



AVIATION WEEK

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## HOT, HOT, HOT

The F-35B short-takeoff/vertical-landing version of the Lockheed Martin Joint Strike Fighter (JSF) is to start sea trials on the USS Wasp this month. It costs more than the F-35A and F-35C and has lower performance, so the U.S. Marine Corps and its allies have mounted a public-relations offensive focusing on its advantages: the ability to fly off Navy amphibious ships and use small airfields with short runways like its predecessor, the AV-8B Harrier.

Navy construction specifications made public in early 2010, however, suggest that the F-35B's exhaust would be much hotter than the Harrier's, enough to damage military-standard surfac-

es and war-zone runways. Lockheed Martin and the Marines dismissed the specifications as outdated and based on worst-case assessments.

Office of Naval Research said in August that it was continuing efforts to devise a cooling system to protect ship decks from thermal fatigue caused by F-35Bs.

Navy documents indicate that the JSF's lift/cruise nozzle has an exit temperature of 1,700F, at least 400F hotter than the Harrier's exhaust and twice the typical Harrier ground temperatures.

Neither the JSF Program Office (JPO) nor the Marine Corps responded to repeated inquiries about the discrepancies between their statements and the documented figures, nor have they explained why the 2010 tests did not lead to less onerous construction standards. Marine officials told Rolls-Royce not to release

former F-35 engineer who saw the phenomenon in late-1990s ground testing. The fragments are then lifted and thrown outward by the high-velocity outflow around the exhaust stream. Navfac specifications call for VL pads to be made of high-temperature concrete—a Ceratech product called Firerok, also marketed for commercial pizza ovens, has been found suitable—poured in a 100 X 100-ft. slab, with continuous bidirectional reinforcement to prevent cracking.

Marine leaders say the F-35B can operate from many times more runways than conventional jet fighters (except the Saab Gripen, designed to operate from narrow 2,600-ft. runways). These numbers are based on surveys conducted in the 1990s, which showed that in Third World countries there were 800 runways of 3,000 ft. or so, versus 144 measuring 7,000 ft. No survey of runway quality was carried out, and many of these runways are likely to be surfaced in asphalt. (One civil engineer

**On touchdown, the 1,700F main exhaust of the F-35B engine is just over 2 ft. from a runway surface or ship deck.**

suggests that the F-35B could find a market as an asphalt-removal system.)

VL test operations at NAS Patuxent River, Md., currently use a pad of standard

AM-2 aluminum mat laid over concrete. The U.S. Air Force describes AM-2 as "heavy, cumbersome, slow to install, difficult to repair, [with] very poor air-transportability characteristics." Matting for a 100 X 100-ft. VL pad weighs 30 tons and comprises 400 pieces, each of which must be individually installed by two people.

USAF has been working on lighter matting made of foam and fiberglass, but it starts to produce "thick, black smoke" above 400-500F. The U.K.'s Faun Trackway, which produces roll-on metal roadways for military vehicles and is expanding U.S. operations, is looking at applications of its technology to support JSF. ■

The company conducted extensive ground-environment tests in January 2010. "Results . . . indicate that the difference between F-35B main-engine exhaust temperature and that of the AV-8B is very small," DTI was told, "and is not anticipated to require any significant [concept of operations] changes for F-35B." In March 2010, then-Marine Commandant Gen. James Conway told the online publication DoDBuzz that the JSF exhaust "at 1,500 degrees is just 18 degrees hotter than a Harrier."

Despite these statements, Navy engineers were preparing in August to issue a \$21 million contract to build a heat-resistant vertical landing (VL) pad at MCAS Beaufort, S.C. It follows a similar VL pad constructed at MCAS Yuma, Ariz. The

the exhaust temperature for the 50-year-old Pegasus engine. Naval Facilities Engineering Command (Navfac) officials referred inquiries to the JPO. The JPO also did not say whether austere-runway tests are planned with the F-35B.

People familiar with Harrier operations say that surface temperatures are much cooler than the exhaust, with estimates around 850F. The Harrier's hot aft nozzles are further from the ground at touchdown than the JSF's, and are smaller and scarfed (cut off at an angle), which increases their perimeter and results in faster mixing between the exhaust and ambient air.

According to Navfac documents, the F-35B exhaust will cause spalling in standard airfield concrete, with a 50% probability of occurrence in the first vertical landing. Spalling is caused by differential heating and moisture boiling between the surface and underlying layers. "The concrete basically explodes," says one

JSF PROGRAM OFFICE



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