Project Introduction

NASA has invested significant effort in the past decade in developing and maturing technologies that enable efficient and effective use of Next-generation (NextGen) Vertical Lift (VL) systems for a broad class of missions and operations. One of the key barriers it faces to the widespread use of VL vehicles within the National Airspace is the cost of maintenance on the vehicles to keep them safe and reliable. Qualtech Systems, Inc (QSI) in collaboration with Lockheed Martin - Mission Systems and Training (LM-MST) seeks to address these maintenance challenges by fielding a predictive Condition Based Maintenance Plus (CBM+) solution leveraging a diagnostic reasoner TEAMS-RDS (Testability Engineering And Maintenance System Remote Diagnosis Server) and prognostic algorithms. CBM+ involves inferring, tracking and forecasting of system degradation based on state awareness acquired from monitored data through fault detection, isolation, identification, diagnosis and prognosis techniques and to proactively plan maintenance actions to improve system availability and safety. QSI-LM's CBM+ solution will furnish the ability to keep the vehicle health status continually ahead of an advancing failure accumulation through a predictive maintenance strategy geared towards replacement-while-in-operation before the ensuing failures render the VL vehicle inoperable. Diagnosis will focus on current health state identification through detection, isolation, root cause analysis and identification of faults that have already occurred, while prognosis will leverage the current health state identification and forecast performance degradation, incipient component failures and probability density (or moments) of remaining useful life (RUL) or Time to Maintenance (TTM) or Time to Failure (TTF). It is anticipated that the CBM+ solution will leverage the currently existing communication capabilities between the aircraft, the pilot and ground-support personnel in a seamless and automated manner.

Anticipated Benefits

NASA's current vision to enhance the level of autonomy for vehicle health management and mission planning makes the proposed effort worthy of funding from several branches within it. The proposed technology, aimed at increasing operational uptime through the use of predictive CBM techniques, and the software tool for supporting its implementation will allow NASA to better plan and execute future Science Missions. The technology can be leveraged to support safety in complex systems, such as NASA's long-duration missions in space science and exploration. This technology can also be applied to autonomous and hybrid/ full electric systems with a vertical lift capability designed for a variety of civil missions. It is envisioned that the technology will also be able to readily operate as part of NASA's next generation Mission Control Technology allowing NASA to utilize the continuous health assessment and mission satisfiability information from the tool for improved mission execution while improving safety, mission success probability and the overall operational uptime of the VL Vehicle.
Among the other agencies FAA’s NextGen program is the most obvious commercialization target for this technology. We envisage the proposed technology to be of significant interest for to DoD Future Lift Vehicle (FVL) program and being network-ready with support for modern web technologies can readily be available as part of the NextGen System Wide Information Management (SWIM) technologies. Apart from the FAA, US Air Force, US Navy, and commercial aviation (e.g., Boeing, Airbus) are the potential customers for the resulting technology. The development of the various interacting technology components for PHM enabled CBM can be easily directed towards mission assurance and will be of direct interest to large scale military systems (systems of systems) such as NORAD, Space Command ground segments, the Joint Strike Fighter fleet, the Navy shipboard platforms, Submarine Commands and ballistic missile defense (BMD) systems. In addition, UAVs, UMGs and other unmanned submersible vehicle markets are potential targets as well. QSI expects to leverage its relationship with manufacturers of these systems, such as the Lockheed Martin’s K-MAX (unmanned cargo helicopter) for which QSI is involved in providing a PHM solution for commercialization of the proposed technology. The product is also expected to be of commercial value to the manufacturers of DoD and military’s remotely guided weapons and reconnaissance systems.

Primary U.S. Work Locations and Key Partners

Organizational Responsibility

Responsible Mission Directorate: Space Technology Mission Directorate (STMD)
Lead Center / Facility: Glenn Research Center (GRC)
Responsible Program: SBIR/STTR

Project Management

Program Director: Jennifer L Gustetic
Program Manager: Carlos Torrez
Principal Investigator: Sudipto Ghoshal

Technology Maturity (TRL)

Start: 3
Current: 4
Estimated End: 4
**Organizations Performing Work**

<table>
<thead>
<tr>
<th>Organization</th>
<th>Role</th>
<th>Type</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glenn Research Center (GRC)</td>
<td>Lead Organization</td>
<td>NASA Center</td>
<td>Cleveland, OH</td>
</tr>
<tr>
<td>Qualtech Systems, Inc.</td>
<td>Supporting Organization</td>
<td>Industry</td>
<td>Rocky Hill, CT</td>
</tr>
</tbody>
</table>

**Primary U.S. Work Locations**

Connecticut

**Closeout Documentation**

Final Summary Chart

([https://techport.nasa.gov/file/29861](https://techport.nasa.gov/file/29861))

**Images**

[Image of a flowchart or diagram related to predictive condition-based maintenance for vertical lift vehicles, Phase I]

**Briefing Chart Image**

Predictive Condition-Based Maintenance for Vertical Lift Vehicles, Phase I