Utility of a Mono Tiltrotor (MTR) Scaled Demonstrator

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Outline of paper

- Introduction
- Methodology
- Results and Discussion
- Conclusions

MTR conceptual design performed...

- ...for payloads from 2 to 20 tons at 1000nm
- General conclusion:
  - Gross weight = 3x cargo weight
  - Fuel weight = ½ cargo weight
- When compared to legacy single and coaxial helicopter concepts at the same tech factor
  - 1/3 the structural weight (~1/3 capital $)
  - 1/3 the fuel weight (~1/3 expense $)
  - 2x the cruise speed (~ 2x productivity)

MTR-SD conceptual and preliminary design performed

- Bottom-up weight and drag analysis
- Preliminary design of the full coaxial proprotor sub-system driven by OTS engine
- Longitudinal stability study from hover, through conversion, and in airplane cruise
- Conclusions aligned with prior concept study:
  - 9400 lb GW ~ 3x the 3000 lb cargo weight
  - 1500 lb fuel weight = ½ the cargo weight
  - 200 kt best cruise speed ~ 2x heli cruise

Categories of utility

- Advance knowledge of fundamentally new subsystems
- Provide operational utility at the MTR-SD scale
- Demonstrate feasibility as a scalable configuration

Advance fundamental knowledge

- MTR embodies subsystems and techniques that are unique in the field of VTOL aircraft
- These unique features are of potential value to the designer of future innovative rotorcraft, or for enhancing legacy rotorcraft concepts
- Research of these features will generate knowledge that is broadly applicable beyond the MTR-SD and beyond the MTR concept

Coaxial proprotor

- Coax propellers and rotors are at TRL 9, but...
- ...Industry has little to no practical experience with coaxial proprotors
- BTC team performed preliminary design and analysis of 25ft diameter coax proprotor
- This torque balanced, gyro-dynamically neutral subsystem has value for all TR concepts
- Mach and Froude tests would establish fundamental generic engineering knowledge

Vertically suspended load

- Untreated slung loads are practical, but risky due to unsteady aerodynamic loads
- Treatment is uneconomical at 4-5 cruise L/D
- But, at 10+ cruise L/D treatment is attractive
- And, pitch axis suspension is advantageous for longitudinal stability and control
- Furthermore, JMIC is an emerging standard
- Research on treatment of JMIC for suspended load operations is of fundamental value for higher L/D VTOL concepts

Passive wing morphing

- Mechanized wing morphing is a mature technology applied to CTOL production aircraft
- However, passive wing morphing is novel for aircraft having a take-off and landing capability
- This subsystem reduces hover download, avoids hover gust loads, and eliminates the weight of mechanized actuation, while providing a high cruise L/D
- Fundamental theory and validation through wind tunnel testing has been achieved
- Airborne wing deployment in a rotor wake has been demonstrated at a small scale

Multi-body VTOL

- A universally accepted aeroelastic method of validating or invalidating a novel multi-body configuration is needed
- Exclusively empirical methods are expensive and generate knowledge exclusive to a particular configuration
- MTR-SD offers an opportunity to couple analytical and empirical methods to rapidly validate a very non-traditional concept
- A general coupled approach applicable to any emerging multi-body concept would facilitate technical innovation

Utility at MTR-SD scale

- Market acceptance of innovation requires breakthrough utility that for fielded systems would be impractical or impossible
- Identification of breakthrough utility emerges through dialog between vendor and customer
- History shows that new aircraft concepts are proven through military application before the development of a civil market

Cargo UAV

- Navy supply ships require survivability features commensurate with operating environment
- MTR-SD range and speed combined with JMIC standardized packaging enables:
  - Sustainment of expeditionary troops from ships stationed safely beyond littorals
  - A revolutionary method of employing the Maritime Prepositioning Ship (MPS)
  - Vertical re-supply in high risk environments using relatively low cost platforms

Aerial fuel re-supply

- Some VTOL missions require the aircraft to be refueled for extended range operations
- An MTR-SD operating as a Cargo UAV from MPS with bulk fuel could give fuel by drogue
- Furthermore, the MTR-SD has the speed to give fuel to carrier based fast moving F/A-18s
- Finally, MTR-SD has the altitude to give fuel to strategic aircraft in-route over the carrier group

Derivative applications

- Conventional aircraft concepts require that the fuselage be a predetermined size and shape
- Modular design of the MTR-SD enables rapid “fuselage swapping” in the field
- Potential missionized fuselages could include:
  - MEDIVAC with life support at the battlefield
  - Offensive weapons for gunship operations
  - Sensor and surveillance platforms
  - Others...all while lift system remains in operational service

Demonstrate scalability

- If proven feasible, the MTR concept would provide breakthrough capability at a JHL scale
- The MTR-SD provides the empirical baseline for predicting JHL scale feasibility

Conclusions

- MTR-SD subsystems provide generic research opportunities to advance scientific knowledge and enable future VTOL concepts
- MTR-SD system delivers unique military capability enabling otherwise inconceivable amphibious operations
- MTR-SD development lays the empirical foundation and establishes the engineering processes for scaling up to a breakthrough heavy lift VTOL configuration