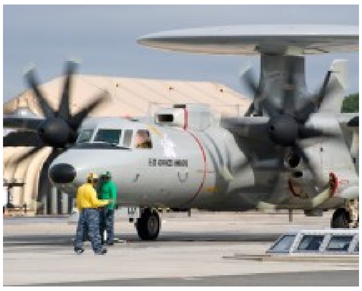
Big Wave Surfing

The Electromagnetic Aircraft Launch System's first launch of the E-2D Advanced Hawkeye is another step forward for the new-technology catapult



Written by: Eric Tegler on October 10, 2011

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An E-2D Advanced Hawkeye prepares to launch using the Electromagnetic Aircraft Launch System (EMALS) at the full-size shipboard-representative test site at Joint Base McGuire-Dix-Lakehurst, N.J. U.S. Navy photo by Kelly Schindler

The first electromagnetic catapult launch of an E-2D Advanced Hawkeye from the runway at Joint Base Lakehurst on September 27 was totally unremarkable – just the way the test team likes it.

The 45,000 pound aircraft accelerated down the catapult and into the air propelled by a wave of electromagnetic energy, recording the 62nd launch of a manned aircraft by the new Electromagnetic Aircraft Launch System (EMALS). EMALS will become operational in 2015 with the *USS Gerald R. Ford* (CVN 78) and will be the launch system for all future carriers. Because it is not planned to be retrofitted to Nimitz-class carriers, it will share the stage with steam catapults for at least another 50 years.

> *An EMALS launch looks and, according to flight crews, feels largely the same as a steam catapult launch, with one exception. There's no steam rising from the shuttle track. Steam pressure and the large piston it drives to haul an aircraft down the catapult have been replaced by electric power. Electrical current is essentially converted into the electromagnetic forces to accelerate the aircraft along the launch stroke.*

The basic concept has been researched since the 1980s. Capt. James Donnelly, PMA-251 Aircraft Launch and Recovery Equipment Program Manager, calls EMALS "a big wave generator for a surfer with an aircraft attached." The idea of "surfing" down the deck on a catapult stroke is an appealing one, but EMALS offers more than just a novel way of launching aircraft.

Developed by a contractor team led by General Atomics, EMALS promises reduced manning requirements, a lower thermal signature, increased reliability, reduced topside weight, reduced installed volume and greater capability for launching unmanned aerial vehicles. It is also said to be more precise than steam systems, reducing the sudden shock to the airframe transmitted by conventional catapults, offering a smoother launch and up to 30 percent more launch energy potential to cope with heavier fighters.

Over an aircraft's life cycle, the resulting potential reduction in airframe fatigue may prove to be significant. Just as importantly, EMALS' combination of reduced manning and greater reliability frees deck crews from much of the drudgery of servicing the catapults after each launch cycle. Donnelly, a former catapult and arresting gear officer, explains that the fewer moving parts of the EMALS system mean less routine maintenance and quicker repair. In fact, EMALS average mean time to repair is projected to be one hour versus several hours for steam catapults. The reduced workload translates to better-rested, more alert, and thus safer deck crews.

General Atomics was awarded the System Development and Demonstration (SDD) contract (valued at $435.3 million) for EMALS in 2004. Since then it has constructed and begun extensively testing the EMALS system at Lakehurst. The new electromagnetic catapult resides next to a steam catapult at one end of Lakehurst's 12,000 foot runway.

The equivalent of three deployments worth of activity has been conducted at the test site already. That activity has included 7,259 armature movements, 4,406 catapult maneuvers, 1,298 no-load strokes and 1,494 dead-load strokes. As of this writing the system had launched the F/A-18E 25 times, including the first aircraft launch, which took place in December 2010. EMALS has also accomplished 18 T-45 launches and 18 C-2A launches, along with the most recent E-2D launch.

EMALS consists of six major subsystems:

- Prime Power Interface
- Launch Motor
- Power Conversion Electronics
- Launch Control
- Energy Storage
- Energy Distribution System

The Prime Power Interface provides the connection with the ship's electrical distribution system and delivers power to drive the energy storage generators.

The Launch Motor, a 100,000 horsepower linear induction motor, is a compact, modular, integrated flight-deck structure that converts electrical current into the electromagnetic forces to accelerate the aircraft along the launch stroke. The design tolerates the range of conditions experienced in the flight-deck environment and operating scenarios. A simple moving shuttle interfaces with the aircraft in the same manner as existing catapults. After the aircraft launches, the electric current in the motor will reverse to brake the shuttle to a complete halt without the use of a water brake.

The deletion of the water brake not only removes a layer of complexity but may contribute to the rest and quality of life of those sleeping a couple decks below in junior officers quarters.

> *"The water brake has been removed, so from that perspective, the [catapult] will get quieter," Donnelly says. "You'll continue to hear the shuttle noise, jet blast deflectors and hooks hitting the flight deck in the arresting gear area."*

Power Conversion Electronics derive power from the energy store and convert this power to a traveling wave of energy of the appropriate voltage and current to drive the shuttle along the launch stroke. Based on solid-state technology already in use by General Atomics, the conversion electronics are packaged as compact modules in cabinets located below deck.

For Launch Control, EMALS uses a state-of-the-art system to finitely deliver the current into the

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launch motor in real time. More precise end-speeds are achievable over a wider range of aircraft types and weights than those characteristic of steam catapults. System architecture with inherent redundancy is achieved by use of commercial off-the-shelf components where possible, and modularity is emphasized to ease installation and maintenance.

Energy Storage devices (potential energy is stored via a flywheel device that will fully power a cat stroke even if the electrical power supply is disrupted) provide the required energy for each two- to three-second launch. The energy storage devices are recharged from ship's power between launches.

Finally, the Energy Distribution System delivers the energy from the power conversion system to the launch motor. The system is comprised of cables, disconnects, and terminations. Among other features, EMALS incorporates a closed loop control system with diagnostic health monitoring. The latter can detect launch anomalies within 500 microseconds and adjust to compensate for issues ranging from aircraft engine flameouts to blown tires.

General Atomics has already embarked on building the required gear for CVN 78's EMALS at its Tupelo, Miss., facility including launch motors, inverter and block switch assemblies, and energy distribution cable assemblies. Both the delivery of EMALS hardware and SDD testing are on schedule, with the former actually ahead of schedule. General Atomics expects to deliver all remaining hardware due in 2011 and to begin warehousing hardware in Tupelo in 2012.

Back at the test site the E-2D from the Navy's test and evaluation squadron, VX-20, taxied back to the catapult and shut down. When asked about the shot, which hurled the Hawkeye to an end speed of about 125 knots, the pilot, Lt. Cmdr. Brian Tollefson said, "It felt just like a steam catapult to me. Real smooth."

From inside the E-2D's glass cockpit, one catapult may indeed be indistinguishable from another, the pre-launch procedures being identical. Similarly, the E-2D looks much the same as the E-2C, though it is a significantly different airplane. But both EMALS and the Advanced Hawkeye are pushing the state-of-the-art, said Hawkeye and Greyhound Program Office (PMA-231) Program Manager Capt. Shane Gahagan following the launch.

> *"EMALS and E-2D are demonstrating great capability for the future battle group. Each system displays technology leaps, replacing legacy systems of approximately the same 50-year design age. Seeing the two testing together today is a significant milestone."*

There will be many more E-2D launches at Lakehurst. Each aircraft type, including the F-35C, is expected to undergo 63 to 65 launches before type certification. SDD testing is slated to continue at Lakehurst through late 2011, with a second phase of aircraft compatibility testing to begin next year. Reliability testing will reportedly continue through 2013, at which point the system should be installed on the *Ford.*

Curiously, Donnelly says he does not think that the EMALS system has been hardened against the electromagnetic pulse (EMP) threat from nuclear weapons, but asserts, "From an EMI perspective as far as what the system emits, we've taken care of that. The vulnerability of this system is no different from any other system that I know of."

Naval Sea Systems Command will likely have a more definitive answer, but if the system has no direct or indirect EMP protection, it would be notable. Nonetheless, once in place, EMALS should offer operators the ability to accurately dial up the requisite energy to launch a fully loaded Growler on one stroke and a much lighter UAV or UCAV on the next. Each aircraft will be surfing the wave.

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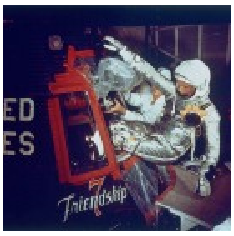

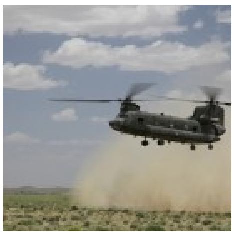

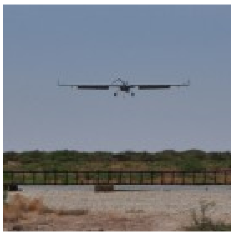

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