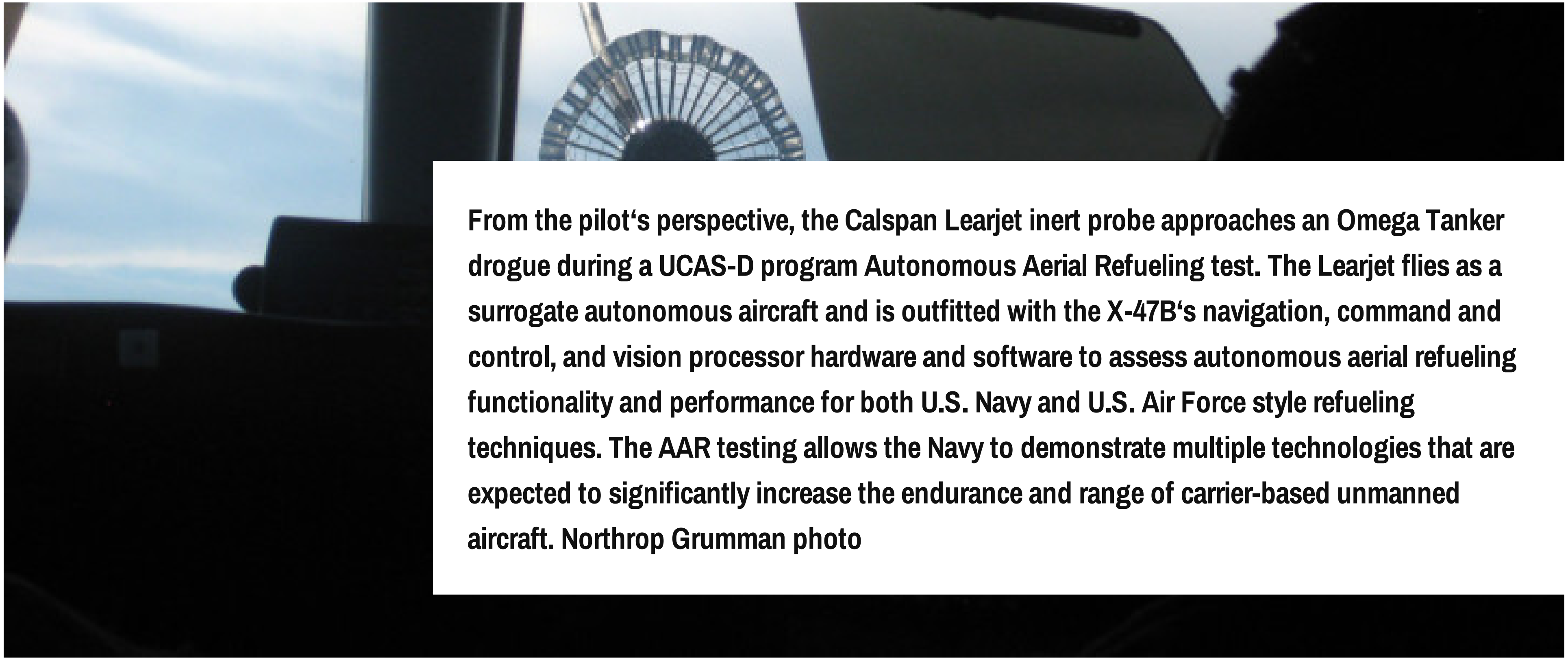
Autonomous Aerial Refueling (AAR) Demo Aims To Hit the Basket

BY ERIC TEGLER - OCTOBER 9, 2013



From the pilot‘s perspective, the Calspan Learjet inert probe approaches an Omega Tanker drogue during a UCAS-D program Autonomous Aerial Refueling test. The Learjet flies as a surrogate autonomous aircraft and is outfitted with the X-47B‘s navigation, command and control, and vision processor hardware and software to assess autonomous aerial refueling functionality and performance for both U.S. Navy and U.S. Air Force style refueling techniques. The AAR testing allows the Navy to demonstrate multiple technologies that are expected to significantly increase the endurance and range of carrier-based unmanned aircraft. Northrop Grumman photo

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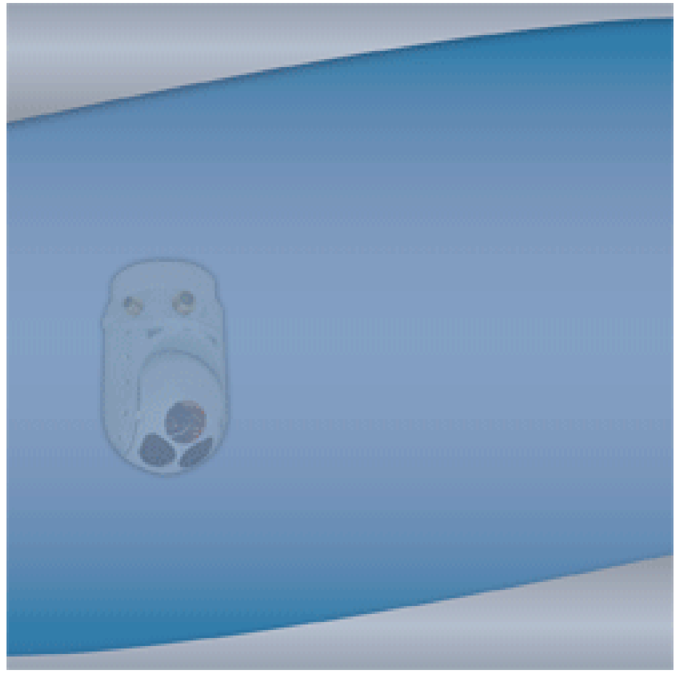

Later this fall, the U.S. Navy and its industry partner, Northrop Grumman, hope to demonstrate that an unmanned aircraft borrowing extant systems can pull up behind a tanker, deploy its aerial refueling probe, and successfully plug into a drogue-style basket – by itself.

The autonomous aerial refueling (AAR) demonstration is part of the larger UCAS-D demonstration that made history in July when the unmanned X-47B made two successful arrested landings on the USS *George H.W. Bush*.

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Flying a refueling probe into a basket in-flight is one of the two most demanding tasks in naval aviation, along with making a final approach to an aircraft carrier and landing aboard.

Flying a refueling probe into a basket in-flight is one of the two most demanding tasks in naval aviation, along with making a final approach to an aircraft carrier and landing aboard. Both evolutions call for inches-precise maneuvering. It's not surprising then, says Navy Combat Air System program manager Capt. Jamie Engdahl, that the AAR demonstration will use the same software and similar hardware that the X-47B used to land autonomously on the carrier.

AAR combines technology used in UCAS-D with a surrogate aircraft – a Lear 25 provided by Calspan, a Buffalo, N.Y.-based aerospace/automotive research firm. The demonstration builds on more than a decade of previous research and testing of Precision Relative GPS (PRGPS) capability by the Air Force Research Laboratory, DARPA, NASA and the Navy. In 2006, the DARPA/NASA autonomous aerial refueling demonstration (AARD) achieved an autonomous rendezvous and basket plug behind a tanker using a NASA F/A-18 employing PRGPS algorithms and nose-mounted camera sensors.

An X-47B Unmanned Combat Air System (UCAS) demonstrator completes an arrested landing on the flight deck of the aircraft carrier USS George H.W. Bush (CVN 77), July 10, 2013. The landing marked the first time any unmanned aircraft had completed an arrested landing at sea. As part of its UCAS-D demonstration the U.S. Navy and Northrop Grumman are testing autonomous aerial refueling (AAR). Northrop Grumman photo by Alan Radecki

The current Navy-funded demonstration integrates UCAS-D elements, assessing their functionality in aerial refueling scenarios. It will also assess a government-designed tanker refueling interface system.

"That's one of the cool things about this program," Engdahl says. "We put Calspan on contract to get the refueling probe complete and to provide the aircraft. Northrop brought its [camera] vision system, we brought the precision GPS system from the X-47B and Northrop integrated it all into the guidance, navigation and control package."

In January 2012 test flights, the Calspan Learjet had maneuvered around a contracted Omega Aerial Refueling Services 707 tanker autonomously, using prototype hardware and software. For the latest AAR phase in August, Northrop Grumman technicians installed the X-47B's navigation, command/control and vision processor hardware and software on the Lear 25 at Calspan's facility. A government team installed its Refueling Interface System and Tanker Operator Station on the Omega 707.

In the test flights that followed, the Calspan Lear rendezvoused with the tanker, flew formation and made an approach, maneuvering to within five feet of the extended basket. The aircraft was hand-flown by a Calspan pilot who responded to digital messages from the tanker just as an unmanned aircraft would, testing improved communications/control systems. The join-up/maneuvering procedures were exactly the same as those used for manned aerial refueling.

In carrier operations, the X-47B is fully integrated into the ship's network. Its guidance/navigation/control computer is fed position data from the carrier's embedded GPS/INS across a TTNT (Rockwell Collins Tactical Targeting Network Technology) link. The aircraft compares the data to its own onboard satellite navigation to generate a continuously updated PRGPS position.

The combined data stream, onboard processors and sensors allow the X-47 to autonomously position itself for final approach and to make the minute adjustments necessary to catch the arresting gear with its tailhook. A landing signal officer (LSO) is also on the network, and on approach, can wave-off the X-

47 by pressing a button just as with a manned aircraft. The UCAS then autonomously waves-off, flying away in precisely prescribed fashion.

AAR applies the same UCAS-D PRGPS algorithms, datalinks and hardware to aerial refueling. All that is really different is new source code for refueling-specific commands, the tanker refueling interface system, and the addition of camera sensors that sync visual data with the PRGPS inside the aircraft's guidance computer.

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In practice, the tanker refueling station operator is on the same network employed by the carrier and aircraft. When refueling is imminent, a mission controller on the ship or at a field passes command of the vehicle to the tanker refueling station operator.

The unmanned vehicle then follows the same procedure a manned aircraft does for refueling: rendezvous, establishing formation in "port observation" off the tanker's left wing, clearance to "pre-contact" behind the tanker and extended drogue or boom, and finally, clearance to contact the boom or drogue. The unmanned vehicle is walked through the process by the tanker station operator, who passes digital messages to the aircraft, which then executes their commands.

Engdahl describes the unmanned vehicle's operation as "task-based autonomy" just as with carrier ops.

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If the vehicle misses the plug or it doesn't seat correctly, it autonomously recognizes the problem and backs out or away in the same procedural fashion as a manned aircraft would. Likewise, if the tanker refueling station operator sees something he doesn't like, he pickles a switch just like an LSO does, waving off contact or pre-contact.

"It's fascinating to watch this." Engdahl adds. [The Lear] is digitally programmed so when you press the wave-off button you know exactly how it will fly away because there's not a different human pilot every time."

Because the Calspan Lear is equipped with in-flight simulator software, it can replicate the exact flying qualities of the X-47B, ensuring the surrogate aircraft and tanker fly within the same envelope as the unmanned aircraft would. (For hand-flying, the Lear is equipped with both traditional yokes and a side-stick.) As such, AAR accurately points to what is potentially possible.

"As a demonstration program we're opening all this stuff up, proving out the networks and messaging, allowing people to think about the paradigms," Engdahl explains.

This Calspan Learjet, shown with inert probe in aerial refueling observation position, flies as a surrogate autonomous aircraft. Photo courtesy of CTSi

More food for thought will arise when fully autonomous plugs are made. The Lear's new refueling probe is inert, so no fuel will be transferred, but the concept will otherwise be fleshed out.

“Once we get our final clearance to contact, then we’ll take this same aircraft and have the pilot do some manual plugs to ensure that the structures are good,” AAR’s director says. “They’ll look at the data, then we’ll come back and do ‘closed loop,’ coupled flight and run through all the procedures and plug.”

> **There is clearly potential, however, not just for unmanned aircraft. AAR may demonstrate the usefulness of grafting X-47-like systems to manned aircraft.**

What extrapolations will then be made? “Come see me in a couple months,” Engdahl teases. There is clearly potential, however, not just for unmanned aircraft. AAR may demonstrate the usefulness of grafting X-47-like systems to manned aircraft.

“If you can have a system that requires nobody onboard to do these very difficult tasks and you find that it can do them repeatably and safely, it means that you can move toward reducing training requirements,” Engdahl theorizes. “You can then focus more on the hard parts of combat aircraft – the mission, forward air control, weapons employment, and ROE.”

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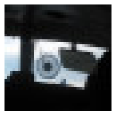

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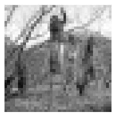

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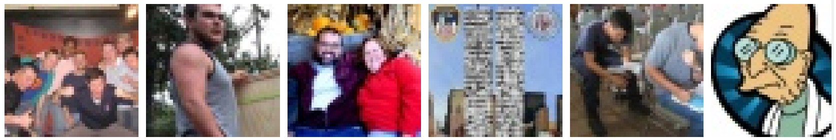

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