

Precision recovery

A new GPS-based landing system will guide F-35 pilots to pin-point carrier touch-downs – and a portable version may also support rapid deployment of expeditionary air units

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The US Navy (USN) is preparing to place an order for Raytheon's Joint Precision Approach and Landing System (JPALS), to be installed on all of its aircraft carriers and amphibious assault ships.

The US Naval Air Systems Command (NAVAIR) on 25 March approved production of the system, the aircraft component of which is installed on all three variants of the Lockheed Martin F-35 Lightning II, and should sign a contract with Raytheon at the beginning of May. This will launch serial production of the technology, says Raytheon, and lead to JPALS being installed on 11 nuclear-powered aircraft carriers and eight amphibious assault ships, with the first units to be delivered in 2020.

JPALS is a differential, GPS-based precision landing system that guides aircraft to land on carrier or assault vessel decks. The navigation equipment is used by the F-35 and will also

be installed on the in-development Boeing MQ-25A Stingray unmanned in-flight refueling tanker, while other USN aircraft will continue to use the service's existing tactical air navigation system.

"In layman's terms, it provides a kind of a tunnel [on the head-up display] for the airplane to fly through to get at the same landing point every time safely," says Brooks Cleveland, Raytheon's senior aviation adviser for precision landing systems.

Raytheon promises that the system is 99% reliable, guiding an aircraft to a 20x20cm (8x8in) spot on a carrier's deck in almost all weather and up to Sea State 5: an ocean surface condition where rough waves are cresting as high as 2.5m (8ft). JPALS uses an encrypted, anti-jam data link to connect to software and receiver hardware built into F-35s and MQ-25A tankers, as well as an array of GPS sensors, mast-mounted antennas and shipboard equipment.

Pilots returning to a carrier for landing will first engage with JPALS at about 200nm



JPALS equipment has been trialled extensively on land using US Marine Corps' B-model

(370km) away, where they start receiving range and bearing information. Then, at 60nm, the jet automatically logs into the JPALS queue, receiving more precise data while beginning two-way data-link communication. At 10nm the pilot starts receiving precision data for landing, following visual cues to land on an exact spot.

Using JPALS is more covert than relying on a legacy tactical air navigation system and radio transmissions between a pilot and air traffic control, says CJ Jaynes, Raytheon executive technical adviser for JPALS. "You do not have to have an air traffic control tower. You don't have to have anyone talking to you," she says. "A system can be on the ground and a pilot can go all the way to his landing point without any communication whatsoever."

Because the system relies on a direct encrypted data link, the likelihood of interception

Technology will boost efficiency of embarked operations with US Navy's newest fighter



AUTOMATED LANDING SYSTEMS AND THE US NAVY ARE OLD PALS

JPALS, the Raytheon-developed Joint Precision Approach and Landing System being readied for installation on all the US Navy's (USN's) aircraft carriers and US Marine Corps amphibious assault ships, brings the latest GPS technology to bear on the oldest problem in naval aviation: landing safely on the moving runway that is the deck of a "flat top".

But the system, which should be delivered from 2020, is not the first of its type – the navy has been using a predecessor system to address this problem since the 1980s.

This current PALS "electronic landing aid" is radar-based, and has been installed on every USN carrier starting with the USS *John F Kennedy*, where it was certified for service in 1988 following trials. Developed by Textron Systems, PALS operates in one of three modes: fully automatic; pilot manual control based on cockpit displays of glide slope and centreline error; and pilot control based on approach controller talk-down.

Two systems – one aircraft-based and one shipboard – operate independently, and must provide identical data to the incoming pilot. In a 2003 University of Tennessee master's thesis assessing techniques for certifying that these independent elements are indeed providing identical information, John Ellis describes the system as "a vital component of modern naval aircraft recovery".

Ellis notes that in the *John F Kennedy* trials "the benefits the system provided to naval aviation were immediately recognised".

PALS dates, ultimately, to the 1950s. A Textron retirees newsletter article notes that work by Bell – later a Textron division – led to the first automatic landing in 1954. The first automatic landing on a carrier deck was in 1957, with a navy pilot putting a Douglas F-3D down on the USS *Antietam*.

Production systems were certified for use from 1963, but early examples apparently suffered from reliability problems as they consisted of "more than 30 units of electronic equipment, consisting of hundreds of vacuum tube operational amplifiers".

Subsequent digitalisation – and now the advent of GPS – have been welcome improvements. ■

– a risk with a broadcast, which could give away the position of the aircraft or ship – is also lower, says Cleveland.

In July 2018, the USS *Wasp* amphibious assault ship used JPALS for the first time to guide a US Marine Corps (USMC) F-35B onto its deck. The USS *Essex* has also been using the system. Both assault ships carry engineering, manufacturing and development (EMD) units that will be replaced with production versions.

Raytheon says Italy also plans to buy the system for one of its aircraft carriers, and the UK Royal Navy has expressed an interest in buying two systems for its pair of Queen Elizabeth-class carriers.

Raytheon thinks the system has potential for other USN carrier-based aircraft too, including the Boeing F/A-18E/F Super Hornet, Bell Boeing V-22 Osprey and Northrop

Grumman E-2 Hawkeye. The landing system can be added to any aircraft with a GPS, an inertial navigation system, a software reprogrammable radio and enough computing power, says Jaynes.

EXPEDITIONARY USE

In January 2019, Raytheon demonstrated a portable version of JPALS guiding in a USMC short take-off and vertical landing F-35B to a touchdown at Yuma Proving Ground in Arizona. In attendance were personnel from the USN, USMC and US Air Force (USAF), says the company.

Those services are interested in JPALS as a way to rapidly set up and facilitate air traffic control operations at expeditionary bases, which are part of a Pentagon idea to make the position of air forces unpredictable – a strategy to keep near-peer adversaries such as >>

» China or Russia on their heels should war break out. In particular, the USAF is showing strong interest, says Jaynes.

“The reason the air force is interested is they are developing a concept of operations called ‘agile basing’, where they intend to bring in their air wing, maybe stay in a location for 24 to 48h, and then move the entire air wing to a new location,” she says.

The USMC is also interested because it could play a role in the Pacific theatre, says Cleveland. “This system is perfect for that island hopping,” he says.

The expeditionary version could be

“The ultimate goal we envision is handling up to 50 aircraft with that landing system”

CJ Jaynes

Executive technical adviser for JPALS, Raytheon

packed in ruggedised cases or integrated into a Humvee or Polaris RZR light tactical all-terrain vehicle, either of which could be quickly air dropped.

“The goal is to have [a] multi-runway, multi-aircraft [capability], with the ultimate

goal we envision an end space where you can handle up to 50 aircraft with that landing system,” says Jaynes. “And you could touch down [at] points within 20nm of that ground station.”

For a second demonstration of the expeditionary version of JPALS at NAS Patuxent River in Maryland on 8 and 9 May, Raytheon has invited back all of the US military services, plus international development partners on the Joint Strike Fighter programme. “Any country that’s buying an F-35 – whether it’s an A, B or C model – is a potential customer for this,” says Jaynes. ■

STRATEGY GREG WALRON SINGAPORE

Modifications to launch F-35B from Japan’s Izumo-class warships are no surprise

Some military secrets are better kept than others. The emergence of Tokyo’s real plan for its pair of Izumo-class helicopter destroyers was always, to naval observers, more a matter of when than if. With their 248m (814ft) length, expansive flight decks and large hangars, the JS *Izumo* and her sister JS *Kaga* are the largest ships in the Japan Maritime Self-Defence Force (JMSDF) – and aircraft carriers in all but name.

The facade finally fell away in late 2018, when Tokyo confirmed that the two ships – whose official complement was a mere nine helicopters – would be modified to operate the Lockheed Martin F-35B, the short take-off and vertical landing (STOVL) variant of the F-35 family.

The US Marine Corps already operates the F-35B from its amphibious assault ships, and the UK will fly the type from the Royal Navy’s (RN’s) pair of new flat tops, HMS *Queen Elizabeth* and *Prince of Wales*. Tokyo plans to obtain around 40 F-35Bs, topping off an eventual fleet of over 105 F-35As that will be operated by the Japan Air Self-Defence Force.

“It has been one of the worst-kept secrets that these ships have the potential to operate as light aircraft carriers with STOVL aircraft,” says Nick Childs, senior fellow naval forces and maritime security at the International Institute for Strategic Studies. “Given developments in naval capabilities around the region, this move was perhaps inevitable.

It was just a case of when and precisely how.”

Fully loaded, the Izumo class ships displace 27,000t, which compares with 22,000t for the RN’s former *Invincible* class. The ships will reportedly carry about 10 F-35Bs in addition to helicopters and, possibly, the Bell Boeing V-22 Osprey, which Japan is also obtaining. The deck has two large elevators leading to its spacious hangar deck.

Tokyo’s pacifist constitution precludes the acquisition of aircraft carriers, resulting in the linguistic gymnastics required for the “helicopter destroyer” designation.

Malcolm Davis, senior analyst, defence strategy and capability at the Australian Strategic Policy Institute, sees a strong rationale for an integrated JMSDF fixed-wing capability. He points to Japan’s complicated geography and “multi-axis” challenges from China, North Korea and Russia.

For Japan’s maritime and air forces, he says: “Power projection within this maritime and archipelagic space is essential. They can certainly rely on land-based airpower, but organic naval air combat capability has a timeliness and operational flexibility in and around the Senkakus in the East China Sea, or maybe even the Ryukyus, that land-based air would lack.”

The crystallisation of Tokyo’s carrier plans comes amid increasing concern about the growing military might of China, which is developing a powerful blue water

navy. Beijing already has a single operational aircraft carrier, the 60,000t *Liaoning*, which operates the Chengdu J-15; a Chinese copy of the Sukhoi Su-33.

Beijing, leveraging its vast civilian ship-building capability, is also deploying new destroyers, cruisers and submarines, in addition to its growing arsenal of land-based missiles and aircraft.

POWERFUL CAPABILITY

In addition to core F-35 attributes such as stealth and sensors, Japan’s aircraft will have powerful anti-shipping capability in the form of the Kongsberg Joint Strike Missile – though the weapon is too large for the STOVL F-35B to carry internally.

Despite the promise of fixed-wing carrier operations, taking complicated fifth-generation fighters to sea is no easy matter.

“There may be issues of having to provide extra workshop facilities, redesigning weapons magazines, and in particular providing all the support for the F-35B’s surveillance and reconnaissance capabilities,” says Childs. “The Japanese may also have to decide whether or not they want to equip the Izumo class with a ski-jump ramp like the British, but unlike the Americans.”

The JMSDF’s addition of fixed-wing aircraft brings history full circle. Japan was a pioneer in naval airpower, using carriers to devastating effect in the Second World War, including at Pearl Harbor on 7 December 1941. ■



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After updates, 27,000t vessel will carry more than helicopters

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Blue skies for Lightning

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