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ABSTRACT

CV-22 Engine Inlet & Scroll Time on Wing Improvement Test

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The CV-22 fulfills US Special Operations Command's requirement for high-speed, long-range insertion and extraction of Special Operations Forces (SOF) in hostile or denied territory. Its unique mission requirements require the aircraft to operate in extremely austere environments. This has proven to be challenging on the engine life. As such, Rolls Royce and Bell-Boeing have been developing a series of Industry-initiated improvements to increase the collective engine time on wing (TOW). One of these improvements is focused on enhancing the particle separation capability of the engine intake through a re-designed engine inlet and scroll. As Air Force Special Operations Command's (AFSOC's) highest CV-22 priority initiative, Industry proposed installing the prototype engine inlet/scroll modification kit on two aircraft for an extended TOW evaluation during normal operations by operational aircrew at Kirtland Air Force Base (AFB) NM. However, this plan was not without risks, as the modified inlet and scroll did not undergo any propulsion ground or flight testing. The program was relying on Computational Fluid Dynamics (CFD) analysis stating that the risks of an engine compressor stall or engine surge were low. While the loss of an engine in a typical multi-engine turbo prop aircraft is often seen as a manageable emergency procedure, the results of an engine failure can be more dire in a CV-22 in certain regimes of flight, such as low speed hover. As a result, the 413th Flight Test Squadron (413 FLTS) from the 46th Test Wing at Eglin AFB was tasked to demonstrate safety of flight throughout a limited set of points over the CV-22 operating envelope. The US Navy's Air Test and Evaluation Squadron Two One (HX-21) at Naval Air Station Patuxent River was a participating test organization and executed a parallel test effort using a degraded engine on an MV-22.

The planning phase was not without challenges. The combined test community had less than three months from the initial task to test execution. The high profile test involved the US Navy and three Air Force Major Commands (MAJCOMs) and required inter-MAJCOM memorandums of agreement along with parallel safety review boards through the Air Force and Navy. The team designed an incremental buildup approach to ensure the modification kit did not have adverse impacts on engine performance and to build aircrew confidence in the modification before executing test points in the aircraft's single-engine avoid region. The buildup approach was executed in two phases: edge of operating envelope testing (MV-22, Patuxent River) and operationally representative tasks in an austere environment (CV-22, Kirtland AFB). Both aircraft were modified with the proof of concept inlet/scroll kit on one side of the aircraft and the production kit on the other side.

HX-21 executed the envelope testing phase, to include ground testing, from 29 Mar - 6 Apr 2011 in 6.9 flight hours. The team executed all buildup flight test points in airplane mode, conversion mode and helicopter mode from the surface to 25,000 feet density altitude. No anomalies were observed during execution of this phase. The 413 FLTS completed the high density altitude hover testing and operationally representative tasks at Kirtland AFB from 12 Apr - 5 May 2011 in 10.1 flight hours. The team designed a series of buildup events where the aircrew executed low visibility approaches (LVAs), to include brownout landings, simulated fast rope exercises and go-arounds in brownout conditions. After executing 16 LVAs and exposing the engines to approximately 3 hours of brownout conditions, the team demonstrated a series of aerial refueling tasks. No safety of flight issues such as engine surges or compressor stalls were encountered during flight; however, the team encountered significant issues when trying to demonstrate that the modified engine performance remained within acceptable tolerances. Throughout the CV-22 evaluation at Kirtland AFB, the modified engine was consistently 2-5% less efficient and degraded faster than the unmodified engine. Despite troubleshooting and additional flights to attempt to isolate the problem, the team was unable to conclude whether the issue was related to the engine modification kit or other external factors.

These challenges drove some of the key lessons learned from this developmental effort. LL1: It is very difficult to develop and execute a controlled engine performance test on a production aircraft with no instrumentation. The external factors (environmental, procedural, configuration control, malfunctioning equipment) and large variances in data from the

production recording system made it nearly impossible to make any type of assessment on the potential performance impact the modified inlet/scroll had on the engine in a short duration test. The hands down best solution for this type of evaluation is to locate or develop an engine test stand capable of testing an instrumented inlet and engine under controlled environmental conditions. LL2: Make the collection of baseline data a priority; a small investment up front can save significant pain later. While this was included in the test plan, it was omitted from the final execution events due to schedule constraints. LL3: Work hard to eliminate external variables that you can control. While many variables are beyond the test team's control, managing those you can (e.g. configuration control of the test asset during routine maintenance, consistent procedures when collecting engine performance data) will remove points of contention during data analysis. LL4: A word on high visibility, fast paced programs: control the flow of information, safety of flight prevails. There were some 30 organizations involved in this project. The test team had to control the flow of information in a way that was useful and constructive, ensuring each major player was kept in the loop. We did this through daily status e-mails and large teleconferences. We all felt the schedule pressure and we committed to executing and finishing on time. However, we never let these pressures impact the non-negotiable goal of safely executing the test program and providing the end user with a safe product. Ultimately, despite the unknown performance questions, all agreed there were no safety of flight issues preventing the inlets from being installed on two operational aircraft at Kirtland. The extended TOW evaluation is now in data collection phase and on-going today.

CV-22 Simulated Fast Rope Ops, Brownout Conditions