Design and Integration of a Low Observable Engine Intake and Outlet for the MULDICON Platform

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Low Observable (Intake) Design
NATO-STO AVT-251

- Multi-Disciplinary Design and Performance Assessment of Effective, Agile NATO Air Vehicles
- MULDICON – MULti-DIsciplinary CONfiguration
- 5 sub-groups:
  - Designs Specification and Assessment Group (DSAG)
  - Aerodynamic Shaping Group (ASG)
  - Engine Integration Group (EIG)
  - Control Concept Group (CCG)
  - Structural Concept Group (SCG)
MULDICON Wing and Engine


<table>
<thead>
<tr>
<th>Engine Design</th>
<th>UCAV_F</th>
<th>UCAV_G</th>
<th>UCAV_G, v4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrust @ TO (kN)</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>(\dot{m}) @ TO (kg/s)</td>
<td>126.55</td>
<td>113.95</td>
<td>113.95</td>
</tr>
<tr>
<td>(\dot{m}) @ CR (kg/s)</td>
<td>38.40</td>
<td>33.57</td>
<td>33.57</td>
</tr>
<tr>
<td>Fan diameter (m)</td>
<td>0.990</td>
<td>0.900</td>
<td>0.908</td>
</tr>
<tr>
<td>Throat area (m(^2))</td>
<td>0.550</td>
<td>0.450</td>
<td>0.555</td>
</tr>
<tr>
<td>Nozzle area (m(^2))</td>
<td>0.380</td>
<td>0.340</td>
<td>0.340</td>
</tr>
<tr>
<td>Length (m)</td>
<td>2.300</td>
<td>2.200</td>
<td>2.200</td>
</tr>
</tbody>
</table>
Tools

- **CATIA**
  - CAD model

- **ICEMCFD and TRITET**
  - Mesh generation for CFD and RCS

- **M-Edge**
  - CFD calculations

- **SAFIR**
  - IR analysis

- **NASTRAN**
  - Structural analysis

- **GRECO and Puma-EM**
  - RCS analysis
Intake Integration Design Process

• **Version 1**
  – UCAV_F Engine
  – Preliminary wing using NACA-64A profile
  – Early version of the duct design tool

• **Version 2**
  – UCAV_G Engine
  – Wing design 3
  – “CAD-duct”

• **Duct Design**
  – Stand alone duct design with shape parameters slightly adapted to final wing and engine (offset intake throat and engine fan, and duct length)

• **Version 3**
  – UCAV_G, v4 Engine
  – Wing design 3
  – Intake duct from duct design process
Intake Duct Design Tool

Approx. 4.5*10^6 cells / 1.5*10^6 nodes

No. 13

No. 21

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Intake Integration – Version 1

Front view:

vers. 1.1

vers. 1.2

vers. 1.3

Side view:

Top view:

PR = 0.986, DC60 = 0.119

PR = 0.927, DC60 = 0.541

PR = 0.960, DC60 = 0.385

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Intake Integration – Version 2

Free stream:
- $M_1 = 0.8000$
- $V_1 = 236$ m/s
- $P_1 = 22616$ Pa
- $P_{10} = 34474$ Pa

Throat:
- $PR = 0.960$
- $DC60 = 0.385$
- $PR = 0.927$
- $DC60 = 0.541$

AIP:
- $PR = 0.960, DC60 = 0.385$

Duct:
- $PR_i = 0.9911$
- $M_i = 0.5323$
- $V_i = 162$ m/s
- $P_i = 28108$ Pa

Duct:
- $A_1 = 0.4910$ m$^2$
- $T_1 = 231$ K
- $A_{D1} = 1.2965$

Duct:
- $A_{D2} = 0.6366$ m$^2$
- $R_{D2} = 5.9783 \times 10^6$

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Intake Integration – Version 3
Intake Integration – Version 3

Cruise conditions: Mach 0.80, Alt. 11 km

Version 3.0
PR = 0.986, DC60 = 0.291

Version 3.1
PR = 0.987, DC60 = 0.189

Version 3.3
PR = 0.989, DC60 = 0.127

Version 3.4
PR = 0.982, DC60 = 0.316
IR Signature

Case 1

Case 3

Case 2

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A multidisciplinary approach
Questions