Air Force Scientific Advisory Board

Airborne Tactical Laser (ATL) Feasibility for Gunship Operations

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**Promise of Tactical Laser on a Gunship**

**Key attributes:**

- Precision lethality
- Track and hit moving targets
- “Danger-close” of meters
- Minimal collateral damage
- Clandestine and invisible engagements
- Deep, onboard re-chargeable magazine*
- Variable effects – disrupt to destroy
- Reduce platform vulnerability
- Fewer crewmembers needed

* Electric lasers only, chemical lasers require chemical replenishment
Assess current state of airborne tactical laser technologies
- Consider both chemical and electric/solid state lasers
- Identify platform integration issues (on C-130, C-27, C-17)

Examine gunship operations and tactics, techniques and procedures
- Identify missions, operational requirements, logistics or sustainment issues which might limit laser weapons employment

Assess tactical laser effectiveness against offensive and defensive gunship targets
- Identify potential effects
- Assess vulnerability and countermeasures

Recommend technology options for near, mid, and far-term
Outline

- Gunship mission
- System considerations
- Advanced Tactical Laser (ATL) ACTD
- Recommendations
Current Gunship Mission

- **Tactics**
  - Night time and day time permissive ops due to platform vulnerability
  - Close-in pylon turn

- **Principal Gunship requirements**
  - Situation awareness
  - Lethality
  - Persistence
  - Survivability
**Effectiveness and Tactical Target Lethality**

Laser Weapons More Effective (Lower Collateral Effects)

Kinetic Weapons More Effective (Larger Explosive Effects)

* Laser & kinetic weapons could play complementary roles
  * A Gunship with both laser and kinetic weapons can execute more missions
Outline

- Gunship mission
- System considerations
  - High energy laser choices
  - Beam control and atmospheric propagation
  - Aircraft integration & options
- Advanced Tactical Laser (ATL) ACTD
- Recommendations
System Considerations

Weapon lethality: \( \sim 2 \text{ kW/cm}^2 \) at 7 km, dwell time 1/2 s to <10s

System Attribute

- Laser power
- Laser efficiency
- Thermal management
- Duty cycle
- Aperture
- Beam quality
- Jitter
- Atmospheric effects
- Standoff

- Weight and “wall plug” power requirements
- Target prosecution rate
- Spot size on target
- Survivability
### High Energy Lasers

<table>
<thead>
<tr>
<th>Attribute</th>
<th>COIL (1.31 um)</th>
<th>Bulk SSL (1.06 um)</th>
<th>Fiber SSL (1.07 um)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propagation Effects</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>Ocular Hazard</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>Rechargeable Magazine</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
<tr>
<td>Technical Maturity</td>
<td>⬤</td>
<td>⬤</td>
<td>⬤</td>
</tr>
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</table>

**Solid State Laser provides a technically maturing option with operationally relevant magazine depth, good beam propagation, and decreased danger close distances**
### Principal challenges:

**Maintenance of aimpoint and rejection of platform-induced jitter**

**Payoff:** Reduces laser power, and lower system weight

### Disturbance vs. Severity

<table>
<thead>
<tr>
<th>Disturbance</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jitter (Platform motion)</td>
<td>Severe</td>
</tr>
<tr>
<td>Aero-optics Turbulence</td>
<td>Benign in forward region</td>
</tr>
<tr>
<td>Atmospheric Turbulence</td>
<td>Benign</td>
</tr>
<tr>
<td>Thermal Blooming*</td>
<td>Significant (COIL) Benign (SSL)</td>
</tr>
</tbody>
</table>

*Distortion caused by laser heating of the atmosphere (water vapor)*
Trade Offs between Laser Power, Aperture and Jitter

Bigger Optics or More Laser Power?

**Larger Laser, Smaller Aperture**
- Simpler beam director integration
- Reduced requirements on beam quality and jitter
- Stressing thermal/power integration

**Smaller Laser, Larger Aperture**
- Simpler laser integration
- More stringent requirements on beam quality and jitter
- Enhanced ISR capability

- Laser requirements can be considerably reduced by increasing aperture size and reducing platform jitter
- Same lethality is achievable with variety of power-aperture combinations with system implementation (e.g., weight) implications
- High fidelity system models are needed to guide laser weapon system development
System Considerations

- **Weapon lethality:** ~2 kW/cm²
dwell time 1/2s to < 10s

- **Mission characteristics:**
  - 7 km slant range, 50 s continuous run time
  - 10% duty cycle

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<table>
<thead>
<tr>
<th>System Attribute</th>
<th>Nominal System Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser Power</td>
<td>100 kW</td>
</tr>
<tr>
<td>Efficiency</td>
<td>14%</td>
</tr>
<tr>
<td>Thermal Management</td>
<td>615 kW Peak load input</td>
</tr>
<tr>
<td></td>
<td>31 MJ storage</td>
</tr>
<tr>
<td></td>
<td>310 kW dissipation</td>
</tr>
<tr>
<td>Duty Cycle</td>
<td>10%, 50s continuous run time</td>
</tr>
<tr>
<td>Beam Quality</td>
<td>2</td>
</tr>
<tr>
<td>Jitter</td>
<td>2 urad</td>
</tr>
<tr>
<td>Atmospheric Effects</td>
<td>Compensation not needed</td>
</tr>
<tr>
<td>Aperture</td>
<td>50 cm</td>
</tr>
<tr>
<td>Standoff</td>
<td>7 km slant range</td>
</tr>
</tbody>
</table>
Platform Integration

AC-130 and AC-27 gunships

- Key challenge to A/C Integration:
  - Available weight and volume
  - Electric power
  - Thermal management
  - Platform vibration isolation

- Onboard capabilities vary across platforms
  - Available A/C engine power
  - Use A/C fuel as thermal sink
  - Ram air cooling
    (non Low-Observable)
**Finding: Laser Augmented Gunship is Potentially Feasible for AC-130**

Add laser system: SSL 100 kW, 50 cm aperture, 50 s run time, 10% duty cycle  
Retain: 105 mm gun  
Remove: 25 and 40 mm guns

<table>
<thead>
<tr>
<th>Payload removed</th>
<th>Laser weapon system payload added</th>
</tr>
</thead>
<tbody>
<tr>
<td>25mm &amp; 40mm guns, ammo, rack</td>
<td>Laser device</td>
</tr>
<tr>
<td>Fewer crew members (2)</td>
<td>Beam Director/Optics</td>
</tr>
<tr>
<td>ALLTV</td>
<td>Electric Power System</td>
</tr>
<tr>
<td>Rest station</td>
<td>Thermal Management System</td>
</tr>
<tr>
<td>Weight equivalent of drag count</td>
<td>C3 for laser</td>
</tr>
</tbody>
</table>
Add Laser system: SSL 75 kW, 50 cm aperture, 50 s run time, 10% duty cycle
Add other weaponry: precision guided munition (SOPGM) for complementary weaponry effects

Laser weapon system payload added

- Laser device
- Beam Director/Optics
- Electric Power System
- Thermal Management System
- C3 for laser
- Mission Systems (no 30 mm gun)
- SOPGMs (50)
Gunship Operational Options

- AC-130 with an integrated laser weapon system and retaining 105mm gun
  - Expanded mission with combined HEL and KE

- Flight of two aircraft, for example:
  - AC-27 with laser weapon, AC-130 with guns only
    - AC-27 operates as an adjunct to AC-130
    - Battle management resides in the AC-130
    - Two-way data link with streaming video
  - Two AC-27s (one with guns, one with HEL)
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Advanced Tactical Laser (ATL) ACTD

**Objective**
Demonstrate Military Utility Assessment of Modular HEL Weapon for Ultra-Precision Strike Missions

**Key Attributes**
- Fills the entire C-130 Cargo Bay
- 50 cm optics in a 130 cm retractable turret
- Sealed Exhaust COIL

NC-130
ATL ACTD Status

- Low power ground and flight tests completed
- High power laser installed on the aircraft and activated (on the ground)
- High power flight test not yet conducted
- ACTD to end in September 2008
  - Followed immediately by an EUE

As an integrated platform, could provide unique test and evaluation opportunity
Outline

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Recommendation 1: Near Term Technology Development

Start with system analysis for combined laser and kinetic Gunship, ensure technology developments are consistent with system requirements.

- Initiate a comprehensive system engineering program to integrate laser weapon system on a Gunship.
- Complete programs to mature SSL.
- Aggressively pursue beam control system improvements including better jitter control and lightweighting.
- Lightweight and improve electric power and thermal management technologies.
Recommendation 2: Mid and Far Term Technology Development

- Incorporate future laser weapon system technologies for a Gunship (AC-130 or AC-27) into Air Force laser weapon roadmap:
  - Develop higher power, higher efficiency fiber SSL
  - Develop higher power, higher efficiency bulk SSL
  - Enhance beam control technologies (jitter below diffraction limit)
  - Reduce the total system weight

- Focus funds on developing a fieldable laser system
  - Build a laser weapon system which meets size, weight, power, laser efficiency, beam quality and jitter requirements
  - Design program based on goal of militarily useful system

Fund platform modification only after laser system is well demonstrated
Recommendation 3: Extended User Evaluation (EUE) Using ATL

Purpose of EUE: Assess potential military utility

- Develop a detailed, comprehensive EUE Plan
- Explore a range of scenarios using integrated airborne testbed
  - Repeat and expand target sets beyond the 2 DRMs
  - Include diagnostics of beam at target
  - Validate detailed M&S for alternative scenarios
- Restrict upgrades of the ACTD configuration to beam control
  - Measure platform jitter impacts on system performance
  - Retain existing COIL as is for EUE
- Emphasize potential user test and evaluation
  - Develop CONOPS
  - Conduct ground tests to enhance current lethality database
Summary

- Laser development for Gunship applications should focus on solid-state laser (SSL) solutions
  - SSL more promising for gunship operations
    - Less absorption in the lower atmosphere
    - Larger magazine
    - Less complex logistics requirements

- Suggested way ahead – Develop future gunship with combined SSL and kinetic capabilities
  - Demonstration of laser system as first step before platform modification
SAB Study Panel

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- Dr. Joan Woodard
- Dr. David Whelan

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