LESSONS LEARNED AT PAX RIVER

The Coming of the F-35 Fleet

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Lessons Learned at Pax River: The Coming of the F-35 Fleet

Overview

Developmental testing is a fact of life for operational fleets. As one test engineer commented during our visit to Pax River, "we continue to do developmental testing on the Super Hornet here at Pax." And with more than 50,000 flight hours on the F-35 fleet and an operational squadron with the Marines, to be joined by the USAF this year and the Navy next year, the F-35 fleet has already taken off.

There are currently more than 250 F-35 pilots and 2,400 aircraft maintainers from six nations already trained and more than 110 jets are jointly under construction at the Fort Worth and Cameri production facilities.

The F-35 has become tactically operational in the USMC while the aircraft is undergoing developmental testing by the Pax River and Edwards AFB with an F-35 Integrated Test Force (ITF) for the USAF and USN . What is not widely understood is that the ITF is managing the ongoing developmental testing for the life of the program.

With the scope, complexity and concurrent global reach of the F-35 program, a new approach to testing was set in motion.

As Andrew Mack, the F-35 ITF chief test engineer put it:

When the F-35B Block 2B became cleared for IOC, (VMFA-121) there were many stories about what it cannot do; that really is not the point.

The plane will evolve its capabilities over time based on spiral development.

The point is that is a very capable combat jet at the block it has achieved already.

And the impact is immediate. ---stealth from the sea is brand new for the Marine Corps and Navy.

In other words, the program is one of "spiral development" in which combat F-35 Type/Model/Series (T/M/S) airplanes emerge throughout the process to operate as effective combat assets, even while the developmental testing for all three types of F-35s continue.

Put bluntly, the F-35B in the hands of the Marines is a fully "up" combat aircraft (both airframe, sensors and weapon systems) addition to the USMC Air/Ground team. All Squadron Pilots in Marines, USAF and Navy, and in partner Air Forces will be backed up by the best test community in the world at Edwards and Pax. This partnership forged for decades will continue a dynamic synergistic combat way for the entire life of the F-35 Global Enterprise.

F-35 B Aboard the USS Wasp, May 2015. Credit Photo: Second Line of Defense

For the Lightning II, the past decade of putting together a unique, and innovative approach to shaping the F-35 fleet has paid off and has built a solid foundation for the decade ahead. As US fighter pilots and their partners generate fleet and ultimately

combat experience, that will lead to never ending innovations and developmental testing.

Put bluntly, if you waiting for the end of developmental testing come back in 30-40 years. Meanwhile, the F-35 fleet will have reshaped air combat operations.

The global enterprise is a key part of what happens at Pax River. The UK is an integral part of the team, and as Gordon Stewart, UK MoD flight engineer at Pax described this powerful and productive partnership.

This is the most integrated test team I have ever worked on. As we work the way ahead, it might be a UK person, a Lockheed person, or a US government person who provides the best solution. It is a very well integrated team at the working level.

It is a very different test process than in the past, although what is happening in the F-35 program is the way we are approaching the future as well. In the past, there was much more serial testing.

Twenty years ago when I first started, the contractor would do something and then throw it over the fence to the government, which would look at it, approve it and then pass it on to the operator.

Now with the pace of technology, and the role of software, we have a much more integrated process. We are shaping the evolution of the aircraft as it goes out the door as well.

At Pax, we are testing a software version ahead or a couple ahead of what the fleet is getting at the moment. In effect, we are testing the next iteration of the aircraft.

And the Edwards and Beaufort efforts provide important pieces to the evolution as well. We have an integrated RAF and Royal Navy team at Edwards. 17 (R) squadron at Edwards is a mix of RAF and RN.

At Beaufort, we have a UK team and one of our aircraft, and we are working closely with the USMC. That is another key element of the joint integrated effort, from our point of view.

In an historic first, there was no clearer example of the global nature of the program when the first F-35 to fly across the Atlantic landed at Pax River. At 1430 on February 5, 2016, the first Italian made F-35A flew into the pattern at Patuxent River Naval Air Station, Maryland and touched down.

The Italian AF pilot call-sign "Ninja" had only flown the jet for 50 hours previous to his seven hour trans-Atlantic dead of winter flight. And most amazing for reliability the airplane, which was the first built in Italy itself, had only 15 flight hours prior to the trans-Atlantic flight completed the entire mission "up and up" with no "gripes" or maintenance problems.

The landing of AF-01, which flew first in Italy in September, was by one of the Italian pilots trained at Luke AFB in the Fall and highlighted the progress of the program. The flight from Cameri to Pax River added some hours to the program, which has now more than 50,000 hours flown by the fleet to date.

Historically, allies and partners who operate U.S.-generated fighter aircraft would do so sequentially over time as the type/model/series progressed, with U.S. fighter pilots flying the newest jets first and then allies next as production was generated off of U.S. lines.

For example, the first flight by the U.S. of the F-16 was in 1977, however, it took until 2001 for the first USAF F-16s to be introduced into the Italian AF. Under the terms of a USAF and Italian AF agreement named the "Peace Caesar" program was the lease of F-16s to make up for shortfalls in Typhoons in the Italian Air Force fleet.

Put in blunt terms, the Italians are flying the most advanced U.S. combat jet in current production at the same time as the U.S. services. This provides a unique moment in history and a clear opportunity for shaping new global capabilities.

A key aspect of the global nature of the program is the ability of the fighter pilots of different services and nations to share experiences. With regard to the transatlantic flight, Ninja commented:

I talked with the Marines about their flight – they went from Yuma to Pax – and their flight plan to come over in 2014. They were very helpful. Semper Fidelis is what I have to say about that.

Ninja also underscored that the advantage of learning to operate the aircraft from the ground up was an opportunity to shape new combat approaches as with all members of the first ever concurrent state-of-the art international fighter program. Training, Tactics and Procedures (TTPs) will be applied critiqued and modified over and over bay all Air warriors in the F-35 global consortium. Diversity of experiences can lead to unity of purpose to always have the best TTPs to fight and win in air combat.

The pilots interviewed in January and February 2016 at Pax River highlighted a number of key qualities of the F-35 which they valued and which would allow combat fleets to shape innovative new approaches moving forward.

Among the key qualities highlighted were the following:

- The excellent flying qualities of the aircraft and the advanced flying controls;
- The human-machine interface which allowed the pilots to focus on the mission, rather than flying the aircraft;
- The enhanced safety and security with regard to flying off of or onto amphibious ships or carriers; Because of a very significant feature of the stability of the aircraft which would directly lead to expanding mission training time versus pure flight training about the carriers.
- The integration of the sensors along with the touch screens allowing very flexible management of the mission.

Ninja provided his perspective on the F-35 after he landed in Pax River from the Azores.

The great thing about the F-35 is that the human-machine interface (HMI) is so good and so built around the pilot that you don't have to learn how it works. You just use it. You can configure the screens to configure for the mission.

The aircraft is built to understand; you are building a strategy, not focusing on managing the sensors or really focused on the flying function.

I was able to see the aircraft surrounding me through the clouds, such as keeping distance with my tankers, by using my helmet and the Distributed Aperture System and see the C-130s below me below the clouds.

ATLANTIC OCEAN (Oct. 2, 2015) Cmdr. Tony "Brick" Wilson and Lt. Chris "TJ" Karapostoles exit F-35C Lightning II carrier variant joint strike fighters assigned to the Salty Dogs of Air Test and Evaluation Squadron (VX) 23 on the flight deck of the aircraft carrier USS Dwight D. Eisenhower (CVN 69). Credit: USS Eisenhower

Because we were at Pax, we had a chance especially to talk with carrier pilots as well. For these pilots, the coming of the F-35 C to the carrier is a significant step forward for

the U.S. navy. It is about moving from the limits imposed by the current air wing, and getting on with the innovation suggested by Rear Admiral Manazir to fight more effectively in the extended battle space.

The US Navy cycles operational pilots into the test program and back again. One operational carrier squadron fighter pilot who is now in his test pilot tour at Pax in the F-35 program will go back to the fleet and he put it very bluntly about the impact of the F-35C:

With the current air wing (i.e, with the Super Hornet and Hornet as the tip of the spear), we are wringing out our tactics for a tactical advantage, which is also, at the same time, at the edge of the envelope for survival.

We are spending a lot of time making sure that we have the right tactics and the mastery of those tactics by pilots to survive and succeed.

It is about keeping a level of competence and capability where you're not going to die.

There are points where you have a twenty second window. You miss that window and you might be blown up.

When you're traveling at those speeds, we are talking really only a couple of seconds that you have.

And, if you're not performing tactics exactly as they're prescribed, you put yourself in a kill zone.

With the F-35, we are jumping a generation in tactics and now looking at the expanded battlespace where we can expand our impact and effect.

You need to take a generational leap so we are the ones not playing catch up with our adversaries.

And looking forward with regard to the F-35 and its evolving capabilities, Ninja highlighted a number of key aspects.

This is one of the first aircraft that you can take off and after about two flights dropping bombs, and firing weapons.

Your mission systems are so good that you can start operating weapons very early in your training and operations.

We have to air-to-air pilots working with air-to-ground pilots and merging the cultures.

You are not focusing on your sensors; you are focusing on the end objective of your mission.

The big difference with this aircraft is situational awareness.

You see everything, and I mean on the surface and on the ground and you command attack, defense and electronic warfare functions within the aircraft.

In short, the plane is here and is already reshaping the thinking of several air powers, the USMC, the USAF, the USN, the Australian RAAF has generated its Plan Jericho to leverage the plane, the RAF sees it as a key part of its triple transition involving modernization of Eurofighter intersected with the F-35s flying from their new carrier, the Italians are doing a double transition with Eurofighter modernization with F-35s, the Norwegians and Dutch are preparing to fly an all fifth generation fleet. And all of these squadron pilots are currently flying together at Luke AFB with the F-35As and for the USMC and RAF at Beaufort Air Station with the Bs.

The future is now.

The F-35 Learning Curve

Pax River is the home of a key F-35 Integrated Test Force (ITF), which is focused on various aspects of the sea services F-35Bs and F-35Cs. The ITF test regime is on the airframe, and flying characteristics in modes both symmetric and asymmetric, of the Lightning II.

Another F-35 test center is at Edwards AFB and is focused on expanding the flight envelope for the F-35A variant and verifying the capabilities of the mission systems and the fusion of information in the cockpit for the Lightning II force.

One of the most under appreciated aspects about the test program is how the concurrent learning among the various test centers provides enhanced confidence and accelerates testing with all T/M/S of this new aircraft.

The cross learning from the USMC F-35B, the service's first T/M/S to achieve IOC, to the USAF F-35A to the USN F-35C model — with the preparation of the first RAF F-35B squadron — has meant that the USN can operate its Cs more rapidly and with more confidence and capability than in a traditional single-model aircraft test program.

The developmental testing across the board at Pax is converging on the emergence of an airplane that features excellent, handling qualities. Every F-35 pilot interviewed by the *Second Line of Defe*nse team over the past few years has commented on the stable flight characteristics of the Lighting II. This was especially being proven in the most demanding and unforgiving combat flight requirements — carrier operations in all weather and sea sates.

It was noted that just like the USMC experience with F-35B, flight stability and control for safety and ease of a vertical landing, the same man-machine interface albeit different for Carrier arrested landings, is built into the F-35C.

Consequently, the prospects for reducing initial pilot training and re-qualification time for experienced Naval Aviators on the basics of safe landings and take-offs —with regard to both vertical and angled deck carrier flight ops —is a noteworthy accomplishment of the F-35 design.

This eventual reduction in required training for deck and carrier qualification means more flights can be used for tactical training.

An especially important impact maybe experienced with new pilots or "nuggets," first tour aviators, who may have a safer basic training focus on landing and take-off requirements, requiring fewer hops because the aircraft is essentially easy to fly. If this is the case, then more expanded tactical training and operational time can be built into the Training & Readiness (T&R) syllabus within the same amount of resources required by an AV-8 or an F/A-18 just to learn and also stay current.

During our visit to Pax, we had a chance to discuss the test approach, test results and thinking about the way ahead with two key members of the ITF.

The first was with Tom Briggs, F-35 Pax River ITF Air Vehicle Engineering Department Head, who has more than 25 years of naval aviation test experience and has tested aircraft during 25 different at-sea detachments..

The second is CDR J. Ryan Murphy, the USN Director of Test and Evaluation, F-35 Naval Variants. CDR Murphy is an F/A-18 pilot with significant operational experience — including command of Strike Fighter Squadron (VFA) 143 — and highlights the Navy approach for test pilots to come in and out of the operational community.

Question: From your perspective, how have you built synergy across the broader test community?

Briggs: An under-appreciated reality is that the commonality of the aircraft allows the USAF and USN test communities to work closely together in shaping the way we test. Aircraft characteristics or anomalies, which the Air Force may see first at Edwards, we can leverage and vice versa.

We do a lot of information sharing with Edwards down at the individual team level. Our propulsion testers talk with their propulsion testers. Our weapons testers coordinate with their weapons testers. Our flying qualities folks talk with their flying qualities folks. So we understand what they have seen before we go into a similar line of testing and we share flight reports.

If there's a problem that they see, we take a look at our data to see if we have something similar. If we start to see a problem, we let them know so that they can take a look as well. Together we leverage our testing and ensure the other capitalizes on what we've found.

There's a lot of that sharing that goes on, which frankly, for me, on a Navy test site to hear regularly from an Air Force test site is a little bit remarkable. Together we make

that work and we do our best to keep each other moving forward with our test programs.

And, that's allowed us to take some very quick steps and very large steps during our testing. If you take a look at the density of test points across the entire envelope versus a legacy flight test program, the F-35B and C testing is much thinner.

And, by the time the F-35A has done something, the F-35B test approach is less dense. And, by the time we do it on the C, it's even less dense. So the amount of data we need to gather for specification verification is markedly reduced by the time we're doing it with the third variant.

The significant commonality built into the program allows for convergent ways to work the way ahead.

The electro-hydro static actuators, which work well on the A at 9Gs, work pretty well on the B and C at 7Gs. In effect, instead of having three test programs, you have in effect something like a one and a half or twofold spread over the three variants.

And, when you look at Edwards, where the mission effectiveness testing is occurring, they fly different mixes and matches of aircraft, F-35Bs with F-35Cs and with F-35As. In a lot of cases, it's two F-35As and an F-35B and F-35C in the mix.

So, the sensors, the communications back and forth between the aircraft, and the maturing of the software happens across multiple variants at the same time.

We are shaping joint operations from the ground up if the service cultures can embrace this change.

Question: Let us focus on the at-sea Developmental Testing done to date on the F-35C.

CDR Murphy, you came to Pax five months ago after your most recent operational deployment.

How would you characterize what we have seen and will see in the F-35C DT process?

CDR Murphy: For the C, when you look at DT-I, DT-II, DT-III, by and large, they are very similar to each other. What changes is aircraft, how we have the aircraft loaded. DT-I was just the basic aircraft with no ordnance. For DT-II, we added internal stores. For DT-III, we're going to have internal and external stores on the aircraft.

The testing you saw on DT-I and DT-II focused on the handling qualities behind the ship, landings with and without crosswind, launches with and without crosswinds, and minimum end speed catapult launches.

Those kinds of tests are going to be the same kind of tests we do on DT-III.

The difference will be that we are going to do them with a heavier aircraft with external stores.

Also, we're not going to have a whole lot of fuel to play with because we're carrying so much weight in ordnance.

Question: The handling qualities of the aircraft have been clearly noted by the pilots. What will be the impact of the performance gains by the aircraft in the hands of the operators?

Briggs: The flight control capabilities of the F-35 have already made it clear that the F-35B training burden should be much less than the Harrier, particularly in preparing pilots for recovery aboard ships; and with the approach handling qualities in the F-35C, there should also be less preparation required for shipboard landing with the F-35C versus the current F/A-18 platforms.

Carrier landings are demanding and require a great deal of training, with the pilot controlling the proper glide slope, line up and angle of attack.

With the F-35 control laws, the aircraft is dramatically assisting the pilot, and the pilot is now setting and monitoring the aircraft rather than controlling everything on the approach to the ship.

And, we will see how the new pilots — versus more experienced pilots — can benefit from these flight control capabilities built into the aircraft.

CDR Murphy: We will see the real impacts as the airplane comes to the carrier deck. The aircraft performs so well behind the boat, we could well see a reduction in training time with regard to flying the aircraft, especially around the carrier.

The key benefit is that as the amount of necessary training time to fly the aircraft goes down, the amount of available tactical training time goes up, which will be a significant gain for the fleet.

Question: The Navy is the last service to acquire the F-35 and has been widely perceived as dragging its feet and providing significant opposition to acquiring the aircraft.

Does this mean that the roll out of the culture changes (of the sort you are talking about) will see a slow cycle as well?

CDR Murphy: I do not think so.

There has been a barrage of literature out there, which has not always painted the aircraft in a favorable light, and our carrier pilots read that literature.

But, as the cadre of pilots grows and the aircraft makes its way to decks of carriers, you will see significant change rapidly.

We operate air wings; meaning that when a new air system comes to an air wing, the entire air wing is affected and its culture changed.

And, since the air wing trains together and deploys together, the F-35 will become ingrained as part of that air wing very rapidly.

Other Navy air wings will look at this experience and competitively seek to be as good or better than the last air wing that operated the F-35. Peer pressure is a powerful learning tool.

Question: Although the F-35 represents a very new capability, it stands on the back of what has been done in the past, and harvests the results of significant work from before and operational achievements of earlier air systems.

How do you view this aspect of the learning curve?

Briggs: You have hit upon an important point.

The handling characteristics of the aircraft are unprecedented.

Its flight controls scheme and the amount of automation are re-shaping the pilot's role, allowing them to focus on the tactical and strategic aspects of their mission, rather than on how they control the aircraft to be in the right part of the sky at the right time, or how they will recover aboard a pitching carrier at night.

We are where we are because the F-35 program has leveraged the development work of programs like the A-12 and the Navy's MAGIC CARPET initiative, as well as the significant investments in risk reduction that were made early in the F-35 program.

The investments in risk reduction during the concept demonstration phase of the program and the final aircraft, which are now being built, has been significant.

And these investments are paying off in the robustness of the F-35B lift fan and propulsion system, in the precision of the flight control system, and other key elements that make this a very effective aircraft from a flying characteristic point of view.

Question: The Navy seems to rotate the test pilots here from operational squadrons into the test program. How important is that?

CDR Murphy: Very important.

From a test perspective, having recent operational experience allows a test pilot to tie any aircraft deficiencies directly to the impact that deficiency might have on the mission.

When test pilots rotate back to the fleet, they take with them the knowledge and experience they have gained working on their particular program, in this case the F-35.

This provides a basis of knowledge in the fleet and assists in the introduction of the aircraft.

It's amazing the difference between a Lieutenant or Lieutenant Commander test pilot traveling from Pax River to an operational air station and talking to people about the F-35 as opposed to even that same Lieutenant or Lieutenant Commander who is now a part of an operational squadron talking about flying the F-35.

To many young pilots who have not reached the end of their first operational tour, that operational Lieutenant or Lieutenant Commander has a lot more credibility as a squadron pilot than he did six months earlier when he came down from Pax River, even though it is the same person.

The Emergence of the F-35C and Its Impact

In a visit to Pax River on January 8, 2015, we had a chance to talk with members of the Integrated Test Team at Pax River, which includes Marines, Navy, Brits and civilians as well as contractors.

This team is wringing out the F-35C from the standpoint of its ability to operate on the carrier. The team looks at flying characteristics not the mission systems, which are tested at Edwards AFB.

Because the Navy pilots involved in the testing rotate from operational combat squadrons, discussions with them highlight the coming impact of the F-35C on the air wing as well. They can discuss with expert authority the culture gap between the F-35C and the Hornet, the 4th Gen fighter/strike aircraft currently operational in all USN Carrier Air Wings.

As test pilots, having gone through very vigorous school and fleet operational experiences, they are uniquely qualified to understand the dynamics of change associated with the coming of the USN F-35 Lighting II into the fleet.

On this visit, we engaged with USN Test Pilots. Our last visit was to engage with the USMC Test Pilots flying the F-35B. It should be noted that both Navy and Marine avia-

tors wear the same Navy Wings of gold, and Marines —in addition to flying the F-35B — will also have USMC squadrons of F-35Cs on board Navy carriers.

In this interview, we had a chance to discuss the results to date and the way ahead with LCDR Daniel "Tonto" Kitts, a VX-23 Test Pilot who is working on F-35C carrier suitability. "Tonto" is now working as a test pilot focusing on carrier suitability, but he also has significant operational experience with the "Rhino," otherwise known as the Super Hornet. He was the det officer-in-charge (OIC) for the second phase of carrier landing testing in CVN DT-II and is preparing for CVN DT-III later this year.

Also participating in the interview was CDR Theodore "Dutch" Dyckman, a fleet combat pilot and now a VX-23 Test Pilot and the Pax River ITF Operations Officer. CDR Dyckman flew in both DT-I and DT-II and is preparing for DT-III later this year.

We discussed a wide range of issues, which demonstrated the breadth of knowledge and experience of these two pilots, but the interview presented here focused on the demonstrated flying qualities of the F-35C and the perceived impact of those capabilities on carrier qualifications and operations.

We also touched on the significant gap between their experience and the broad perception that the Navy is reluctant to become an F-35 force, which is most definitely not true.

Question: Carrier landings are challenging.

They are dangerous and require a lot of training to get them right and to enhance the safety of the pilot, the crews, and the ship.

In fact, during the Vietnam War, there were tests done of carrier pilots' heart rates which we actually higher when landing on a carrier than when being shot at over Hanoi.

How does the F-35 affect the landing challenges associated with trap and cat operations?

Answer: The plane flies very well.

The flying qualities are excellent and the machine systems built into the plane significantly enhance the ease of landing and taking off from the carrier.

The F-35C Aboard the USS Nimitz during DT-1. Credit: US Navy Media

Basically with the F-35 you get your mission cross-check time back. Normally once you start the approach your scan is solely meatball, line up, and angle of attack. Your mission cross-check time behind the ship is zero because you're just doing that scan.

With the F-35 and its enhanced flight controls and superb handling, the aircraft doesn't deviate much from the desired flight path, which greatly eases the workload on the ball and frees up your scan. It almost makes flying the ball a relaxing task.

Question: Ease of flying can clearly translate not just into safety but training time.

What do you see as the impact?

Answer: Before you go to the boat, everything stops in the squadron. All training stops two to three weeks where all you're doing is banging left-hand turns. No one is doing any tactical training.

Everyone's bandwidth is concerned with how they are landing at the ship. Once you've been out on the ship for a few days and the landings are looking better, then finally you can start working on what we want to work on again tactically.

Where you've just taken a pause from all your tactical performance for the past nearly month, that's going to go away with the F-35, which will allow you to be dedicated to your tactical performance.

Question: Clearly, the Super Hornet is an excellent airplane, but the F-35 is a very different aircraft with a different approach to air system operations.

How do you see the F-35 affecting tactical training?

Answer: With the current air wing, we are wringing out our tactics for a tactical advantage, which is also, at the same time, at the edge of the envelope for survival.

We are spending a lot of time making sure that we have the right tactics and the mastery of those tactics by pilots to survive and succeed.

It is about keeping a level of competence and capability where you're not going to die. There are points where you have a twenty second window. You miss that window and you might be blown up. When you're traveling at those speeds, we are talking really only a couple of seconds that you have. And, if you're not performing tactics exactly as they're prescribed, you put yourself in a kill zone.

With the F-35, we are jumping a generation in tactics and now looking at the expanded battlespace where we can expand our impact and effect.

You need to take a generational leap so we are the ones not playing catch up with our adversaries.

Question: Admiral Manazir talks about shaping greater reach for the carrier and your point is that with the coming of the F-35 your tactics will change?

ATLANTIC OCEAN (Oct. 2, 2015) - An F-35C assigned to the Salty Dogs of Air Test and Evaluation Squadron (VX) 23 makes an arrested landing aboard the aircraft carrier USS Dwight D. Eisenhower (CVN 69).

Answer: That is correct and the air wings will rapidly recognize the impact as they get their squadrons of F-35s. They will put in the rear view mirror all of the uninformed comments made by many people who do not know the aircraft and what it can do.

And what we see as testers will proliferate rapidly in the fleet as squadron pilots see the impact on their lethality and survivability.

Question: There clearly is a cultural challenge in the Navy in making the transition.

How do you view this transition as working out?

Answer: Navy leadership is clearly leading the charge, people like Admiral Manazir and other leaders.

Naval Aviation is clearly focused on integrated warfighting in the expanded battlespace. The F-35 is a key part of that focus.

The air wings are not yet a key part of that transition, but when the planes get to the squadron, change will happen more rapidly than many people think.

Already, the first training squadron of F-35s came to Fallon for an exercise and that was an eye opener for Fallon.

The knowledge is there inside the Navy.

And, equally important, is getting it down to the user to understand what the airplane is going to do and to accept what's already been designed to do.

That is the challenge.

Editor's Note: There is another aspect of the impact of fifth generation systems on pilots, notably the new pilots who come directly into fifth generation systems.

A key point was made about an Aussie F-22 exchange pilot who is an experienced F/A-18 operator.

For RAAF Fighter Pilot Matthew Harper, the systems in the fifth generation aircraft, which take a giant leap forward with the F-35, provide the pilot with a decision making role, not an over-burdened "look at your screens" and sort out what to do role.

He summarized the impact that he saw with three key examples:

First, within the first 30 minutes of sitting down in the simulator, he grasped that his ability to dominate the air space with the F-22 was clear.

Second, the abilities of the pilots are significantly augmented with fifth generation capabilities. He cited a recent example where a USAF pilot with only 350 total flight hours flew in Red Flag and dominated his airspace. For Harper, this would be virtually impossible to imagine in any other plane.

Third, he cited the experience of a USAF F-15C pilot who told him:

"I have more SA with only 20 hours on the F-22A than I ever had with over 1500 hours on the F-15C."

The overarching point of the presentation was that the fifth generation experience was about disruptive change, not evolution. You needed to get into the fifth generation platform to experience the change and learn how to shape tactics and concepts of operations relevant to 21st century operations, rather than perfecting your 20th century piloting skills.

He went out of his way to compare the Super Hornet to the F-22A with a core focus on how the former was NO WAY the later. Whereas the F-22A was an SA and information dominance machine, the Super Hornet was a classic aircraft which had the limitations of any airplane not built from the ground up to be an information dominance aircraft for the 21st century battlespace.

While the Super Hornet is a significant upgrade from the Hornet, it is not and never will be able to deliver what a fifth generation aircraft can deliver: integrated data fusion and re-shaping the pilot and squadron roles in prosecuting air dominance and support to the joint force in the battlespace.

In short, the leap ahead is crucial; and reworking the culture of the RAAF will be necessary to leverage the disruptive technology built into fifth generation aircraft.

The UK at Pax River: Integrated, Innovative and Creating 21st Century Airpower

Our visit to the Pax River Integrated Test Force (ITF) concluded with an interview with two members of the British contingent of the ITF, along with a senior U.S. test engineer — which, in itself, was a demonstration of how the ITF works as the UK is an equal partner in an integrated team effort.

UK Pilots and engineers contribute to the overall roll out of capability for the F-35 program, as well as the U.S. contributing to a number of aspects of the UK F-35B roll out as well.

In addition to the obvious leveraging of cost efficient synergy, all F-35 pilots and test engineers being present at the source of engineering and flight test challenges avoids miscommunication and any lag time of important two-way information. It is a partnership wisely forged to deliver the best and safest aircraft for combat.

And, it is a harbinger of continued success for the concurrent development of the global F-35 combat enterprise.

What was striking about the day was the significant gap between the working reality of the dedicated professionals in the F-35 program, including test pilots putting their life on the line every flight, and the world only a few miles away inside the Beltway. At Pax, the F-35 is moving rapidly to becoming a 21st century combat reality.

Ski jump testing of F-35B at Pax River. June 2015.

Many cubical commandoes have made a career using second order interlocking google searches that are essentially hypothetical opinion pieces with no actual research to comment on the F-35. The vast amount of 'literature" discussing the plane has little or nothing to do with the reality at Pax and all the actual tactical flying going on at many military airfields where the F-35 fleet can be found.

What has been missed is the success of this new approach and a revolutionary tactical aircraft with the best cockpit information fusion system in the world shaping the way ahead. Key elements, now being realized, that were built into the program to drive effective capability evolution going forward have been simply ignored or disdainfully and ignorantly mocked in print.

The ITF at Pax is a case in point whereby the cross learning is significant; and the cross learning with Edwards — as well as squadrons elsewhere — a key driver in innovation.

The F-35 as it evolves its software, and its ability to shape a more integrated combat capability in the extended battlespace is about a 21st century "no platform fights alone" capability; it is not about getting ever more proficient in yesterday's tactics, and systems; it is about a generational leap. The ITF at Pax understands this and is a key driver for such change.

The future is in good hands if the quality of the three members of the ITF interviewed about UK developments is any measure of the way ahead.

The first member of the discussion about UK engagement was with Gordon Stewart, UK MoD engineer, with significant Harrier experience and a key participant in recent ski jump testing.

The second member was Squadron Leader Andy "Gary" Edgell, RAF Test Pilot, who is an experienced Harrier pilot and extensively involved in the F-35B and F-35C testing process.

The third member was Tom Briggs, who was part of an earlier group of interviews, and is the F-35 Pax River ITF Air Vehicle Chief Test Engineer, who works closely with the Brits in shaping the capability that will fly to the UK in the form of the first IOC UK squadron in 2018.

As we have noted earlier, the UK is shaping its first operational squadron in the US, which will then fly to the UK in 2018 in time for the Queen Elizabeth sea trials. At the

same time, the UK is building out its UK infrastructure to move forward as a key element of what will eventually become a European F-35 air enterprise.

In blunt terms, this means that the UK will have its aircraft at least three years earlier than if relied simply on building its own infrastructure and then generating an operational squadron from that infrastructure. This is a factor which is largely ignored by the critics of the program.

Question: How does the ITF work from a UK point of view?

Gordon Stewart: "Let me speak to my case. I am employed by QinetiQ, but I am working here on behalf of the UK Ministry of Defence. At the ITF, there around 900 people working here with the vast majority being U.S. Around 2/3s of the work force are contractors, and a third is government, and within that mix there are a number of UK nationals.

The UK is the only level one partner in the F-35 program, which means that we are more closely involved in the test phase of the program than other partners. And, in my case, I work as a Flying Qualities (FQ) engineer on the 30-40 person FQ team as an integrated member.

As FQ engineers, we look at things like flight control laws and how the pilot interacts with those controls and what the aircraft feels like to fly in a wide range of conditions. Where we do identify issues as we expand into new areas of the flight envelope, we work closely with the control law designers in Fort Worth to have those issues resolved.

We deal with the software that relates to flight controls, and those systems feeding data into the flight controls from the mission systems. Things like how the aircraft is going to get information from the ship as to where it is, what direction it is going, or how fast it is going. There are pieces of that which feed into the flight controls to help with recovering the aircraft to the ship and making that whole process safer, and more effective."

Question: The UK is making a joint investment in development and your role is to have a foot in both camps so to speak.

You deal directly with the UK air worthiness certification process as well from the standpoint of being dual hatted within the ITF?

Gordon Stewart: "Part of my job is operating in the same role as the US personnel. This gives me the benefit of direct involvement in the program at a working level, and allows the ITF team here to benefit from my UK STOVL test experience.

At the same time, my engagement here helps the UK process, for when the UK-based airworthiness team has a question back in the UK, we are often able to provide answers based on our unique position here within the ITF.

I was involved with the DT-II Short Takeoff and Vertical Landing (STOVL) testing aboard USS Wasp and in the preparations for STOVL DT-III this fall. This type of UK involvement in US ship trials allows us to feed our experience into the planning for UK First of Class Flight Trials on HMS Queen Elizabeth."

Question: The integrated part of the F-35 effort is often ignored.

How would you describe the approach to integration in the test team at Pax River?

Gordon Stewart: "This is the most integrated test team I have ever worked on. As we work the way ahead, it might be a UK person, a Lockheed person, or a US government person who provides the best solution. It is a very well integrated team at the working level.

It is a very different test process than in the past, although what is happening in the F-35 program is the way we are approaching the future as well. In the past, there was much more serial testing. Twenty years ago when I first started, the contractor would do something and then throw it over the fence to the government, which would look at it, approve it and then pass it on to the operator.

Now with the pace of technology, and the role of software, we have a much more integrated process. We are shaping the evolution of the aircraft as it goes out the door as well. At Pax, we are testing a software version ahead or a couple ahead of what the fleet is getting at the moment. In effect, we are testing the next iteration of the aircraft.

And the Edwards and Beaufort efforts provide important pieces to the evolution as well. We have an integrated RAF and Royal Navy team at Edwards. 17 (R) squadron at Edwards is a mix of RAF and RN. At Beaufort, we have a UK team and one of our aircraft, and we are working closely with the USMC. That is another key element of the joint integrated effort, from our point of view."

Question: You are part of the F-35B process as well as the coming of the new UK carrier.

What changes involved with the ship affect the F-35B and how does the F-35B handling process affect the ship?

This question was discussed by both Gordon Stewart and Squadron Leader Edgell and they focused on four key elements.

First, the handling qualities of the aircraft are so dramatically different from the Harrier that they could approach ship operations very differently. Rather than being heavily focused on flying the airplane, they could focus upon the mission.

Squadron Leader Edgell: "I can still remember vividly a Harrier flight from HMS Illustrious in really rough sea conditions where I launched to conduct 1v1training with the Typhoon. As I was fighting the Typhoon, the whole time, in the back of my mind, I was thinking of the difficulties that awaited me when recovering to the carrier. My mind was not fully on the task of fighting the Typhoon because I was concerned with the challenges that lay ahead.

With the F-35B, this problem is significantly ameliorated. The whole confidence factor of getting home safely is just another step in the generational jump provided by this aircraft."

Second, the U.S. was building the Joint Precision Approach and Landing System (JPALS) as the ship-air integration pairing system; the Brits were building in a new system, the Bedford Array Landing System, onboard the carriers, to work with the F-35 man-machine system, to enhance the safety and effectiveness of landing at sea.

Squadron Leader Edgell: "The Bedford Array Landing System is a formation of lights embedded within the deck. When the ship is pitching, then the system compensates by changing which lights are illuminated so that from the pilot's perspective he has a fixed aim point for landing. But, in reality, the aim point is actually moving up and down the deck."

Third, the UK carrier and its ski jump provided a way to better use deck space.

Gordon Stewart: "The ski jump offers improved take off performance compared to a flat deck take off. For a heavily loaded jet, this translates into a shorter deck run or lower wind over deck requirements, which offers the ship flexibility in how the deck is used."

Fourth, based on all of the above, the UK was very successfully pioneering SRVL or Shipboard Rolling Vertical Landings.

Squadron Leader Edgell: "Normally, RVL {a slow speed, fixed glidepath approach in the semi-jetborne flight regime} is a land-based recovery option. Historically, when we took Harriers back to a ship, we recovered via a vertical landing, which is purely jetborne flight.

Given the culmination of various qualities of the F-35B, we can now conduct semi-jetborne rolling vertical landings onto the carrier, known as Shipborne RVLs. Using the additional airflow over the wing, and the subsequent gain in lift, this approach provides flexibility in operations due to the extra 'bring back' - a term given to payload returning to the carrier vice jettisoning prior to recovery."

We then returned to the earlier discussion of the ITF approach and its future. But, prior to that we asked Tom Briggs to clarify what has become almost the holy writ for some analysts, namely, that the F-35B engine is a showstopper for the decks of the ships on which it will land, because of the impact of engine heat on the deck.

Briggs: "We have focused on this from the beginning and it is clearly not a show stopper — and, at this point, not even a serious issue.

When we were on the first sea trials aboard the Wasp there was deck degradation from a hot engine, but that engine belonged to the Osprey. The landing was not perfect, so there was some deck scorching from the Osprey engine.

It's not that the F-35B engine is not putting out a lot of heat; it is. But, in part, the flight control system and the propulsion system are controlling that output and reducing the amount of time you're exposing heat onto the flight deck."

The next DT test will focus in part on the F-35B and its flying qualities in terms of operations in higher sea states and difficult sea operating conditions.

Gordon Stewart: From a purely handling point of view, we expect this aircraft to operate much better than the Harrier in returning to the ship in difficult sea states. We expect to have better systems to guide you back to the ship and to get you on there more safely and effectively."

The F-35 integrated test approach is both a glimpse of the future as well as a foundation for that future. The fusion cockpit of the aircraft, as well as the integration of the fleet and its impact and its ability to extend the reach of the carrier as part of integrated operations, provides a challenge to reshape the testing approach going forward.

According to Briggs: "So we're getting at F-35 now. But, if you take a look at some of the initiatives that are going on with the integrated warfare capabilities, and how you are going to marry up its sensors, its fusion engine, how you stimulate it, how it responds, and how you integrate them into a network architecture — that is where we are going.

It is not an in and of itself aircraft. It is a significant network enabler.

In the test community, and for the F-35 this is mostly at Edwards, we are taking a look at how the aircraft, the ship, the satellites are responding, communicating, talking, displaying. There is a lot of effort going on in that. The Navy's spent a fair amount in their network integrated warfare capability."

And, it should be noted that the next partner to benefit from Pax River for its F-35 program will be Italy. Recently, Italy flew its second Italian built F-35, known as AL-2. Feb-

ruary 4, its mate AL-1 will fly across the Atlantic fueled by an Italian KC-767A tanker to Pax River for further testing.

This is just another example of the collaborative approach built into the F-35 program.

Editor's Note: What the Pax River testers are doing is concurrent testing, not serial testing. As the testers made clear throughout the visit, this is the way ahead, not going back to serial testing.

Secretary Wynne made this point during a visit to Eglin AFB in the fall of 2013.

After his presentation to the leadership of the 33rd Fighter Wing, Secretary Wynne was asked to discuss the challenge of what is called concurrency. The answer by Wynne provided one of the best understandings of the reality of the approach taken in the modern aerospace industry.

There would have to be concurrency no matter when you started the process.

Because we tend, in industry, to hire to a very tight line; enough to get the job done; but not enough to be accused of introducing an overrun. As a result, we do not see the funding to the full up line that industry would like to maximize efficiencies.

And industry will not put people on until they get slightly behind schedule. This is because we're so worried about people cutting the program back, as the start is usually contentious, and up the line customers threaten to leave us high and dry and having to lay off a bunch of recently hired people.

And the other thing is one does not discover many problems until we get later in the program. The top-level design is roughly perfect; with the devil in the details. This is called integration.

Concurrency tends to sway like a pendulum of a clock from we want to involve the users early because we want the user feedback, and we want the engineers to get beat up and understand that they screwed up in the design. This is called direct feedback.

But you can't get that if you wait, wait, wait, wait, and then have the tests and all your engineers have gone onto other projects, and they never actually meet the user because we waited so long.

And then the other side of it is, if you waited, would you really have solved that problem?

I don't know.

It is a question of balance. Every program manager is going to be subject to demands to meet the IOC as quickly as possible versus counter demands that they should've waited and fed in changes to airplanes number one through twenty before going operational. Only when top leadership takes overt possession of the Program Manager's (PM's) dilemma is it called concurrency.

We will always want to feed in the air changes to airplanes one through twenty.

But doing development without deployment guarantees you will not have a new asset out there reshaping capability.

It also guarantees that the impact on operations will be shaped by testers, and not by operators.

An Italian First: The F-35 Crosses the Atlantic and Lands at Pax River, February 5, 2016

Last week saw one of the worst snow storms ever experienced in the Washington DC area. And the weather the last couple of days have been rough as well with storms and heavy rain.

But yesterday after a stormy beginning, the sun peeked through at Naval Air Station, Pax River, and like Le Bourget many years ago was about to witness and historic first. At 1430 on February 6th, AF-1 poked its nose into the skies around Pax River and landed at the facility which functions in an integrated manner with Edwards AFB as the home of the integrated test team of the F-35.

Historically, allies and partners who operated U.S.-generated aircraft would do so down the line so to speak as production was generated off of US lines. For example, the first flight by the U.S. of the F-16 was in 1977. The first F-16s came to Italy in 2004 on a lease to make up for shortfalls in Typhoons in the Italian Air Force fleet.

AL-1 touches down at Pax River after flying from the Azores across the Atlantic. Credit: Lockheed Martin

Four years ago, a field at the Cameri Air Field near Milan Italy, began development of an F-35 final assembly plant, the first outside of the United States for the F-35. Here the Italians are building wings for the F-35 program, in general – the first integrated onto a USAF F-35 recently – and full up planes for themselves and the Dutch. The first F-35 came off of the line in early 2015. Then on Sept. 7, 2015 the first F-35A assembled outside the US, made its very first flight from Cameri airbase. Later in 2015, the Italian AF took delivery of AL-2, the second F-35 built in Italy.

In stark contrast to the F-16 experience, the first F-35A to cross the Atlantic was flown by Italy not the USAF. Put in blunt terms, the Italians and the partners are flying the most advanced US combat jet in current production at the same time as the US services, which provides a unique moment in history and a clear opportunity for shaping new global capabilities.

The landing of AF-1 – which flew first in Italy in September – by one of the Italian pilots trained at Luke AFB in the Fall highlighted the progress of the program. The flight from Cameri to Pax River added some miles to the program which is nearly 50,000 miles flown by the fleet to date.

The pilot's call sign is Ninja and we interviewed him when he flew the F-35 at Luke in the Fall of 2015. During that interview he highlighted the unique international quality of the program:

Question: What does an integrated F-35 fleet bring to coalition combat, from your point of view?

Answer: *We will write the TTPs together.*

The commonality from the very beginning will be built into any operation which you do with your coalition partners.

And we are working from the ground up with the USAF, which is different as well from before.

We have made significant progress in the past two years, which is often not grasped by those not involved in the program.

And let me return to the point we discussed earlier about the difference between multi-mission and multi-tasking and the impact on operations.

You do not have to switch your configurations for air-to-air to air-to-ground or whatever the mission for which you have been pre-configured.

You can do what you need to do with the situational awareness built into the jet and the fleet and then fly to the mission.

After Ninja landed, reporters had a chance to discuss the flight with Ninja, and we will provide a full report on that interview in the near future, for it was comprehensive and wide ranging in discussing the jet and its clear capabilities right now resident in the aircraft.

It should be noted that the jet flew with a Eurofighter, an Italian KC-767 tanker and with two C-130s for support for rescue in case needed. Flying across the Atlantic in winter against heavy head winds is no picnic, but the jet not only had no problems, but performed with ease and comfort according to Ninja.

Although the jet has enough fuel to fly from the Azores to Canada without refueling, it was refueled in flight three times for safety and security. It was refueled twice in the clouds, and the flight controls allowed the aircraft to do the air refueling very well and with the DAS system built into the jet and accessed as well by the helmet, the pilot was able to see all members of the formation even through the clouds. He shifted from autopilot to hand flying as appropriate throughout the flight of seven hours from the Azores.

He emphasized that the plane was easy to fly, rock solid ("I have no gripes") and as we saw at Nellis adjusted the very flexible two screens to provide the data which he needed to manage the flight across the Atlantic in formation. He pushed across against 120 knot headwinds. The helmet worked well; and the ergonomics were excellent for the flight as he was comfortable throughout the flight.

And he was doing all of this after having only 50 hours of flight time in the jet!

Although accompanied by much more attention and publicity, the famous formation flight by Balbo and his mates with 12 hydroplanes from Rome to Rio de Janeiro, the flight by a Ninja more than 70 years later was also a first of historic significance. But in this case, an Italian delegation, five journalists and the welcoming Pax River F-35 ITF was what greeted him.

Ninja Discusses His F-35 Flight Across the Atlantic: The Right Stuff Italian Style

On Feb. 5, the Italian Air Force's first F-35, AL-1 with code "32-01" and markings of the 32 Stormo Wing landed at Naval Air Station Patuxent River, Maryland, at the end of the JSF's first ever transatlantic flight.

The aircraft was piloted by "Ninja," an Italian Air Force test pilots, belonging to the Reparto Sperimentale Volo (Test Wing) from Pratica di Mare, and who had successfully completed his initial F-35 flight training at Luke AFB in November 2015.

To put this in perspective, the pilot had only 50 flight hours of F-35 flsying experance. And the Lightning II Ninja flew across the North Atlantic in winter had only 15 flight hours on before he took off on his historic flight. 32-01was the first plane to came off of the Italian assembly line at Cameri Italy..

And this was done in the middle of winter, flying in and out of cloud layers over the turbulent North Atlantic against 120 knot headwinds. It was remarkable flying.

After his 7 hour flight he sat down with reporters to discuss the flight and what he sees as the way ahead for the F-35 program.

"We started from Cameri. We had bad weather. For the first day, we went from Cameri to Lajes AFB in the Azores via Palma de Mallorca. This was the first time the F-35 had landed in Portugal. We had to wait out the weather for a day and then flew the 2000 plus miles past St Johns to Halifax to the Boston area and then we arrived in Maryland.

For safety and security reasons, we had four air refueling during this second leg, and given how bad the weather was the fourth refueling was done close to Pax River again for safety and security reasons. The flight lasted 7 hours.

We had to go through a Cold Front and heavy headwinds (120 knots). Five out of seven were flown in difficult conditions."

Question: You flew in formation and through heavy clouds, we understand?

Ninja arrives at Pax River after the 7 hour flight from the Azores. Credit: Lockheed Martin

Answer: "We had four aircraft total; and kept tight formation; and refueled in the clouds as well. We had two C-130s just in the case; the tanker, a Typhoon headed to Red Flag and the F-35."

Question: So you were in a new aircraft, single engine, flying in the middle of winter across the North Atlantic in heavy headwinds?

Answer: That characterizes it.

Question: Did you hand fly the plane to stay in formation?

Answer: The plane is very reliable, and I hand flew some times, but auto pilot handled a great deal of the flight.

Question: What about the air refueling events?

Answer: We had 100% success even in the clouds; the big thing here is that the plane is very stable and reliable with no problems. We had no disconnections; the F-35 is a very stable airplane.

Question: This is the first F-35 built on a new assembly line. Did that come into play in your calculations in flying the aircraft?

Answer: We did 15 flight hours with AL-1 prior to crossing the Atlantic and we had no issues, and I mean NO issues.

It is the first F-35 built outside the United States. Our workers at the FACO worked as a team as a team to get this result. We are building for our own air force and wings for other air forces.

We flew the jet 5 times back to back to back to back prior to coming. I don't think that has ever been done before as well.

Question: How many flight hours do you have on the F-35?

Answer: About 50 real flight hours. I was formerly a Tornado pilot in the reconnaissance role. And then became a test pilot.

Question: After the testing here, what is next for the jet?

Answer: We will take the first two aircraft to Luke AFB. Then in a few months will bring additional aircraft to Luke. This summer we will ferry number 4 and 5 to give us a full complement of five at Luke.

All the student pilots at Luke fly the aircraft in the fleet whether US, Australian, Norwegian or Italian. And the training allows us to learn common TTPs from the ground up.

We are building a fifth generation approach from the ground up.

Question: When you sit in the F-35 cockpit and flew across the Atlantic how did the various systems assist you in the flight?

Answer: The great thing about the F-35 is that the human-machine interface (HMI) is so good and so built around the pilot that you don't have to learn how it works. You just use it.

You can configure the screens to configure for the mission.

The aircraft is built to understand; you are building a strategy, not focusing on managing the sensors or really focused on the flying function.

I was able to see the aircraft surrounding me through the clouds, such as keeping distance with my tankers, by using my helmet and the Distributed Aperture System and see the C-130s below me below the clouds.

Question: Did you have any problems with your helmet?

Answer: No. I used the Gen II helmet and the Gen III has improved the helmet, but my helmet worked flawlessly during the flight. I was able to fulfill the mission and I am here.

Question: How different is flying the Tornado compared to the F-35?

Answer: How can answer and be polite? There is no comparison. Recently, I flew the Tornado after learning to fly the F-35. It was a real shock to go back in time.

I had to move my head and focus on the switches and sensors – you have to manage the aircraft to fly.

The F-35 is totally different.

Question: What is it like to cross the Atlantic with DAS?

Answer: It is IR so much of its functionality is used during the night not the day, although you do look through your legs and could see buildings, intersections, and various landmarks while flying.

Question: Many more people saw Lindbourgh land at Le Bourget in 1927 than are here today. There are four reporters here to witness your arrival, and let make no

mistake about it, this is an historic day in which an Italian flew the first F-35A with an Italian assembled aircraft, rather than the USAF having done so.

How does that feel from an Italian point of view?

Answer: It feels great. It is a different mindset. We are working at a different level than we have done in the past.

It must be weird from your point of view to have an Italian fly the first F-35 across the Atlantic. We are making history. We are building it; we are flying it; we are maintaining it.

We talk about facts. I am a pilot. We have flown all these flight hours with no problems; we are living a new reality. The aircraft is extremely reliable.

We are close to 50,000 flight hours with aircraft. That is a fact.

We had a no gripe no maintenance discrepancy during the flight as well.

Question: When the Marines we barred from flying from Pax River to the Farnbourgh air show in 2014, how did this affect your preparation and thinking?

Answer: I certainly realized that I was going to be first and felt that pressure. But with regard to the flight I talked with the Marines about their flight – they went from Yuma to Pax – and their flight plan to come over. They were very helpful.

Semper Fidelis is what I have to say about that.

Question: How was the airplane ergonomically?

Answer: I did not think about it until you asked the question. The seat is very comfortable. You can stretch your legs in front of you. The helmet was confortable, and the seat was very supportable and comfortable. With this helmet I do not have to turn my head, which makes it easier as well for the pilot.

Question: When did you learn that you would do this flight?

Answer: We started working this about six months ago and worked various scenarios for the flight including divert requirements if needed.

But the aircraft holds so much fuel that there is an additional safety factor built in. After 30 minutes after take off from the Azores I could reach the coast of Canada flying high. If I needed to fly lower, I would need a refueling.

We also brought our tankers to Edwards last year to do refueling of the F-35 and worked through various procedures and operating conditions.

Question: This plane is designed to drop bombs and fire missiles. What you can see going forward with regard to training with regard to weapons?

Answer: It is a lot easier than you think. This is one of the first aircraft that you can take off and after about two flights dropping bombs, and firing weapons. Your mission systems are so good that you can start operating weapons very early in your training and operations.

We have to air-to-air pilots working with air-to-ground pilots and merging the cultures.

You are not focusing on your sensors; you are focusing on the end objective of your mission.

The big difference with this aircraft is situational awareness. You see everything, and I mean on the surface and on the ground and you command attack, defense and electronic warfare functions within the aircraft. The HMI is processing this and allowing you to be more strategic in your role.

You have different screens and different set ups that we are using as we fly the aircraft, and over time we can help the pilots standardize ways to usual the two screens optimally.

During my flight, I mostly used the two screens in the following way:

Half a screen provided a long-range view to look further; the second half showed the formation.

And the second screen contained my targeting Pod in one half and DAS in the other.

I hand flew because I wanted to play with the screens and figure out how to make best use of the systems during flight.

Question: How is the F-35 a game changer for the Italian Air Force?

Answer: The F-35 gives us much greater global reach. We have so much gas in the aircraft and it is so fuel efficient, it gives us options in the various scenarios we are likely to face in our area of operations.

Rolling Out the F-35 Fleet from the Testing Perspective: An Interview with the Chief Test Engineer for the F-35 ITF at Pax River

During a recent visit to Pax River, we had the chance to discuss the F-35 test approach and way ahead with Andrew Maack, F-35 Integrated Test Force (ITF) site director and chief test engineer. Although we were at Pax River, the F-35 ITF is rooted in an integrated team at Edwards AFB as well, and the two teams, although in different physical locations, are part of the same team.

In 2014, Maack received a Department Navy award (2013 Test & Evaluation (T&E) Lead Tester Award) for his performance and accomplishments. Maack would be the first to tell you that the team deserves the credit, but he has 30 years of Navy test and evaluation experience on the F-35 program as well as on other Attack, Jammer, and V/STOL platforms and it was from his comprehensive test experience that he discussed the F-35 program with us.

He made several points, which we will focus on below.

First, developmental testing goes on throughout the life cycle of a combat air program. He noted that developmental testing with the F/A-18 was ongoing and, with a software upgradeable airplane such as the F-35, developmental testing would not end until the

NAWCAD At-a-Glance

NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION

MISSION

Naval Air Warfare Center Aircraft Division (NAWCAD):

- Is the principal research, development, test, evaluation and fleet support activity for manned and unmanned aircraft for the U.S. Navy and Marine Corps.
- Operates test ranges, test facilities, laboratories and aircraft necessary to support the fleet's acquisition requirements.
- Supports other Department of Defense (DoD) activities, federal agencies and international partners in alignment with U.S. national security objectives.

Our Mission Areas Include:

- Aircraft Launch and Recovery Systems
- Aviation Support Equipment
- Air Vehicle Propulsion Systems
- Aircraft Testing
- Aircraft Test and Evaluation Ranges
- Aircraft Modeling and Analysis
- Air Vehicles *(Manned and Unmanned)*
- Aircrew Equipment and Life Support
- Airborne Surveillance Systems
- Air Anti-Submarine Warfare Systems and Sensors
- Aircraft Electronic Warfare Test and Evaluation
- Air Platform Systems Integration
- Aircraft Active and Passive Signatures
- Ship and Shore Electronic Systems
- Training and Training Systems
- Aircraft Prototyping Facility (SCIF-level hangars)

COMPONENT COMMANDS

Naval Air Warfare Center Training Systems Division (NAWCTSD): Principal Navy center for research, development, test and evaluation, acquisition and product support of training systems.

- Integrates the science of learning with performance-based training and measurement of training effectiveness.
- Provides requirements analysis, design, development and full life cycle support for a wide spectrum of military warfare specialties, including naval aviation, surface, undersea and cross-warfare training systems.
- Provides inter-service coordination and training systems support for U.S. Army, Marine Corps and Air Force.

Naval Test Wing Atlantic, comprised of:

- Approximately 140 aircraft in more than 40 type/model/series
- Air Test and Evaluation Squadrons VX-20, HX-21, VX-23
- Unmanned Aerial Systems Test Directorate
- U.S. Naval Test Pilot School

CAPABILITIES

Atlantic Test Ranges: Fully-instrumented and integrated test ranges, including:

- 2,700 square miles of controlled airspace, including 1,700 square miles of restricted airspace
- Access to 50,000 square miles in the mid-Atlantic Warning Areas
- Radar and optical tracking systems
- Fixed and mobile assets for diverse testing and training scenarios
- Telemetry data center for real-time radio link reception, translation, processing and display of test data. Fixed, mobile and deployable tracking instrumentation diversity: radar, electro-optical and GPS
- Threat and Target Systems: Electronic warfare threat simulation and stimulation systems, fixed and mobile
- Target Diversity: land, sea and air, fixed and dynamic

Air Combat Environment Test & Evaluation Facility (ACETEF): Virtual battlespace for electronic warfare (EW). Links to weapons system platforms and other DoD facilities provide a mix of real and virtual contacts during testing or training scenarios. Facilities include:

- Manned flight simulator
- Large anechoic chamber
- Shielded hangar
- Computing center
- EW integration system test lab
- Warfare simulation lab and threat air-defense lab

continued...

AERIAL VIEW OF PATUXENT RIVER, MD

CAPABILITIES ...continued

Electromagnetic environmental effects facilities: EW flight test capabilities including sensor stimulation and measurements. Ensures all aircraft avionics are compatible with other systems on board and in the intended operating environment.

Air vehicles/material labs: Adhesive bonding and technology lab, landing gear composites, organic coatings and surface interactions.

Air vehicle test and analysis: Materials analysis/non-destructive structural testing, failure analysis, engineering investigations, composite repair and coating evaluations.

Dynamic aircraft signature measurements: Characterize aircraft signatures in both the radar and infrared bands of the electromagnetic spectrum.

Hush house: Integrated airframe-engine testing to determine installed engine performance. Includes an enclosed test area with sound attenuation structure.

Propulsion systems evaluation facility: 55 test and support areas. Centralizes test data from facilities at Patuxent River, MD, Tullahoma, TN, and Lakehurst, NJ.

Avionics/mission and sensors: Tests mission systems and radio frequency sensors. Includes antenna testing laboratory, automated systems, ship/shore communication system. Designs, integrates and tests communication systems and ship's signal exploitation for Navy ship construction programs. Provides in-service engineering for CG 47 and DDG 51 class ships.

Aircrew systems: In addition to training systems noted above, includes crew station technology lab, ejection tower, thermo physiology lab and horizontal accelerator.

Catapult and arresting gear carrier suitability testing

Full range of acquisition support for air combat systems

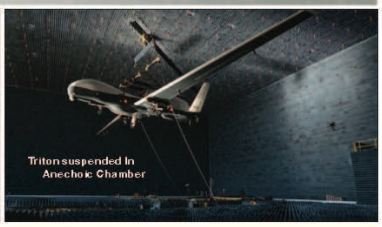
Rapid Prototyping, Aircraft Modification and Lead Systems Integration

Maritime support with vessels out of Patuxent River, MD, and Key West, FL

AERIAL VIEW OF LAKEHURST, NJ

Manned Flight Simulator

First X-47B UCAS catapult launch makes naval aviation history



Triton suspended in Anechoic Chamber

SITES

Patuxent River, MD

- 13,800 acres, including Naval Air Station Patuxent River and nearby Webster Outlying Field
- 935 buildings, including 10 hangars, 8.76 million square feet of facilities
- Five runways (longest is 11,800 feet)

Lakehurst, NJ

- 7,430 acres of 42,000-acre Joint Base McGuire/Dix/Lakehurst complex
- 4,000 acre test area
- 3,000 square miles of controlled airspace
- 11,000-foot runway arrested-landing site

Orlando, FL

- NAWCTSD/ Naval Support Activity Orlando
- 40 acre facility located within the Central Florida Research Park

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program did.

Second, the F-35 program is more complex than programs before it, and they had to craft a test approach that fit the complexity of the aircraft and program itself. The integration of both Edwards and Pax to conduct ongoing synergistic testing was a key point in that direction.

Third, the program is one of "spiral development" in which combat F-35 Type/Model/Series (T/M/S) airplanes emerge throughout the process to operate as effective combat assets, even while the developmental testing for all three types of F-35s continue. Put bluntly, the F-35B in the hands of the Marines is a fully combat-capable asset that will evolve over time.

Fourth, the airplane is the most integrated combat jet ever built, in terms of systems, fusion, and software. And, even though integrated, it is a very robust system in which cascading issues from any particular component or system really has limited effect on the overall F-35 air combat system. This robustness is found in the integrated systems' ability to continue functioning in the presence of component failures. Thus, it is a safe combat aircraft.

Fifth, to put the team together required a different cultural approach, whereby specialists must act as integrators across the airframe and avionic components of the airplane. This is clearly different from legacy programs.

Sixth, the decade of putting together the unique and innovative approach to shaping the F-35 fleet is laying down the foundation for the decade ahead in which the services and partners generate the combat experience — which will then lead to further innovations and developmental testing.

Put bluntly, if you are waiting for the end of developmental testing, come back in 30-40 years.

Meanwhile, the F-35 fleet will have reshaped air combat operations.

Question: How integrated is the test force here and at Edwards?

Answer: Very. We talk and work together every day. A lot of times, people want to draw a distinction between Pax and Edwards, and that is really not applicable to this program. What is unique about the F-35 program really is the scope and scale of what we are doing.

It is not only different from what we have done before, but frankly there are some very real-world throughput issues. By having both Pax and Edwards integrated, we can expand the test space.

Let me give you an example. The data generated and communicated by the F-35 is unprecedented. This means that from a testing point of view we run up against telemetry limits. What we can use in DoD-related telemetry from the planes in flight is really pushed into a very tight box. We are limited to four or five airplanes at a time as the max that we can operate for the kind of bandwidth we are pulling off of F-35s at any given time.

The test data from what we call the orange instrumentation on the plane — specialized flight test instrumentation like pressure transducers and load strain gauges and things like that — are part of the significant bandwidth we transmit. And, when combined with bus data, it is indeed a very large bandwidth compared to our legacy programs.

Question: Developmental testing is not a one-off to get the planes out the door until the next model series arrives. What is the role of developmental testing in the life cycle of a combat airplane?

Answer: Put simply, developmental testing is for the life cycle of the airplane. People would be surprised, if they do not follow the business, at how much developmental flight-testing goes on today on the F/A-18. There are continuous needs generated by new weapons, or communication requirements, especially with the F-35 coming to the fleet.

With the F-35, clearly this type of developmental testing is for the life cycle. There is no reason to expect otherwise.

Question: It is clear that you are having to adjust the test culture to deal with the F-35.

How would you describe the change?

Answer: One aspect is clearly with regard to testers themselves. With legacy aircraft, you tended to have various specialists — a hydraulics expert, or flight controls expert, or a radar expert.

On the F-35, unlike anything that I've dealt with before — and I've been in test and evaluation for 30 years now — you find you certainly still have specialists in those areas. However, it's not satisfactory to only know that system because it is so interactive across the airframe from a software standpoint, from a controls standpoint, that it really requires everyone on the team to be an integrator. You need to be an integrator across all the different disciplines on the airplane, and that's been a challenge.

Question: In this past decade, you have established your basic test approach, which really is built around spiral development.

And this decade is laying down the foundation for the next where the combat experiences of the service and partner fleet become folded into the next round of development of the aircraft.

How would describe the process that you have established?

Answer: We have been developing three different variants of the F-35. It was clear that the services would need the aircraft prior to some notional finished aircraft.

And so the program was intentionally put into a spiral development type of mode in which there were going to be defined blocks. And each block represents a combat-ready variant of the aircraft, or of a particular model of the aircraft.

We defined all the different capabilities of the airplane that were going to be shaped over time. The end point, so to speak.

And then we divided them up into blocks in which there were going to be useful war fighting capabilities. Those were provided at incremental blocks to the airplane.

At the same, there was a flight envelope established as an expectation for each of those block developments.

All of our test planning was scoped around being able to clear — for flight sciences — a given envelope to meet a milestone promise date for the particular block in question. And, from the mission system side, developing those missions systems and weapons that were promised for each of those blocks.

For example, when the F-35B Block 2B became cleared for IOC, there were many stories about what it cannot do; that really is not the point. The plane will evolve its capabilities over time based on spiral development. The point is that it is a very capable combat jet at the block it has achieved already.

And the impact is immediate.

Stealth from the sea is brand new for the Marine Corps and Navy.

Question: How do you manage risk in the program?

Answer: Everything has to be evaluated, and our team does an excellent job of evaluating the risk at hand versus the need for the test. A high-risk test, which has a high value, is the flight that you should be flying more so than the flight that is next to nothing for risk but is questionable as to whether it even has to be flown from a value perspective.

The very first level of risk reduction, of what we do in a program like this, is to scope out what is really necessary to do and what is not necessary to do.

Your best safety net is creating a culture that is not risk averse but is positive, proactive, and dedicated to moving forward, yet at the same time does not compromise safety.

You need sound reasons for doing your testing; not just testing for testing's sake.

Question: In your testing, how robust have you found the F-35 as baseline aircraft to be?

In testing, the concern about cascading failure states is always very high when you start to operate the airplane. This concern is based on the general fact that once you integrate everything, a small problem all of a sudden can cascade into an enormous problem.

What I will say has been absolutely outstanding in the F-35 design has been the robustness of failure accommodations on the airplane. When systems fail, it is difficult for me to come up with examples of things that have not generally displayed tremendous — tremendously good — robustness. And, by robustness, I mean being able to isolate the problem while being able to continue operating the aircraft.

Shaping a Way Ahead: Lessons Learned from Dunkirk

The F-35 working with robotic elements and with new weapons can empower a distributed operations approach. This approach is being tested out at various centers of innovation within the U.S. military and will be synergistic with allied partners.

Traditional assets, such as the large deck amphibious ship or the large-deck carrier, will be rethought as the new approach and new capabilities are introduced into the force.

Continuing to invest in past approaches and capabilities makes little sense. And ultimately, the fifth-generation aircraft and associated systems can drive significant cultural change.

But there is nothing inevitable here.

The United States is at a crucial turning point. In a stringent budgetary environment and with a demand to shape a post-Afghan military, the crucial requirement is to invest in the future not the past.

But it is not just about airframes or stuffing as much as you can in legacy aircraft. The new aircraft represent a sea change with significant savings in terms of fleet costs and overall capability at the same time.

The sustainability of the new aircraft is in a world significantly different from legacy aircraft. Digital maintenance is part of the revolution in sustainability. The sustainability

revolution enables a significant increase in the sortie generation rates for the new combat aircraft. And in addition to this core capability, there is a significant transition in combat approaches facilitated by the new aircraft.

The aircraft can shape disruptive change by enabling distributed operations. The shift is from linear to simultaneous operations; it is a shift from fighters needing reachback to large aircraft command and control and ISR platforms to 360-degree dominance by deployed decision makers operating not in a network but a honeycomb.

These lessons have been recently highlighted in the Trilateral Exercise held at Langley AFB in December 2015.

If this exercise was held 12 years ago, not only would the planes have been different but so would the AWACS role. The AWACS would have worked with the fighters to sort out combat space and lanes of operation in a hub spoke manner.

With the F-22 and the coming F-35, horizontal communication among the air combat force is facilitated so that the planes at the point of attack can provide a much more dynamic targeting capability against the adversary with push back to AWACS as important as directed air operations from the AWACS.

As General Hawk Carlisle put it:

"The exercise was not about shaping a lowest common denominator coalition force but one able to fight more effectively at the higher end as a dominant air combat force.

The pilots learning to work together to execute evolving capabilities are crucial to mission success in contested air space."

Modernization of assets, enhanced capabilities to work together and shaping innovative concepts of operations were seen as key tools for the U.S. and the allies to operate in the expanded battlespace in order to prevail…..

And as the RAF highlighted:

"Whoever can gather, process and exploit the most information in the quickest time will win the information war and ultimately the fight.

With fifth generation aircraft being able to instantly share data with their fourth generation cousins, the Typhoon can become and an even more effective and capable jet fighter."

Fifth-generation aircraft both generate disruptive change and live off of disruptive change. Taking a fleet approach, rather than simply focusing on the platforms themselves, highlights their potential for disruptive change. Properly connected or interoperable with one another, the new aircraft can work together to operate like a marauding motorcycle gang in an adversary's battlespace.

Rather than operating as a linear force, the marauding motorcycle gang creates chaos within the OODA loop of the adversary. In fact, the F-35 is really about shifting from the OODA loop with the machine-man interface doing much of the OO and focusing attention on the DA.

By having an onboard combat systems enterprise able to respond in real time to the impacts that the aircraft are creating in the battlespace, they can respond to the fractual consequences of the battle itself.

Rather than going in with a preset battle plan, the new aircraft can work together to disrupt, destroy, and defeat adversary forces within the battlespace. It is about on-the-fly (literally) combat system processing power that enables the pilots to act like members of a marauding motorcycle gang.

The fifth-generation aircraft enable the pilots to become key decision makers within the battlespace and, if properly interconnected, shape a distributed operations approach to battle management and execution.

They are key elements of C4ISR D, which is deployed decision making rather than data collection sent back to decision makers for less timely actions. C5ISR D is the core capability that 21st-century military forces need for strategic advantage.

For the United States to have an effective military role in the new setting of regional networking, a key requirement will be effective and assured combined command, control, and communications, linked by advanced computing capabilities to global, regional, and local intelligence, reconnaissance, and surveillance assets (C5ISR).

The services will need to ensure that there is broad synergy among U.S. global forces fully exploiting new military technologies and the more modest capabilities of regional allies and partners.

Indeed, C5ISR is evolving to become C5ISR D, whereby the purpose of C5ISR is to shape effective combined and joint decision-making. The USMC clearly understands and embraces the disruptive capabilities of the fifth-generation aircraft. For the USMC, TAC Air does not simply play a close air support role in any traditional sense.

It is an enabler for distributed operations when such operations are essential to either conventional strike or counterinsurgency warfare. USMC aviation has allowed the USMC ground forces to operate with greater confidence in deploying within the civilian population in Iraq. Aviation's roles in both non-kinetic and kinetic operations have allowed the USMC to avoid operating within "green zones" so as to facilitate greater civilian-military relations.

Aviation has also provided an integrated asset working with the ground forces in joint counter-IED operations. And quite obviously, battlefields of the future will require the USMC to operate upon many axes of attack simultaneously. Such an operation is simply impossible without a USMC aviation element.

For the USMC thinks ground in the air and the forces on the ground can rely 24/ 7 on USMC aviation forces to be with them in the ground fight.

As Lt. Col. "Chip" Berke, the F-22, F-35, F-16 and F-18 Marine Corps former squadron commander, put it in a presentation on airpower at the Copenhagen Airpower conference last year:

As a JTAC the key requirement is that the airplane show up. The A-10 pilots are amazing; the plane will not always able to show up in the environment in which we operate; the F-35 will. That is the difference for a Marine on the ground.

The F-35 will be a "first-generation flying combat system" that will enable air-ground communication and ISR exchanges unprecedented in military history. The pilot will be a full member of the ground team; the ground commanders will have ears and eyes able to operate in a wide swath of three-dimensional space.

But if other airpower leaders simply mimic the operations of older aircraft with the fifth-generation aircraft, the promise of the new air operations will not be realized.

As Robert Evans, a specialist on C2, formerly a senior USAF officer and now with Northrop Grumman put it about the dynamics of change:

If warfighters were to apply the same C2 approach used for traditional airpower to the F-35 they would really be missing the point of what the F-35 fleet can bring to the future fight.

In the future, they might task the F-35 fleet to operate in the battlespace and affect targets that they believe are important to support the commander's strategy, but while those advanced fighters are out there, they can collaborate with other forces in the battlespace to support broader objectives.

The F-35 pilot could be given much broader authorities and wields much greater capabilities, so the tasks could be less specific and more broadly defined by mission type orders, based on the commander's intent. He will have the ability to influence the battlespace not just within his specific package, but working with others in the battlespace against broader objectives.

Collaboration is greatly enhanced, and mutual support is driven to entirely new heights.

The F-35 pilot in the future becomes in some ways, an air battle manager who is really participating in a much more advanced offense, if you will, than did the aircrews of the legacy generation.

And going back to my comment about the convergence of planning and execution, and a warfighter's ability to see and sense in the battlespace … that's only relevant if you take advantage of it, and the F-35 certainly allows warfighters to take advantage of it.

You don't want to have a fifth-generation Air Force, shackled by a third-generation system of command and control.

The result would be that the United states and its allies will repeat the failures of the French facing the Germans in World War II where they had superior tanks with outmoded tactics and command structures, and with the predictable results.

The new aircraft simply do not function in the way the old do. Indeed, one lesson of Dunkirk needs to be remembered when shaping an innovative military strategy for the Pacific in the 21st century: new capabilities without new concepts of operations will lead to strategic failure.

A military force is truly blessed if the combat leaders at all levels in the chain of command have the proper weapons and also the wisdom to employ them against a reactive enemy. History of combat often shows that their not understanding or exploiting that advantage can offset one army's engagement-winning weapons.

It is true that weaker forces through brilliant leadership can vanquish the more technology-capable and stronger army. Of course, as Napoleon said, he also wanted a general who was lucky, and all combat leaders know how the great unknown of luck can also determine the outcome.

And to add to the mix is another great thinker, Damon Runyon, who once quipped, "The race is not always to the swift nor the battle to the strong, but that's the way to bet."

By all static order-of-battle accounting, the Miracle at Dunkirk should have never been necessary, because the British and French had a number of key elements that could have allowed them to win, including superior tanks to the attacking Germans and rough parity in the air.

But the French and British were defeated; the British Expeditionary Force was evacuated and lived to fight another day on to the eventual V-E Day. So betting on the French and the British was the wrong chip to play on the table of the battlefield.

The Germans Blitzkrieg generals down to the lower ranks were all "making their own luck" by exploiting the French and British approaches with the weapons they had.

The fall of France may have some interesting lessons on CONOPS and decision making against a reactive enemy. And those lessons argue for shaping a transition from legacy air CONOPS to new distributed air operations CONOPS leveraging the F-22 and F-35.

The Germans were a quicker and smarter force that defeated the French and the British. Words echoing from history tell us that story and also can now bring an interesting lesson learned to the current debate on what is becoming known as "distributed air operations."

The shift from "legacy" air operations to distributed air operations is a significant operational and cultural shift. Characterizing the shift from fourth- to fifth-generation aircraft really does not capture the nature of the shift. The legacy aircraft operate in a strike formation, which is linear and runs from Wild Weasels back to the AWACS.

The F-22 and F-35 are part of distributed operational systems in which the decision makers are distributed and a honeycomb structure is created around which ISR, C2, strike, and decision-making can be distributed.

A new style of collaborative operations is shaped but takes away the ability of an adversary to simply eliminate assets like the AWACs and blind the fleet. Distributed operations is the cultural shift associated with the fifth-generation aircraft and investments in new weapons, remotely piloted aircraft, and the crafting of simultaneous rather than sequential operations.

Unfortunately, the debate about fifth-generation aircraft continues as if these are simply aircraft, not nodes driving significant cultural changes in operational capabilities.

In a fascinating book by Hugh Sebag-Montefiore on the courageous men in the British army who fought the Germans to allow the escape from Dunkirk, some of these lessons were highlighted. (Hugh Sebag-Montefiore, Dunkirk: Fight to the Last Man (Cambridge, MA: Harvard University Press, 2008).)

In writing the book, the author provided significant insight into how the British and French lost to the Germans in the European forests and battlefields. Comments taken from diaries of the survivors provide significant insight into lessons learned by not engaging in the cultural revolution that one's new technology provides.

The British and French had new equipment, which, if properly used and embedded into appropriate concepts of operations, might well have led to a different outcome at the beginning of the war.

And the first lesson here is simply to develop advanced equipment is not even half the job. First and foremost: "The campaign showed that politicians must never, even in peacetime, deprive their armed forces of the equipment they need. Complacently assuming that the equipment can be manufactured once war is declared is demonstrably unwise." (Ibid. xiv).

A second lesson learned is that if you do not adapt your command structure to the technology, you will lose. A theme that the author developed was that although the French had tanks, World War I generals who simply were not able to adapt to the tactics of armored warfare commanded them. These difficulties were aggravated a hundred times by the style of French leadership.

The soldier who should have had most influence on the way in which the first counter-attack was mounted was X Corps' commander General Grandsard, who had direct control over the divisions in the Sedan sector. He was a Corps' commander General Grandsard, who had direct control over the divisions in the Sedan sector. He was a general of the old school, who had not understood that French strategy must change in line with Guderian's (the German general in charge of the attack) new mobile tactics. (Ibid, 100.)

The author when discussing command style introduced a really key term very relevant to the shift from sequential to simultaneous air operations:

"The need to refer back to Guderian was, however, limited by the entrepreneurial culture he fostered: German officers were expected to make up their own minds on how to achieve the objectives Guderian set and how to act in a crisis." (Ibid, 101.)

A third lesson was the importance of getting inside the enemy's OODA loop. The French command structure was too slow to use information and to act on that information on a timely manner. The German commanders were allowed significantly greater freedom of action and could act in minutes, whereas the French operated in terms of hours:

"The rapid German response to the threat posed by the counter-attack only serves to underline the slowness of the French . . . In other words, the Germans began their own counter-attack within 10 minutes of identifying their target, whereas it had taken the French more than 12 hours to launch their troops into the attack." (Ibid. 105)

A clear advantage of the new aircraft is their technical capability to get inside the enemy's OODA loop; but without change in how command structure works, no clear advantage can be realized.

A fourth lesson is the challenge of the enemy exploiting your weaknesses for which he has trained to exploit. The German tankers confronting superior armor in the advanced French tanks were able to exploit weakness in those tanks because of intelligence about the weaknesses and training to exploit those weaknesses.

From the diary of a German survivor with regard to meeting the superior French tanks:

The tanks' silhouettes were getting larger, and I was scared. Never before had I seen such huge tanks. . . .

My company commander gave clear instructions over the radio describing which targets to aim at, and the enemy tanks were just 200 meters away before he gave the order to fire. As if they had

been hit be lightening, three of the enemy tanks halted, their hatches opened and their crews jump out. But some of the other tanks continued towards us, while some turned. . . .

Presenting their broadsides to us. On the . . . side of the tank there was an oil radiator behind some armor.

At this spot, even our (smaller Panzer 2) tanks' 20mm guns could penetrate the amour, and the French tanks went up in flames immediately after they were hit there. It was then that our good training made such a difference. (Ibid. 101-102)

The Chinese study of the classic U.S. air battle and the perceived value of targeting USAF or USN large battle management systems such as AWACS reminds one of the need to get rid of the AWACS as a lead element in any offensive operations and sequential air battle and to move to distributed capabilities in simultaneous operations.

A fifth lesson is to develop logistical systems that allow one to exploit advantages of new technology.

The superior French tanks were refueled by trucks and dependent upon truck-provided fuel.

The Germans parked a "farm" of fuel containers to which the tanks came for refueling and could thus keep up the speed of the attack:

They (the key French tanks) could not even be expected in their first assembly area at Le Chesne, fifteen miles southwest of Sedan, until 6 am. It would then take around six hours to fill them with petrol, another two to move the five miles to their positions to the Mont Dieu forest, and two more hours to refuel them again. . . .

In contrast, the Germans overcame their refueling difficulties by transporting petrol to the front in cans. Once the cans were in the vicinity of the panzer divisions, all the tanks nearby could be refueled simultaneously on any terrain.

The French, on the other hand, had the petrol brought to the front in lorries, which, not being tracked, could not be used over rough ground. Even when the French armor was refueled on a

road, the vehicles' petrol tanks had to be filled up consecutively rather than simultaneously which took much longer than the German method. (Ibid. 109-120)

Keeping the old tanker approach in place while you add the new aircraft undercuts the ability of those aircraft to operate in a distributed approach. By moving the tanker line back significantly, one can refuel almost like the German "fuel farm" and not expect the tankers like the French trucks to come to them. Even the difference between simultaneous versus sequential attacks was underscored as crucial to the success of the Germans and the negative impact on French morale.

As one French officer commented, "Simultaneous attacks would have been very difficult for us. But attacking in waves in this manner means they lose their courage after seeing their burning comrades." (Ibid.107)

In short, the core lesson to learn is to buy appropriate numbers of new equipment and to adapt the operational culture, including the logistics systems, to allow the blue team to exploit their advantages.

Unless one wants outcomes such as the French and British experienced in the forests of Europe against the Germans, it is crucial to accelerate the shift to a new culture and capability built around distributed operations.

The old system of sequential air operations built around legacy aircraft, AWACS, and multiple assets needs to be replaced in a timely manner by a well-resourced distributed operations enterprise.

The current Deputy Commandant of Aviation, Lt. General Davis, when CG of 2nd MAW underscored how important he saw the F-35 as a tool in the hands of what he called the I-Pad generation pilots.

I think it is going to be a fantastic blending of not only perspectives but also attitudes. And what I really look forward to is not the old guys like me, but the very young guys who will fly this fantastic new capability. The older generation may have a harder time unleashing the power and

potential of the new gear – the new capabilities. We might say "why don't you do it this way" when that approach might be exactly the wrong thing to do from a capabilities standpoint.

My sense is the young guys will blend. We've already picked the first Prowler pilot to go be an F35 guy. He's going to do great and he's going to add perspective and attitude to the tribe down at Eglin getting ready to fly the jet that's going to make a big impact on the F35 community.

I think it's going to be the new generation, the newbies that are in the training command right now that are getting ready to go fly the F35, who are going to unleash the capabilities of this jet. They will say, "Hey, this is what the system will give me. Don't cap me; don't box me. This is what this thing can do, this is how we can best employ the machine, its agility its sensors to support the guy on the ground, our MEU Commanders and our Combatant Commanders and this is what we should do with it to make it effective."

Editor's Note: We first published this essay in 2010 and included it in The Renorming of Airpower published later that year. We included a revised version in our book on Pacific strategy.

Recently, we discussed fifth generation enabled warfare with a senior naval aviator and during that discussion he emphasized a number of key points with regard to the role of the F-35 in enabling a more effective approach to shaping the sea services capabilities to prevail in the extended battlespace.

(1) The capabilities of fifth generation aircraft reduce the amount of time necessary to do the OO of the OODA loop with a focus on the decision making part of the loop and a general restructuring of how decisions can be taken from the edge of the battlespace.

(2) A key focus is upon working new ways to distribute information throughout the battlespace.

(3) It is about parsing of information as well.

(4) To focus simply on distribution of information will always be subject the limitations of the platform operating in the battlespace

and the key opportunity driven by fifth generation is the enhanced lethality and survivability of other combat assets.

(5) The F-35 is not a replacement aircraft, and that the U.S. Navy's discussion of 6th generation is not really about a platform but a decade or more of fifth generation warfare learning and a determination of what comes next, less in terms of a generational aircraft iteration and much more in terms of what can and needs to be added to the blue side combat capability going forward.

(6) The shift from COIN to higher tempo warfare is a key shift. And the usual argument about the spectrum of warfare misses the point that it is about enhanced decision making in a more rapid operational environment regardless of the spectrum on which you are fighting.

(7) The shift in training is crucial:

"We tend to be conservative in our TTPs and are still captured by the replacement platform mentality. We do not want to do TTPs for the F-35B informed by the Harrier; we do not want to do TTPs for the F-35C informed largely by Super Hornet thinking. We need a paradigm shift in the war fighting culture with regard to the F-35."

(8) The F-35 is both informing and informed by this shift towards warfighting in the extended battlespace.

(9) The reach not range approach is a central part of F-35 enabled operations.

(10) The intersection of the coming of the F-35 with the overall evolution of new technologies and concepts of operation is the role of the sea base.

(11) A key dynamic going forward will be upon the interaction of the systems operating within that extended battlespace with the software evolution of the F-35 combat systems.