



Demonstration of the Optionally Piloted
K-Max Helicopter
Lucky Peak Helibase
5-15 October, 2016

Overview of Preliminary Results

Background: Departmental Manual (350 DM 1) charges The U.S. Department of the Interior (DOI) Office of Aviation Services (OAS) with responsibility for **“conducting DOI aircraft and equipment research and development efforts.”** Since 2011, OAS has collaborated with DOI Bureaus and Offices to conduct Operational Test and Evaluation (OT&E) of unmanned aircraft systems (UAS) in Departmental science and natural resources missions. The 2015 Unmanned Aircraft Technology Demonstration Overview, Amendment #1, (<https://www.doi.gov/sites/doi.opengov.ibmcloud.com/files/uploads/2015%20Unmanned%20Aircraft%20Technology%20Demonstration%20Overview%20%2812-5-2014%29%20and%20Amendment%201%20%288-9-2015%29.pdf>) provided a phased, risk-managed approach to safely conducting UAS OT&E in the more complex wildland fire mission area. Following successful completion of Phase 1A and 2, testing of Phase 3A (Amendment #1) was conducted. These OT&E tests were also consistent with the 2015-2020 DOI UAS Integration Strategy (https://www.doi.gov/sites/doi.opengov.ibmcloud.com/files/uploads/DOI_UAS_Integration_Strategy_2015-2020.pdf)

Purpose: This series of tests examined the capability of the optionally piloted helicopter for performing cargo and water dropping missions in representative western wildfire terrain and conditions.

Test Objectives:

1. Examine the ability of the system for delivering cargo in the unmanned configuration to a variety of precise locations.
2. Examine the ability of the system to conduct trailing water drops for the purpose of building a “wetline” during a simulated wildfire.
3. Examine the ability for the aircraft system to deliver a spot drop of water to a predetermined location.
4. Assess the ability of the aircraft to evaluate the outcome effectiveness of water drops using the on-board IR sensor.
5. Evaluate the ability of UAS for hotspot detection through dense smoke.
6. Continue to educate the builders of the system on the wildland firefighting mission so they understand the environments they will be expected to work in and can make appropriate enhancements to the system.
7. Provide a demonstration to fire/aviation leadership across the government for the purpose of understanding the capability of the aircraft system.
8. Obtain feedback from fire/aviation leadership to inform future system improvements, workflows, and applications.

Test Conditions: The test was conducted at the Lucky Peak Helibase on the Boise National Forest. The base is located in the mountains about 20 miles northeast of Boise. The terrain around the base is typical of areas we would expect to see fires throughout the West. The conditions during the testing were typical late summer/early fall conditions. Weather conditions ranged from 40-80 degrees and the winds experience ranged from 0-25 MPH from various directions. Visibility conditions at the beginning of the test were typical of the inversion conditions and corresponding dense smoke (from the nearby Walker fire) that often preclude manned aircraft operations in the morning on wildfires. Water and cargo delivery were also completed in typical western wildfire terrain on the mountain just west of the helibase.

Test Aircraft: The aircraft used for this test was the Kaman K-Max Helicopter. The demonstration aircraft was owned by the Kaman Corporation. The Lockheed Martin Corporation originally developed the supplemental unmanned technology for the U.S. Marine Corps to perform resupply to and backhaul from forward operating bases, avoiding the improvised explosive device (IED) threat ground convoys were susceptible to. The company operated the system for this event. The aircraft and demonstration were conducted, and paid for by, the Lockheed Martin/Kaman Corporations as part of a government sponsored notice of demonstration for which this aircraft was offered and subsequently selected.

Flight Data: The test aircraft flew on seven separate days from October 6-15. Each of those days there was one flight in the morning and one flight in the afternoon. Each flight was used to practice the maneuvers for the demonstration and to work with trained firefighters for water and cargo delivery. A total of 11 sorties were flown averaging about 2.5 hours each. Although the aircraft was flying in the unmanned mode for the event there was a safety pilot on board to meet FAA requirements to see-and-avoid other traffic and to preclude the necessity for obtaining an FAA Certificate of Authorization and Waiver (COA).

Results / Lessons Learned:

1. Examine the ability of the system for delivering cargo in the unmanned configuration to a variety of locations.
 - The system was able to consistently and reliably deliver cargo to various GPS locations provided to the operator.
 - This mission had been consistently and reliably accomplished for several years, over thousands of flight hours in Afghanistan for the U.S. Marine Corps.
 - Cargo delivery was very accurate, with the aircraft able to deliver four separate cargo loads to predetermined GPS points using the longline with no damage to the loads.
 - The carousel on the aircraft was capable of delivering multiple loads to multiple locations on one flight.

- Cargo backhaul (retrieval) was also accomplished, with the aircraft accurately flying to the predetermined pickup point with great accuracy. The aircraft was able to autonomously provide a stable platform that enabled the crew to quickly and easily attach the backhaul material to the cargo hook.
- Integration with firefighters was seamless and their existing training was adequate to work with K-max for hooking up cargo.
- The aircraft is certified to carry up to 4500Lbs in this configuration.



2. Examine the ability of the system to conduct trailing water drops for the purpose of building a “wetline” during a simulated wildfire.

Results

- The system was able to link together progressive drops to create a continuous wetline.
- The firefighter on the ground was able to relay coordinates for the release point.
- Future enhancement will allow for targeting directly from helicopter and/or from a manned/unmanned platform overhead with appropriate infrared targeting capability.
- Drop height and speed were easily adjusted based on conditions.
- The aircraft system successfully laid out drop target and path using Google Earth and then transferred information to Ground Control Station (GCS) operator.



3. Examine the ability for the aircraft to deliver a spot drop of water to a predetermined location.
 - The system was extremely accurate when coming to a specific point for a hovering drop (+/- 5 feet)
 - Successfully completed spot drops with the 100' and 55' longlines.
 - Drop height was fully adjustable depending on conditions.
 - Bucket swinging was easily corrected by the GCS operator
 - Live HD video exhibited negligible lag and enabled the operator to move the aircraft for more precise targeting.
 - Using the electro-optical (EO) camera, operator was able to locate and drop on a standard orange panel used by wildland firefighting crews today.



4. Assess the ability of the aircraft to evaluate the effectiveness of water drops using the on-board infrared (IR) sensor
 - The IR sensor was easily able to show the location and footprint of water delivered and the relative impact on the temperature of the ground.
 - It clearly showed the accuracy of linking up multiple drops and would be useful in identifying critical line gaps that could be corrected in subsequent drops.
 - The EO camera was capable of staying locked on geographic reference points. This was an enhancing feature for maintaining situational awareness.
5. Evaluate the ability of UAS for hotspot detection through dense smoke.
 - The IR sensor was easily able to see through smoke.
 - Even through this smoke, the IR sensor was able to see an active wildfire (Walker fire) more than 12 miles away.
 - Easily identified hotspots even during the heat of the day.

6. Educate the system builders on the firefighting mission so they have a better understanding of the environments they will be expected to work in and have the ability to make appropriate enhancements to the system.
 - Over the course of the week there was a lot of interaction with trained fire personnel to help the vendor understand the mission. The vendor was very receptive to firefighter recommendations.
 - DOI's Office of Aviation Services (OAS) provided the vendor with expert guidance from the National Helicopter Specialist relative to the Pilot Testing Standards (PTS) for interagency longline qualification standards.
 - Typical terrain scenarios were valuable in demonstrating to the vendor the kinds of environments the system would be expected to operate successfully in.
7. Provide a demonstration to fire/aviation leadership across the government for the purpose of understanding the capability of the aircraft
 - Participation in the event was quite large with over 100 people attending.
 - Several media outlets covered the story and there was significant positive press as a result. There have been numerous requests for follow-on interviews and requests for additional information.

Conclusions: Overall the demonstration and scenario-based flights exceeded expectations. The helicopter configured in the unmanned operating mode performed well in mountainous terrain and was able to deliver cargo and water with the same or better precision, as it was capable of in the manned configuration. The on-board EO camera and IR sensor were very useful in not only providing situational awareness to the operator but for assessing the outcome impacts of the water drops. The sensor can also be used to send video to anyone with authenticated users with connectivity to the web. The ability to ferry the aircraft with a pilot on board is highly desirable for moving the aircraft from fire to fire without the added operational burden and cost of having to comply with current FAA restrictions regarding the operation of UAS within the National Airspace System (NAS). The ability of the aircraft to launch, operate, and recover completely within the Temporary Flight Restriction (TFR) that is usually placed over a sustained wildfire and the FAA's granting of Beyond Visual Line of Sight (BVLOS) flight authority to DOI within a TFR, provides exceptional mission functionality. The ability of this technology to support both manned and unmanned operations enables DOI to contract and use the helicopter in the manned configuration when visibility conditions permit manned aircraft operations (clear day) and to further use the aircraft during periods of reduced visibility (morning inversions) and night, when manned aircraft are currently unable to support ground firefighters with direct attack and logistical supply operations due to safety issues. Although there are fine-tuning enhancements that are needed to fully realize the potential of this technology, our conclusion is that the currently capability is usable and continued operation testing and integration is warranted in accordance with the 2015 Unmanned Aircraft Technology Demonstration Overview, Amendment #1.

Recommendations for Further Testing:

1. Work with the Federal/State fire managers to seek out funding for further program development for UAS on wildfires.
2. When funding becomes available, work with vendor to complete enhancements identified during the week at Lucky Peak.
3. Utilize the aircraft on either prescribed (RX) fires and/or selected wildfires during the 2016 fire season.
4. Develop a 5-year evaluation plan that will facilitate increased usage over time with a goal of full integration at the end of that period.

Additional Information Resources:

- [Feds Check Out Unmanned Aircraft For Fighting Wildfires](#) (North West Public Radio)
- [Officials say pilot-less helicopters could help combat wildfires](#) (KBOI 2)
- [U.S. Department of Interior hosted a demonstration of an unmanned helicopter](#) (Idaho Statesman)
- [Lockheed-Martin unveils pilotless wildland firefighting helicopter](#) (KIVI TV)
- [Feds eye pilotless helicopters to battle wildfires](#) (AP)
- [Military Technology Used for Fighting Fires](#) (KTVB)
- [Pilotless helicopter for firefighting successfully tested near Boise](#) (Spokesman Review)
- [Feds observe demo of unmanned firefighting helicopter](#) (KTVZ)
- [Remotely-piloted helicopter demonstrates dropping water on a simulated fire](#) (Fire Aviation)

Video

- <https://vimeo.com/mstvideos/review/142309554/8198b3bef0>