University of Maryland

TLAS Design Proposal

In response to the 2005 Annual AHS International Student Design Competition – Graduate Category

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Atlas Heavy-Lift Helicopter

• A low-cost, low-risk solution for a shipboard compatible heavy-lift VTOL transport
  – Designed in response to 2005 AHS Request for Proposal, sponsored by Boeing

• Provides maximum productivity for minimum cost
  – Proven configuration, innovative technology
  – Designed for the rigors of ship-based deployment
  – Equipment and avionics designed for optimal mission capability
Mission Requirements

• Deliver payload from L-Class vessel to 125-nm radius
  – Primary payload: Future Combat System (20 tons)
  – Secondary payload: Two 463L pallets (10 tons total)

• Live on L-Class or CVN vessel
  – Automated structural folding for hanger-deck stowage
  – Facilitate shipboard maintenance

• 1000-nm self-deployment capability
• Maximum cruise speed at minimum cost
Configuration Selection

• Balanced approach considering cruise speed, shipboard compatibility, and cost
  – **Single Main Rotor:** efficient hover, operational flexibility, low risk
  – **Tandem / Coaxial:** high masts incur penalties in cruise performance and stowage
  – **Compounds:** wings incur downwash penalty, requires cost and weight to overcome
  – **Quad Tilt Rotor:** complex design carries large financial risk

**Final Design**

*Atlas is a Single Main Rotor/Tail Rotor helicopter*

*Provides best performance at lowest cost*
Sizing of Atlas

- **RFP requirements**
  - Sustained maneuver of twice standard turn rate at cruise speed (6°/sec)
    - Trade study: maximum cruise speed for a given blade loading during maneuver
    - Performance trim code determines stall speed for each blade loading
  - Shipboard Considerations
    - Minimum footprint, stowage, and deck clearance
    - Low rotor downwash (low disk loading) for ground crew safety

- **Sizing methodology developed using Tishchenko method**
  - Modified for heavy lift
  - Key trade studies
    - Blade loading
    - Blade aspect ratio
    - Solidity

- **Productivity**
  - Productivity = \( \frac{\text{Payload} \times \text{Range}}{\text{Cost} \times \text{Time}} \)
  - Productivity increased by decreasing Cost x Time
### Atlas Configuration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Takeoff Weight</td>
<td>108,500 lbs</td>
</tr>
<tr>
<td>Empty Weight</td>
<td>55,200 lbs</td>
</tr>
<tr>
<td>Installed Power</td>
<td>23,700 hp</td>
</tr>
<tr>
<td>Disk Loading</td>
<td>10.6 lb/ft²</td>
</tr>
<tr>
<td>Number of Blades</td>
<td>7</td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>20</td>
</tr>
<tr>
<td>Main Rotor Dia.</td>
<td>116 ft</td>
</tr>
<tr>
<td>$C_T/\sigma$</td>
<td>0.079</td>
</tr>
<tr>
<td>Solidity ($\sigma$)</td>
<td>0.111</td>
</tr>
<tr>
<td>Acquisition Cost</td>
<td>$56 M</td>
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</tbody>
</table>

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[Diagram of Atlas Configuration]

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[Diagram of helicopter with dimensions and configurations]
**Advanced Turboshaft Engines**

- Atlas’ engines are more powerful, lighter, and more efficient than current heavy turboshafts

<table>
<thead>
<tr>
<th></th>
<th>Atlas Engine</th>
<th>AE1107</th>
<th>Performance Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>7,916 hp</td>
<td>6,150 hp</td>
<td>+ 29%</td>
</tr>
<tr>
<td>P/W</td>
<td>8.88 hp/lb</td>
<td>6.33 hp/lb</td>
<td>+ 40%</td>
</tr>
<tr>
<td>SFC</td>
<td>0.34 lb/hp/hr</td>
<td>0.44 lb/hp/hr</td>
<td>- 19%</td>
</tr>
</tbody>
</table>

- Large installed power gives exceptional performance
  - OEI hover at 3000 ft, ISA+20 in accordance with RFP requirement
  - 12,500-ft hover ceiling with 20-ton payload
  - 176-kt maximum cruise speed with 20-ton payload
Drivetrain Configuration

- Three-engine configuration provides benefits over two-engine configuration
  - Optimum installed power
  - Lower weight
  - Lower cost
  - Lower risk
- Innovative split-torque, face-gear transmission
  - 10% weight savings over conventional designs
  - Improvements in load-handling and layout
Shipboard Compatibility – Rotor Folding

- Trade study to determine number of blades: Seven chosen for folding consideration
  - Powered, automatic main rotor folding
  - Compact, lightweight hydraulic motors used for folding
  - Rotor blades locked with respect to hub to ease swashplate/pitch link loads
  - Original design eliminates hydraulic slip ring
    - Fixed hydraulic manifold on hub
    - Linear actuator with hydraulic quick disconnect extends from hub and connects to fitting on hub
Tail Rotor and Empennage

- Bearingless hub, composite blades
- Tail gearbox uses efficient face gears
- Empennage folds to meet height restrictions of CVN hangar
  - Automatic folding, fully integrated with main rotor folding

3 different folded configurations:
- “Fully Folded”: Rotor blades and tail boom fold; provides the maximum reduction in overall dimensions for storage
- “Main rotor only”: Compact configuration; tail boom does not block the rear loading door
- “Tail boom only”: Provides easy unobstructed access for tail assembly maintenance
Rotor Hub and Blades

- Innovative hybrid composite/titanium hub
  - Elastomeric bearings for low parts count, improved maintainability
  - Compact elastomeric lead-lag damper
  - Graphite/epoxy minimizes weight and improves maintainability

- Composite blades with tailored flap-bending/torsion coupling reduce 7/rev vibratory loads and reduce shaft power
- Blade manufacturing methods optimized for reduced cost
Active Trim Tab and Vibration Control

• Active trim tab for in-flight rotor blade tracking
  – Shape Memory Alloy (SMA) actuation
  – Reduced maintenance and operating costs
  – Less stringent blade manufacturing tolerances
  – Optimal tracking at all flight conditions

• Vibration control
  – LIVE isolators on main rotor pylon
  – Flap-bending/torsion coupling in composite blades
  – Adaptive magnetorheological (MR) tuned-mass dampers respond to changing vibration frequencies
  – Vibration levels below 0.05 g
Structure and Landing Gear

- Bulkheads constructed of graphite / epoxy
- Composite sandwich skin eliminates stringers and fasteners, simplifying manufacture
- Keel beams constructed as sine-wave beams to maximize energy absorption in the event of a crash
- Armored seats, Electromagnetic Polymer surrounding cockpit provides protection for pilots and crew

Retractable for reduced parasite drag
- Magnetorheological (MR) struts allow for changing loading conditions
Cargo Area

- Treadways, floor rollers, integral hard points, winch permit easy loading of FCS vehicle or two 463L pallets
- Landing gear adjusts cargo floor attitude for effortless loading
- Folding ramp and clamshell doors allow Atlas to transport large objects protruding out the aft of the cargo bay

- External sling-load capability
Adverse Weather and Night Operations

- Multi-mode radar (MMR)
  - Ground mapping
  - Terrain avoidance
- Forward Looking Infrared (FLIR)
- Night-vision goggle capable
- Navigation/avionics suite
  - Joint Tactical Radio System
  - Differential GPS
  - TACAN
  - Inertial Navigation System
  - Dual VHF Omnidirectional Range
  - Automatic Direction Finder
- Lightning protection: 200-kA strike get-home capability
- De-icing on main and tail rotor blades
Cockpit Features/Mission Systems

• Five reconfigurable 9”x12” Multi-Function Displays
• Fly-by-wire system
  – Low weight
  – Improved performance
• Shipboard landing aids
• Countermeasures
  – Radar/infrared warning receiver
  – IR jammer
  – chaff/flare dispenser
  – Hard points on fuselage for .50 caliber guns
• AFCS modes: SAS and autopilot
  – RD, RCAH, and ACAH
  – Flight track following, automatic position hold
• Environmental Protection
  – EMI Protection
  – Positive pressure and filters for NBC protection
• Backup instruments in case of failure
Maintainability

- Fuselage designed for good maintainability
  - Kick-in steps facilitate access to engines, transmission, and tail rotor
  - Engine cowlings double as maintenance platforms
  - Quick-access panels for LRUs
  - Easy access to all systems
  - Integrated walkway on tail boom

- Low-maintenance rotor and blades
  - Corrosion-resistant elastomeric bearings
  - Composites resist crack propagation and fatigue

- Health and Usage Monitoring System (HUMS) for fault detection
  - FADEC system also monitors engine status
  - Automatic track-and-balance via automated tracking tabs
  - Neural network post-flight data analysis
  - Replace parts based on wear, not flight-hours
Derivative Applications

• ASW Applications
  – Airborne Laser Mine Detection System
  – Sonar dunking/Sonobuoys

• Emergency medical evacuation
  – Carries 12 litters

• Troop transport
  – Up to 44 fully-equipped soldiers

• Firefighting
  – 20-ton Bambis Buckets
  – 5,200 gallon capacity

• Civil Transport

Bambi Buckets in action
Atlas provides performance enhancements over current heavy helicopters to significantly expand military logistics capabilities.

<table>
<thead>
<tr>
<th></th>
<th>Design Gross Weight (108,500 lb GTOW)</th>
<th>Max. Fuel, No Payload (68,500 lb GTOW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Cruise Speed</td>
<td>150 kts</td>
<td>160 kts</td>
</tr>
<tr>
<td>Max. Cruise Speed</td>
<td>176 kts</td>
<td>172 kts</td>
</tr>
<tr>
<td>Best Range Speed</td>
<td>145 kts</td>
<td>129 kts</td>
</tr>
<tr>
<td>Max. Range</td>
<td>325 nm</td>
<td>395 nm</td>
</tr>
<tr>
<td>Best Endurance Speed</td>
<td>81 kts</td>
<td>60 kts</td>
</tr>
<tr>
<td>Max. Endurance</td>
<td>2.8 hr</td>
<td>4.1 hr</td>
</tr>
</tbody>
</table>

$1000+ \text{ nm self-deployment range: exceeds RFP requirement}$
Conclusion

- Atlas: a reliable, highly-capable, versatile platform for heavy-lift transport
  - Low maintenance helicopter with significantly lower operating costs than current models
  - Comparable acquisition costs to current helicopter
  - Many additional applications
  - Exceeds the requirements set forth in the RFP at the lowest acquisition cost possible