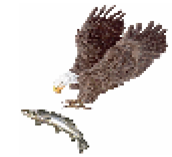


Mono Tiltrotor (MTR) Project

International Powered Lift Conference

Gaylord Texan Resort and Convention Center

4 October 2005

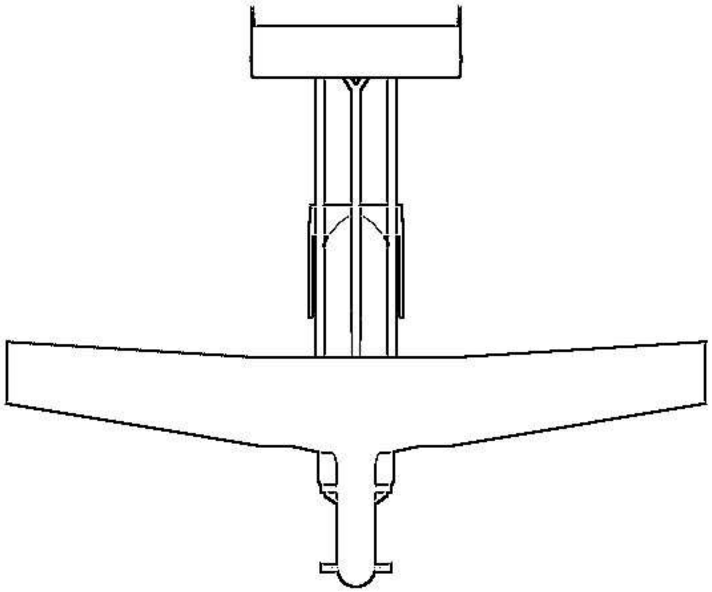
Baldwin Technology Company, LLC

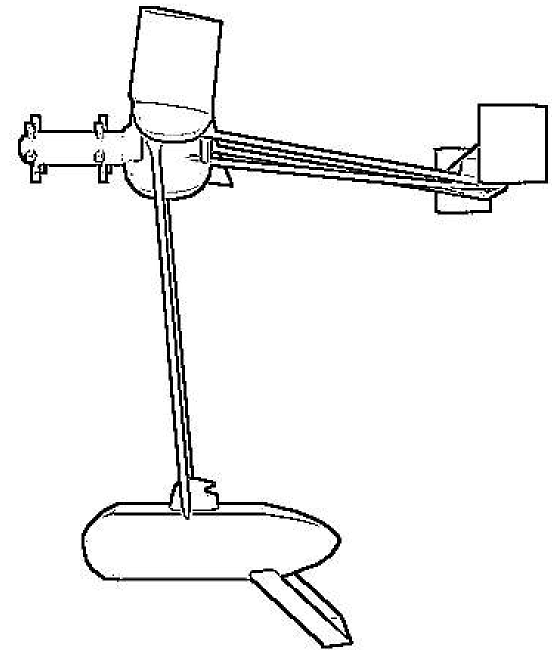
www.baldwintechnology.com

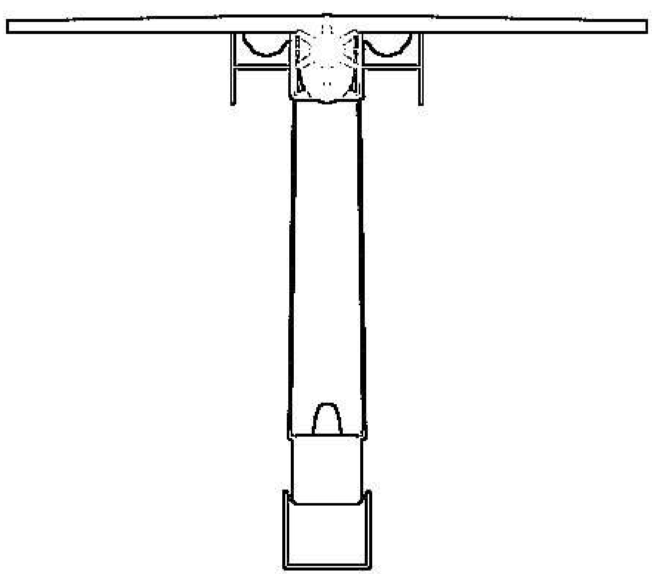
Agenda

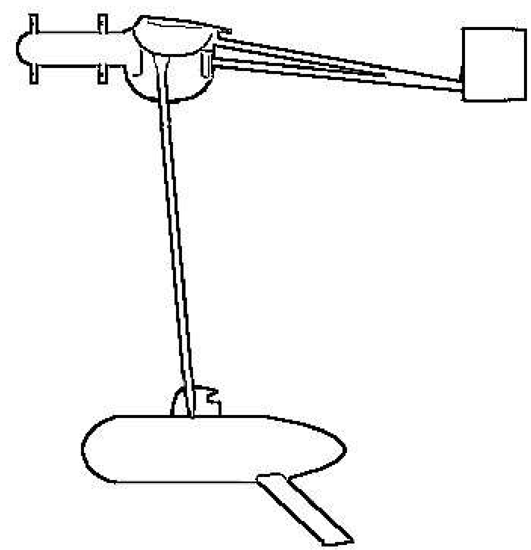
- MTR project overview
- Motivation for wind tunnel testing
- Technical challenges
- Research goals
- System modeling and analysis
- Seabasing application of technology

MTR 3-View Illustrations









MTR Project Description

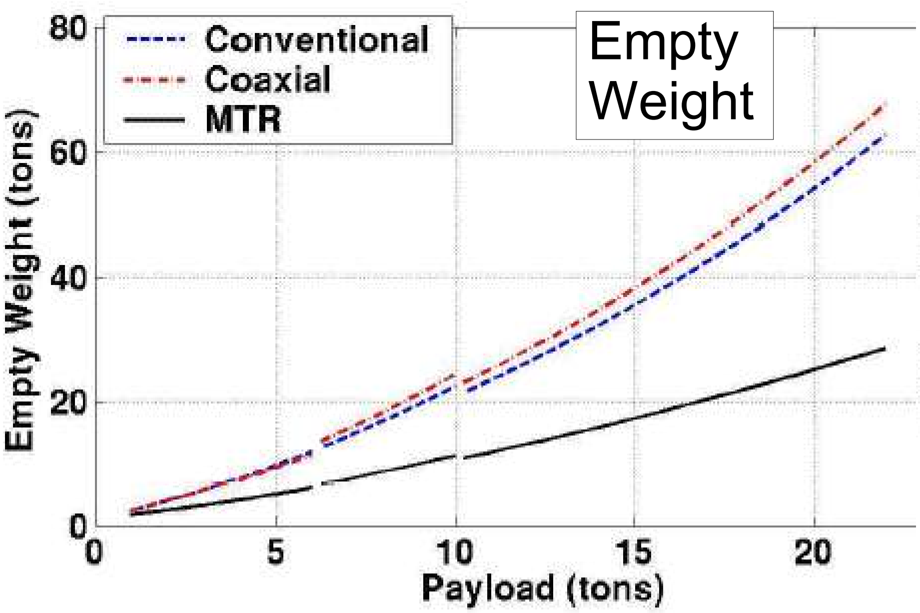
- **Objective:** validate MTR architecture for emerging joint service needs and programs
- **Approach:**
  1) Wind tunnel test & analysis at small scale (400# GW)
  2) Preliminary design at representative scale (5.5 ton GW)
  3) Preliminary analysis at large scale (59 ton GW)
- **Goals:**
  1) Prove kinematics/aerodynamics of folding structure
  2) Reduce to practice at scale suitable for 40'x80' wind tunnel
  3) Identify necessary technical differences at large scale
- **Payoff:** affirmatively answer outstanding questions regarding stability, control, loads, and handling qualities

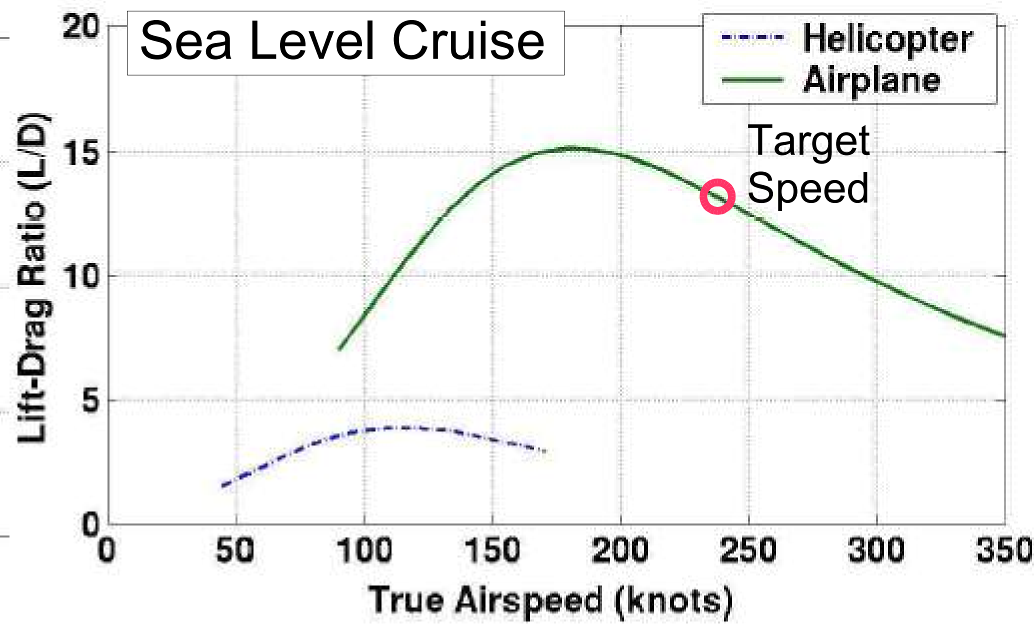
Motivation

Concept analysis finds 1/3 empty weight, 1/3 fuel compared to legacy helicopters at similar component technology level...

Max. Range is related to:	Est.	Calc.	Method
- empty weight fraction (W_{EMPTY}/GW)	--	43%	Parametric
- aerodynamic efficiency (L/D)	10	11+	Coefficient
- propulsive efficiency (e)	60%	60-80%	BEMT/FVW

...for aircraft having a range of 1000nm (2 ton -- 20 ton load)





SOURCE: Conceptual Design Studies of a Mono Tiltrotor (MTR) Architecture; 10 DEC 2004; Contract Number: N00014-03-C-0531

Specific Motivation

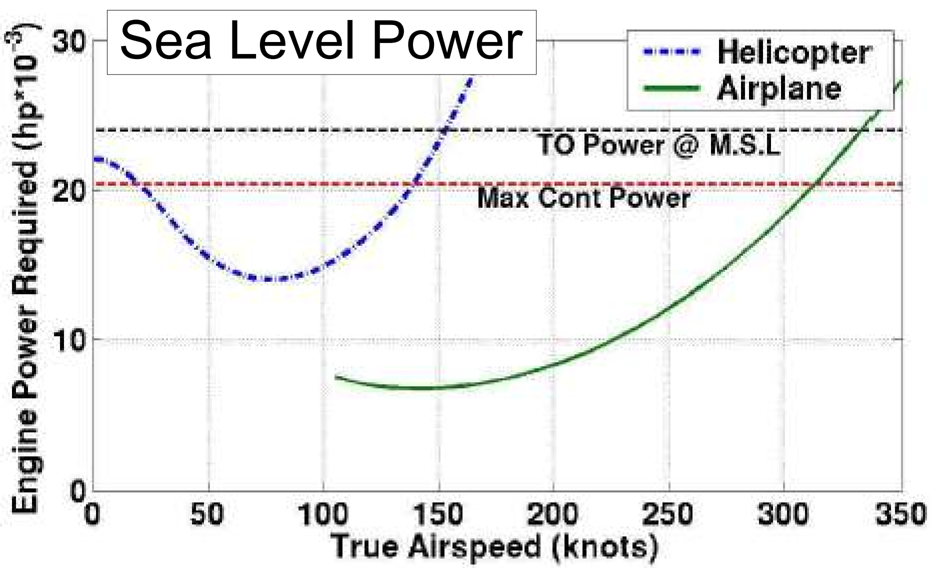
Refined design & analysis for 20 ton load / 1000 nm range vehicle:

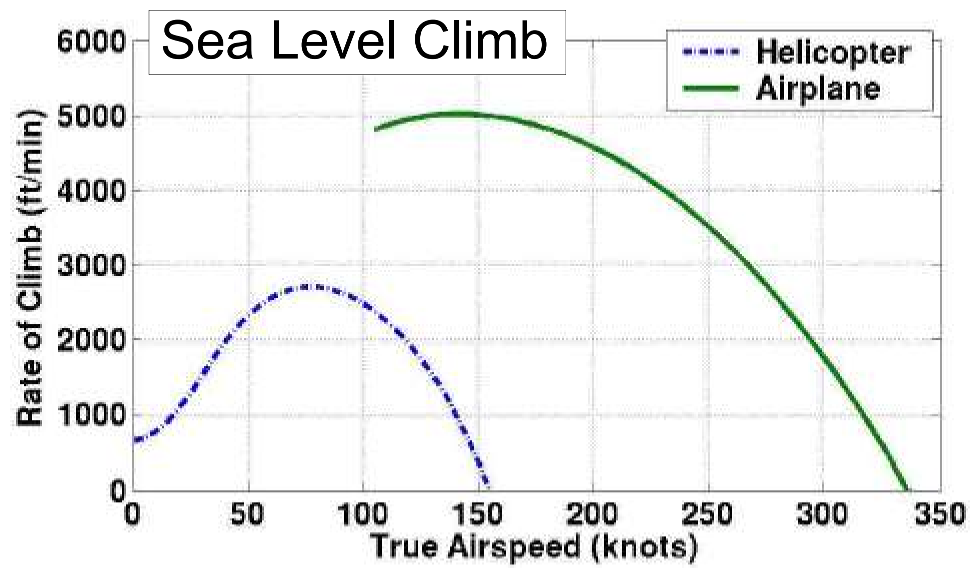
	Heli	Convert	Airplane
Speed (kts)	0	120	260
Altitude (ft)	SL	SL	20K
Loading (psf)	12	12/98	98
L/D	-	4/8	14

25K Service
26K Absolute

20 ton load + 12 ton fuel + 27 ton structure = 59 ton gross

79 ft rotor : 95 ft wingspan : 24,600 BHP (4 x AE1107C)

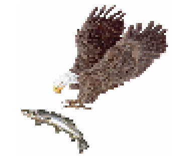




SOURCE: Performance and Trade Studies of a Mono Tiltrotor (MTR) Design; 02 JUN 2005; American Helicopter Society Forum

BTC

Top 3 Promising Innovations



1) Offset pivot, folding wing panel ("morphing")

- Implemented in TBF-1 Avenger, with hydraulic actuation
- c.p. is in front of hinge line; positive AoA lifts wing panel
- Need to demonstrate having mostly aerodynamic actuation

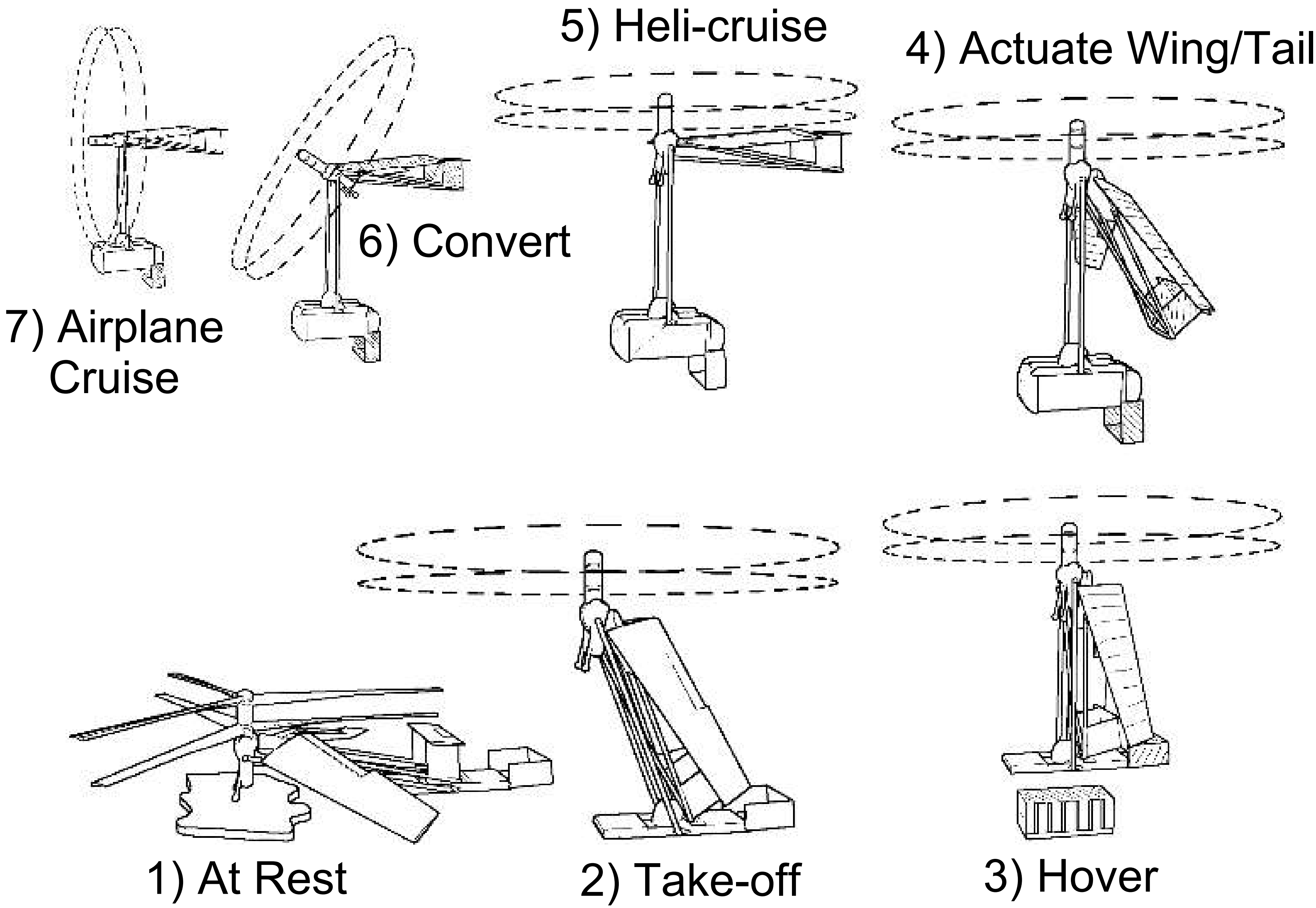
2) Tilting coaxial rotor

- Implemented in Ka-50 Hokum, as an aerobatic helicopter
- Potential stability improvements over conventional tiltrotor
- Need to assess dynamics of conversion and maneuver

3) Pitch axis suspended load

- Implemented using fixed wing, hoverbatic, R/C airplane
- Load stabilizes conversion between hover and cruise
- Need to demonstrate at a useful scale with useful load

System Architecture Illustrations



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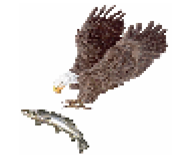
Aerodynamic Challenges



1) Wing panel & tailboom deployment in rotor wake

- Schedule tail position to maintain positive AoA on wing panels
- Guide wing panels by having ailerons in free stream
- Isolate rolling moments to the wing panels themselves
- Do kinematic/aerodynamic analysis and wind tunnel testing

2) Coaxial hover/propulsive efficiency

- Low disk loading hover, and much lower disk loading in cruise
- Analyze using BEMT, vortex theory, CFD.

3) Flat plate equivalent drag and cruise L/D

- Assess/minimize drag of unconventional design
- Validate analysis through wind tunnel testing

Aeroelastic Challenges

1) Wing panel & tailboom deployment in rotor wake

- Dynamics of pivotally suspended wing panel in turbulent wake
- Tail buffet excitation of wing panel and rotor dynamics
- Test for suitable tailboom actuation schedule

2) Coaxial inter-rotor spacing

- Hub spacing for tip clearance increases vehicle weight/size
- Tip clearance during maneuvers needs to be characterized
- Do comprehensive analysis using CAMRAD II and DYMORE
- Consider active control for tip clearance in larger configurations

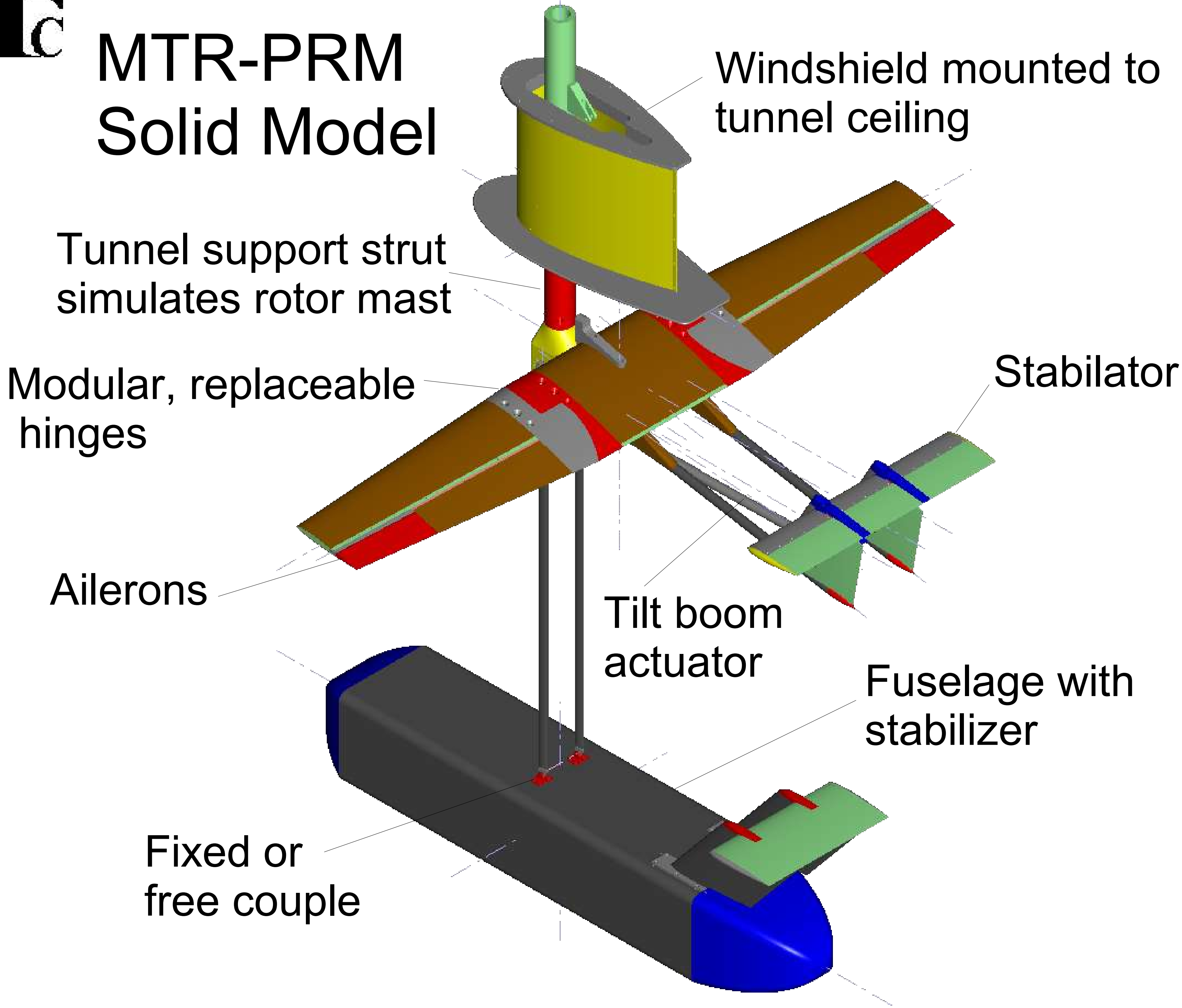
3) Suspended load stability & control

- Provision for automatic yaw alignment in forward flight
- Translate control laws from c.p./c.g. to an operator at the load
- Assess control laws using comprehensive aeroelastic analyses

Performance Goals / Requirements

1) Parametric Research Model (PRM)
   - Prove viability of wing/tail kinematics/aerodynamics
   - Establish scalable design rules for wing/tail kinematics
   - Baseline passive forces and moments
2) Preliminary Design of Scaled Demonstrator (SD)
   - Reduce invention to a practical & representative design
   - 2 ton, 54”x44”x42” H containerized load => 5.5 ton GW
   - 700 nm range with 200 kt cruise at 20,000 ft
   - Testable within the Ames 40' x 80' wind tunnel
3) Preliminary Analysis of Heavy Lift (HL) rotor & controls
   - Same analysis as for SD, but at 59 ton gross weight
   - Identify technical differences from SD baseline

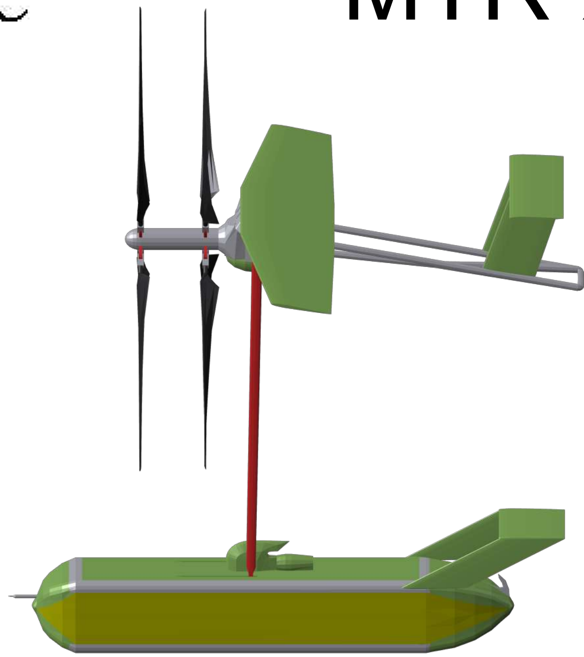
MTR-PRM Solid Model



Transition Plan

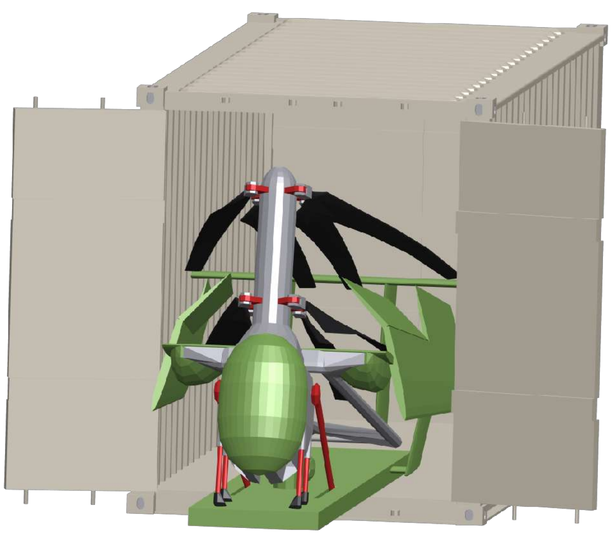
- Contracted FY05 Work
  - Design, build, test, and analyze unpowered Parametric Research Model (PRM)
  - Design and analysis of Scaled Demonstrator (SD)
    - Preliminary design of rotor, hub, & controls
    - Conceptual design of all other components
  - Analysis of Heavy Lift (HL) rotor, hub & controls
- Next steps
  - PRM: add powered rotor and test all flight modes
  - SD:
    - Detailed design and manufacture of XVU2 prototype
    - Test in Ames 40'x80' wind tunnel
    - Free flight ACTD for ammunition logistics
  - HL: transition to Joint Heavy Lift Program Office

MTR-XVU2 Illustrations

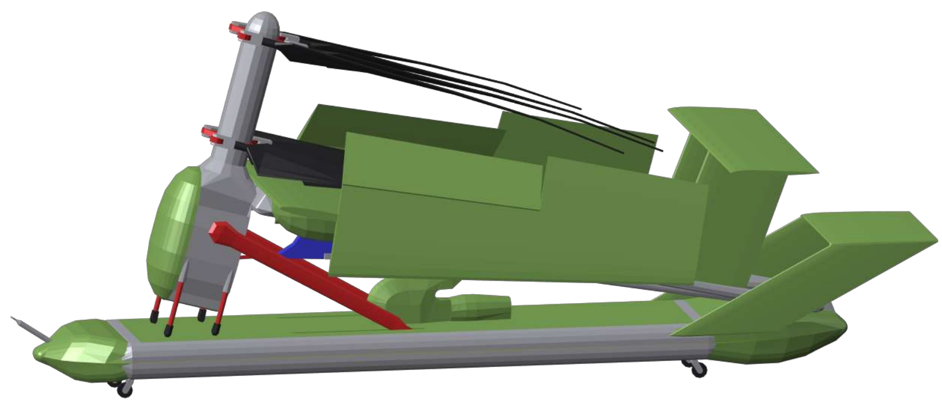


Cruise at 240 kts

Capture 3000 lbs Load

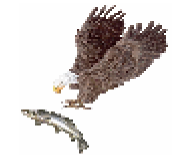


Stow in 20ft ISO container



Collapse and Fold

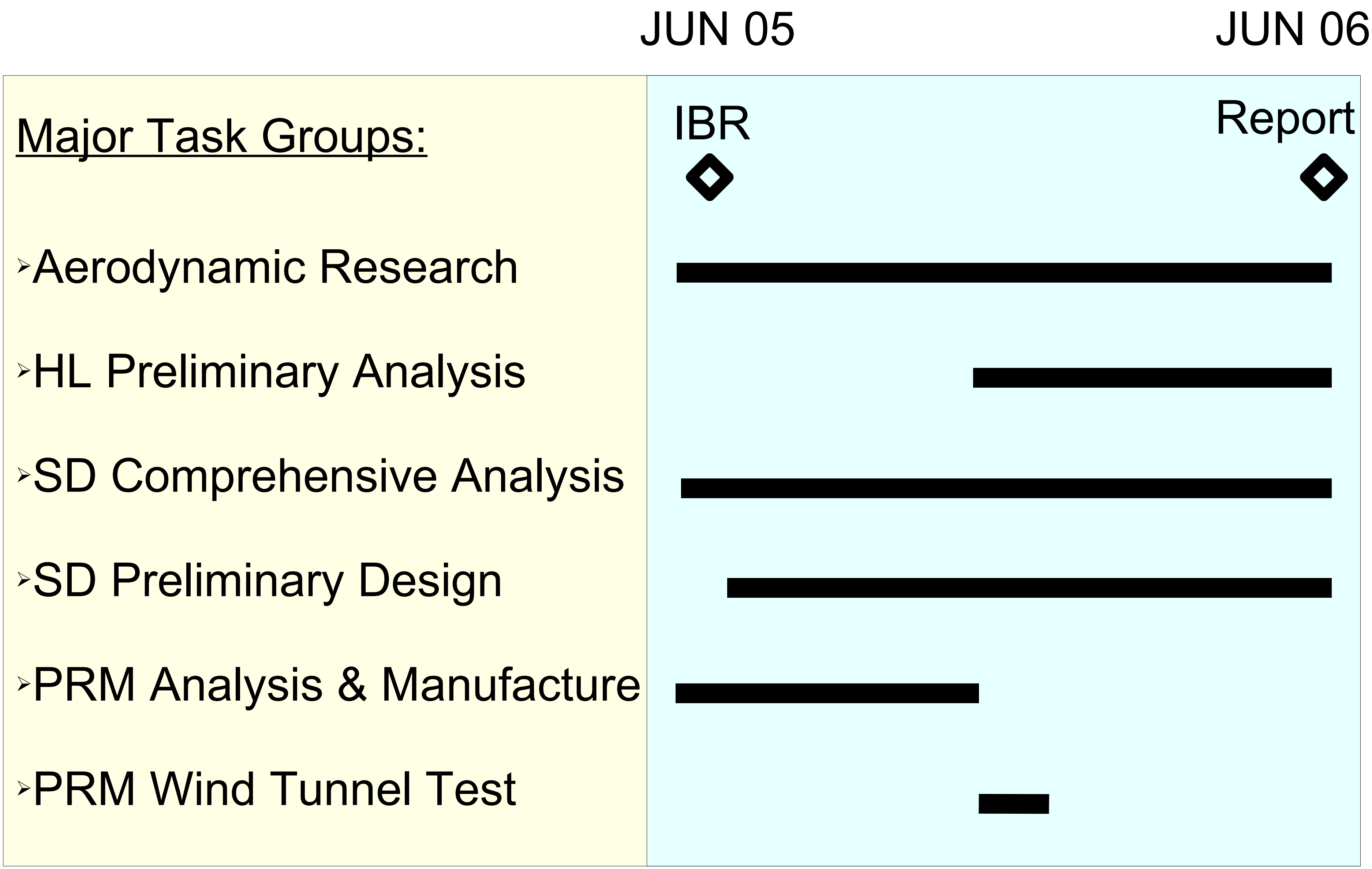
BTC



Baldwin Technology Company Team

Research & Test:	**UMd Rotorcraft Center**
Comprehensive Analysis:	**Army Research Labs – VTD**
Design & Build:	**Eagle Aviation Tech Inc** (Hampton, VA)
Operational Concepts:	**Whitney, Bradley & Brown (WBB)**
Unique Skills:	**Key Industry Consultants**

MTR schedule of contracted work



102 discrete subtasks organized to level 5 WBS