analysis
- Demonstration of standalone nonlinear-aerodynamics-only optimization
- Parallel execution of computationally intensive CFD analysis/sensitivity analysis code

# FY 99 Plans

- CORBA implementation of complete system
- Multidisciplinary analysis with medium-fidelity codes, suitable for incorporation in multidisciplinary optimization
- Calculations of trimmed aeroelastic loads with nonlinear corrections
- Parallel execution of multiple computationally intensive analysis/sensitivity analysis codes