CH-53K – Heavy Lift Replacement Program

Executive Summary

- CH-53K flight testing continues, using the four Engineering Development Model (EDM) aircraft, three system developmental test articles (SDTA), and the Ground Test Vehicle (GTV). The seven flyable aircraft have flown 1,212 flight hours as of September 12, 2018.
- The late December 2019 Initial Operational Capability (IOC) will be delayed. Current projections estimate that IOT&E will start in early 2021 due to the need to correct multiple design deficiencies discovered during early testing. These include: airspeed indication anomalies, low reliability of main rotor gearbox, hot gas impingement on aircraft structures, tail boom and tail rotor structural problems, overheating of main rotor dampers, fuel system anomalies, high temperatures in the #2 engine bay, and hot gas ingestion by the #2 engine, which could reduce available power. The Program Office is working a major schedule revision.
- The Program Office is requesting additional funding to complete sufficient developmental testing to enter IOT&E with a KPP compliant system. Technical problems have extended SDD well beyond original projections.
- The Program Office is transitioning the CH-53K production line from West Palm Beach, Florida, to Stratford, Connecticut. With the exception of the first four STDA aircraft, final assembly of all remaining aircraft will be completed at the Stratford facility. DOT&E is working with the Program Executive Office and the Program Office to ensure aircraft produced on the Stratford production line are production representative.
- LFT&E is ongoing. Testing of tail rotor components, cockpit and cabin armor, and the GTV against threshold threats is deferred due to funding until FY20. Live fire testing against objective, operationally relevant threats has not yet been funded.
- Navy analysis indicates the CH-53K is on track to meet the Survivability Key Performance Parameter (KPP) only if technical mitigations to unexpected deficiencies, which the Navy is currently developing, are successful. Preliminary analyses indicate that the CH-53K is more survivable than the legacy CH-53E aircraft.

System

- The CH-53K is a new-build, fly-by-wire, dual-piloted, three-engine, heavy lift helicopter slated to replace the aging CH-53E. The CH-53K is designed to carry 27,000 pounds of useful payload (three times the CH-53E payload) over a distance of up to 110 nautical miles, climbing from sea level at 103 degrees Fahrenheit to 3,000 feet above mean sea level at 91.5 degrees Fahrenheit.
- The CH-53K design incorporates the following survivability enhancements:
  - Large Aircraft Infrared Countermeasures with advanced threat warning sensors (combines infrared, laser, and hostile fire functions into a single system), an AN/APR-39D(V)2 radar warning receiver, and an AN/ALE-47 countermeasure dispensing system
  - Pilot armored seats, cabin armor for the floor and sidewalls, fuel tank inerting, self-sealing fuel bladders, and 30-minute run-dry capable gear boxes
- The Navy intends the CH-53K to maintain a shipboard logistics footprint equivalent to that of the CH-53E.

Mission

Commanders employ the Marine Air-Ground Task Force equipped with the CH-53K for:

- Heavy lift missions, including assault transport of weapons, equipment, supplies, and troops
- Supporting forward arming and refueling points and rapid ground refueling
- Assault support in evacuation and maritime special operations
- Casualty evacuation
- Recovery of downed aircraft, equipment, and personnel
- Airborne control for assault support

Major Contractor

Sikorsky Aircraft (a Lockheed Martin subsidiary company) – Stratford, Connecticut

Activity

- The Defense Acquisition Executive approved the CH-53K program's Milestone C decision for entry into low-rate initial production (LRIP) on February 28, 2017. USD(AT&L) delegated the CH-53K program to the Navy and it became an Acquisition Category 1C program on November 21, 2017.
- The program has seven flyable aircraft to support integrated developmental and operational flight testing. All four EDM aircraft have been flying in the integrated test program since EDM-4 achieved first flight on August 31, 2016. The contractor has delivered three of the six SDTAs, all of which are participating in the test program. The seven flyable aircraft have flown 1,212 flight hours as of September 12, 2018. Delivery of SDTA-4 to Patuxent River is projected for August 2019.
- The Navy used the GTV to qualify key dynamic components; assess aircraft stresses, vibrations, and rotor performance; and support long-term reliability testing and verification of aircraft systems performance. The GTV is a complete CH-53K that is fully representative of the EDM aircraft. The Navy is transporting the GTV via a transportability demonstration on a C-17 airlifter to China Lake, California. The GTV will then be the test article for full-up system-level LFT&E projected for FY20.
- Sikorsky manufactured the first four of six SDTA aircraft at its facility in West Palm Beach, Florida. The Navy intends for four SDTA aircraft to be used for IOT&E. The Program Office has incorporated retrofit periods into the master schedule to ensure these SDTA aircraft will be production representative. Final assembly of all CH-53K aircraft is transitioning to its Stratford, Connecticut, facility for the fifth and sixth SDTAs and LRIP aircraft. SDTA-5 and SDTA-6 are at the first stages of assembly. Full-rate production is planned for the Stratford plant.
- The Navy completed live fire testing of the CH-53K engine disk in November 2017 and the main and tail rotor servos in December 2017. Live fire testing of the tail rotor flex beam (which connects the tail rotor blade to the hub) is delayed pending finalization of a new design that will meet design lifetime requirements without fracturing or delaminating. The Navy is continuing to develop live fire test plans to support testing of the GTV and cabin armor at China Lake, beginning in FY20.
- In March 2018, the Program Office conducted a comprehensive survivability summit to rebaseline the assessment of overall aircraft survivability. The Navy is modifying aircraft survivability equipment (ASE) to address cybersecurity requirements (data at rest protection), mitigate obsolescence (removable media and computer processors), and reduce life-cycle cost (via elimination of components). The Navy is upgrading the infrared countermeasure subsystem and adding hostile fire indication.
- Due to ASE program delays, the Navy has deferred deployment and testing of the updated ASE and it will not be available for IOT&E. The Navy will use legacy ASE during IOT&E and will employ legacy ASE for IOC, which is slipping. The Navy intends to examine updated ASE in FOT&E and retrofit it to the fleet as it becomes available.
- The Program Office completed Revision C of the U.S. Marine Corps CH-53K Heavy-Lift Replacement Program Test and Evaluation Master Plan (TEMP) to reflect programmatic changes and updates to the cybersecurity test strategy, including a new emphasis on cybersecurity.
- The Navy is continuing testing in accordance with the DOT&E-approved TEMP and a DOT&E-approved 2010 Alternative LFT&E plan.

Assessment

- The Program Office lacks sufficient funding to complete the SDD Phase on the original timeline due to technical problems that have extended SDD beyond original projections. SDD must be fully funded as soon as possible. The December 2019 IOC may not be not achievable. Current projections estimate that IOT&E cannot start until early 2021. The Program Office is working a major schedule revision. Schedule compression pressure has the potential to adversely affect training for the IOT&E aircrews and maintainers.
- Design of the CH-53K is not finalized, aggravating schedule and cost concerns. Sikorsky continues to address design deficiencies discovered in developmental testing:
  - The aircraft pitot-static system does not provide reliable airspeed indications in various flight regimes resulting in poor automatic flight control system performance. Sikorsky is investigating relocating the pitot-static sensors but has not finalized a solution.
  - Service life projections for the main rotor gearbox are falling short of the requirement. Sikorsky is developing solutions involving modification of internal gears and their interfaces.
  - Engine and auxiliary power unit hot gas impingement on the aircraft structure during some flight regimes has not been solved. On several test flights, telemetry indicated temperatures on the composite skin of the aircraft were approaching structural limits. This necessitated termination of some maneuvers to prevent aircraft damage.
  - Testing revealed performance anomalies in the CH-53K tail boom design. The tail structure experienced unexpected vibrations and resonances, and redesign efforts are in progress to mitigate vibration-induced damage to hydraulic lines and other components in the tail.
  - The tail rotor flexbeam experienced material delamination and cracking. The first shipset of the redesigned flexbeam has been installed on EDM-1 and flight testing is in progress.
  - Main rotor dampers are overheating. The contractor has proposed a new rotor damping configuration involving lower damping action, which has been installed on EDM-1. Sikorsky is gathering and analyzing flight test data, but evaluation of the change effectiveness has not yet been completed for the entire CH-53K flight envelope.

  - Sikorsky has not finalized the fuel system configuration; the original design called for a suction-only fuel feed to reduce vulnerability to ballistic threats. General Electric is developing a liquid ring fuel pump to replace the existing pumps. Component qualification testing is underway with the first pumps to be delivered for flight test in 2QFY19. If boost pumps are required, additional live fire testing may be required.
  - The #2 engine bay is experiencing high temperatures that could damage components in that bay. The contractor has not yet identified a permanent solution.
- LFT&E against the threshold threats is ongoing. While testing revealed some vulnerabilities, preliminary analyses indicate that the CH-53K is more survivable than the legacy CH-53E against small-arms, automatic weapons fire, and legacy man-portable air-defense system threats.
- Ballistic testing of the main and tail rotor servos showed a potential for the servos to jam in some conditions when impacted with the threshold threat. Component testing of the engine disk did not indicate any significant aircraft-level vulnerability resulting from cascading damage when subjected to ballistic impact.
- The CH-53K is currently on track to meet the survivability KPP but not without mitigations to address deficiencies uncovered in testing. This includes a self-sealing coating for the main gearbox lubrication sump, which the Navy is currently investigating. Any design changes to the aircraft design to address technical deficiencies may require additional live fire testing to fully assess their effects on aircraft survivability.
- The planned Phase II live fire testing against objective threats, described in the DOT&E-approved Alternate LFT&E Strategy, has not been funded. This phase is essential for an adequate survivability assessment against operationally relevant threats. This phase includes component tests for the main rotor assembly and tail rotor hub against threshold threats, originally scheduled to support the Milestone C decisions. As a result, any deficiencies identified in this phase of testing will need to be addressed after IOC likely with engineering change proposals.

Recommendations

The Navy should:

1. Secure additional funding to:
   - Complete the SDD phase of the program
   - Complete live fire testing against objective threats
   - Accelerate LFT&E to minimize problem discovery post-IOC
2. Revise the program schedule for achievable, event-driven milestones.
3. Continue to investigate mitigations to address design deficiencies identified in test.