The Chengdu Jian-20
Kris Douglas, Sam Kantor, Michael Palles and Grant Parrish
Configuration and Geometry

- Geometry estimated using 3-view drawing and graphics application
- Relatively long, high-volume fuselage compared to existing 5th generation fighters

<table>
<thead>
<tr>
<th>J-20 AIRFRAME GEOMETRY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length (ft)</strong></td>
</tr>
<tr>
<td>70.5</td>
</tr>
</tbody>
</table>
## Configuration and Geometry

### J-20 Planform Geometry

<table>
<thead>
<tr>
<th>$S_{\text{wing}}$ (ft$^2$)</th>
<th>$b$ (ft)</th>
<th>$S_{\text{ref}}$ (ft$^2$)</th>
<th>AR</th>
<th>$C_r$ (ft)</th>
<th>$C_t$ (ft)</th>
<th>$C_{\text{ave}}$ (ft)</th>
<th>$\lambda$</th>
<th>$\Lambda_{\text{LE}}$ ($^\circ$)</th>
<th>$\Lambda_{\text{TE}}$ ($^\circ$)</th>
<th>$\Gamma$ ($^\circ$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>493.2</td>
<td>42.6</td>
<td>829.9</td>
<td>2.19</td>
<td>34.0</td>
<td>4.9</td>
<td>19.5</td>
<td>0.15</td>
<td>49.9</td>
<td>-8.4</td>
<td>-3.9</td>
</tr>
</tbody>
</table>

### Wing-Mounted Control Surface

<table>
<thead>
<tr>
<th>Wing-Mounted Control Surface</th>
<th>Area (ft$^2$)</th>
<th>% $C_{\text{ave}}$</th>
<th>% $b/2$</th>
<th>Centroid Location Relative to Nose (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aileron</td>
<td>20.8</td>
<td>13.0</td>
<td>38.7</td>
<td>55.7</td>
</tr>
<tr>
<td>Trailing Edge Flap</td>
<td>30.8</td>
<td>23.2</td>
<td>32.0</td>
<td>56.1</td>
</tr>
<tr>
<td>Leading Edge Slat</td>
<td>17.9</td>
<td>9.7</td>
<td>44.6</td>
<td>44.0</td>
</tr>
</tbody>
</table>

### Non-Wing-Mounted Control Surface

<table>
<thead>
<tr>
<th>Non-Wing-Mounted Control Surface</th>
<th>Area (ft$^2$)</th>
<th>Average Chord (ft)</th>
<th>Length (ft)</th>
<th>Dihedral ($^\circ$)</th>
<th>Centroid Location Relative to Nose (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canard</td>
<td>48.0</td>
<td>6.6</td>
<td>7.3</td>
<td>10.7</td>
<td>25.2</td>
</tr>
<tr>
<td>Tail</td>
<td>53.5</td>
<td>6.6</td>
<td>8.2</td>
<td>59.8</td>
<td>60.2</td>
</tr>
<tr>
<td>Aft Ventral Fin</td>
<td>16.7</td>
<td>4.9</td>
<td>3.4</td>
<td>-60.3</td>
<td>59.6</td>
</tr>
</tbody>
</table>
## Weight Estimation

<table>
<thead>
<tr>
<th>Aircraft Component</th>
<th>Multiplier and Reference</th>
<th>Reference Value</th>
<th>Weights (lb)</th>
<th>CG Location Aft of Nose Apex (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Wing</td>
<td>9.0×Wing Area (ft$^2$)</td>
<td>493.2</td>
<td>4438.8</td>
<td>48.8</td>
</tr>
<tr>
<td>Horizontal Tail</td>
<td>4.0×Horizontal Tail Area (ft$^2$)</td>
<td>125.3</td>
<td>501.2</td>
<td>40.0</td>
</tr>
<tr>
<td>Vertical Tails</td>
<td>5.3×Vertical Tail Area (ft$^2$)</td>
<td>73.0</td>
<td>386.9</td>
<td>60.7</td>
</tr>
<tr>
<td>Fuselage</td>
<td>4.8×Fuselage Wetted Area (ft$^2$)</td>
<td>1566.7</td>
<td>7520.3</td>
<td>33.0</td>
</tr>
<tr>
<td>Landing Gear</td>
<td>0.033× GTOW Guess (lb)</td>
<td>75000</td>
<td>2475.0</td>
<td>37.9</td>
</tr>
<tr>
<td>Installed Engine</td>
<td>1.3×Engine Weight (lb)</td>
<td>5000</td>
<td>6500.0</td>
<td>53.2</td>
</tr>
<tr>
<td>&quot;All-Else Empty&quot;</td>
<td>0.17×GTOW Guess (lb)</td>
<td>75000</td>
<td>12750.0</td>
<td>33.0</td>
</tr>
</tbody>
</table>

| Empty Weight (lb)       | 34572.2                                                    |
| Fuel and Payload (lb)   | 40427.8                                                    |
| CG Location (%MAC)      | 20                                                        |
| CG Estimate based on Gear Placement (%MAC) | 18.6 |

<table>
<thead>
<tr>
<th>Wing Loading (lb/ft$^2$)</th>
<th>90.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrust-to-Weight</td>
<td>0.507</td>
</tr>
<tr>
<td>Thrust-to-Weight (Afterburners)</td>
<td>0.853</td>
</tr>
</tbody>
</table>
Gear Placement Guidelines

- Tipback angle between 12 and 15 degrees
- Overturn angle between 54 and 63 degrees
- Results in CG location of approximately 18.6% MAC
Stability Characteristics

- Varied Number of Panels
  - Chordwise
  - Spanwise
- Multiple Runs Varying
  - Mach Number
  - Angle of Attack
  - Sideslip Angle
  - CG Location
- Produced
  - Stability Derivatives
  - Lift Induced Drag
  - Trim Drag
- Wing Airfoil: NACA 64206
- Tail Airfoils: 7% Thick Biconvex
Convergence History

Neutral Point Location vs. Number of Panels and Mach Number

CL Alpha vs. Number of Panels and Mach Number

Cm Alpha vs. Number of Panels and Mach Number

Cn beta vs. Number of Panels and Mach Number
Stability Derivatives

- $C_n$ vs Alpha
- $C_L$ vs Alpha
- $C_m$ vs Beta
- $C_n$ vs Beta

Mach numbers: 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6
Drag Estimation: Viscous Drag

- Viscous Drag calculated using friction2k6 code on course website, at Mach 0.1 to 2.9 and altitudes of 15, 25, and 35 kft
- Combined skin friction and form drag coefficient did not vary with altitude (identical to four decimal places)
Drag Estimation: Lift-Induced Drag

Chengdu J-20 Subsonic Drag Polar

Canard Schedule

- Calculated using AVL and FRICTION.exe
  - FRICTION.exe for profile drag
  - AVL for induced drag
- Trim drag included
Drag Estimation: Trim Drag

- Balanced 14% unstable
- Minimum trim drag near 30% unstable
- Suggests other factors drive static margin
- Varies little with Mach number
Drag Estimation: Wave Drag

- Wave drag estimated using AWAVE and awaveFileMake.m updated to include arbitrary fuselage shapes
- Little variation with angle-of-attack for small $\alpha$
Drag Estimation: Wave Drag

Volumetric wave drag represents a high percentage of the available thrust at high Mach.
Drag Estimation: Total Drag

Chengdu J-20 Total Drag Buildup (35 kft)

- Note the jump in drag at the sonic speed due to onset of wave drag
- Maximum Mach clearly impacted by engine performance
Performance: Maximum Speed

- $M = 2.13$ (shock forms on nose cone)
- $M = 2.81$ (shock forms on probe)
- Enough thrust to achieve $M \approx 2.5$

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>Mach Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-22</td>
<td>$M = 2.25$</td>
</tr>
<tr>
<td>F-35</td>
<td>$M = 1.6+$</td>
</tr>
<tr>
<td>J-20</td>
<td>$M = 2.1-2.5$</td>
</tr>
</tbody>
</table>
Performance: Range

Max range calculated using Breguet Range equation and weight fractions

V/C assumed constant at each speed for these calculations
Performance:
Takeoff Distance & Climb Rate

- Ground roll required: 1398ft (black)
- Distance to achieve MIL 50’ clearance requirement: 144ft (red)
- Total take-off distance: 1542ft
- Climb angle for best rate of climb: 19.2°
Conclusions

• Configuration characteristics
  – large internal volume (i.e. munitions capacity)
  – long range
  – supersonic cruise capability

• Optimized for use as a long-range interceptor and air-to-surface attack platform

• Actual performance dependent upon engine development
References


Questions?

http://www.freerepublic.com/focus/f-news/2655343/posts