University of Maryland

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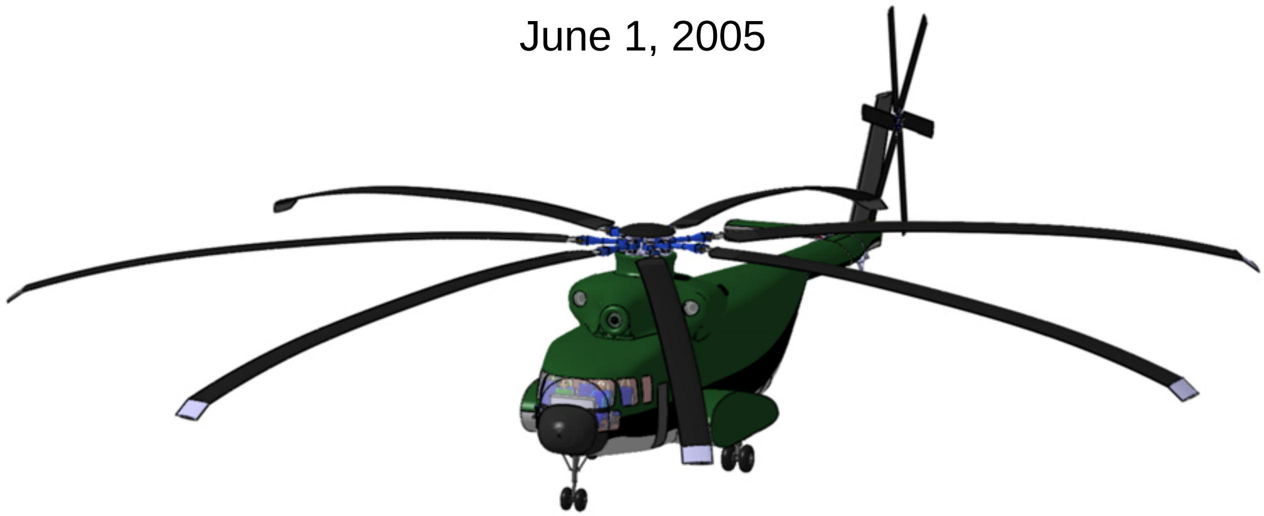
ATLAS Design Proposal

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

June 1, 2005



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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

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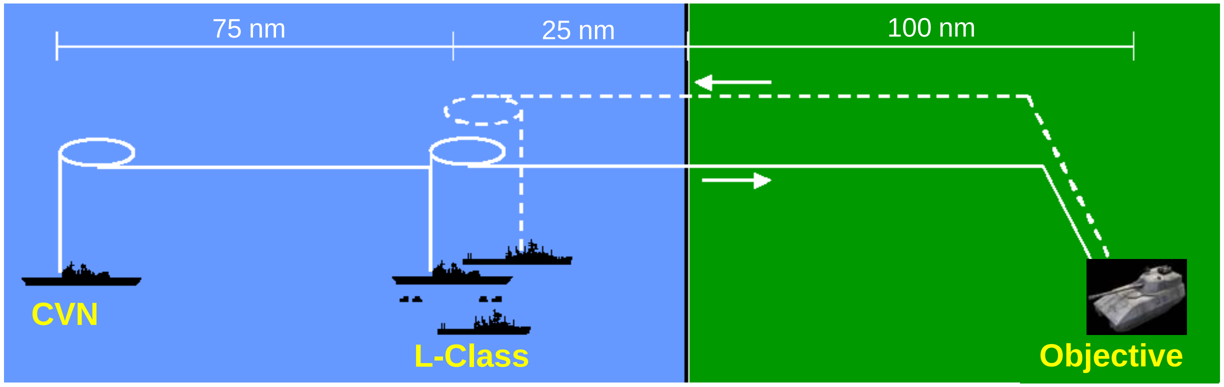
- Deliver payload from L-Class vessel to 125-nm radius
  - Primary payload: Future Combat System (20 tons)
  - Secondary payload: Two 463L pallets (10 tons total)



- 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

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- **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

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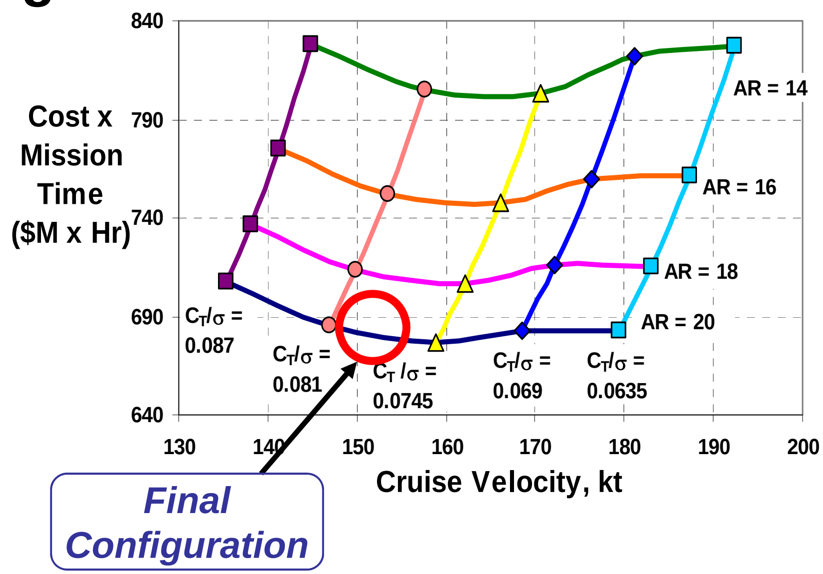
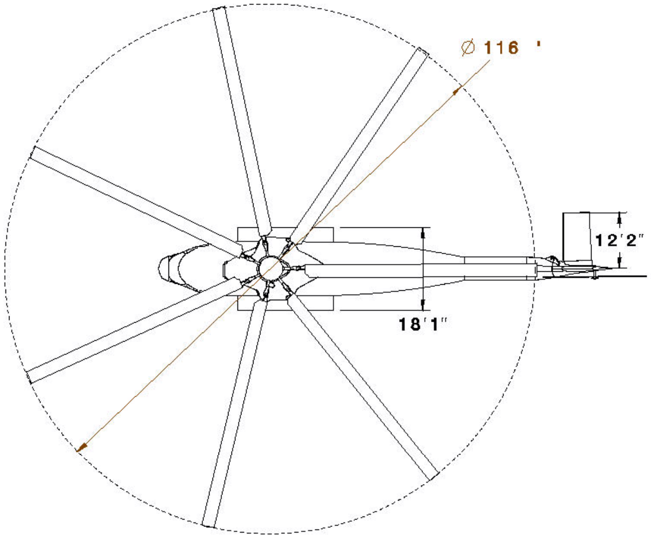
- **RFP requirements**
  - Sustained maneuver of twice standard turn rate at cruise speed (6°/sec)
    - Trade study: maximum cruise speed for a given blade loading during maneuver
    - Performance trim code determines stall speed for each blade loading
  - Shipboard Considerations
    - Minimum footprint, 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

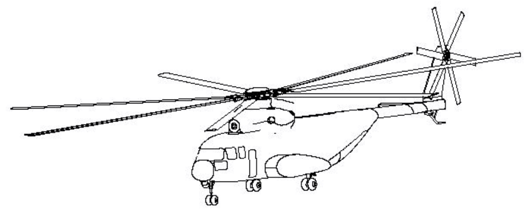


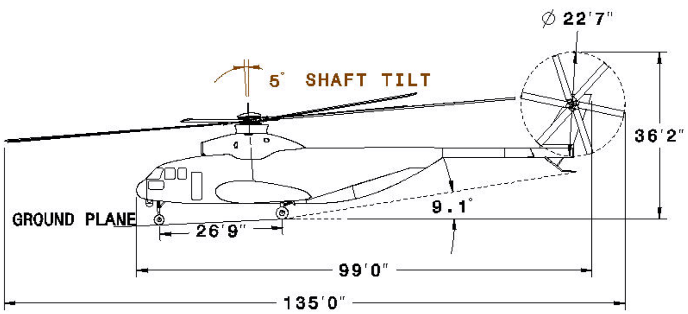
High blade loading decreases empty weight

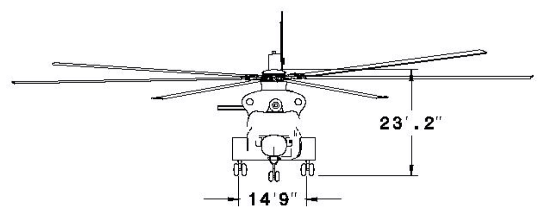
- **Productivity**
  - $\text{Productivity} = \dfrac{\text{Payload} \times \text{Range}}{\text{Cost} \times \text{Time}}$
  - Productivity increased by decreasing Cost x Time

Atlas Configuration









Takeoff Weight lbs	108,500
Empty Weight lbs	55,200
Installed Power hp	23,700
Disk Loading lb/ft^2	10.6
Number of Blades	7
Aspect Ratio	20
Main Rotor Dia. ft.	116
C_T/σ	0.079
Solidity (σ)	0.111
Acquisition Cost $M	56

Advanced Turboshaft Engines

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

	 Atlas Engine	 AE1107	Performance Improvement
Power	7,916 hp	6,150 hp	+ 29%
P/W	8.88 hp/lb	6.33 hp/lb	+ 40%
SFC	0.34 lb/hp/hr	0.44 lb/hp/hr	- 19%

- **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

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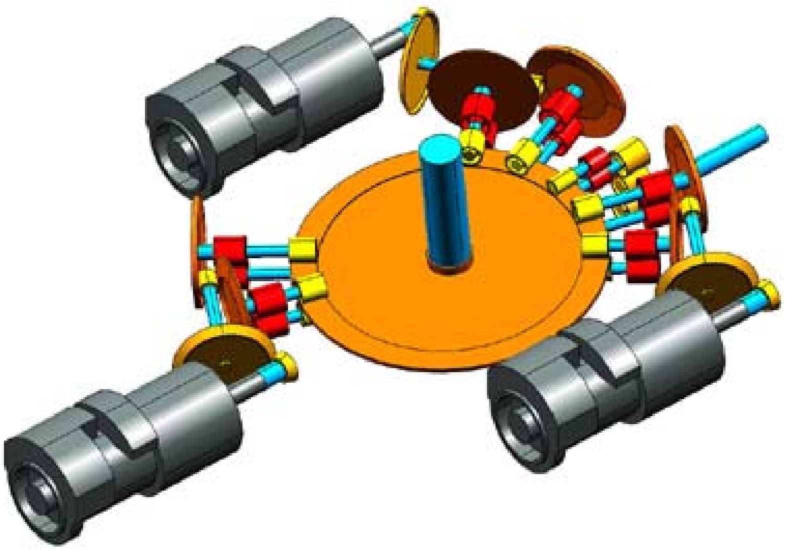
- **Three-engine configuration provides benefits over two-engine configuration**
  - **Optimum installed power**
  - **Lower weight**
  - **Lower cost**
  - **Lower risk**
- **Innovative split-torque, face-gear transmission**
  - **10% weight savings over conventional designs**
  - **Improvements in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



Shipboard Compatibility – Rotor Folding

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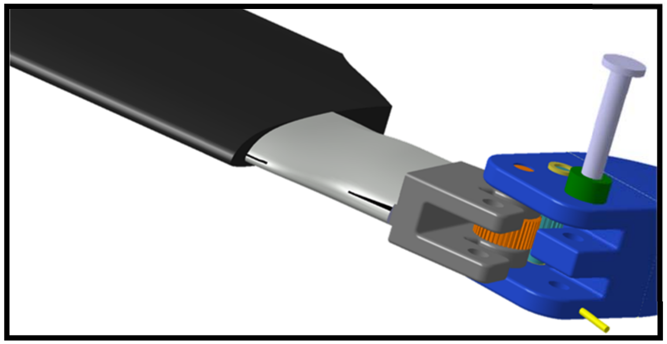
- **Trade study to determine number of blades: Seven chosen for folding consideration**
  - Powered, automatic main rotor folding
  - Compact, lightweight hydraulic motors used for folding
  - Rotor blades locked with respect to hub to ease swashplate/pitch link loads
  - Original design eliminates hydraulic 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

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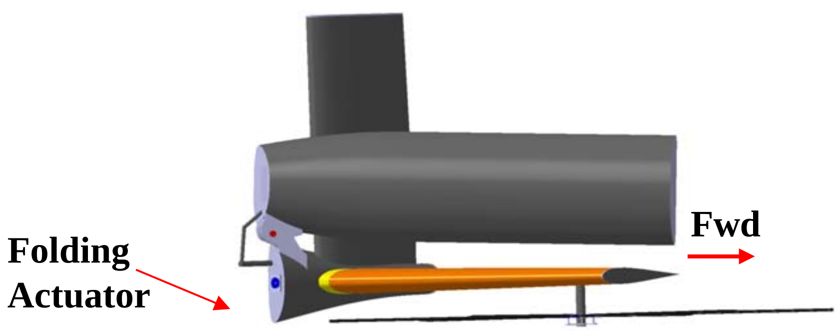
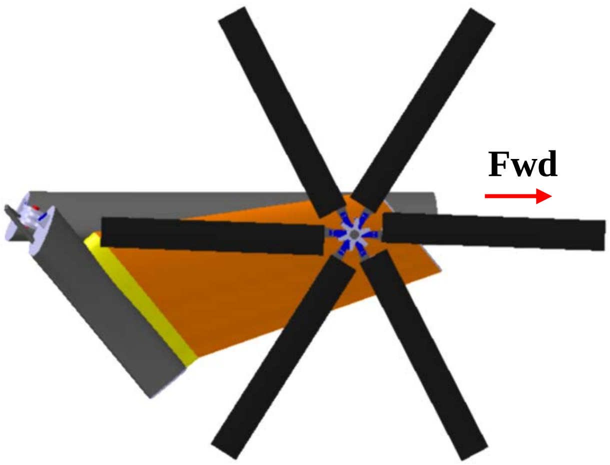
- Bearingless hub, composite blades
- Tail gearbox uses efficient face gears
- Empennage folds to meet height restrictions of CVN hangar
  - Automatic folding, fully integrated with main rotor folding

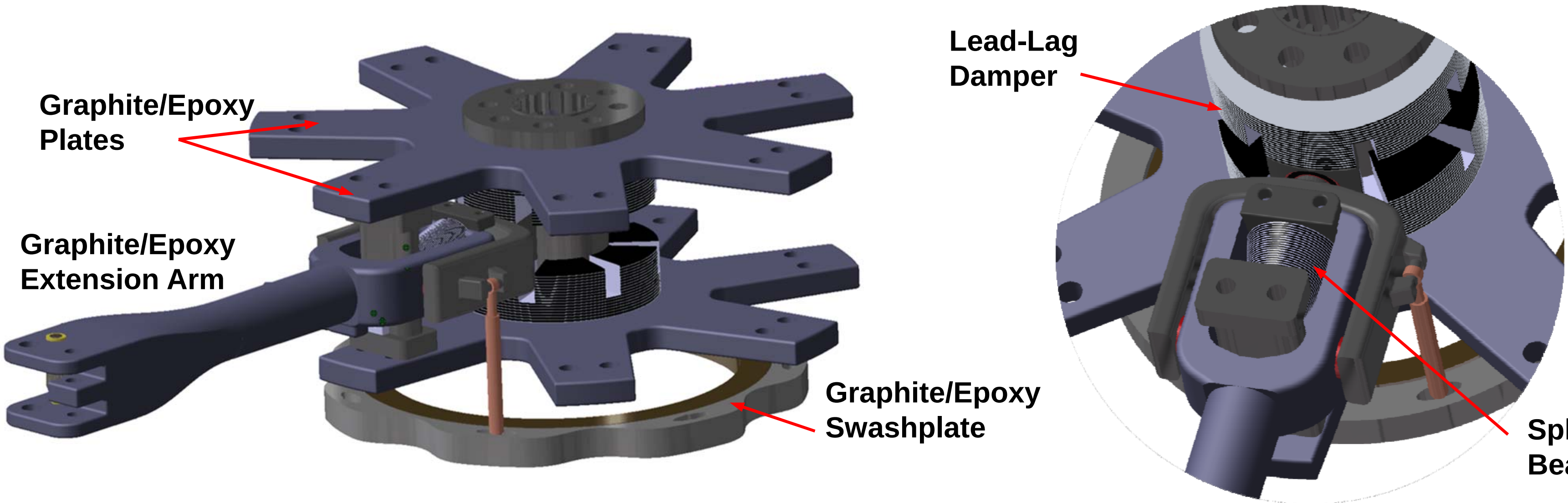




- 3 different folded configurations:
  - "Fully Folded": Rotor blades and tail boom fold; provides the maximum reduction in overall dimensions for storage
  - "Main rotor only": Compact configuration; tail boom does not block the rear loading door
  - "Tail boom only": Provides easy unobstructed access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

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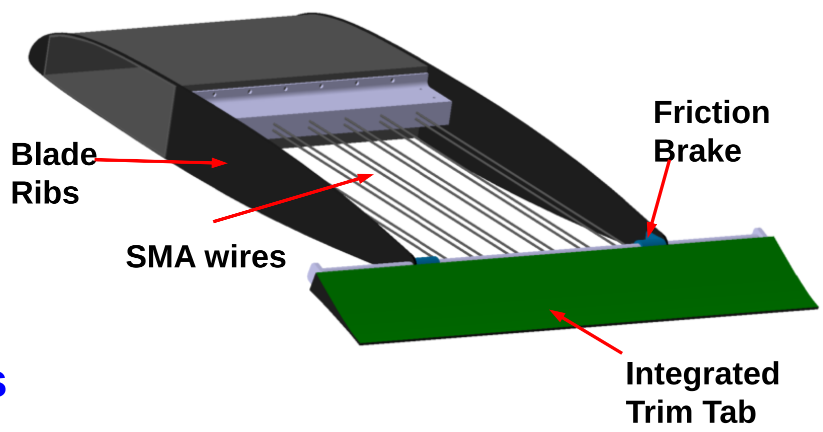
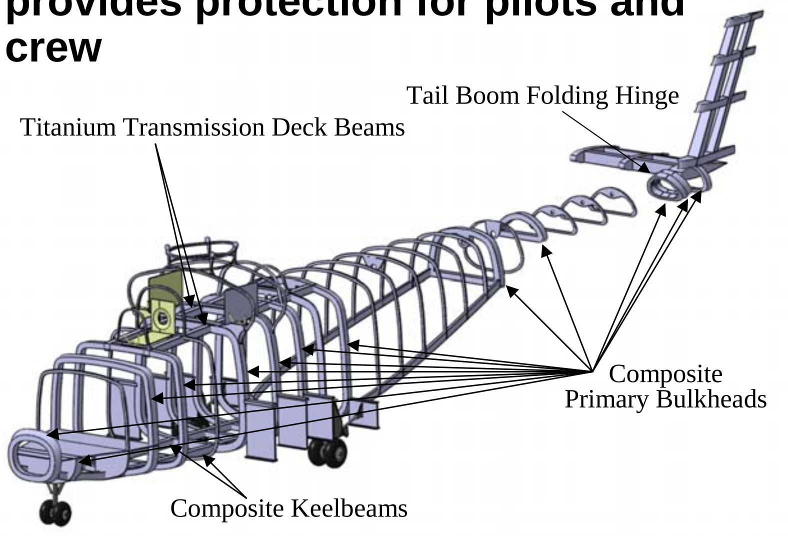
- **Active trim tab for in-flight rotor blade tracking**
  - Shape Memory Alloy (SMA) actuation
  - Reduced maintenance and operating costs
  - Less stringent blade manufacturing tolerances
  - Optimal tracking at all flight conditions



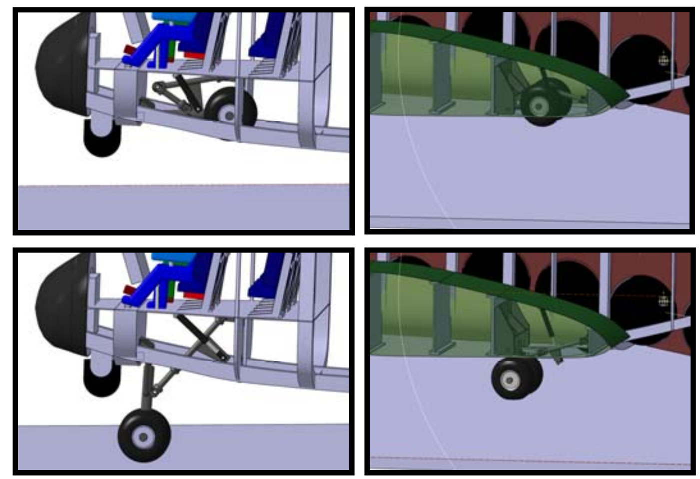
- **Vibration control**
  - LIVE isolators on main rotor pylon
  - Flap-bending/torsion coupling in composite blades
  - Adaptive magnetorheological (MR) tuned-mass dampers respond to changing vibration frequencies
  - Vibration levels below 0.05 g

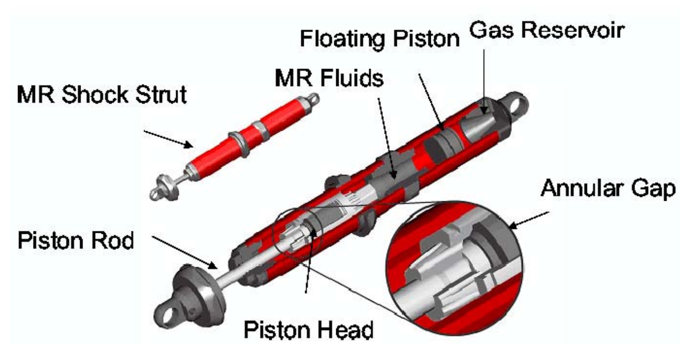
Structure and Landing Gear

- 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

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- 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

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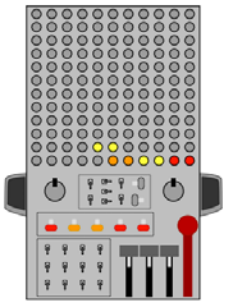
- **Five reconfigurable 9”x12” Multi-Function Displays**
- **Fly-by-wire system**
  - **Low weight**
  - **Improved performance**
- **Shipboard landing aids**
- **Countermeasures**
  - **Radar/infrared warning receiver**
  - **IR jammer**
  - **chaff/flare dispenser**
  - **Hard points on fuselage for .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**

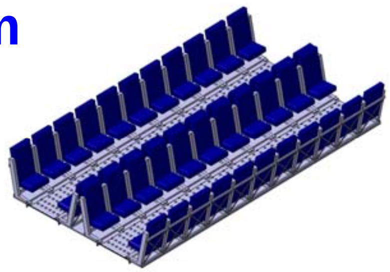


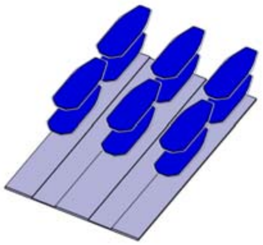
Maintainability

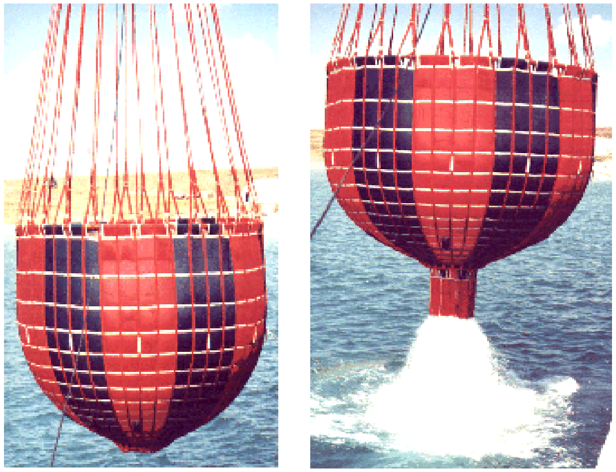
- Fuselage designed for good maintainability
  - Kick-in steps facilitate access to engines, transmission, and tail rotor
  - Engine cowlings double as maintenance platforms
  - Quick-access panels for LRUs
  - Easy access to all systems
  - Integrated walkway on tail boom
- Low-maintenance rotor and 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 Bambi Buckets**
  - **5,200 gallon capacity**
- **Civil Transport**







Bambi Buckets in action

Performance

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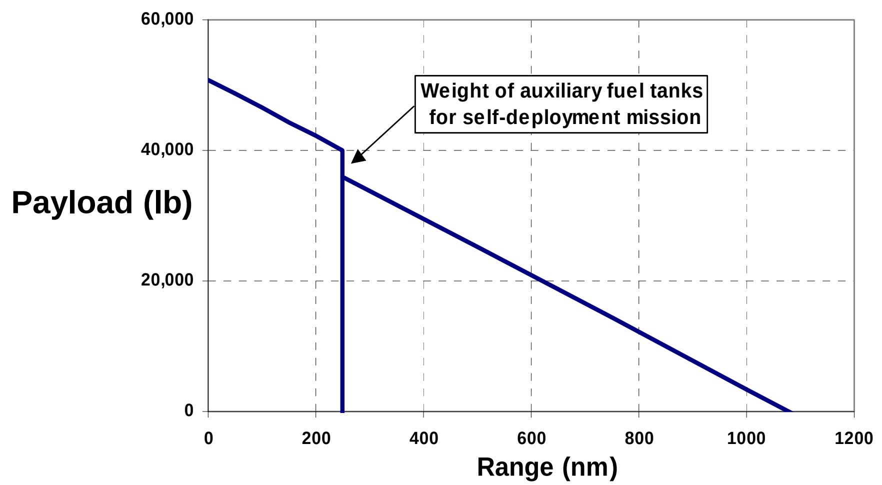
Atlas provides performance enhancements over current heavy helicopters to significantly expand military logistics capabilities

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



1000+ 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**

ATLAS