Revolutionary Vertical Lift Technology Project: Variable-Speed Power Turbine Technology Demonstration

Completed Technology Project (2017 - 2018)

Project Introduction

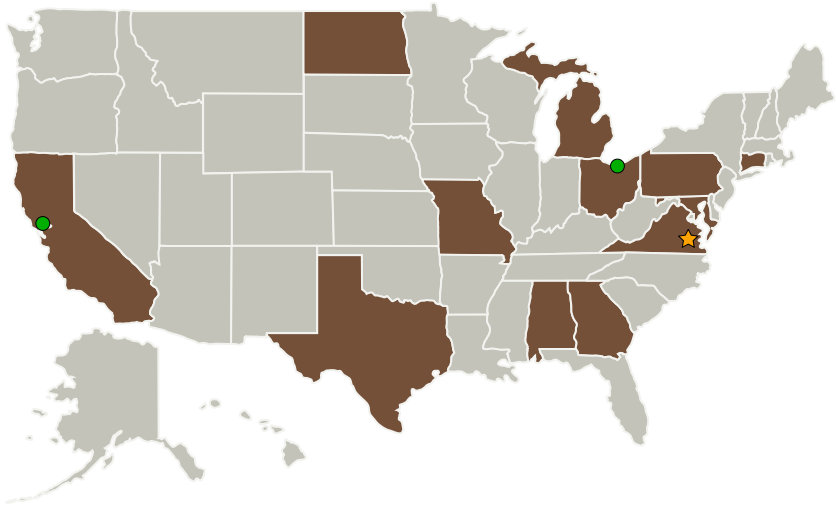
Demonstrate 50% improvement in efficient operational capability using a Variable-Speed Power Turbine concept. To enable this improvement, the rotordynamics mechanical challenges from operating across variable shaft speeds must be accomodated. Also, aerodynamics research for the engine high-efficiency turbine component design must be conducted over a wide range of incidence angle variation. The engine must be able to operate efficiently at low Reynolds number and the wake-induced unsteadiness within the component must be reduced. These technologies will be demonstrated in a component test conducted jointly with several partners.

Anticipated Benefits

Efficient variable engine rpm capability enables higher cruise and takeoff efficiency levels and reduces fuel burn.

Using the engine to efficiently vary main rotor rpm will dramatically improve speed capability and efficiency of conventional, compound and tiltrotor vertical lift configurations.

Primary U.S. Work Locations and Key Partners





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Organizations Performing Work	Role	Type	Location
★Langley Research Center(LaRC)	Lead Organization	NASA Center	Hampton, Virginia
●Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California
Bell Helicopter Textron, Inc.	Supporting Organization	Industry	
Department of Defense(DoD)	Supporting Organization	US Government	Washington, District of Columbia
General Electric Company	Supporting Organization	Industry	Boston, Massachusetts
Georgia Institute of Technology(GA Tech)	Supporting Organization	Academia	Atlanta, Georgia
Georgia Tech Research Corporation	Supporting Organization	Academia	Atlanta, Georgia
●Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio
lockheed martin engineering services	Supporting Organization	Industry	
Monterey Technologies, Inc.	Supporting Organization	Industry	Monterey, California
North Dakota State University	Supporting Organization	Academia	Fargo, North Dakota

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Organizational Responsibility

Responsible Mission Directorate:

Aeronautics Research Mission Directorate (ARMD)

Lead Center / Facility:

Langley Research Center (LaRC)

Responsible Program:

Advanced Air Vehicles

Project Management

Program Director:

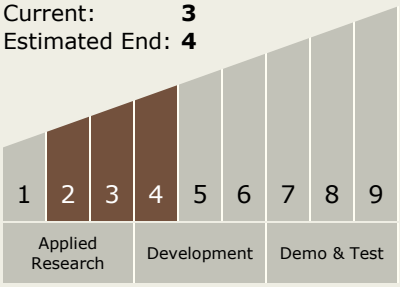
James A Kenyon

Project Manager:

Susan A Gorton

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **4**



Technology Areas

Primary:

Continued on following page.

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Organizations Performing Work	Role	Type	Location
Pennsylvania State University(Penn State)	Supporting Organization	Academia	State College, Pennsylvania
Pratt and Whitney	Supporting Organization	Industry	
San Jose State University Research Foundation	Supporting Organization	Academia	
Sikorsky Aircraft Company	Supporting Organization	Industry	
The Boeing Company(Boeing)	Supporting Organization	Industry	Chicago, Illinois
United States Naval Academy	Supporting Organization	Academia	Chester, Maryland
United Technologies Research Center	Supporting Organization	Industry	
University of Maryland(UMCP)	Supporting Organization	Academia	College Park, Maryland
University of Michigan	Supporting Organization	Academia	Ann Arbor, Michigan
University of North Dakota(UND)	Supporting Organization	Academia	Grand Forks, North Dakota
Washington University in St. Louis	Supporting Organization	Academia	Saint Louis, Missouri

Technology Areas *(cont.)*

- TX01 Propulsion Systems

Target Destination

Earth

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Co-Funding Partners	Type	Location
Department of Defense(DoD)	US Government	Washington, District of Columbia
General Electric Company	Industry	Boston, Massachusetts
German Aerospace Agency(DLR)	International	Cologne, Germany
Netherlands Aerospace Center(NLR)	International	Amsterdam, Netherlands
Office National d'Etudes et de Recherches Aerospatiales(ONERA)	International	Paris, France
Pratt and Whitney	Industry	
United Technologies Research Center	Industry	

Primary U.S. Work Locations	
Alabama	California
Connecticut	Georgia
Maryland	Michigan
Missouri	North Dakota
Ohio	Pennsylvania
Texas	Virginia

Closeout Summary

Brief Summary of Completion / Accomplishment: Technical Challenge: Variable Speed Power Turbine (VSPT) Demonstration Tech Challenge Exit Criteria: Demonstrate variable speed power turbine with 50% improvement in efficient operational capability Cascade testing defines the loss buckets for incident tolerant blade designs required for VSPT. Completed VSPT cascade testing at high and low inlet turbulence levels over a large range of Mach number, Reynolds number, and incidence to provide a benchmark data base to validate the ability of CFD analysis codes to predict the VSPT losses over the entire flight operating envelope. VSPT Design to meet the TC objectives and full scale VSPT test Rig Design completed. Joint US Army AATD / NASA VSPT component contracts awarded to Pratt & Whitney (P&W) and General Electric Aviation (GE). The P&W 4 stage VSPT design met the VSPT efficiency goals at 100% speed or maximum rated power (MRP) for vertical lift and a 55% speed or maximum continuous power (MCP) for cruise. The VSPT design efficiency exceeded 90% over the entire operating range. Successful completion of VSPT rig test achieves

goals and demonstrated the potential of the VSPT concept as a viable approach to improve engine efficiency over a wide range of operating conditions. The full-scale VSPT 3 stage component rig was installed in the P&W Canada Continuous Flow Turbine Rig facility and tested over a wide range of operation. The facility emulated the engine inlet flow conditions to the VSPT compete with swirl and turbine main frame struts. Design and computational analysis tools validated experimental results. CFD was integrally used in the VSPT design process. Post-test analysis of the detailed rig data indicated the CFD had accurately predicted (pre-test predictions) radial distribution of the key flow field parameters, the vane pressure distributions, and the overall performance over the wide operating range.

Closeout Documentation

Variable Speed Power Turbine Technology Demonstration Closeout
(https://techport.nasa.gov/file/41597)