Aerodynamic Analysis of the A10

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Description of the A-10

• The A-10 was built to fill the need for a close air support, ground attack vehicle.

• It is heavily armed, capable of carrying multiple laser guided munitions, along with its primary weapon: a built in 30mm GAU-8/A Avenger Gatling Gun.

Gun Test Video
Aftermath

• The A-10 is designed to survive, and remain flying even when suffering massive damage.

• Low wing loading of 200 kg/m² (40 lbs/ft²)
Key Flight Conditions

• Cruise Speed
  – 1525 m
  – 173.1 m/s
  – M=.521

• Combat Speed
  – 1525 m
  – 196 m/s
  – M=.590

www.wikipedia.org/wiki/A-10
Tornado Model Geometry
Nose Considered (0,0,0)

- CG (wings only) = (10.6, 0, 0.26)
- Wing
  - Apex = (7, 0, 0)
  - Partition 1
    - Root Chord = 3.04 m
    - Half-span = 2.8 m
    - Sweep = 0
    - Dihedral = 0°
    - Taper = 1
    - Root Airfoil – 6716
    - Tip Airfoil – 6716
    - -1° Incidence
  - Partition 2
    - Root Chord = 3 m
    - Half-span = 6 m
    - Sweep = 0
    - Dihedral = 7°
    - Taper = 0.65
    - Root Airfoil – 6716
    - Tip Airfoil – 6713
    - -1° Incidence

- Tail
  - Apex = (14.2, 0, 0)
  - Partition 1 (Horizontal)
    - Root Chord = 2 m
    - Half-span = 2.7 m
    - Sweep = 0
    - Dihedral = 0
    - Taper = 1
    - Root Airfoil – 0012
    - Tip Airfoil – 0012
    - No Twist
  - Partition 2 (Vertical)
    - Root Chord = 2.1 m
    - Half-span = 2.2 m
    - Sweep = 0
    - Dihedral = 90°
    - Taper = 1
    - Root Airfoil – 0012
    - Tip Airfoil – 0012
    - No Twist
Tornado Geometry/Panel Output

3D wing and partition layout

- Aircraft body x-coordinate
- Aircraft body z-coordinate
- Body y-coordinate

- MAC
- Ref point
- C.g.
Neutral Point

- @ 8.45 m from nose
- Results in static margin of 13.1%
- Within 0.1% for all flight conditions
Spanloading of Wing, Local $C_l$ Plots For Combat Strafing/Bombing Runs

![Graphs showing force per meter vs span station and local lift coefficient vs span station](image-url)
Alpha Sweep for Combat Run
-90:5:90

Coefﬁcient dependency on alpha

awwar.com
Damage Analysis

- The A-10 is designed to absorb massive amounts of ground fire and remain flying

http://www.teamwarthog.org/html/history.html

www.kowabunga.org
Damage Example

- Assume 1 wing shot off
- CG based on wings, but also assumed that a fuselage was present so that the CG wasn’t as skewed
Spanload with Damage

Spanload shifted outboard from before, and now the tail must make up a lot of the lost lift
$C_l$ with Damage

- Increased $C_l$ on wing to make up for lost lift, but a max $C_l$ of 1.2 still is within reason

www.wikipedia.org/wiki/A-10
LamDes Modeling

LamarDesign Program - A-10 Thunderbolt -

2.00  -8.45  3.04  43.64  0.0  0.0
0.0
5.  0.  0.  -0.00  .4  .2
-7.00  0.00  -0.0  1.0
-7.00  -02.8  -7.0  1.0
-7.70  -08.8  -7.0  1.0
-9.70  -08.80  -7.0  1.0
-10.04  -02.80  -0.0  1.0
-10.04  -00.00
3.  0.  0.  .20  .4  .2
-14.20  -00.0  0.  1.0
-14.20  -02.7  00.  1.0
-16.20  -02.70  00.  1.0
-16.20  -0.00
1.0  10.0  20.  0.3  0.58  40.0  0.0006
0.65  0.65  0.0  -0.00  1.0
0.030  1.0  0.0  0.0  0.0  0.0
Static Margin

\[ y = 0.0112x^2 - 0.205x + 0.9675 \]
\[ R^2 = 1 \]

NP, 8.45m
SM, 4.6%
Min D, 9.2m
Wing Twist

Main Wing Twist

Aft Twist Wing
A-10 Takeoff

- A-10 is built to takeoff on short and rugged runways
- It can take off fully loaded (22,950 kg) in 1,220 m
- Only high lift systems are 2 segment, 3 position Fowler Flaps and a very small inboard leading edge slat

http://www.geocities.com/tacticalstudiesgroup/a10roadtakeoff.jpg
A-10 Lidrag

- $e = 0.858$
- $CL = 1.049$
## A-10 Friction

<table>
<thead>
<tr>
<th>Component</th>
<th>Wetted Area (m²)</th>
<th>$C_F$</th>
<th>$\Delta C_D$</th>
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<tbody>
<tr>
<td>Fuselage</td>
<td>61.80</td>
<td>0.00212</td>
<td>0.00288</td>
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<tr>
<td>Canopy</td>
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<td>Twin Engines</td>
<td>25.28</td>
<td>0.00270</td>
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<tr>
<td>Wing</td>
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<td>0.00726</td>
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<td>Horizontal</td>
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<tr>
<td>Twin Vertical Tail</td>
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<td>0.00298</td>
<td>0.00074</td>
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<tr>
<td>Total</td>
<td>213.41</td>
<td>0.01147</td>
<td>0.01415</td>
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</table>

All data was found at $M=0.56$, at the standard cruise alt (1525 m)
Questions?