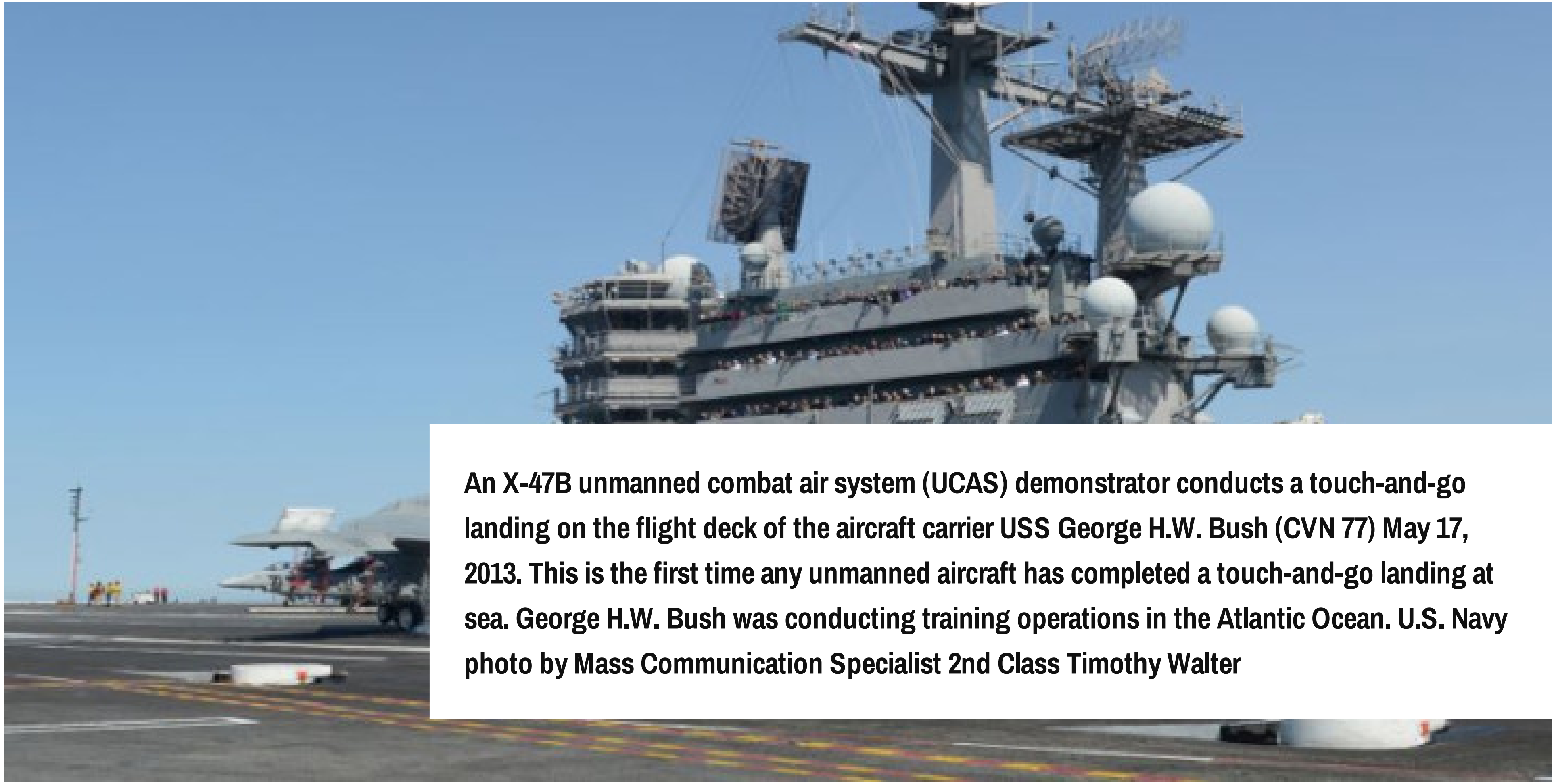
The Navy's X-47B Flies With Air Force Engine

Aircraft's F100-PW-220U is derived from the engine powering F-15s and F-16s

BY ERIC TEGLER



An X-47B unmanned combat air system (UCAS) demonstrator conducts a touch-and-go landing on the flight deck of the aircraft carrier USS George H.W. Bush (CVN 77) May 17, 2013. This is the first time any unmanned aircraft has completed a touch-and-go landing at sea. George H.W. Bush was conducting training operations in the Atlantic Ocean. U.S. Navy photo by Mass Communication Specialist 2nd Class Timothy Walter

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Few realize that as the X-47B performed touch-and-goes on the USS *George*

H.W. Bush (CVN 77) a week after its first catapult launch in late May, it flew with the same Pratt & Whitney engine that has provided thrust for the F-15 and F-16 for decades. Ironically, the unmanned carrier aircraft that the Navy rightly touts as "historic" is propelled by an Air Force engine.

Pratt & Whitney's F100 family of engines traces its origins to a mid-1970s effort to develop two variants of the same powerplant for the Navy and Air Force. Pratt's F401 was slated for the F-14B, but the Navy canceled its development early in the program. That engine's core was shared by the F100 that was in development concurrently for the Air Force. Ultimately the F100 was fitted to the F-15 and, later, the F-16.

"This application didn't need an afterburner," Reed explains. "What it needed was an absolutely reliable, safe powerplant in the 15,000-pound thrust class. That describes the F100-220U. It's the engine that leads the fleet in safety and reliability. For a program like this that would

ultimately have just two airplanes, we didn’t want to be developing engine capability along with airplane capability.”

A Pratt & Whitney F100 turbofan engine is tested at Robins Air Force Base, Ga. The tunnel behind the engine cools the escaping exhaust gases and muffles the intense noise. The mesh cover attached to the forward air inlet is not part of the engine. The F100 is the same engine that powers the X-47B that made its historic touch-and-go landing on board the USS George H.W. Bush (CVN 77) last month. U.S. Air Force photo by Sue Sapp

Today the Pratt & Whitney F100-PW-220U is providing 15,000 pounds of thrust for the X-47B. The engine became the powerplant of choice organically as the Unmanned Combat Air System Demonstrator (UCAS-D) program unfolded, according to Jim Reed, Pratt's director of Advanced Programs, Military Engines.

What began as a Defense Advanced Research Projects Agency's J-UCAS (Joint Unmanned Combat Air System) for the Navy and Air Force saw the latter service exit the program and two platforms – Boeing's X-45 and Northrop Grumman's X-47 – narrowed down to one. Along the way, the aircraft grew in size and took on the shape it has today. As the X-47 became better defined, its requirements "fell perfectly right into the F100 class," Reed observes.

Pratt & Whitney has a long-standing relationship with X-47B airframer Northrop Grumman, and the F100-220, the F-16 variant of Pratt's F100 family, offered 15,000 pounds of thrust without afterburning – just what the UCAS demonstrator needed.

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An off-the-shelf engine made sense not only due to the limited scope of UCAS-D but from a financial standpoint, as Pratt & Whitney would provide engines (three flight-quality units and one ground demonstrator) at its own expense.

Using an engine that has never operated in a carrier aircraft might appear risky, but the F100's origins meant that operational concerns like gas ingestion tolerance (from steam catapults and other nearby aircraft) had been baked into its design since the beginning. Thus, Reed says Pratt's confidence was high that the F100-PW-220U would have the margins needed to operate safely.

> **Modifying the F100's traditionally round exhaust outlet for the X-47B entailed removal of its afterburner and replacing it with a nozzle converting the air coming out of the round engine exhaust to a shape consistent with the unmanned aerial vehicle's (UAV) roughly oval exhaust.**

Adapting the engine for the X-47B boiled down to two primary challenges: the first arising from the shape of the aircraft and the second from its autonomous flight control system.

“Jet engines are typically cylindrical in shape because we’ve got rotating hardware that turns around the same center all the time,” Reed explains. “But what happens in front of the engine or behind it is where most of the modifications occur. As we get into future [aircraft], intake and exhaust systems will likely not be round but contoured with the airplane. That’s a big part of the job.”

For stealth and packaging reasons, the X-47B has what is called a “serpentine inlet,” meaning the inlet is not in line with the engine. This creates airflow distortion. Fortunately, the F100-220 is very tolerant of distortion. The condition is most pronounced while the aircraft is stationary, at full power, as it would be on a catapult launch.

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"That allowed for the best aerodynamic shape for the airplane – a wide, flat, high-aspect ratio exhaust system. We designed that and it's unique to the 220U," Reed says.

The X-47B unmanned combat air system (ucas) demonstrator takes off from the USS George H.W. Bush (CVN 77) on May 17, 2013. U.S. Navy photo by Mass Communication Specialist 2nd Class Tony D. Curtis

The carrier-specific stresses of hard landings and high *g* launches necessitated replacing the standard F100-200 thrust bearing with a higher strength bearing from the F100-229 used in the F-15E and Block 52 F-16s. Enabling the engine to talk with the X-47B was vital as well.

The X-47's autonomous flight control system communicates in a code different than that of the F100's digital control system, so Pratt uses a translator, called an Engine Interface Unit, which takes commands from the airplane and literally translates them into the code the engine uses in F-15s and F-16s. The translator works well, though a broader program would obviously see full integration of the flight/engine control system.

Fuel might be expected to be a further consideration in utilizing the F100, since the Air Force uses JP-8 and the Navy uses heavier, less combustible JP-5. Despite its career-long use of JP-8, Reed says the F100-220U has run on JP-5 throughout the test program and that jet engines are relatively agnostic to the different blends. For example, the Joint Strike Fighter's Pratt & Whitney F135 will fly in both Navy and Air Force variants without modification.

Throughout the X-47B test program that has spanned more than 50 flights on Air Vehicle 1 and approximately 30 on Air Vehicle 2, "the engine has been absolutely flawless," Reed adds, figuratively knocking on wood.

The operational lessons learned may prove more valuable than the technical ones, from Pratt & Whitney's perspective, since the follow-on Unmanned Carrier Launched Surveillance and Strike System (UCLASS) program will be largely intelligence, surveillance, and reconnaissance focused. An emphasis on range and time-on-station will dictate an approach adapting commercial (high bypass) engines for the Navy's first operational carrier-launched UCAS.

But fighter-type engines aren't going away, Reed says.

"We're working on systems for 2030 and beyond with our partners. Whether manned or unmanned, all of those airplanes are supersonic, highly weaponized, and all of them have afterburner."

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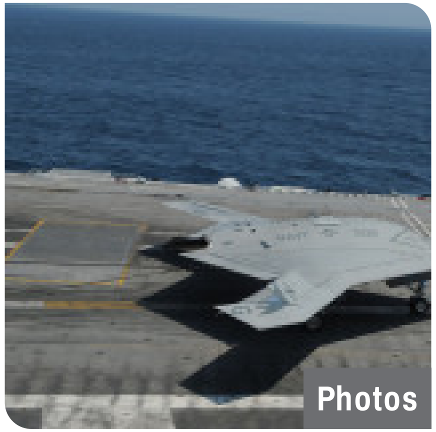

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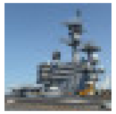

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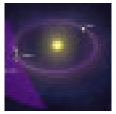

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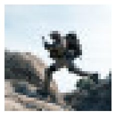

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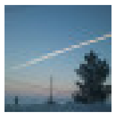

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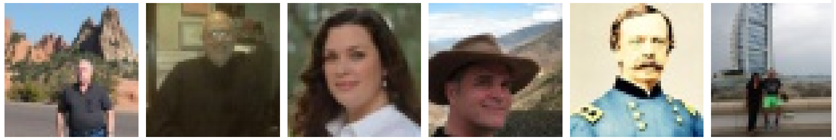

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