

Innovation

This Air Force SBIR/STTR Innovation Story is an example of Air Force supported SBIR/STTR technology that met topic requirements and has outstanding potential for Air Force and DoD.

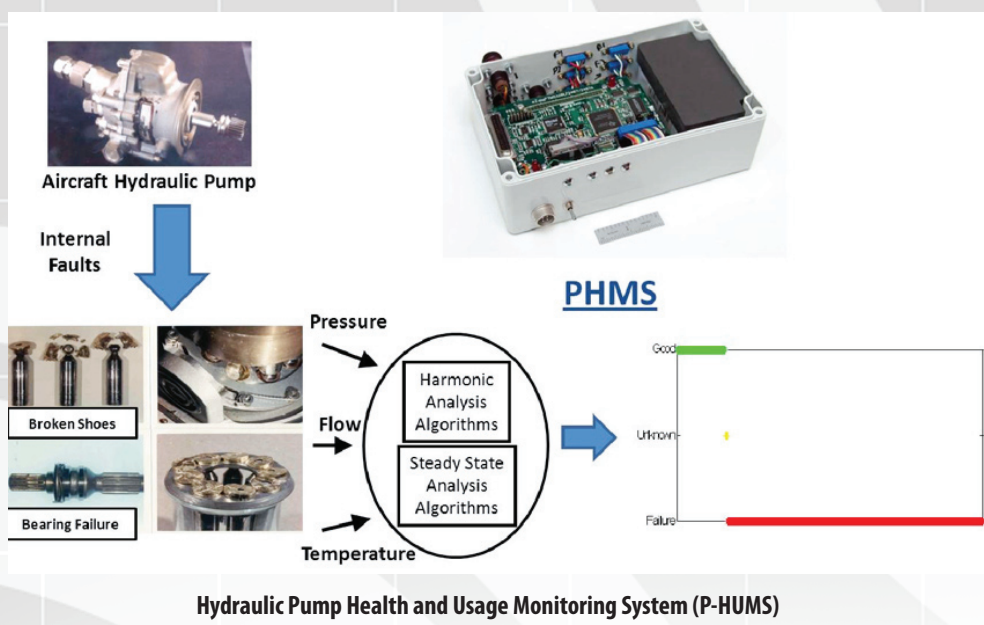
SBIR Topic Number:
OSD01-CBM06

SBIR Title:
In-Line Health Monitoring System for Aircraft Hydraulic Pumps & Motors

Contract Number:
F33615-02-C-5051

SBIR Company Name:
Creare, Inc., Hanover, NH

Technical Project Office:
AFRL Materials and Manufacturing Directorate, Wright-Patterson AFB, OH



A Hydraulic Pump Health Monitoring System

- Aircraft hydraulic pump reliability is critical for flight safety, and continual health status monitoring is vital to warn of incipient problems before failure.
- Creare developed a Hydraulic Pump Health and Usage Monitoring System (P-HUMS) to continuously monitor pumps and warn flight crews at the earliest onset of degradation.
- Providing warning of impending failures before they occur allows maintenance crews to intervene when convenient to minimize aircraft downtime and maintenance costs.
- The P-HUMS provides classification of individual failure classes with greater than 90% confidence, and the ability to classify good versus bad pumps with greater than 99% accuracy. In all cases, these classifications were made while the pumps were operational and still had useful life remaining.
- This system was initially developed and demonstrated on aircraft hydraulic pumps in the AFRL Materials and Manufacturing Directorate, Pump Test Facility. It was recently transitioned to U.S. Army combat helicopter pumps.

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Air Force Requirement

The reliability of aircraft hydraulic pumps is critical for the safety of flight. To avoid catastrophic failures, the aircraft pumps/motors are replaced after a predetermined time interval. Sometimes, the pumps are replaced prematurely, and at other times catastrophic failures occur before scheduled replacement, thereby contaminating the entire hydraulic system. Decontamination results in substantial aircraft downtime, and in some extreme cases, this catastrophic failure can result in loss of aircraft. In pump tests at the Materials and Manufacturing Directorate of the Air Force Research Laboratory (AFRL/RXB), it has been observed that certain parameters develop unique characteristics when pumps approach approximately 90 percent of their useful life. If these parameters were continuously monitored with an in-line health monitoring system, such pumps could be replaced before they failed catastrophically. Replacing such pumps for cause would increase reliability, maintainability and readiness.

SBIR Technology

The overall objective of this program is to improve aircraft reliability and readiness by accurately identifying and diagnosing problems with hydraulic pumps prior to complete failure. This will reduce the number of emergency maintenance repairs as well as the number of unnecessary scheduled maintenance actions. Creare, Inc. developed an in-situ Hydraulic Pump Health and Usage Monitoring System (P-HUMS) that continuously measures key operating parameters and alerts maintenance staff when a pump needs attention. Each P-HUMS, shown schematically on the previous page, consists of a central processor with the hardware and software necessary to execute the health monitoring algorithms in real time, as well as a small number of hydraulic fluid sensors. The substantive result of this project was the delivery of three prototype P-HUMS systems to the AFRL Materials and Manufacturing Directorate. We demonstrated the ability to classify individual Air Force aircraft hydraulic pump failures with greater than 90% confidence, and the ability to classify good versus bad pumps with greater than 99% accuracy. We demonstrated the capability to detect failures such as bearing faults, piston faults, erosion, and cavitation. In all cases, these classifications were made while the pumps were operational with useful life remaining. We also showed that P-HUMS could be generalized to accommodate a range of pump types, capacities, and failure modes; this effort led directly to the technology transition and successful demonstration of this system with a class of U.S. Army combat helicopter pumps.

Potential Air Force Application

P-HUMS provides three advantages to the Air Force over existing maintenance methods: (1) an in-situ, onboard prognostic system for monitoring aircraft hydraulic systems, (2) data acquisition, archival, and analysis tools to facilitate maintenance prognostics, and (3) hardware and software necessary to build a knowledge data base of hydraulic system performance. The overall benefits of P-HUMS to the Air Force include increasing mission capability and availability, reducing the number of unexpected failures, and reducing maintenance costs.

Thus far Creare has demonstrated P-HUMS on both Air Force and Army aircraft hydraulic pumps in laboratory tests at Technology Readiness Level (TRL) of TRL4. Maintenance engineers at the Corpus Christi Army Depot (CCAD) have documented the fact that as many as ten hydraulic pumps per month fail and require maintenance and remediation for one aircraft platform alone, at a total cost of \$3M per year. Total hydraulic pump maintenance costs across the Air Force and Army aircraft fleets reach tens of millions of dollars per year, and much of these costs are due to decontamination of the hydraulic systems and associated aircraft downtime due to catastrophic pump failures. Identifying incipient failures before they occur will reduce maintenance costs, increase aircraft availability, and improve overall mission effectiveness. We are currently evaluating flight test programs with the U.S. Army as well as a large aircraft Original Equipment Manufacturer (OEM) to raise the TRL to TRL5 and justify operational aircraft testing.

Company Impact

This technology enabled Creare to develop a new core competency in the area of diagnostic and prognostic health monitoring technologies. For example, this project opened the door to the development of a U.S. Navy aircraft carrier catapult health monitoring system now in service in support of the entire carrier fleet. That system has been in service since 2006 and is currently in regular use on every active carrier in the U.S. Navy fleet.



SBIR/STTR

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