NASA GL-10 Tilt-Wing VTOL UAS Flight Validation Experiments

William J. Fredericks
David D. North, Mark A. Agate, Zachary R. Johns
NASA Langley Research Center, Hampton, VA, 23681

2015 Transformational Vertical Flight Workshop

Outline

- Motivation for Research
- Key Technologies
- Key Benefits
- Design Overview
- Flight Testing Campaign
- Conclusions

Acknowledgements

- NASA Langley Systems Analysis can Concepts Directorate (SACD)
- Design Environment for Novel Vertical Lift Vehicles (DELIVER) Project, formally known as Vertical Lift Hybrid Autonomous (VLHA) Project

Motivation for Research

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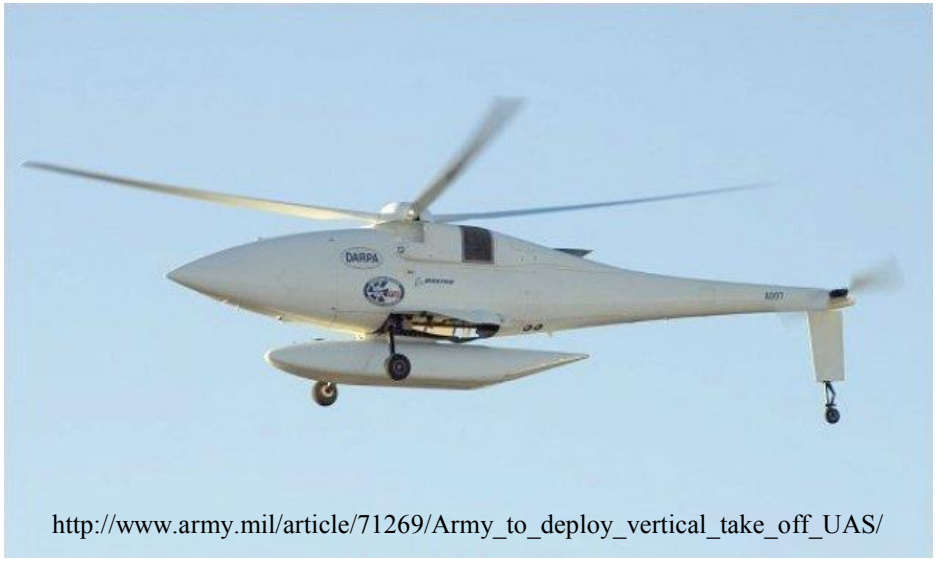

http://www.army.mil/article/71269/Army_to_deploy_vertical_take_off_UAS/

http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104532/scan-eagle.aspx

- Combine VTOL and cruise efficiency
- Achieve direct to destination transportation
  - Acceptable cost
    - Minimal surface infrastructure
    - Energy frugal → Efficient Cruise
  - Community Friendly
    - Low noise
    - Low/zero emissions

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Key Technologies

Distributed Electric Propulsion (DEP)

- Scale Free
  - Nearly constant P/W & Efficiency with size.
- No longer a need to centralize to the minimum number of propulsors.
- Provides a new degree of freedom for aircraft design.

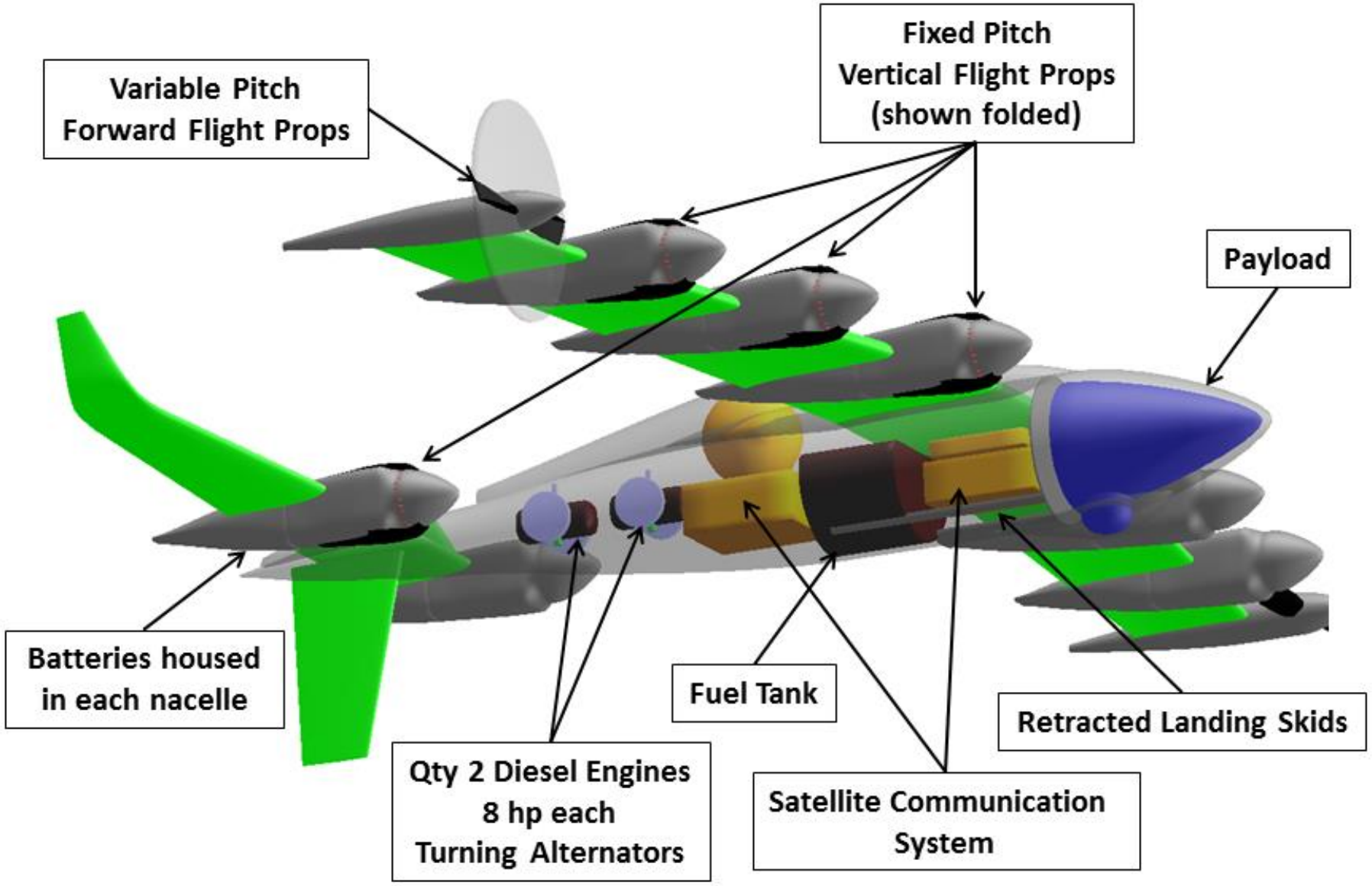
Closed Loop Controls

- Provides artificial stability augmentation to unstable aircraft.
- Smart phone industry enabled low cost IMU sensors.
- There are now dozens COTS closed loop flight control systems that cost less than $200.

Key Benefits

- Cruise Efficiency
  - 4x improvement in L/D relative to helicopter
  - Disk loading is matched to thrust requirement in both configurations.
- Low Community Noise
  - Low Tip Speed Propellers (500 ft/s in hover)
  - Spread spectrum phasing to reduce perceptibility of noise
- Ultra Safe Operations
  - Any motor or propeller can fail at any time and vehicle can safely continue flying.
  - Minimize motor oversizing penality.
- Test Platform for New Technologies
  - Electric Propulsion
  - Autonomy
  - Acoustics

Greased Lightning



Flight Testing Phases

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1. Foamie Hover
2. Foamie Transition
3. GLARF Hover
4. GLARF Transition
5. Greased Lightning Hover
6. Greased Lightning Transition

Indicates Tethered Flight

Indicates Free Flight

GL-10 Flight Videos

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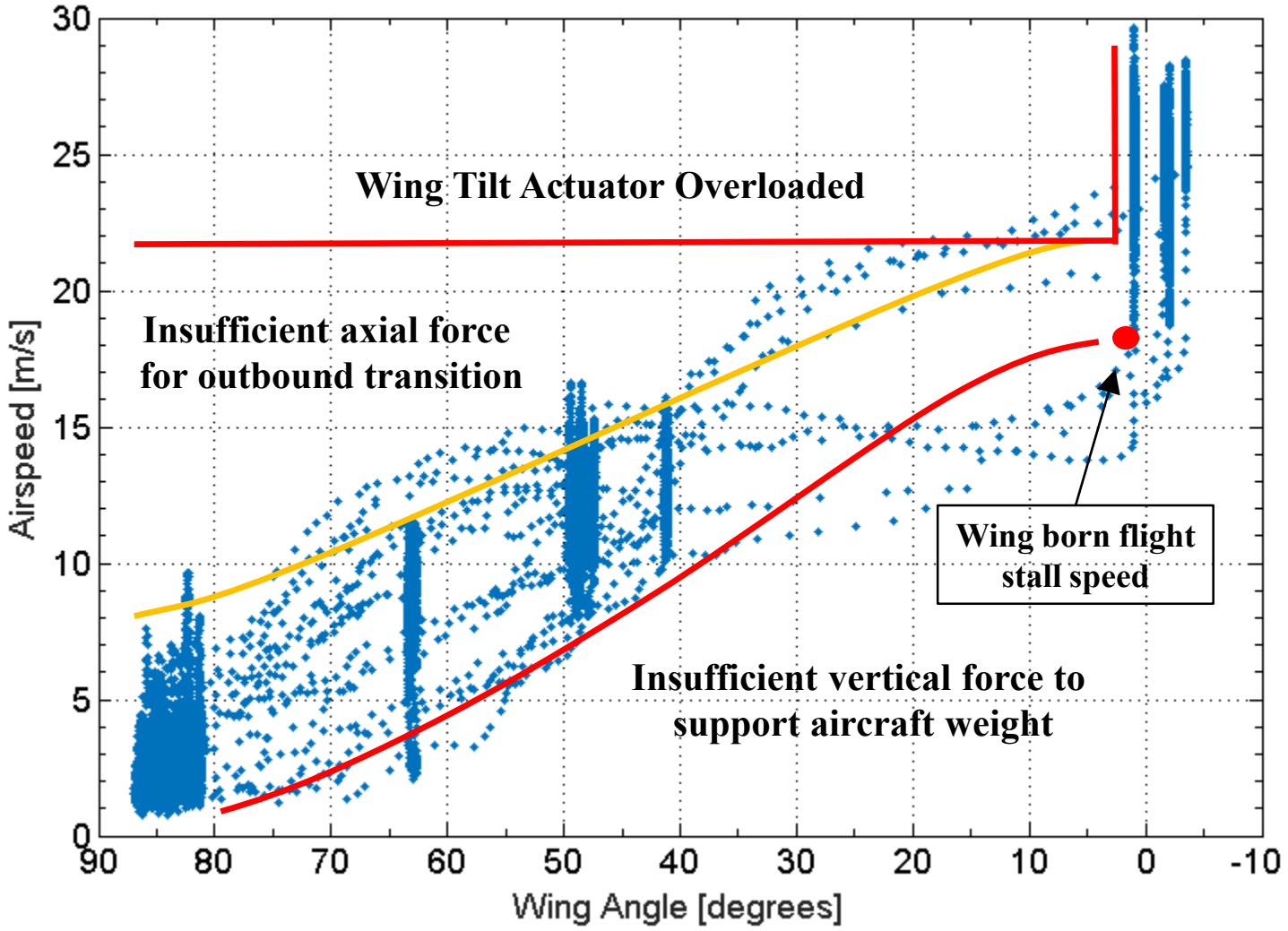
Transition Corridor



Note: differences in wing tilt angle readings caused by calibration differences between different test days.

Conclusions

- It has been demonstrated, via flight test, that it is possible to have a vehicle that is both vertical takeoff and landing (VTOL) and transition into cruise efficient in wing born flight.
- The VTOL cruise efficient aircraft has sufficient control power through out the transition corridor (a short coming of previous VTOL aircraft).
- Use thrust vector control rather than slipstream control.
- This aircraft concept will enable a revolutionary increase in mobility to enable new aviation markets like:
  - Surveillance (Power line / Pipe line inspections, Farms, Marine Science / Fisheries Monitoring, etc.)
  - Package Delivery
  - Personal Transportation

Next Steps

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- Demonstrate 4 times more aerodynamically efficient than a similarly sized helicopter in cruise.
- Demonstrate an autonomous control system not requiring a pilot.
- Demonstrate a hybrid range extender to increase range/endurance 6 times.
- Demonstrate lighter weight, more efficient electric motors and lower noise propellers.
- Demonstrate a reasonable (>35%) useful load fraction (a short coming of previous VTOL aircraft).

Questions

YouTube Video:

"Greased Lightning GL-10 Successful Transition Test"

www.youtube.com/watch?v=kXql26sF5uc