Maturation of the Mono Tiltrotor (MTR) Aircraft Architecture, and Its Application to Heavy Lift and Other Emerging Needs

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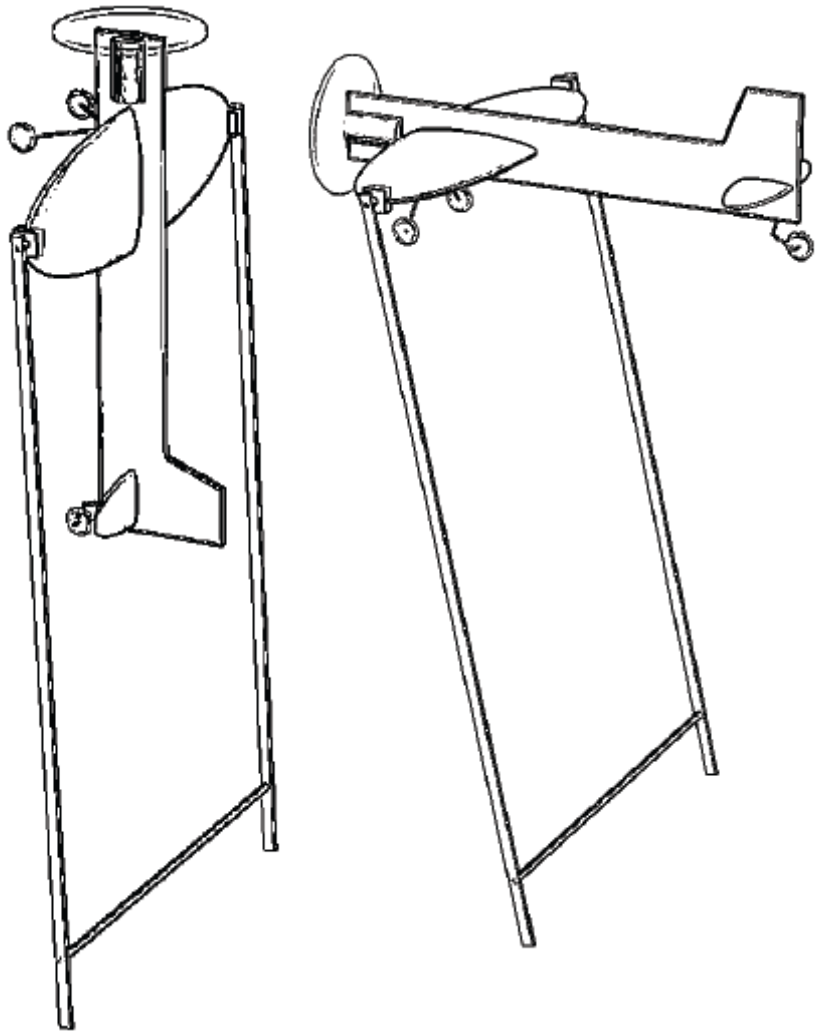
Outline of paper

- Introduction
- Concept Overview
- Applications of the MTR Architecture
- Work Underway
- Risk Management
- Conclusions

Introduction

- MTR is subject of funded research, design, and test activities
- Successful pitch axis suspended load test opened a virgin design space
- MTR evolved from within this design space
- Collaborative, open R&D approach:
  - University of Maryland
  - Army Research Labs
  - Eagle Aviation Technologies Incorporated
  - others

Suspending a payload about the pitch axis of an aircraft



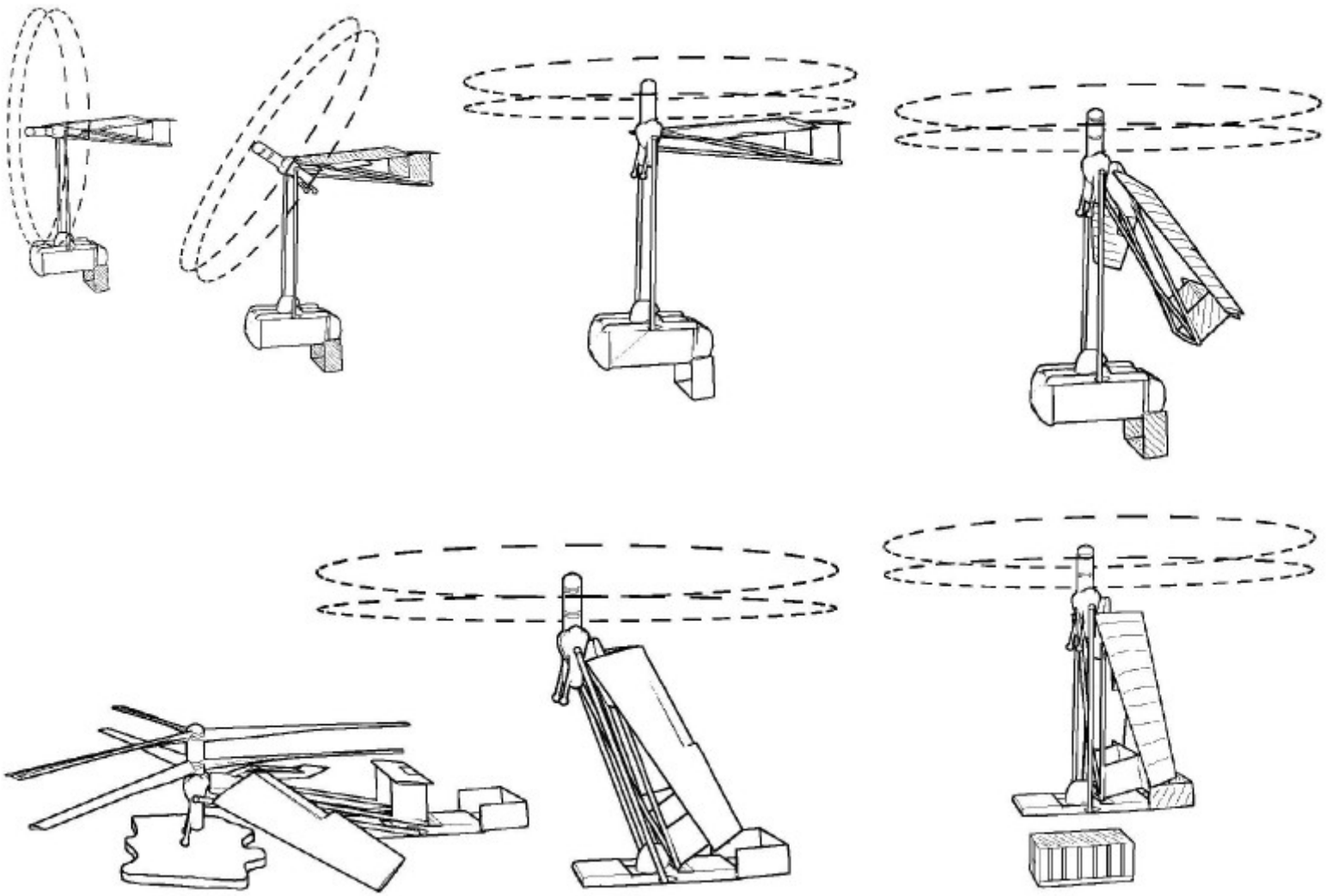
Concept Overview (1 of 2)

- Ideal lift unit (crane helicopter + wing weight)
  - Low disk loading, torque balance, proprotor
  - Suspension strut pinned to gearbox
  - Tailboom aligned with strut in hover
  - Wing panels aligned with tailboom in hover
  - Aerodynamically actuated wing panels
  - Single actuator tilts gearbox under wing

Concept Overview (2 of 2)

- Generic payload unit has minimal constraints
  1) Streamlined shape to minimize drag
  2) Vertical stabilizer for yaw stability
  3) Active rudder for yaw alignment with lift unit
  4) Landing gear for its own weight
- Assessment of scalable value
  - 50% smaller and 65% lighter than a conventional helicopter for 1000nm range
  - High L/D is key to reduced weight

Transition from being at rest to hover, then morphing from helicopter to airplane mode



Potential applications of MTR scalable aircraft architecture

- Military heavy lift
- Military medium lift
- Other military and civil applications

A Heavy Lift application

- Sized to Joint Heavy Lift design requirements
- 79 foot diameter coaxial proprotor
- 6 blades per articulated hub
- Four AE1107C engines driving single gearbox
- A load carrying system for variety of loads
- Compact, unloaded configurations

A payload concept (1 of 3)

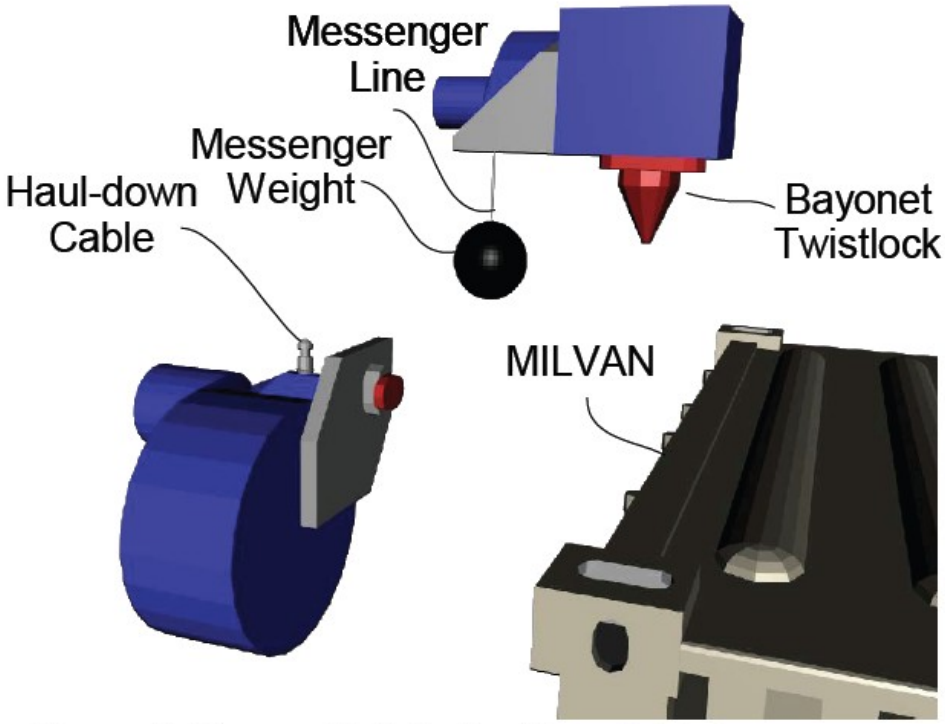


Figure 3: Bayonet twistlock with weighted messenger line, and associated winch.

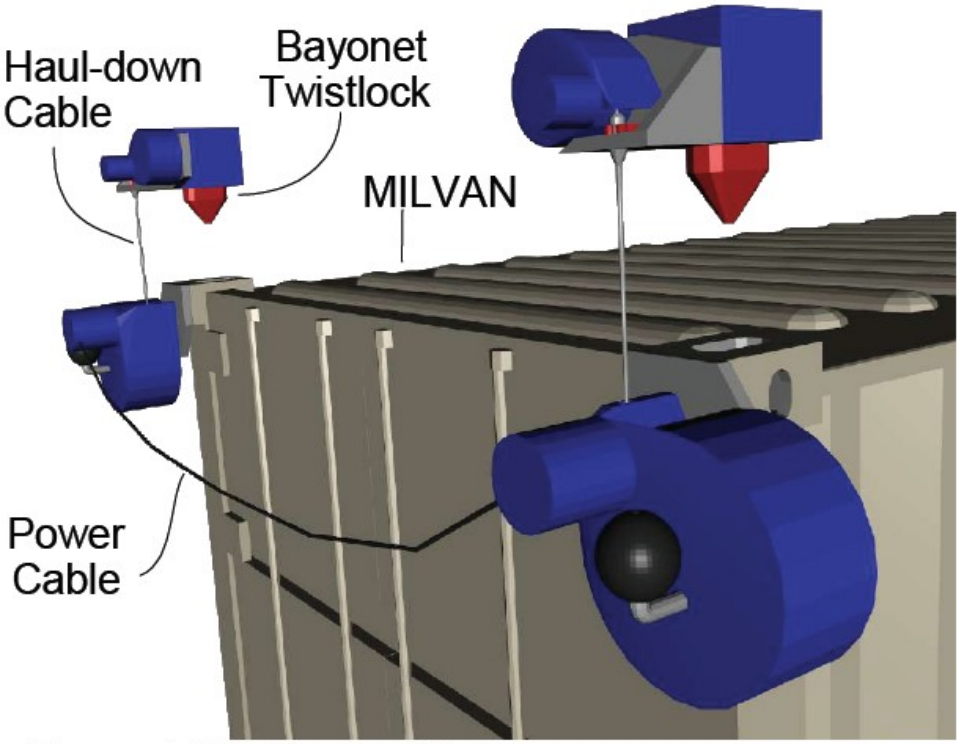


Figure 4: Hauldown cables retracting.

A payload concept (2 of 3)

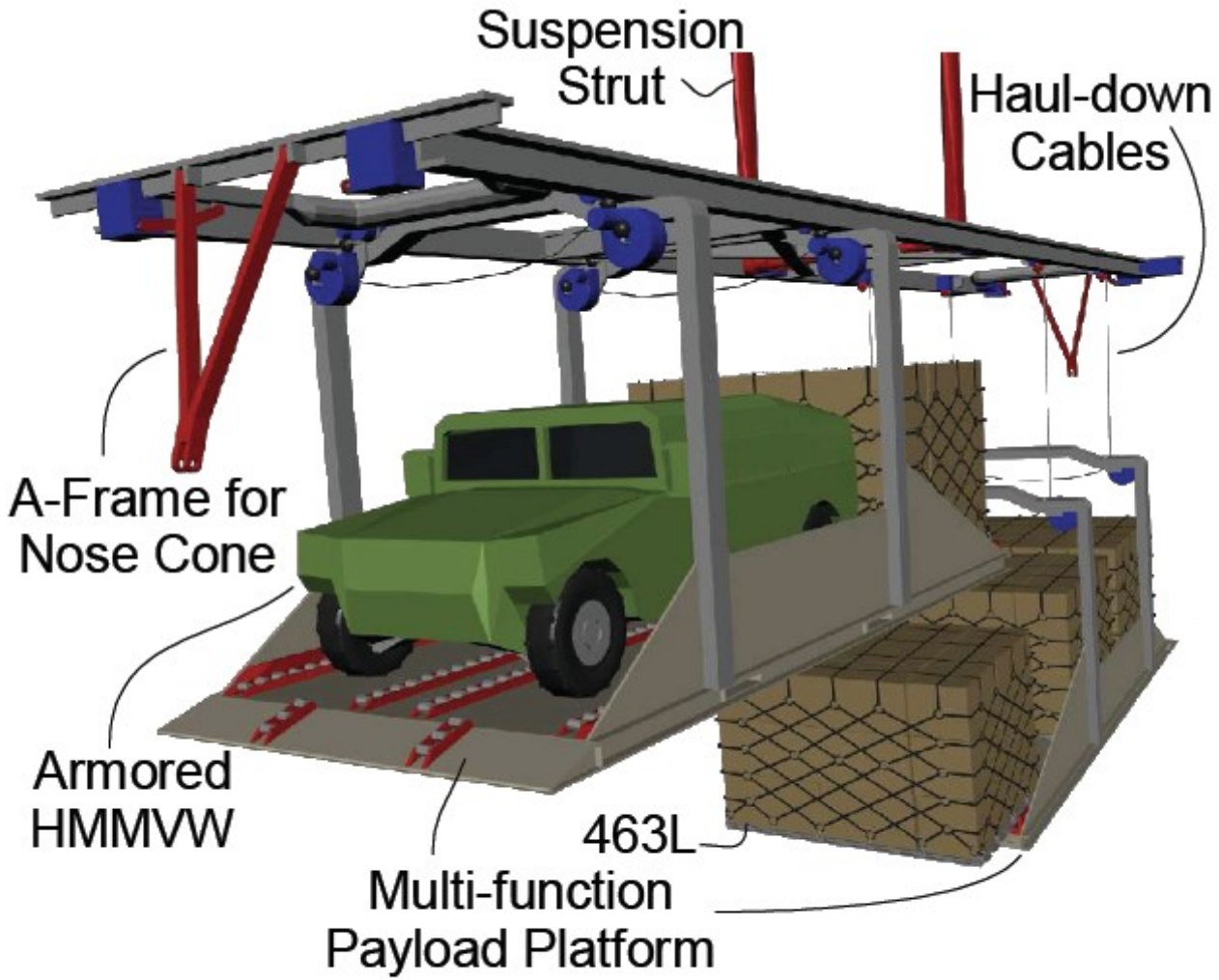


Figure 5: Multi-function Payload Platform (MPP) with HMMWV and four 463Ls.

A payload concept (3 of 3)

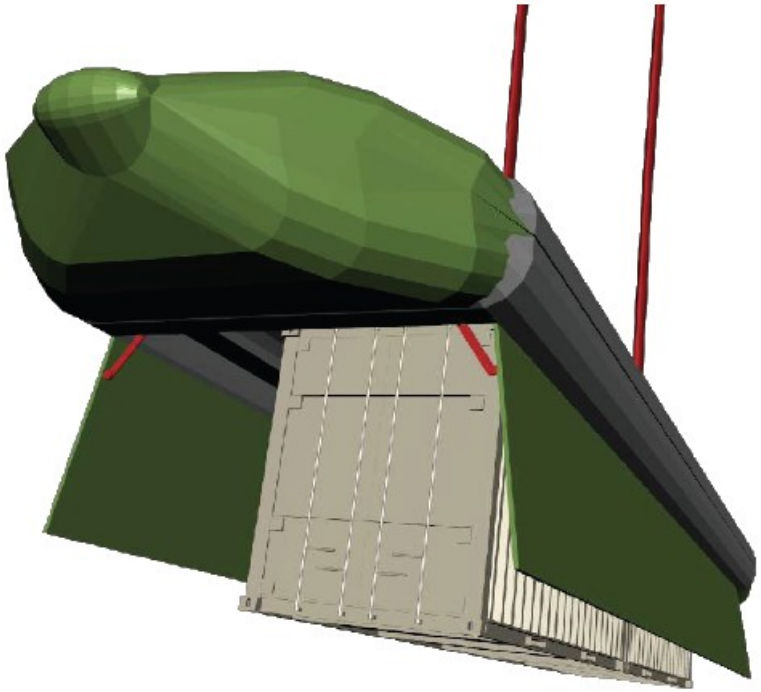


Figure 6: Two MILVANs mounted at the 40 foot bayonet twistlocks, with collapsed fuselage.

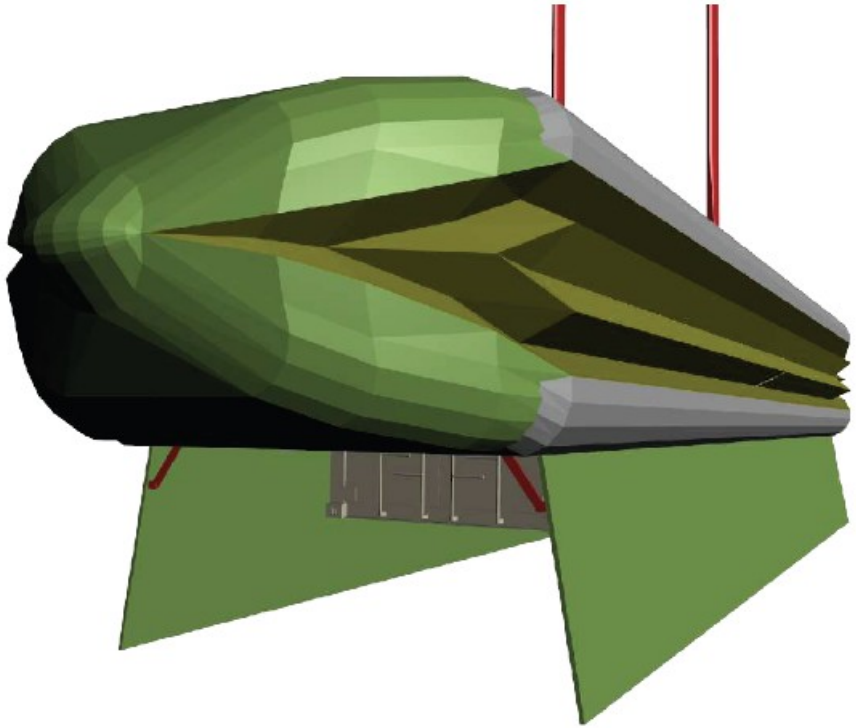


Figure 7: Nose-cone partially opened, with cloth sides of fuselage beginning to unfold.

Cruise configurations

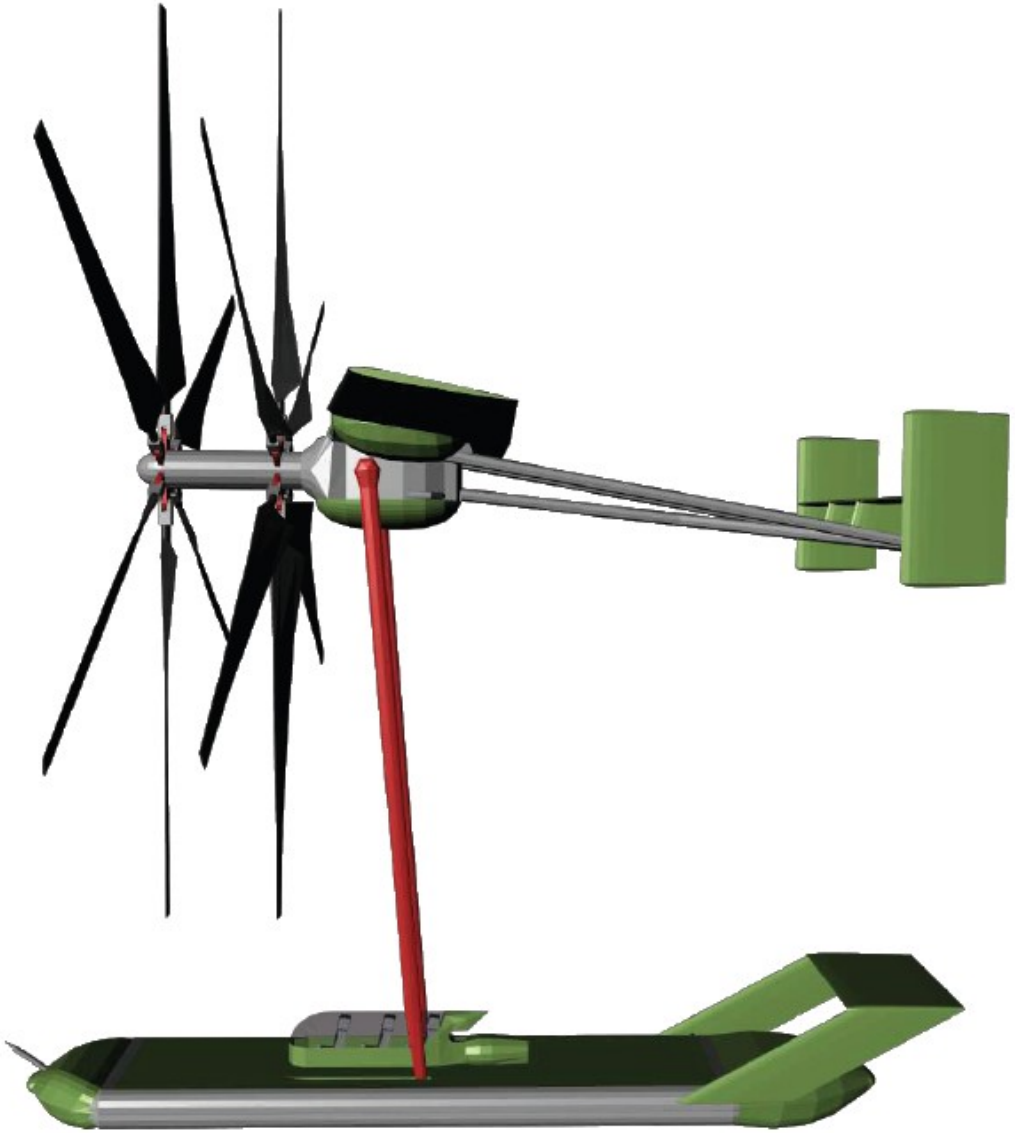


Figure 9: MTR in low drag Dead Head configuration.

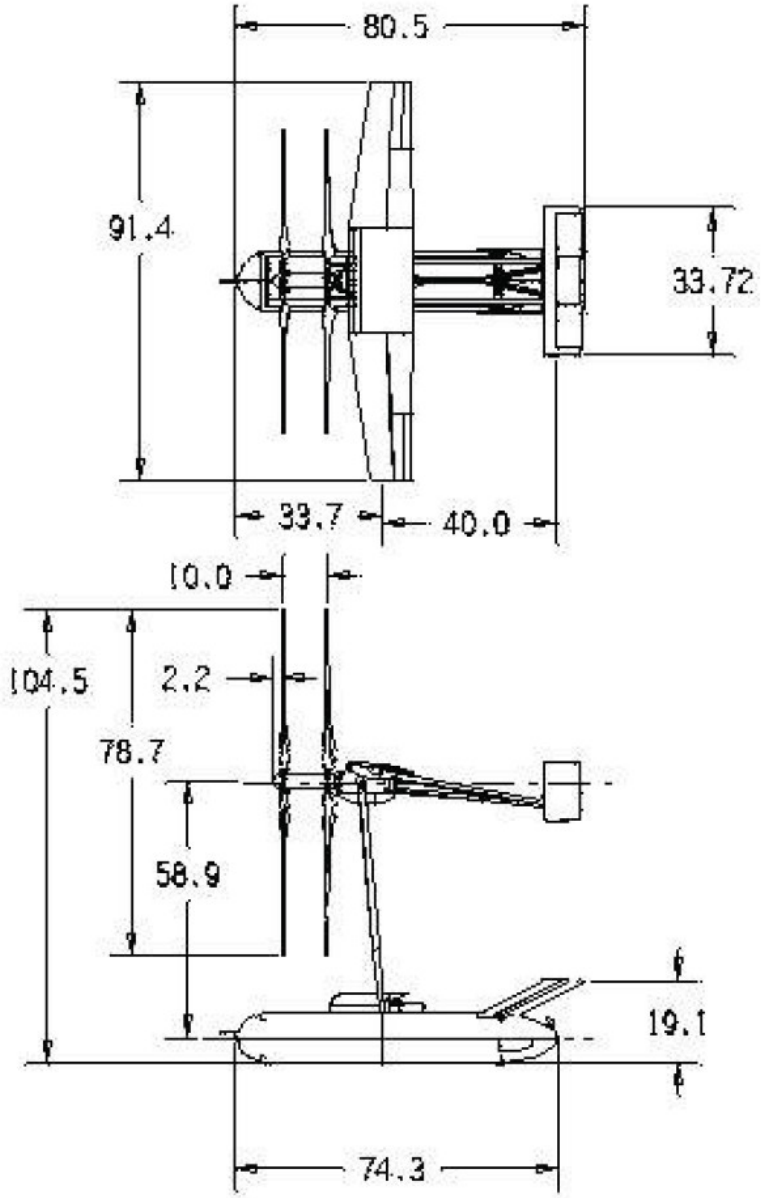


Figure 11: Dimensioned engineering drawing of MTR-JHL with enveloped load in cruise mode.

Stowed configuration

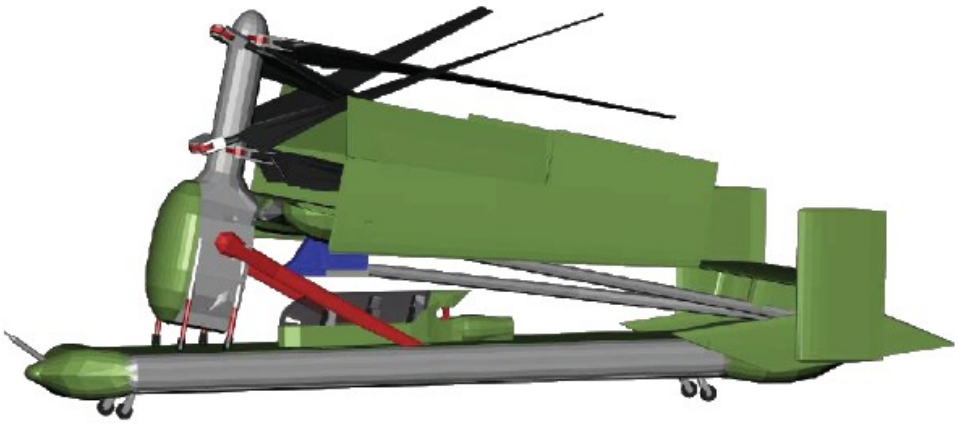


Figure 10: MTR folded for compact stowage and shipboard compatibility.

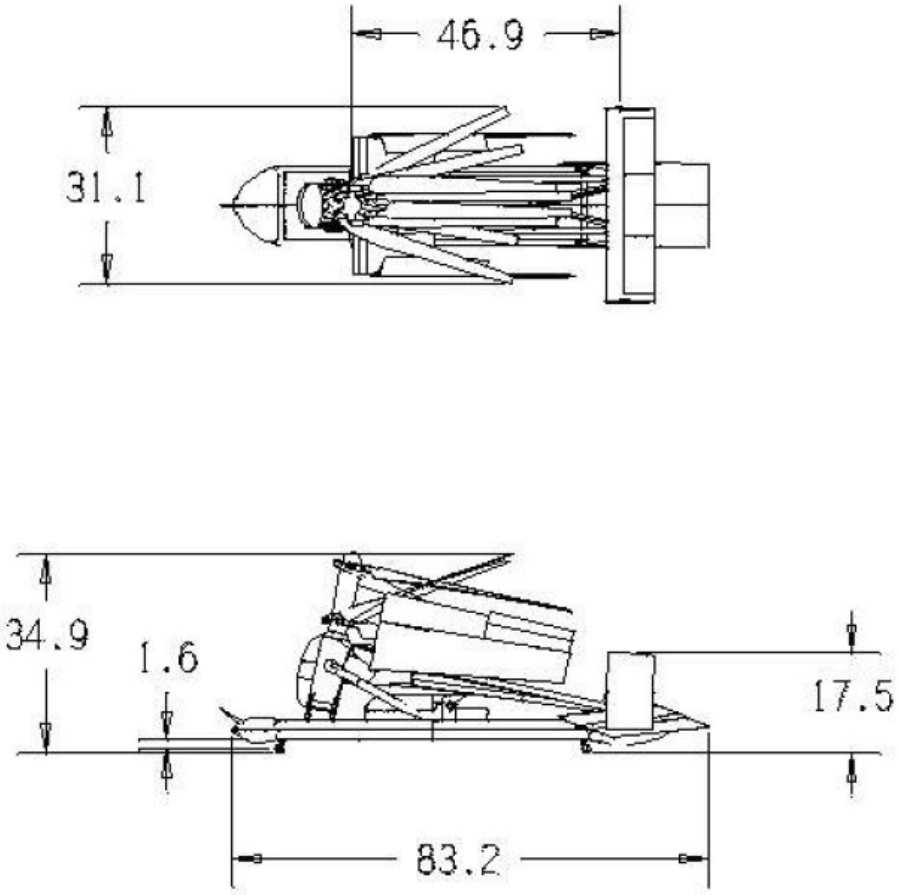


Figure 12: Dimensioned engineering drawing of MTR-JHL in stowed configuration.

A Medium Lift application

- Sized to Vertical Unmanned Utility Air Vehicle (VU2AV) notional requirements
- 25 foot diameter coaxial proprotor
- 4 blades per rigid hub
- Two T800 engines driving single gearbox
- Load carrying system for containerized and palletized loads
- Stowable inside a 20ft ISO container

Other military and civil applications

- UAV logistics connector
- Air transport of ISO containers
- Inter-city transport
  - Disconnected fuselage at passenger stations
  - Regional refueling and maintenance depots
- Personal transportation
- ...

Work Underway

- 12-month AATD task order
- Analytical modeling of key subsystems
- Assess weight, drag, and technical risk
- Three interrelated efforts:
  - Scaled Demonstrator (SD) preliminary design
  - Parametric Research Model (PRM) testing
  - Heavy Lift (HL) preliminary analysis

Scaled Demonstrator (SD)

- Initially sized for 4000lbs load, 200 kts, 700 nm
- BEMT and FVM analysis of coaxial proprotor
- CAMRAD II and DYMORE analysis of system
- Preliminary design of blades, hub, controls, and tilt actuator
- Conceptual design of gearbox, wing panels, empennage, and fuselage
- Incorporating VU2AV features and sizing

Scaled Demonstrator Illustration

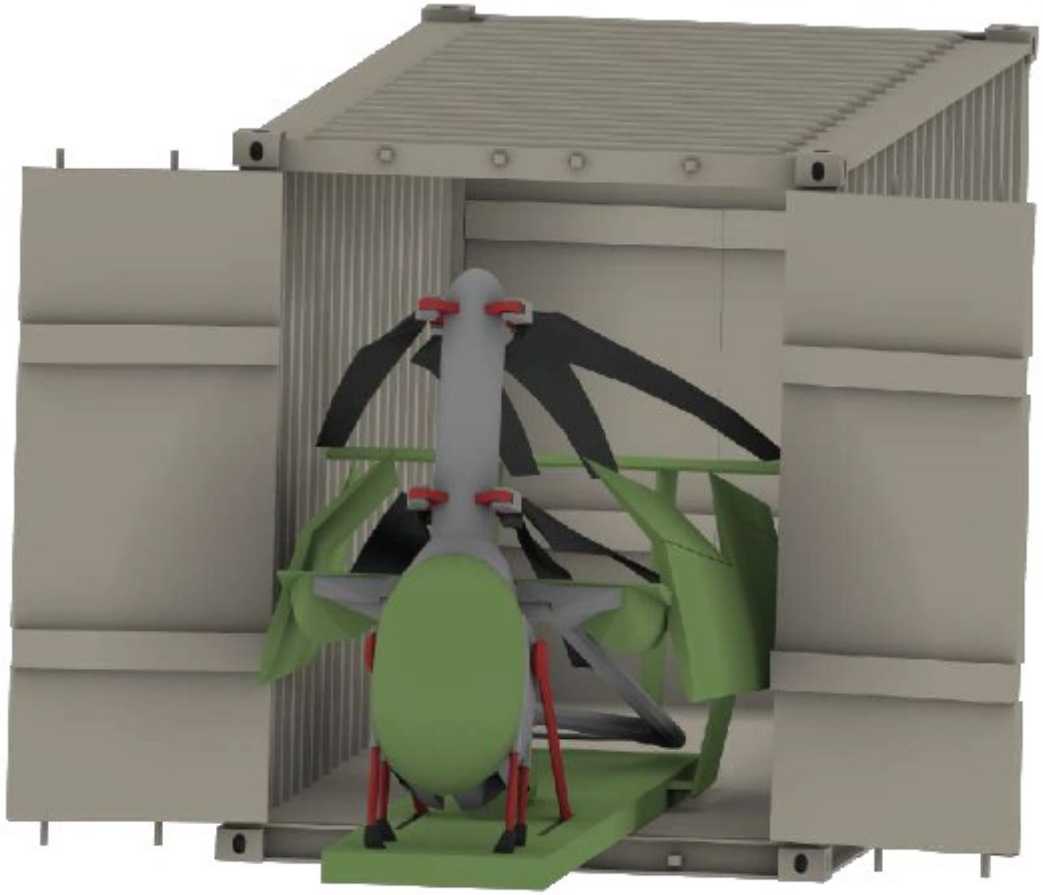


Figure 13: MTR Scaled Demonstrator in folded configuration and stowed in a 20ft ISO container.

Parametric Research Model (PRM)

- Geometric sub-scale representation of the SD
- Purpose of this wind tunnel model
  - Quantify wing panel aerodynamic deployment for several hinge offset angles
  - Measure corresponding lift and drag
- Kinematic/aerodynamic analysis performed to design hinge offset angles
- Empirical data to be correlated with the analytical model

PRM Illustration

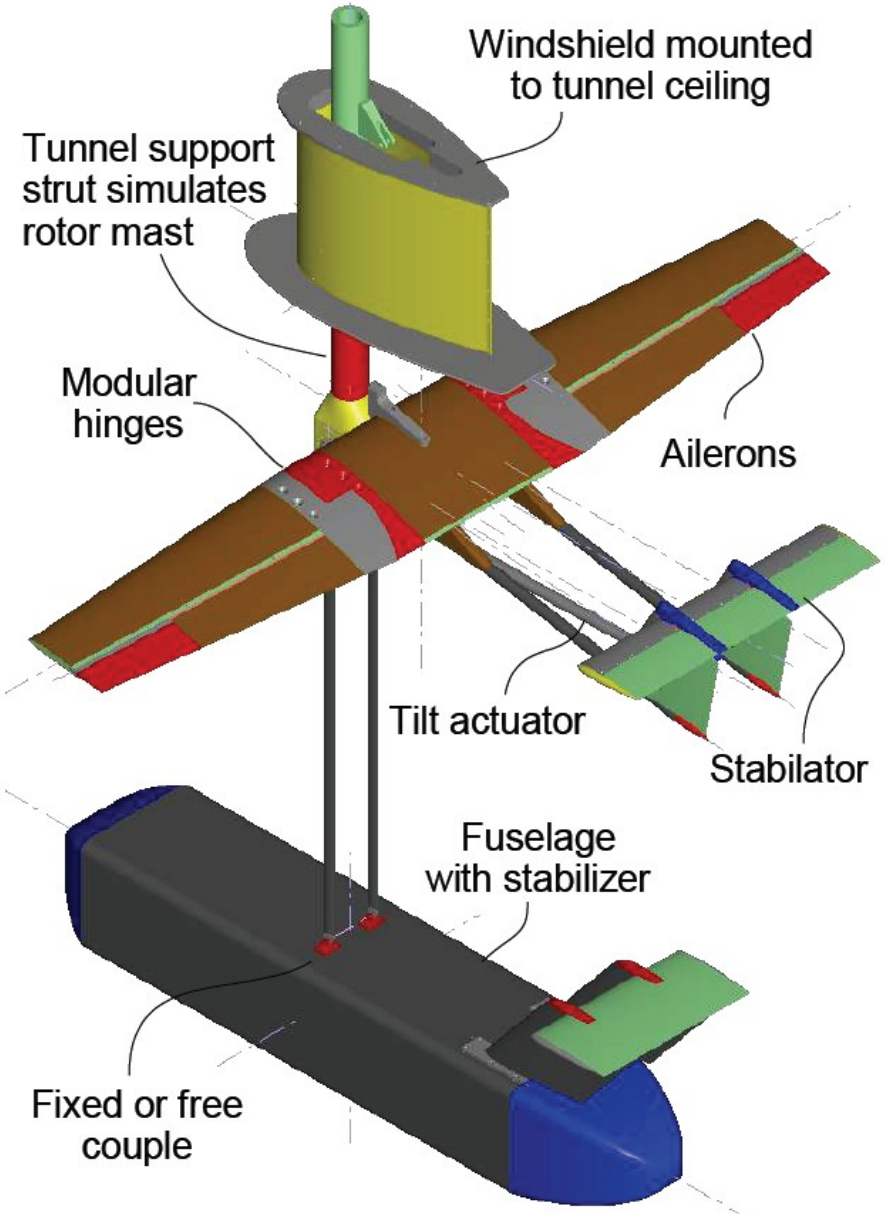


Figure 14: Rendering of the MTR Parametric Research Model with wing and tail deployed.

Heavy Lift (HL)

- Apply SD & PRM knowledge to HL concept
- Adjust SD models to reflect HL inertial properties, material properties, dimensions, etc
- Re-analyze models to identify similarities and differences between SD and HL
- One likely difference is a non-rigid hub and perhaps on-blade control
- Provide detailed information on MTR scalability

Risk Management

1) Free-flight demo of pitch axis suspended load
2) Systematically addressed known VTOL issues
3) Assessed potential economic value
4) Identified vehicle scale to provide both military value and engineering knowledge
5) Design efforts focused on SD, while low cost testing is focused on the PRM
6) PRM and SD lay foundation for HL

Conclusions

1) MTR maturation has occurred in an open and collaborative environment
2) Potential for unprecedented capabilities, while eliminating conventional need for careful synergistic design to all future payloads
3) Morphing fuselage concept has been defined
4) A methodical approach to developing MTR knowledge is underway
5) Risk is managed by identifying fundamental issues, then isolating and exploring each while expending minimal resources