Investigate the complex aerostructural coupling

AGILE - The next generation of collaborative MDO
AGILE Strut-Braced Wing

**TLAR Objectives**

- Architect
- Integrator
- MDAO

**Disciplines**

- AGILE
- SBW
- Final Event
- Open Day
- Hamburg
- Consortium
- October 29, 2020

**Top Level Aircraft Requirements**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Unit</th>
<th>AGILE SBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Range</td>
<td>[km]</td>
<td>3500</td>
</tr>
<tr>
<td>Number of Passengers</td>
<td></td>
<td>90</td>
</tr>
<tr>
<td>Long Range Cruise Mach</td>
<td></td>
<td>0.78</td>
</tr>
<tr>
<td>Fuselage diameter</td>
<td>[m]</td>
<td>3</td>
</tr>
<tr>
<td>Fuselage length</td>
<td>[m]</td>
<td>34</td>
</tr>
</tbody>
</table>

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AGILE Strut-Braced Wing

**TLAR Objectives**

**Architect**

**Integrator**

**Specialists**

**Top Level Aircraft Requirements**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>AGILE SBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dive Mach number (Md)</td>
<td>0.89</td>
</tr>
<tr>
<td>Fuel reserves</td>
<td>5% (100 nm)</td>
</tr>
<tr>
<td>On-board systems</td>
<td>AEA</td>
</tr>
<tr>
<td>Engine Type</td>
<td>TF (under wing)</td>
</tr>
</tbody>
</table>

**Hi-Fi Nacelle Aerodynamics**

**All Electric OBS Design**

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Composite Tailoring

TU Delft in house aeroelastic tool PROTEUS is used to tailor a strut braced wing.

Flight conditions → Fuel and mass cases → Lamination parameters → Laminate thickness → Skin strains → Failure

Cross-sectional modeller → Static/Dynamic aeroelastic response → Aeroelastic analysis → Cross-sectional modeller

Skin strains

Failure

Buckling

AGILE - The next generation of collaborative MDO
Composite Tailoring
Results Top Skin

Strain Factor
Buckling Factor

Main Wing

Strut

In Plane Stiffness
Out of Plane Stiffness

In Plane Stiffness
Out of Plane Stiffness

Main Wing

Strut

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Set-up

- High Fidelity aeroelastic CFD simulations
- Multi-partner process:

- High Fidelity aeroelastic CFD simulations
- Multi-partner process:
CSM - CFD coupling

- Optimized Stiffness & Mass matrices => AMLoad => (3D) CSM model
- 3D CSM model (Nastran) => HighFi aeroelastic analyses
High-fidelity aeroelastic Results

- Static aeroelastic analyses for lift, drag polars
- Wingtip displacements LowFi and HighFi in agreement
- Higher M-number shock waves lead to downward twist reducing the pressure loading.

Mach 0.6
Aeroelastic deformation

CL [-] vs AoA [deg]
AGILE Strut-Braced Wing

Optimization - MDF Architecture

Design Variables
- Wing span [m]
- Wing aspect ratio
- Wing sweep [°]
- Position of strut-wing connection

Constraints
- Maximum fuel
- Maximum wing loading
- Flutter constraint

Objective: Direct Operating Cost [USD]
AGILE Strut-Braced Wing

Optimization - MDF Architecture

<table>
<thead>
<tr>
<th>Design Variables</th>
<th>Baseline</th>
<th>min DOC</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>Span [m]</td>
<td>36</td>
<td>33.46</td>
<td>-6%</td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>14</td>
<td>15.56</td>
<td>-9%</td>
</tr>
<tr>
<td>Sweep [°]</td>
<td>16</td>
<td>15.63</td>
<td>-1%</td>
</tr>
<tr>
<td>Eta Strut</td>
<td>0.5</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td>OEM [kg]</td>
<td>24236</td>
<td>22693</td>
<td>-6%</td>
</tr>
<tr>
<td>Wing mass [kg]</td>
<td>5612</td>
<td>4544</td>
<td>-19%</td>
</tr>
<tr>
<td>Strut mass [kg]</td>
<td>888</td>
<td>786</td>
<td>-11%</td>
</tr>
<tr>
<td>mTOM [kg]</td>
<td>41403</td>
<td>39300</td>
<td>-5%</td>
</tr>
<tr>
<td>Block Fuel [kg]</td>
<td>5681</td>
<td>5121</td>
<td>-10%</td>
</tr>
<tr>
<td>DOC [USD]</td>
<td>14051</td>
<td>13330</td>
<td>-5%</td>
</tr>
</tbody>
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