Delta Flight Path with IDLC/F-35C

Search PDF using ‘Delta Flight Path’

Bright Future?

Oct 2016 David C Isby

"...Technology developed for the F-35C will make the Super Hornet more effective, Shoemaker cited the BAE Systems developed Delta Flight Path system that provides glide slope inputs directly to the F-35's all-digital flight control and avionics systems on final approach. When used in conjunction with a carrier's Joint Precision Approach & Landing System (JPALS) during recent testing, Delta Flight Path enabled 80% of all F-35C landings to hook the number three arresting wire, the indicator of a precise touchdown. According to the air boss when used at Choctaw Field near Naval Air Station Pensacola, Florida, the system made simulated carrier landings so precise that the F-35Cs, "were landing in the same spot on the runway every time, tearing it up where the hook touches down."

The system also reduced the number of missed approaches, bolters (failure to engage an arresting wire) and fouled decks (when the need to get a landed aircraft out of the way delays aircraft waiting to land) to close to zero.

Upgrading Super Hornets by retro fitting Magic Carpet, a Super Hornet-compatible version of the Delta Flight Path system, is a priority. Shoemaker has pressed for an interim version to enter service with operational squadrons starting in autumn 2016, with IOC being achieved in 2019: "I think it is going to give us the ability to look at the way we work up and expand the number of sorties. I think it will change the way we operate around the ship."

Hooray – Stingray!

Today, the risk of landing delays requires an F/A-18 with a pod-mounted refuelling drogue and extra fuel tanks, the so-called buddy tanker, to be airborne when other aircraft assigned to the air wing are landing aboard the carrier. Shoemaker said under current doctrine a carrier air wing configures six to eight tankers aboard the ship. Tanker missions consume a substantial percentage of F/A-18 flight hours, but the air boss believes that once Magic Carpet is operational the buddy tanker requirement will no longer be required: "That will give us flexibility in our strike fighter numbers, increase the number of Growler, which I know we're going to do, and probably the number of E-2D Advanced Hawkeyes, as well."

The change envisaged will also affect the US Navy's future MQ-25 Stingray carrier-based unmanned aerial vehicle (UAV). Until an MQ-25 lands on a carrier flight deck, the only UAV to have done so is the stealthy Northrop Grumman X-47 demonstrator. Air refuelling is the primary role planned for the MQ-25 Stingray to meet a current doctrine for air refuelling aircraft at locations distant from the carrier, but outside the range of enemy weapons. Competing Stingray designs – from Boeing, General Atomics, Lockheed Martin and Northrop Grumman – will have to meet the challenge of reconciling the tanker mission with the secondary continuous intelligence, surveillance, reconnaissance and communications relay mission. Neither air refuelling nor the ISR roles require a stealthy design.

Vice Admiral Shoemaker said: "If you send the MQ-25 out by itself, you need to know where you're sending it so that it doesn't get shot down. Industry is de fining where the sweet spot lies to enable the air vehicle to do both missions." A contract for MQ-25 development is planned to be issued in 2018...."

October 2016 Air International Magazine Vol.91 No.4

Navy F-35C Prepares for Ship Trials, Faces Headwinds

18 Feb 2014 Sandra I. Erwin http://www.nationaldefensemagazine.org/blog/lists/posts/post.aspx?ID=1415

"...A more significant concern is the performance of the redesigned tail hook, which has been tested six times so far. "It's a bit early to say we have definitely nailed this problem," says Burks. "The tail hook has been a major issue for the development of this airplane. It was unexpected until it was discovered in 2011." The first problem was not being able to catch the arresting wire. There was also a structural flaw that caused excessive stress to the bulkhead where the tail hook attaches to the airframe. The re-design took a year and a half. Manufacturer Lockheed Martin Corp. has so far delivered one F-35C with the new tail hook at the Navy's test site at Patuxent River, Md.

Gilmore says the arresting hook system "remains an integration risk as the JSF development schedule leaves no time for new discoveries." He cautions about the "potential for gouging of the flight deck after a missed cable engagement due to an increase in weight of 139 pounds and the potential for sparking from the tail hook across the flight deck because of the increased weight and sharper geometry of the redesigned hook."

One of the most anticipated features of the F-35C is an automated landing system called "delta flight path" that would take the pressure off aviators to nail landings on moving ships. "The delta flight path for the F-35C will make carrier landing so easy," Burks says. "It will be a new era of carrier aviation. …Night landings will not be the number one task to focus on." The system has been tested ashore but has yet to be tried at sea...."

ALL AT SEA – F-35B/F-35C test update SHOWCASE 2016 SYLVIA PIERSON AEROSPACE TESTING INTERNATIONAL

"2015 has proved to be a busy and record-breaking year for the team responsible for testing naval variants of the F-35 Lightning II...

“SINCE 2010 THE PAX ITF HAS FLOWN MORE THAN 1,800 TEST FLIGHTS, LOGGED 2,544 TEST HOURS & COMPLETED 12,800 F-35B TEST POINTS, DIRECTLY RESULTING IN THE USMC IOC FLIGHT CLEARANCE

...The PAX ITF is now 100% complete with its second phase of F-35C testing, conducted aboard USS Dwight D. Eisenhower (CVN 69) from October 2-10, 2015 – the team conducted 66 catapults and 66 arrestments across 17 flights, logging 26.5 flight hours & achieving a total of 280 flight test points and 17 logistics test and evaluation (LT&E) test points....

...WET RUNWAY, BRAKING VALIDATION & HIGH CROSSWIND TESTING

ITF testers proved the aircraft can stop safely in extreme weather conditions and validated the aircraft envelope out to a 25-knot crosswind with high asymmetric air-to-ground loadings. Even in a maximum asymmetry configuration (up to 26,000 lb·ft) with weapons stores on one wing, the aircraft performed well – in fact, the high asymmetry and crosswind required little additional attention from the pilot....

...F-35 STOVL MODE TESTING

The PAX ITF continued to expand the STOVL envelope last year in the clean wing configuration & with symmetric and asymmetric external stores. Flying qualities testing featured semi-jet, short take-off & jetborne modes to clear the aircraft for take-off & landings and airspeeds as low as 70kts with 24,000 lb of asymmetry and jet borne with 10,000 lb of asymmetry. The team performed **rolling vertical landings (RVL), creeping vertical landings (CVL), vertical landings (VL), high altitude CVLs & VLs, slow landings (SL), & short take-off (STO) tests with nominal winds & crosswinds of up to 25kts.** Test pilots reported that flying qualities during asymmetric testing were nearly identical to those in symmetric testing....

...F-35C CARRIER SUITABILITY TESTING

As the team prepared to sail aboard USS Eisenhower (CVN 69) for the second phase of developmental test (DT-II) of the F-35C, it completed prerequisite shore-based catapults and arrested landings, a structural survey with mis-serviced landing gear, and put the GEN III helmet-mounted display (HMD) hardware through ‘shake, rattle and roll’ tests. ‘Shakes’ are unique test events accomplished at the shore-based TC-7 Catapult and Mk-7 Arresting Gear sites, during which new aircraft hardware is tested to the aircraft limits for various shipboard conditions. Typically shakes testing is the last requirement prior to clearance for hardware to operate on the ship.

The team’s primary DT-II goal was to generate at-sea data in support of phase II development of Aircraft Launch and Recovery Bulletins. They also conducted afterburner catapult shots, Delta Flight Path (DFP) approach mode performance testing with a four degree glideslope, day and night Gen III helmet testing, max catapult shots with full internal weapons load, maintenance engine runs, Integrated Power Pack (IPP) and engine runs in the hangar bay, catapult minimum energy shots with internal stores, and night approaches and arrested landings....”

F-35C DT-II Statistics 15 Oct 2015 Lorraine Martin https://www.f35.com/resources/general-manager-weekly-update

https://www.f35.com/assets/uploads/documents/16378/f-35_weekly_update_10_15_15.pdf

"...From Oct. 2-10, the F-35C stretched its wings over the Atlantic Ocean conducting a second round of development testing, aboard the USS Dwight D. Eisenhower (CVN 69). The sea trials went very well, and flight testing concluded four days early despite in-clement weather from Hurricane Joaquin. Let me repeat that: Four days early! As a key objective for this test event, the Integrated Test Force (ITF) from Pax River completed energy testing. This included taking off heavy, at low speeds, and into crosswinds up to 40 knots [WOD with acceptable Xwind component]. The ITF also flew with internal weapons and conducted day and night flights with the Gen III helmet.

During the 17 flights and 26.5 flight hours, the team accomplished 66 catapults and arrestments and 280 flight test points to meet all the test objectives. These are simply phenomenal results, and it was a great job by the ITF, Eisenhower crew and everyone who supported this critical test event on the path to the U.S. Navy declaring IOC in 2018. The knowledge learned from this event serves as the baseline for the third & final F-35C development testing event next year.

Remarking on what the F-35C brings to naval aviation, Rear Adm. John Haley said, “The F-35C brings sensors & an ability to guide the fight, whether it's an air-to-ground fight or an air-to-air fight. We’re going to have an ability that’s going to change how we think about getting to the target, delivering weapons & getting out of the target.”...”

Cats and Traps on the Ike Nov 2015 Air International Magazine

“...The Pax River-based ITF has flown nearly 500 flights, logged more than 700 flight hours, & achieved almost 3,400 test points since January 2015, many in preparation for DT II.... Aircraft CF-03 was expected to perform asymmetric flying qualities testing loaded with [internal] weapons....

...According to a Lockheed Martin press release, during DT I test pilots and engineers credited the F-35C’s Delta Flight Path (DFP) technology with significantly reducing pilot workload during the approach to the carrier, increasing safety margins during carrier approaches and reducing touchdown dispersion. The DFP was developed by BAE Systems at its facilities at Salmesbury and Warton in Lancashire, UK....”

Scorecard - A Case study of the Joint Strike Fighter Program April 2008

Geoffrey P. Bowman, LCDR, USN: http://2011.uploaded.fresh.co.il/2011/05/18/36290792.pdf

"...The capability to operate from a carrier is not as easy as it sounds. Additional weight comes in the form of stronger landing gear, fuselage center barrel strength, arresting hook structure, and additional electrical power requirements. The Navy has added approach speed as a service specific key performance parameter. The threshold for approach speed is 145 knots with 15 knots of wind over the deck. This must be possible at Required Carrier Landing Weight (RCLW). The RCLW is the sum of the aircraft operating weight, the minimum required bringback, and enough fuel for two instrument approaches & a 100nm BINGO profile to arrive at a divert airfield with 1,000 pounds of fuel. The minimum required bringback is two 2,000 pound air-to-ground weapons and two AIM-120s. The Navy further requires that the CV JSF be capable of carrier recovery with internal and external stores; the external stations must have 1,000 pound capability on the outboard stations and maximum station carriage weight on the inboard...."

CV LOADING Mar 2009

"...F-35C Shipboard Bringback ~10,000 lbs..." http://www.aviationweek.com/media/pdf/JSF_Program_Update.pdf

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F-35C Opt AoA: VX-23 'Salty Dogs' F-35C Update - LCDR Ken "Stubby" Sterbenz

VX-23 Ship Suitability Department Head - Paddles Monthly - Sept 2010

"...The max trap weight will be around 46k lbs, with an empty weight of about 35k lbs [10-11K Load]. It will fly an on-speed AOA of 12.3° at 135-140 KCAS [Optimum AofA or Donut]...."

http://www.hrana.org/documents/PaddlesMonthlySeptember2010.pdf

Performance

http://www.f-16.net/f-16_forum_download-id-14367.html

Characteristics SAR Selective Acquisition Report	SAR Baseline Dev Est	Current Est. F-35C:	Current Estimate	RCLW explanation JUMP!
STOVL Mission Performance — 31 Dec 2010	Execute 550 ft STO with 4 JDAM (2 external & 2 internal), 2 AIM -120 (internal), fuel to fly 550 nm	Maximum approach speed (Vpa) at RCLW of less than approx. 144.6 kts with 15 kts WOD at RCLW (of approx. 46,000 lbs Max Landing Weight)	Execute 544 ft. STO with 2 JDAM (internal), 2 AIM-120 (internal), fuel to fly 450nm	(Ch-2) RCLW = Required Carrier Land-ing Weight WOD = Wind Over Deck
Combat Radius NM - CTOL Variant	690		584[1]	(Ch-1)
Combat Radius NM - STOVL Variant	550		469	(Ch-2)
Combat Radius NM -CV Variant	730		615	(Ch-2)

(Ch-2) The current estimates changed from the Dec 2009 SAR due to design maturation.
Short Takeoff and Vertical Landing (STOVL) Mission Performance changed from 524 ft to 544 ft.
Combat Radius Nautical Miles (NM) - STOVL Variant changed from 481 to 469.
Combat Radius NM - Aircraft Carrier Suitable (CV) Variant changed from 651 to 615.
CV Recovery Performance, Approach Speed changed from 143.0 kts to 144.6 kts.

141103-N-MX772-359 PACIFIC OCEAN (Nov. 3, 2014) Landing signal officers observe an F-35C Lightning II carrier variant Joint Strike Fighter as it lands on the flight deck of the aircraft carrier USS Nimitz (CVN 68). Nimitz is currently underway conducting routine training exercises. (U.S. Navy photo by Mass Communication Specialist 3rd Class Siobhana R. McEwen/Released

https://www.flickr.com/photos/compacflt/15521756107/

LM's Navy JSF Completes Historic Flight-Test Program.

PATUXENT RIVER, Md., 12 March 2001 /PRNewswire/

"I could tell from the first flight that the X-35C was going to be representative of a very good carrier plane. When we began aggressive FCLPs (field carrier landing practices) the aircraft really showed off its superb responsiveness and controllability," said test pilot Joe Sweeney,a former U.S. Navy carrier pilot. "We deliberately forced errors in the glide slope, speed and line-up, challenging the plane's ability to respond, and it performed exceedingly well. I can't say enough about this engineering and flight test team."

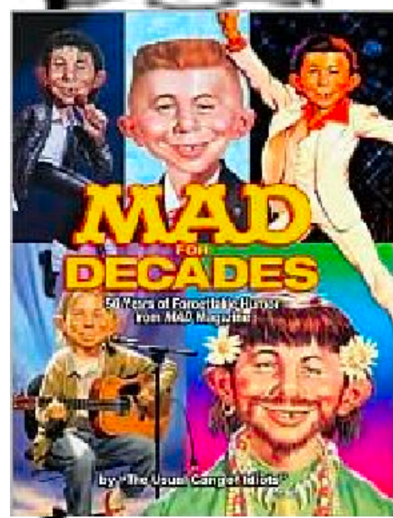
During an FCLP (FCLP = Field Carrier Landing Practice) the pilot shoots an approach exactly as he would on an aircraft carrier. The X-35C, which features a larger wing and control surfaces than the other JSF variants, completed 250 FCLPs during testing.

"We put the airplane through a battery of practice carrier approaches in a very short time. The airplane's performance was outstanding," said Lt. Cmdr. Greg Fenton, a U.S. Navy test pilot assigned to the X-35. "Several of Strike's Landing Signal Officers (LSOs) got an opportunity to observe the airplane 'on the ball', and were quite impressed with its ability to handle intentional deviations during the practice carrier landings."

http://www.thefreelibrary.com/Lockheed+Martin's+Navy+JSF+Completes+Historic+Flight-Test+Program-a071562471

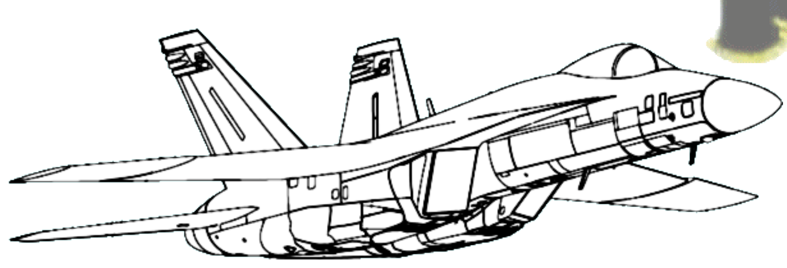
Ship course in red. Aircraft line up on the right of ship wake to be lined up on the angled centreline

FLY NAVY



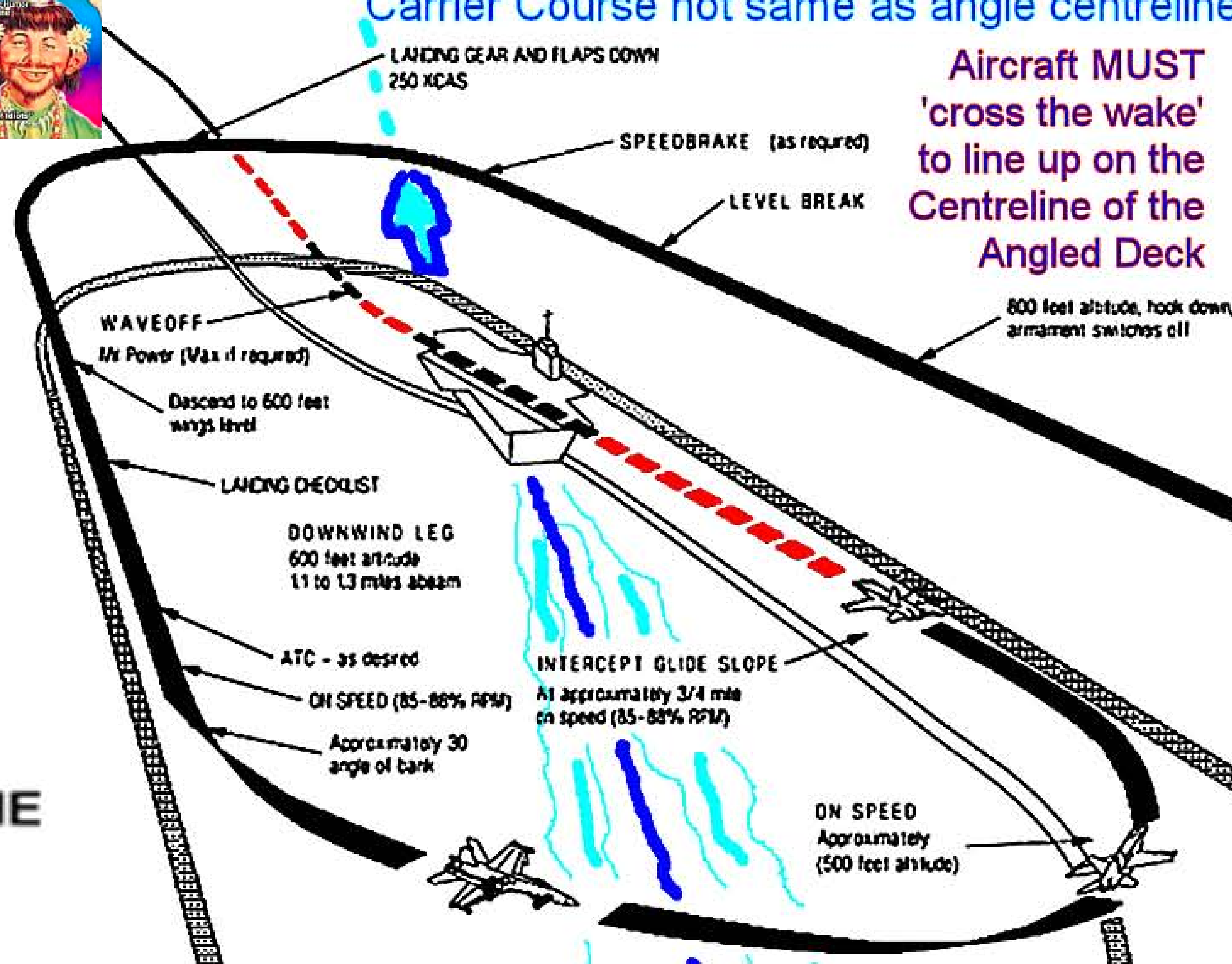
Click for Hornet 'Groovie Movie'

'Second To None' (RAN FAA Motto)



Carrier Course not same as angle centreline

Aircraft MUST 'cross the wake' to line up on the Centreline of the Angled Deck




http://images.defensetech.org/wp-content/uploads/2011/03/f-35c-carrier-approach.jpg
F-35C Delta Flight Path IDLC
Tailhook 2015 Clemence Brief
https://www.youtube.com/watch?v=IGVsrNW7bgU

JSF Carrier Variant Meets First Flight Goals By Graham Warwick 7 June 2010

http://web02.aviationweek.com/aw/generic/story_generic.jsp?channel=defense&id=news/awx/2010/06/07/awx_06_07_2010_p0-232376.xml&headline=JSF%20Carrier%20Variant%20Meets%20First%20Flight%20Goals

"Handling qualities of the F-35C Joint Strike Fighter "exceeded expectations" on the June 6 first flight, says Lockheed Martin test pilot Jeff Knowles.

Handling with landing gear down was a key focus of the first flight as the F-35C has a 30% larger wing and uprated flight controls to reduce takeoff and landing speeds compared with the other F-35 variants.

Knowles says the aircraft approached at 135 kt., compared with 155 kt. for the smaller-winged F-35A and B variants at the same 40,000-lb. gross weight. Takeoff rotation speed was 15-20 kt. slower, he says.

The first F-35C, aircraft CF-1, was formally rolled out in late July 2009 and was expected to fly before the end of the year, but was held in the factory to incorporate late parts and design changes, says Tom Burbage, executive vice president and general manager, F-35 program integration.

The 57-min. first flight focused on gear-down handling & formation flying with the F/A-18 chase aircraft in "an early look at handling around the carrier", says Knowles, adding "The approach was very stable, with good roll response."

The landing gear and arrestor hook were cycled and throttle slams conducted to check engine operation. This was the first flight of a production-configuration Pratt & Whitney F135 engine, says Burbage...."

F-35C CF-01

F-35C Opt AoA: VX-23 'Salty Dogs' F-35C Update - LCDR Ken "Stubby" Sterbenz
VX-23 Ship Suitability Department Head - Paddles Monthly - Sept 2010 (1.3Mb PDF)

http://www.hrana.org/documents/PaddlesMonthlySeptember2010.pdf

"The F-35C is 51.5 ft long and has a wingspan of 43 ft and 668 ft^2 of wing area (7 ft longer wingspan and 208ft^2 more wing area than the Air force or Marine versions.) It also carries 19,800 lbs of internal fuel - 1,000 pounds more gas then the Air Force version. It is powered by a Pratt and Whitney F135 engine that produces 28k lbs and 43k lb of thrust in MIL and AB respectively.

The max trap weight will be around 46k lbs, with an empty weight of about 35k lbs. It will fly an on-speed AOA of 12.3° at 135-140 KCAS [Optimum AofA or Donut]. Due to the fact that flap scheduling is completely automatic, the cockpit was designed without a flaps switch. Additionally, the tail hook retracts into the fuselage and is covered by hook doors that have an as-yet-to-be-determined airspeed limitation..."

LT. Dan "Butters" Radocaj VX-23 Ship Suitability

on-speed AOA of 12.3° at 135-140 KCAS

http://www.calf.cn/attachments/day_100701/1007010605af624d3f9c593fce.jpg

F-35 Landing System by Mike Seltzer

https://quizlet.com/146184972/landing-system-flash-cards/

“Dropping the hook takes approx. 2 seconds and when complete the aft door closes.

Max airspeed for hook extension is 300 KCAS.

The arresting hook is made up of the pivot, the shank, and the hook.

The hook can move laterally 20 degrees in each direction without touching the airframe.

The pivot axis of the hook permits upswing of 5 deg above the waterline through the pivot axis.

When fully deployed the down arrow is extinguished and the RDY caption is illuminated. If the hook has been deployed but is not in its fully extended position - the down arrows is illuminated.

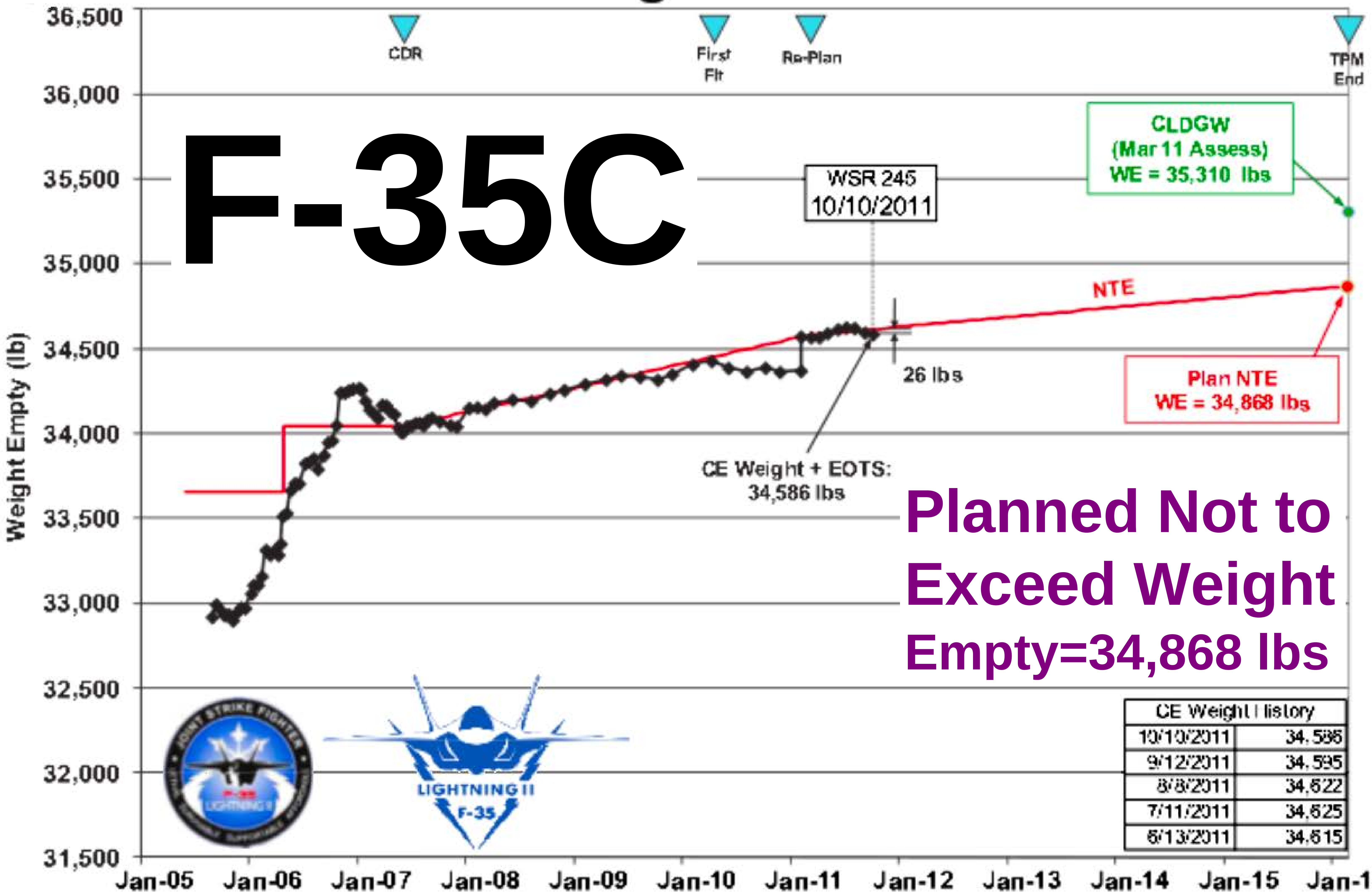
The up arrow on the button illuminates when the hook is raised but not stowed.

[ASHORE] Do not engage more than 10 feet off center.

Max cable engagement speed is 150 KGS at 50,000 lbs.

Maximum MLG tire speed is 226 KGS & Maximum NLG tire speed is 217 KGS.”

CV Weight Status



F-35C exceeds 100 catapults, arrestments during first week at sea

13 Nov 2014 Marina Malenic http://www.janes.com/article/45765/f-35c-exceeds-100-catapults-arrestments-during-first-week-at-sea

The carrier variant of the Lockheed Martin F-35 Lightning II combat aircraft has completed more than 100 catapult launches and arrested landings during its first two weeks of sea trials, pilots and officials told reporters aboard the USS Nimitz (CVN 68) on 13 November.

The two C-model test aircraft on board Nimitz , CF-03 and CF-05, have already satisfied 95% of the threshold requirements for the first of three rounds of sea-based Development Testing I (DT-I), according to US Navy (USN) officials. As of 13 November the aircraft had completed 102 catapult launches and 104 arrested landings with a redesigned tailhook, according to data provided by the F-35 programme office. The pace puts DT-I on track for completion ahead of the scheduled 17 November end date, said programme office officials.

Further, the F-35C has conducted its first night-flight, the Pentagon announced. "LCDR Ted Dyckman piloted test aircraft CF-03 for the inaugural night-flight of the F-35C on 13 November," said F-35 programme office spokesman Joe Dellavedova.

The F-35C's unit price is about USD130 million, making it the costliest of the three variants, but the Pentagon's goal is to lower that price to about USD96 million by 2018 when the navy is expected to allow the aircraft to deploy operationally, said Dellavedova.

Meanwhile, the F-35C's highly anticipated automated landing system,'delta flight path', is proving very reliable thus far, according to pilots.

"It makes landing on the boat a routine task," said Commander Tony Wilson, the pilot who conducted the first F-35C carrier landing on 3 November. Pilots said the feature is somewhat similar to cruise control on cars. Landing on a flight deck "has always been fun and challenging", said Cmdr Wilson. "This makes it fun and routine."”

Amid a Year of Challenges, F-35C Sea Trials Progressing Well

Valerie Insinna 14 Nov 2014

"...However, the gear has been catching the wires on the carrier deck without gouging or otherwise damaging the surface, Wilson said...."

http://www.nationaldefensemagazine.org/blog/Lists/Posts/Post.aspx?List=7c996cd7%2Dcbb4%2D4018%2Dbaf8%2D8825eada7aa2&ID=1667

ABOARD THE USS NIMITZ — For those involved with procuring, developing, testing and piloting the naval variant of the joint strike fighter, the past week of F-35C sea trials has been a reprieve from technical challenges, including engine problems and issues with the tail hook that lead to a complete redesign.

The flight tests kicked off last week when the CF-03 test airplane successfully landed Nov. 3 on the deck of the USS Nimitz aircraft carrier. Since then, the aircraft has completed more than 26 flights, including more than 100 catapult launches, 214 touch-and-go landings and 102 arrested landings as of Nov. 12, according to Navy statistics.

The F-35 performed its first night flight on Nov. 13, joint program office spokesman Joe DellaVedova said in an emailed statement.

"We expected to come out here and have to figure some issues out, and surprisingly everything has been going well," Cmdr. Tony Wilson, a test pilot at Patuxent River, told reporters. The aircraft has integrated onto the carrier without any major problems.

"We're learning things, but everything that we're learning is extremely minor," he said. He declined to comment on any performance or design issues.

The Navy has completed about 95 percent of the test items it set out to perform during its two weeks at sea, as well as additional "nice-to-have" points that can inform later trials, Cmdr. Sean Kern, director of test and evaluation for Patuxent River's integrated F-35 test force, said Nov. 13.

Still on the to-do list are catapult launches in crosswind conditions and recoveries in 40-knot or higher winds. Pilots have flown flights in those high winds during the past week, but more data is needed, he said.

The Navy is the last of the services to field the joint strike fighter, with initial operational capability in fiscal year 2018. Its variant is also the most expensive, costing about $130 million per unit in low rate initial production lot 7.

During a media day aboard the Nimitz on Nov. 13, CF-05 test aircraft took off, flew in pattern around the carrier, and performed an arrested landing. Its tail hook caught the third wire on the ship, which the Navy considers optimal for safety.

Those third-wire engagements have been the norm during tests, Wilson said. So far there has been only one bolter — when a pilot touches down too late and fails to catch onto a wire. The pilot executed a planned touch-and-go, but touched down after the fourth and final wire, technically qualifying it as a bolter.

Navy officials could not comment on whether that was the result of pilot error or an issue with the F-35's new "delta flight path" technology, which helps automate landing on the carrier.

Wilson said delta flight path had performed well in testing and would help to unburden pilots during normal operations, likening it to having cruise control in a car.

"This flight control scheme is revolutionary and is going to pay huge dividends for the Navy," he said. "It's going to make landing on the boat a routine task, and right now landing on the boat is anything but a routine task. That's why the Navy invests so much money into training its pilots and continually training them."

Another positive finding was the performance of the F-35C's new tail hook. During the original hook's initial tests at Naval Air Engineering Station Lakehurst in New Jersey, service officials found the hook did not engage with the cable, said Thomas Briggs, head of the air vehicle engineering department at Patuxent River.

Lockheed Martin then redesigned the tail hook with the input of Atlantic Test Range personnel, he said.

It passed structural demonstrations earlier this year at Patuxent River, but critics like Michael Gilmore, the Pentagon's director of test and evaluation, cautioned that the increased weight and sharpness of the new equipment could cause damage to the flight deck.

However, the gear has been catching the wires on the carrier deck without gouging or otherwise damaging the surface, Wilson said.

The F-35 is planned to return to the carrier for sea trials in summer 2015, when testers will gather data about how it performs with munitions inside its internal bomb bays, Briggs said. In the third set of trials, external payloads on its wings will be added.

Because most of the mission systems testing apply to all variants, they can be tested ashore, Kern said. Once they mature through testing at Patuxent River and Edwards Air Force Base, "we'll bring that capability out to the ship and then look at specific issues involving ship integration out here."

"What we have been looking at here is some of the electromagnetic effects to see if there is any interference issues between the ship's equipment and the aircraft's equipment," he said. "We haven't found any" during this round of sea trials, he added.

F-35C shines in first carrier trials aboard carrier Nimitz

17 Nov 2014 Joshua Stewart

ABOARD THE AIRCRAFT CARRIER NIMITZ IN THE PACIFIC OCEAN — After 10 days of sea trials here, the differences between the F-35C Lightning II and its predecessors are becoming readily apparent as the plane is launched, trapped and maneuvered topside.

Sailors who got the opportunity to work with the next generation strike fighter said the F-35C has attributes that aren't found elsewhere in the air-wing. It has a smoother ride, it's easier to taxi, and it has less complicated landing procedures. In many ways, it does a lot of the heavy lifting itself and takes work away from sailors.

"It's truly an administrative task," said Cmdr. Tony Wilson, the lead test pilot for the F-35C, in an interview Nov. 13 as the 10 day testing wrapped up. Pilots and flight deck crews found the more compact plane easier to fly and maneuver aboard ship, good attributes for an aircraft that's seen many delays and is now slated for a 2018 fleet introduction.

The stealth fighter handles well and its control system cuts the pilot's workload, he said.

The most stressful task in carrier-based aviation — the landing — has been simplified with the **delta flight path**, a program that partially automates the approach and adjusts the plane's trajectory just seconds before the aircraft reaches the flight deck. This system allows pilots to focus more on other aspects of flying, Wilson said.

"It's going to make landing on the boat a routine task," he said. "This makes it fun," he later added.

Compared to legacy aircraft, the F-35C has a more graceful approach, said Lt. Chris Karapostoles, a landing signal officer assigned to Air Test and Evaluation Squadron 23.

Compared to the F/A-18 Super Hornet, also known in aviation circles as the Rhino, the F-35C can adjust its approach faster and smoother, making it more likely to hit the three wire — the ideal landing, Karapostoles said.

'Nothing scary'

Karapostoles' job is to monitor aircraft as they fly in for a landing. Along the way he helps pilots adjust their course, and, if necessary, he waves off landings because of unsafe conditions or a bad approach. The goal is to land aircraft as safely and quickly as possible.

So far there haven't been any wave-offs for a bad approach, but there were a few due to wind and deck motion. It was "nothing scary," Karapostoles said.

One touch-and-go, however, didn't go as well as hoped, officials said. The maneuver was supposed to simulate an approach to a landing, but the aircraft hit the deck too far forward. Had it been a real landing rather than a simulation, the plane's tailhook would have missed the arresting gear, resulting in a bolter where the pilot quickly lifts back off the deck and circles around the carrier to set up for a second attempt, Karapostoles said.

Otherwise the plane has consistently caught the three wire, he said. The three wire is one of four arresting cables on the Nimitz's flight deck and is the preferred landing zone.

The F-35C test pilots have made approximately 100 traps on the Nimitz, and the three wire was caught so many times that the metal cable

X-35C & F-35C FCLP & Arrests NIMITZ Nov 2014
https://www.youtube.com/watch?v=vsHcFQTzwQg

F-35C CF-05 USS Nimitz Nov 2014 DT-I

http://www.navy.mil/management/photodb/photos/141103-N-AZ866-050.JPG

“141103-N-AZ866-050 PACIFIC OCEAN (Nov. 3, 2014) An F-35C Lightning II carrier variant joint strike fighter conducts its first arrested landing aboard the aircraft carrier USS Nimitz (CVN 68). Nimitz is underway conducting routine training exercises. (U.S. Navy photo by Mass Communication Specialist 3rd Class Kelly M. Agee/Released)”

http://www.navy.mil/gallery_search_results.asp?terms=F%2D35C&page=3&r=4

had to be replaced. The one wire, the cable furthest aft on the flight deck, hadn't been used at all, Wilson said.

"We've been beating up the three wire," he said.

When it snags that wire, pilots have a softer landing in the F-35C than what they're used to in legacy aircraft, Wilson said.

Sailors on the flight deck will notice a few changes as well.

Aviation Boatswain's Mate 1st Class (SW/AW) Matt Beilke said the F-35C isn't as long as F/A-18 Hornets and Super Hornets. On a flight deck and hangar where there are dozens of aircraft, every inch counts and this compact size makes it easier to move aircraft around tight spaces.

"The F-35 turns easier," Beilke said. "On the deck it turns on a dime."

Also, it doesn't have to power up as much as legacy aircraft, so there's less hot exhaust on the flight deck, making it a safer environment.

But Beilke also said he can't give a full picture of how well the F-35C will perform in topside maneuvers. Only two F-35Cs and a few other aircraft were on board for the testing. Things might be different when there's a full air wing on board, he said.

He said the F-35C was as loud as other aircraft in the wing, and there didn't seem to be any differences on the flight deck with the one-engine F-35C compared to the two-engine Hornet and Super Hornet.

The test sensors added to the aircraft for flight testing made it a little harder to chain to F-35C and aircraft handlers had to avoid bumping any sensors, he said. Those test sensors will be removed by the time the aircraft hits the fleet. Once that happens, he'll be able to tie up the plane just like he ties up legacy aircraft, he said.

Besides the two-F-35Cs, there were two other new pieces of hardware on the flight deck. Lawnmower-sized generators were brought on board and positioned near the island. Carriers are wired for a 115-volt system to power equipment on legacy aircraft while the F-35C requires a 270-volt system. The generators were put on the deck to provide this alternate voltage.

Officials said that the generators will only be used for carrier tests, and the Navy is adding 270-volt power to carriers during planned availabilities. After receiving the upgrades, carriers will have both 115- and 270-volt systems.

"Ships will be modified," said Jim Gigliotti, the director for F-35C and Navy program manager for Lockheed Martin.

The F-35C made its first carrier trap on Nov. 3. and two of the next-generation aircraft are on the Nimitz for a series of tests. Most of the evaluations focus on catapult launches and landings, and as of Nov. 13 the test team was slightly ahead of schedule and was preparing for the plane's first carrier based launches and recoveries at night.

Future carrier integration tests will evaluate how the F-35C performs with weapons in its bomb bay and with weapons attached underneath its wings.

The Navy plans to purchase 260 F-35Cs to replace aging F/A-18A-D Hornets. The Marine Corps wants 63 F-35Cs for its carrier-based fighter squadrons.

The F-35C is expected to reach initial operating capability in August 2018. By that point the Navy plans to stand up an operational squadron with 10 F-35Cs and trained pilots.

http://www.navytimes.com/story/military/tech/2014/11/15/f-35c-navy-carrier-nimitz-sea-trials-trap/19019879/

https://nimitznews.files.wordpress.com/2014/11/14p00625_31.jpg

F-35C Completes Initial Sea Trials aboard Aircraft Carrier

17 Nov 2014 From Commander, Naval Air Forces Public Affairs

SAN DIEGO (NNS) -- The F-35C Lightning II carrier variant Joint Strike Fighter completed its first phase of developmental test (DT) aboard an aircraft carrier Nov. 14, three days ahead of schedule aboard USS Nimitz (CVN 68).

During the DT-I event, F-35C Lightning II Joint Strike Fighter (JSF) the F-35 Lightning II Integrated Test Force (ITF) from Air Test and Evaluation Squadron 23 (VX-23) located at Naval Air Station (NAS) Patuxent River in Patuxent River, Maryland, tested the carrier suitability of the aircraft and its integration with carrier air and deck operations in the at-sea environment, achieving 100 percent of the threshold test points.

The aircraft demonstrated exceptional performance throughout its initial sea trails, accelerating the team's progress through the DT-I schedule and enabling them to conduct night operations – a milestone typically achieved during the second at-sea phase of developmental tests, as evidenced by the test schedules of the F/A-18 Hornet and F/A-18 E/F Super Hornet.

"We had such confidence in how the plane is flying that we lowered the weather minimums to what the fleet is actually using, knowing that when I lower my hook and come into the groove I'm going to trap," said Lt. Cmdr. Ted Dyckman, Navy test pilot. "That says a lot for the airplane. So, when it came time for night traps, we said the plane is ready and we launched it. It flew very well behind the ship. Even on the darkest night – pretty much as dark as you can get behind the boat. Two hook-down passes and two traps and that says it all right there. It's unheard of to conduct night ops on the first det."

"The engineers responsible for the aircraft's control laws at Pax (Patuxent) River and Fort Worth have done a phenomenal job designing a carefree aircraft from the pilot's perspective," said Cmdr. Tony Wilson, DT I Team Lead. "The F-35C's performance on the ball was revolutionary, providing carefree handling on approach. The Integrated Direct Lift Control (IDLC) allows ball control like no other aircraft. The control schemes of the F-35C provide a tool for the below average ball flyer to compete for top hook. And, Delta Flight Path is an innovative leap in aircraft flight controls – this command enables the F-35 to capture and maintain a glideslope, greatly reducing pilot workload, increasing safety margins during carrier approaches and reducing touchdown dispersion."

The cadre of DT-I test pilots logged a total of 39.2 flight hours as they conducted 33 flights featuring 124 catapults, 222 touch-&-go landings, & 124 arrestments. There were zero unintentional hook-down bolters, or missed attempts to catch an arresting wire on the flight deck. (Two hook-down, intentional bolters were conducted as part of the DT-I test plan.)

Successful carrier landings of the F-35C also point to an effective re-design of the once-troubled tailhook. Initial testing shore-based testing pointed toward tailhook design issues and the Atlantic Test Range (ATR) at NAS Patuxent River captured critical measurement data with their precision photogrammetric technology and modeling capabilities. The re-design collaboration between Lockheed Martin and Fokker Technologies of the Netherlands – with insight and participation by Navy airworthiness engineers – has yielded a preponderance of three-wire landings during DT-I and firmly established the success of the redesign.

The goal of DT-I, the first of three at-sea test phases planned for the F-35C, was to collect environmental data through added instrumentation to measure the F-35C's integration to flight deck operations and to further define the F-35C's operating parameters aboard the aircraft carrier. A thorough assessment of how well the F-35C operated in the shipboard environment will advise the Navy of any adjustments necessary to ensure that the fifth-generation fighter is fully capable and ready to deploy to the fleet in 2018.

http://www.navy.mil/submit/display.asp?story_id=84481

Cats, Traps & a Rooster Tail

Dec 2014 Mark Ayton, Air International

[F-35C Aircraft] "...CF-03/'SD73' and CF-05/'SD75'...

...DEVELOPMENTAL TESTER TEST DIRECTOR

Cdr Shawn Kern is the Director of Test and Evaluation for F-35 Naval Variants and the senior military member within the F-35 Integrated Test Force (ITF) based at Patuxent River. He leads a diverse team comprising 920 members from the US Government, the military and contractors responsible for developmental test of the F-35B and F-35C aircraft during the System Development and Demonstration phase. During DT I, Cdr Kern led the F-35 ITF, provided government oversight of carrier suitability testing and co-ordinated with the USS Nimitz's captain, executive officers and other F-35 stakeholders.

He told AIR International: "Launch testing included minimum catapult end speed determination as well as performance and handling during high and low energy catapult launches and crosswind conditions at representative aircraft gross weights. Approach and recovery testing focused on aircraft performance and handling qualities during off-nominal recoveries in low, medium, high and crosswind wind conditions. Data and analysis from DT I will support the development of initial aircraft launch and recovery bulletins for F-35C carrier operations and Naval Air Training and Operating Procedures Standardisation (NATOPS) flight manual procedures. Test results from DT I will also influence follow-on developmental and operational testing required to achieve F-35C initial operational capability."

Lt Cdr Ted Dyckman is a US Navy F-35 test pilot assigned to VX-23 based at Naval Air Station Patuxent River, Maryland: he made the second-ever arrested landing on a super carrier in aircraft CF-05 on November 3 and the first night-time landing on November 13 in CF-03. Speaking about the F-35C's performance around the carrier, Lt Cdr Dyckman told AIR International: "Everything met expectations and there were no surprises. Going through the burble was a big unknown, but the airplane responded better than we thought it would.

"We saw that the aircraft could trap: the only true bolter was a power call by the Landing Signals Officer when the aircraft touched down long with the hook down but came around and made an arrested landing.

"When the weather started to deteriorate we had such confidence in how the aircraft was flying that we lowered the weather minimums to those used by the fleet. I knew that when I lowered the hook I was going to trap. That says a lot for the airplane.

"Because the autopilots and flying qualities are so good, the workload to fly the jet is reduced and we were confident enough to declare it ready for night-time traps. It flew very well behind the ship and I made two hook-down passes and two traps. It's unheard of to conduct night ops on a type's first period at sea.

"We accomplished everything we set out to do, which allows us to go to DT II and conduct maximum speed catapult shots and carry internal and external stores and asymmetric payloads."...

...Flight testing was split into three phases: day carrier qualification (CQ) and flight deck crew familiarisation;

the development of aircraft launch bulletins (ALB) and aircraft recovery bulletins (ARB). In addition DT I also included Logistical Test and Evaluation (LT&E). Subsets of each phase comprised:

Aircraft Launch Bulletins

- Military rated thrust catapult launches
- Minimum catapult launch end speeds
- Low, medium and high excess wind over deck (WOD) catapult launches
- Crosswind catapult launches
- Bow and waist catapult launches

Aircraft Recovery Bulletins

- Approach handling qualities (AHQ) of F-35C approach modes: delta flight path, approach power compensator (APC), and manual
- Low, medium and high excess WOD recoveries
- Crosswind recoveries
- Bolter performance Logistical Test and Evaluation
- Deck handling including taxiing, towing and tie-down
- Weapons loading
- Basic maintenance, including aircraft jacking and landing gear servicing
- Maintenance support

Preparations

Since the author's previous visit to the F-35 ITF at Pax River in April the main test objectives completed over the summer were arrested landings, touch and goes (a training evolution also known as field carrier landing practice or FCLP) and a structural survey of CF-03. The latter was a methodical check of the aircraft to ensure it was structurally suitable to be flown aboard an aircraft carrier. The survey included testing engineering fixes made to the aircraft's pitch pivot pin and nose wheel steering motor. Although precautionary, the survey was required because functionality problems had been discovered with each component during the F-35C's developmental flight test programme. A subset of the structural testing performed on CF-03, known as a shake, was also completed on CF-05 to ensure it was also suitable for carrier trials. No issues were found.

One other pre-deployment test evolution was electromagnetic environmental effects (E3). This required CF-03 to spend two weeks in the shielded hangar at Pax River, to ensure that electromagnetic interference from the ship's emitters did not affect any of the aircraft's vital systems and cause them to shut down. The official E3 test report was completed on October 16 which cleared the aircraft to embark onboard the carrier.

All requisite carrier suitability testing was concluded on October 17 and the final FCLPs were completed at Pax River four days later.

One interruption to the test programme over the summer was caused by the temporary grounding order resulting from an engine fire on F-35A AF-27, serial number 10-5015, at Eglin Air Force Base, Florida on June 23. Each engine underwent a rigorous inspection process and because of the priority given to DT I, CF-03 was the first to be inspected, analysed and cleared back to flight: CF-05 followed....

...No modifications were required to

the flight deck, not even the Jet Blast Deflectors (JBDs): hydraulic-controlled panels designed to divert hot aircraft exhaust during launches. The panels are raised in preparation for take-off, protecting the flight deck and aircraft behind from the hot aircraft exhaust. Modification of the JBDs will be required for subsequent DT evolutions, when afterburner will be required to launch aircraft with heavier all-up weights than those used during DT I. Any changes implemented will alter the cooling path of the F-35's exhaust plume, which interacts with the carrier's decking differently from that of the twin-engined members of the Hornet family….

…Support Onboard and from Ashore

DT I was supported by a pre-production, nonfleet representative version of the Autonomic Logistics Information System known as ALIS 1.03. According to the F-35 Joint Program Office: "Standard ALIS functions were in place and used to support F-35C operations and maintenance onboard USS Nimitz. The functions were accessible via approved Department of Defense network and cyber security policies and authorisations similar to ALIS support for F-35B STOVL deployments to the USS Wasp (LHD 1)….

…Increased robustness in the aircraft's control laws refers to:

- Pro-rotation during a catapult and bolter.
- Integrated Direct Lift Control which integrates the control surfaces such that wing camber is altered to increase or decrease lift, thus allowing glide slope changes to be made without a large change in engine thrust.
- Delta Flight Path, which is an innovative leap in aircraft flight controls, that commands the aircraft to capture and maintain a glide slope. The system greatly reduces the pilot's workload, increases the safety margins during carrier approaches and reduces touchdown dispersion.

Wind Effects

Aircraft carriers are unique in that they have different wind effects that the pilot and the aircraft's flight control laws must take into account. The overall wind effect is called the burble,…

…"We are evaluating how the control law handles through the burble. Data collected during DT I will now be used by the control law engineers for analysis and to improve our simulator modelling. Because the burble is such a dynamic and integrated wind system there are challenges to modelling it accurately. Future F-35 pilot training will benefit from this work," said Cdr Wilson….

…We started making intentional errors in our approaches [off-nominal]. This allowed us to see how the aircraft's flight control laws react to corrections input by the pilot and the effect of the burble while trying to make the corrections. "The pilot intentionally lines up [on approach] on either side of the landing area…starting either high or low, or flying fast or slow to see if there is enough time to input the correction and get back on centreline, on glide slope and on speed [flying a proper approach speed] prior to touch down. "As we fly off nominal approaches, if the LSO [landing signals officer] doesn't see a timely correction or doesn't feel that the pilot is going to land safely, he or she will wave them off.

"The LSO [who is located on a

Cats, Traps & a Rooster Tail

AIR International's *Mark Ayton reports from the USS* Nimitz *during the F-35C Lightning II's first carrier suitability development test period referred to as DTI*

At 12.18 Pacific Standard Time on November 3, US Navy test pilot Cdr Tony Wilson caught the number three-wire on USS *Nimitz* (CVN 68) in F-35C CF-03. This single event, the result of many tens of thousands of man hours devoted to the F-35C's carrier suitability, made history: Wilson was the first pilot to land the carrier variant of the Joint Strike Fighter on a super carrier.

Less than one hour later, US Navy test pilot Lt Cdr Ted Dyckman also made an arrested landing aboard *Nimitz* in F-35C CF-05: DT I had successfully begun.

Throughout the two-week test period, USS Nimitz remained under way in the Pacific Ocean off the coast of Southern California and Baja California, Mexico.

Determining Carrier Suitability

The purpose of DT I was to test the F-35C's suitability in the at-sea environment, including integration with carrier air and deck operations. Test objectives were achieved through a series of test events designed to gradually expand the aircraft's operating envelope from a carrier. DT I also provided opportunities to conduct general maintenance and fit tests for aircraft and support operations; training with the ship's crew; and simulated maintenance operations.

Flight operations were conducted in nominal and off-nominal conditions with F-35C System Development and Demonstration aircraft CF-03/'SD73' and CF-05/'SD75'. Both examples configured with Block 2B software are unique test aircraft assigned to Air Test and Evaluation Squadron 23 (VX-23) 'Salty Dogs' based at Naval Air Station Patuxent River in Maryland, more commonly known as Pax River.

Four test pilots flew in DT I: Cdr Tony Wilson, DT I Team Lead; Lt Cdr Ted Dyckman; Lockheed Martin's Elliott Clemence; all from the F-35 ITF/VX-23 at Pax River; and Cdr Christian Sewell, F-35 ITF Operations Officer from Air Test and Evaluation Squadron 9 (VX-9) based at Naval Air Weapons Center, China Lake, California.

Flight testing was split into three phases: day carrier qualification (CQ) and flight deck crew familiarisation; the development of aircraft launch bulletins (ALB) and aircraft recovery bulletins (ARB). In addition DT I

1 F-35C CF-05/'SD75', flown by Lt Cdr Ted Dyckman, turns on to final approach for his first arrested landing onboard USS *Nimitz* on November 3. This was flight 91 for aircraft CF-05. *Andy Wolfe/Lockheed Martin* 2 CF-05 catches the number two wire in the hands of Cdr Elliott Clemence, at the end of the aircraft's 95th flight on November 5. *Alexander Groves/Lockheed Martin*

1 An aircraft captain signals a command to Cdr Wilson at the end of a flight in CF-03 on November 9. *Alexander H Groves/Lockheed Martin* 2 Aircraft CF-05 launches on its 101st flight, with Elliot Clemence in the cockpit, on November 12. This was a high-energy launch from catapult four. *Andy Wolfe/ Lockheed Martin* 3 The catapult officer signals to the flight deck crew as the aircraft's nose bar engages with the shuttle on catapult two. *Alexander Groves/ Lockheed Martin* 4 Cdr Clemence gives signals a 'thumbs up' to the flight deck crew after catching the number two-wire on the USS *Nimitz* on November 5. *Alexander Groves/Lockheed Martin* 5 The F-35's windshield and canopy showing the embedded charges activated in the event of an ejection. *Andy Wolfe/Lockheed Martin*

also included Logistical Test and Evaluation (LT&E). Subsets of each phase comprised:

Aircraft Launch Bulletins
- *Military rated thrust catapult launches*
- *Minimum catapult launch end speeds*
- *Low, medium and high excess wind over deck (WOD) catapult launches*
- *Crosswind catapult launches*
- *Bow and waist catapult launches*

Aircraft Recovery Bulletins
- *Approach handling qualities (AHQ) of F-35C approach modes: delta flight path, approach power compensator (APC), and manual*
- *Low, medium and high excess WOD recoveries*
- *Crosswind recoveries*
- *Bolter performance*

Logistical Test and Evaluation
- *Deck handling including taxiing, towing and tie-down*
- *Weapons loading*
- *Basic maintenance, including aircraft jacking and landing gear servicing*
- *Maintenance support*

Preparations

Since the author's previous visit to the F-35 ITF at Pax River in April the main test objectives completed over the summer were arrested landings, touch and goes (a training evolution also known as field carrier landing practice or FCLP) and a structural survey of CF-03. The latter was a methodical check of the aircraft to ensure it was structurally suitable to be flown aboard an aircraft carrier. The survey included testing engineering fixes made to the aircraft's pitch pivot pin and nose wheel steering motor. Although precautionary, the survey was required because functionality problems had been discovered with each component during the F-35C's developmental flight test programme.

A subset of the structural testing performed on CF-03, known as a shake, was also completed on CF-05 to ensure it was also suitable for carrier trials. No issues were found.

One other pre-deployment test evolution was electromagnetic environmental effects (E3). This required CF-03 to spend two weeks in the shielded hangar at Pax River, to ensure that electromagnetic interference from the ship's emitters did not affect any of the aircraft's vital systems and cause them to shut down. The official E3 test report was completed on October 16 which cleared the aircraft to embark onboard the carrier.

All requisite carrier suitability testing was concluded on October 17 and the final FCLPs were completed at Pax River four days later.

One interruption to the test programme over the summer was caused by the temporary grounding order resulting from an engine fire on F-35A AF-27, serial number 10-5015, at Eglin Air Force Base, Florida on June 23. Each engine underwent a rigorous inspection process and because of the priority given to DT I, CF-03 was the first to be inspected, analysed and cleared back to flight: CF-05 followed.

Ship Modifications

The biggest single pieces of equipment required by the test team for DT I onboard the USS *Nimitz* comprised two control rooms: a deployable debrief facility or DDF (a Conex container able to house 18 people) on loan from the US Air Force, and a 12-person van with a control room in the back. Both were loaded aboard the USS *Nimitz* at the beginning of October, installed and tied down in the hangar deck.

Temporary alterations needed to the ship to support testing included brackets welded onto the starboard bow to hold the F-35

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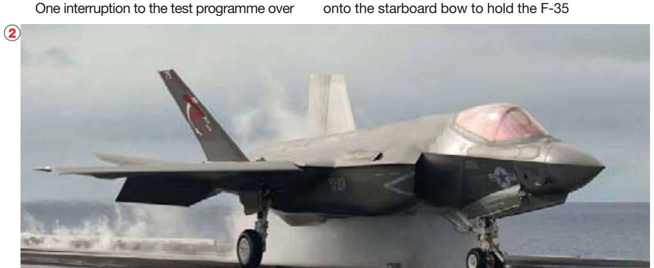

DEVELOPMENTAL TESTER

Lt Cdr Ted Dyckman is a US Navy F-35 test pilot assigned to VX-23 based at Naval Air Station Patuxent River, Maryland: he made the second-ever arrested landing on a super carrier in aircraft CF-05 on November 3 and the first night-time landing on November 13 in CF-03. Speaking about the F-35C's performance around the carrier, Lt Cdr Dyckman told AIR International: *"Everything met expectations and there were no surprises. Going through the burble was a big unknown, but the airplane responded better than we thought it would.*

"We saw that the aircraft could trap: the only true bolter was a power call by the Landing Signals Officer when the aircraft touched down long with the hook down but came around and made an arrested landing.

"When the weather started to deteriorate we had such confidence in how the aircraft was flying that we lowered the weather minimums to those used by the fleet. I knew that when I lowered the hook I was going to trap. That says a lot for the airplane.

"Because the autopilots and flying qualities are so good, the workload to fly the jet is reduced and we were confident enough to declare it ready for night-time traps. It flew very well behind the ship and I made two hook-down passes and two traps. It's unheard of to conduct night ops on a type's first period at sea.

"We accomplished everything we set out to do, which allows us to go to DT II and conduct maximum speed catapult shots and carry internal and external stores and asymmetric payloads."

ITF's own anemometer to measure wind-speed and direction to a higher fidelity than those already fitted to the ship.

Cdr Wilson explained: "That's extremely important for shooting minimum or maximum sinks. One test evolution, and probably the most dangerous, involves the aircraft being shot off the front end with no excess airspeed. If there is any pick-up, the aircraft can potentially sink. We targeted in excess of 10ft [3m] of sink. We needed the high fidelity anemometer to measure the head and cross winds, the force of which are tied directly to the amount of aircraft sink. On the open ocean the wind always varies by two or three knots [rather than being constant]: that margin can affect the amount of sink we see."

Fibre-optic lines and power cables were run from the flag bridge (just below the ship's bridge where cameras and instrumentation are installed) to bus the data down eight levels to the control rooms.

No modifications were required to the flight deck, not even the Jet Blast Deflectors (JBDs): hydraulic-controlled panels designed to divert hot aircraft exhaust during launches. The panels are raised in preparation for take-off, protecting the flight deck and aircraft behind from the hot aircraft exhaust.

Modification of the JBDs will be required for subsequent DT evolutions, when afterburner will be required to launch aircraft with heavier all-up weights than those used during DT I. Any changes implemented will alter the cooling path of the F-35's exhaust plume, which interacts with the carrier's decking differently from that of the twin-engined members of the Hornet family.

Flight Deck Crew

All of the flight deck crew members involved in DT I were assigned to the USS *Nimitz*, and some went to Pax River in mid-October for training. The intent was to train the trainers. They returned to the ship and prepared the remainder of their crew for the arrival of the F-35C.

The F-35 ITF team at Pax River worked with the USS *Nimitz* for almost a year; as an operational entity, the warship's crew had considerable experience that was vital to making the DT I effort a success. Cdr Wilson was in no doubt about the part they played in DT I: "We welcomed their feedback. The flight deck crew are the guys that conduct flight operations day in, day out, and were able to advise us on what they encountered while handling the F-35C. The ship was as much a part of the test team as anybody else."

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TEST DIRECTOR

Cdr Shawn Kern is the Director of Test and Evaluation for F-35 Naval Variants and the senior military member within the F-35 Integrated Test Force (ITF) based at Patuxent River. He leads a diverse team comprising 920 members from the US Government, the military and contractors responsible for developmental test of the F-35B and F-35C aircraft during the System Development and Demonstration phase.

During DT I, Cdr Kern led the F-35 ITF, provided government oversight of carrier suitability testing and co-ordinated with the USS Nimitz's captain, executive officers and other F-35 stakeholders.

He told AIR International: *"Launch testing included minimum catapult end speed determination as well as performance and handling during high and low energy catapult launches and crosswind conditions at representative aircraft gross weights.*

Approach and recovery testing focused on aircraft performance and handling qualities during off-nominal recoveries in low, medium, high and crosswind wind conditions. Data and analysis from DT I will support the development of initial aircraft launch and recovery bulletins for F-35C carrier operations and Naval Air Training and Operating Procedures Standardisation (NATOPS) flight manual procedures. Test results from DT I will also influence follow-on developmental and operational testing required to achieve F-35C initial operational capability."

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1 Aircraft CF-03 (flight 184) piloted by Cdr Tony Wilson and CF-05 (flight 93) piloted by Lt Cdr Dyckman wait for launch from the bow catapults of the USS *Nimitz*. *Dane Wiedmann/Lockheed Martin* 2 F-35C CF-03 taxiing to its parking position after Cdr Tony Wilson completed its 189th flight on November 8. *Andy Wolfe/Lockheed Martin* 3 The shooter's view across the deck of aircraft CF-03 on catapult two from inside the Integrated Catapult Control System. *Dane Wiedmann/Lockheed Martin*

Support Onboard and from Ashore

DT I was supported by a pre-production, non-fleet representative version of the Autonomic Logistics Information System known as ALIS 1.03. According to the F-35 Joint Program Office: "Standard ALIS functions were in place and used to support F-35C operations and maintenance onboard USS *Nimitz*. The functions were accessible via approved Department of Defense network and cyber security policies and authorisations similar to ALIS support for F-35B STOVL deployments to the USS *Wasp* (LHD 1).

"In addition, standard operating instructions and procedures were in use to support F-35 operations during situations when ALIS functions were not immediately available. There was a combination of F-35 ITF and Lockheed Martin personnel on board and ashore to support operations aboard USS *Nimitz*."

Chief Test Engineer Tom Briggs told *AIR International*: "ALIS was not fully integrated with the USS *Nimitz* for this test detachment. However, the test team used the ship's ability to transmit data to and from the shore in order to link to an ALIS server in Fort Worth. This allowed us to maintain configuration management of the aircraft and to process maintenance activities, such as pre-flight inspections, repairs when necessary, compliance with time-based inspections, and routine post-flight inspections. These are the same basic capabilities for which we use ALIS at our test sites in the SDD portion of the programme."

Test Objectives

DT I is primarily focused on how the aircraft's avionics integrate with the ship, so there is no instrumented work of cats (catapult launches) and traps (arrested landings) to be undertaken on the ship: that was carried out by NAVAIR at Naval Air Weapons Station Lakehurst, New Jersey in 2012. At the end of a cat shot at either Lakehurst or Pax, the aircraft rotates about its main gear and flies away. At the ship, things are a little different. After the cat shot the aircraft is in the air but rotates about its centre of gravity rather than its main gear with a 60ft (18.3m) drop at the end of the cat. DT I evaluated how the jet reacts to the drop.

According to Cdr Wilson: "The engineers responsible for the aircraft's control laws at Pax and Fort Worth have done a phenomenal job designing a carefree aircraft from the pilot's perspective. So as long as everything goes as it should, the plane will rotate on its own and pick up a fly-away attitude without the pilot having to take control. That's not a huge jump because our legacy aircraft already do that but the F-35 has other functions written into its control laws that increase its robustness and make it less susceptible to failures."

Increased robustness in the aircraft's control laws refers to:

- ***Pro-rotation during a catapult and bolter.***
- ***Integrated Direct Lift Control which integrates the control surfaces such that wing camber is altered to increase or decrease lift, thus allowing glide slope changes to be made without a large change in engine thrust.***
- ***Delta Flight Path, which is an innovative leap in aircraft flight controls, that commands the aircraft to capture and maintain a glide slope. The system greatly reduces the pilot's workload, increases the safety margins during carrier approaches and reduces touchdown dispersion.***

ENGINEERING MASTER

Tom Briggs was designated Chief Test Engineer for development test and oversees the execution of testing and approving any required changes to the test plan or the conduct of testing from an engineering perspective.

As Chief Test Engineer, he helped prepare the ITF team (comprising more than 230 people from the F-35 ITF and the crew of the USS Nimitz) for testing at sea and helped co-ordinate the expectations of the ship's crew as to what would be tested and how planned testing would integrate with their operations.

Tom told AIR International: "The main test points were to verify that the F-35C's approach handling qualities were satisfactory across a variety of wind conditions; to determine its launch characteristics and performance from all four of the ship's catapults and across a variety of wind conditions; to look at the integration of the aircraft with the ship both on the flight deck and in the hangar bay; and to test the ability of the F-35C to use the ship's flight-related systems to perform inertial alignments, instrument approaches and basic navigation to and from the ship.

"Use of the aircraft's sensors and its fuel dump function were also tested. Data obtained from the tests will now be analysed to support the overall verification of the F-35C against the Joint Contract Specification as well as developing the initial aircraft launch bulletins and verifying that the initial aircraft recovery bulletins are satisfactory."

Wind Effects

Aircraft carriers are unique in that they have different wind effects that the pilot and the aircraft's flight control laws must take into account. The overall wind effect is called the burble, and there are three main components.

Vortices generated off the left bow typically travel down the landing area (LA). To visualise this particular effect, just imagine a very weak tornado lying on its side and along the LA. Wind disturbance created by the ship's island becomes turbulence, which has to be flown through when landing due to the angled deck construction.

The third effect is colloquially called the rooster tail. As wind travels down the flight deck it drops off the end causing a big downdraught but then shoots back up forming the rooster tail.

As the pilot flies the final few hundred yards of the approach, the first wind effect he or she will encounter is a slight uplift (the rooster tail) followed a couple of seconds later by the downdraught. The pilot must compensate for both as well as the other components of the burble.

"We are evaluating how the control law handles through the burble. Data collected during DT I will now be used by the control law engineers for analysis and to improve our simulator modelling. Because the burble is such a dynamic and integrated wind system there are challenges to modelling it accurately. Future F-35 pilot training will benefit from this work," said Cdr Wilson.

Avionics

Explaining the types of avionics testing, Cdr Wilson said the E3 anechoic chamber work

OPERATIONAL TESTER

Cdr Christian Sewell is a test pilot assigned to a detachment of Air Test and Evaluation Squadron 9 (VX-9) 'Vampires' from Naval Air Weapons Station China Lake in California based at Naval Air Station Patuxent River in Maryland. The unit is the US Navy's fast jet operational test squadron. Cdr Sewell works as a liaison officer between the operational test (OT) and developmental test (DT) teams.

He told AIR International: "I update the OT community (including the Joint Operational Test Team at Edwards Air Force Base, California) on the status of DT testing, current air system performance, deficiencies and developments to aid them in their OT test design and planning. Conversely, as a developmental test pilot with OT experience, I aid the DT test team [the F-35 ITF at Pax River] in identifying issues that may pose problems during operational testing before the jet reaches an OT period. The goal is to identify areas that may affect operational effectiveness and suitability early in the programme so they can be addressed, hopefully leading to successful OT periods and fleet introduction.

"Carrier suitability is extremely important to the navy's OT community. My participation in DT I was undertaken from an operational tester and a fleet operator's points of view to help ensure the F-35C is suitable for its intended operational environment, the aircraft carrier. Information gained from DT I will be used to help plan F-35 OT test periods embarked onboard an aircraft carrier."

Alexander H Groves/Lockheed Martin

1 Aircraft CF-05 on a port side deck elevator immediately forward of the ship's island. *Dane Wiedmann/Lockheed Martin* 2 Aircraft CF-05 approaches the flight deck with Cdr Christian Sewell at the controls. *US Navy* 3 A perfect three-wire trap on November 12 by Cdr Sewell, following an approach under high-wind conditions. *Andy Wolfe/Lockheed Martin* 4 The F-35C test team aboard the USS *Nimitz* on November 14 after the conclusion of DTI.

at Pax River demonstrated that the ship's emitters had not interfered with the aircraft's avionics, "but we have to see how well the avionics integrate with the ship because we are testing a system…it's not just a plane itself, it's a plane and its ability to operate around the aircraft carrier."

DT I involved multiple avionics tests: INS alignment to make sure there's a datum that works well with the ship; aircraft sensors to ensure there are no hiccups during catapult shots and recoveries when the aircraft sustains jarring, and the communication links used to maintain contact with the ship.

Communication links evaluated during DT I were the ship's approach radar, the ship's ICLS (Instrument Carrier Landing System), the ability to use the ship's inertial navigation system (INS) to align the aircraft's INS and TACAN (tactical air navigation system), and the aircraft's radio systems.

The two-week 'at sea' period was the first time the F-35 ITF exercised the links with the ship.

Flight Operations

F-35C flight operations throughout DT I were conducted using a graduated approach in terms of complexity and severity of each test point.

Initial flights were for pilot carrier qualification to make sure the pilots were comfortable flying around the ship. "All four pilots deployed are experienced naval aviators with multiple tours under their belt. So from a pilot training perspective we minimised our risk in that way. But we still needed to make sure they were comfortable," said Cdr Wilson.

Each pilot flew multiple, nominal practice approaches with no deviation during the first couple of days. Cdr Wilson explained how every naval aviator is taught from day one of their flight training that when flying the approach to the ship they must stay on the glide scope generated by the IFLOLS (Improved Fresnel Lens Optical Landing System), fly it as tight as possible and remain on the centreline.

During the CQ portion, pilots undertook the initial cat shots with a 25 knot excess airspeed to minimise aircraft sink. As the aircraft shoots off the front of the warship, at the very least it should stay level and fly away: zero sink from a pilot's perspective. "The amount of sink should be similar to every other cat shot each pilot has ever undertaken," opined Cdr Wilson, adding that excess airspeed was subsequently dropped to 15kt during the CQ portion.

"After CQs we started to expand out the envelope looking at the cross winds on the front end of the ship. We cleared up to 10kt of cross wind on all four catapults: the bow cats one and two at the front of the ship and the waist cats three and four at the side.

Cdr Wilson explained the process: "For efficiency we concurrently tested the approach handling qualities at the back end of the ship throughout a nominal wind cell of 20 to 30kt: the typical range in which the fleet flies.

STATISTICS FROM DT I

Start date: *November 3*
Completion date: *November 14*
Flights: *33*
Flight hours: *39.2*
Catapult launches: *124*
Touch-and-goes: *222*
Arrested landings: *124*
Bolters: *2 intentional with the hook down*
Threshold test points completed: *100%*

We started making intentional errors in our approaches [off-nominal]. This allowed us to see how the aircraft's flight control laws react to corrections input by the pilot and the effect of the burble while trying to make the corrections.

"The pilot intentionally lines up [on approach] on either side of the landing area…starting either high or low, or flying fast or slow to see if there is enough time to input the correction and get back on centreline, on glide slope and on speed [flying a proper approach speed] prior to touch down.

"As we fly off nominal approaches, if the LSO [landing signals officer] doesn't see a timely correction or doesn't feel that the pilot is going to land safely, he or she will wave them off.

"The LSO [who is located on a platform positioned 120ft (36.6m) from the end of the ship and 40ft (12.2m) from the centreline on the port side] is a pilot trained to observe the aircraft as it flies down the approach watching for deviation in pitch attitude using a camera that shows whether the aircraft is on or off centreline. Listening to the aircraft, the LSO is trained to recognise changes in rates of vertical and horizontal movement to ensure the aircraft is going to clear the ramp at the aft of the ship and recover safely aboard. The LSO plays a vital role in the safe recovery of aircraft aboard the ship.

"Getting aircraft back to the boat is our first concern: our second is [preventing] what we call a long bolter. This occurs if the pilot fails to correct a big deviation and lands well beyond the four-wire [the last arrestment cable along the deck]. For safety purposes any time an aircraft touches down on the deck, the pilot needs sufficient deck to de-rotate, and get the throttle back to mil[itary] power to fly away. There's not enough time for the plane to de-rotate with a long bolter, which means it could still have downward direction so when [the aircraft] rolls off the front end of the boat it's going to sink.

"Once we were satisfied with the approach handling qualities, we started slowing the end speed of the cat shots, anchoring at a minimum point to achieve the desired sink rate or the desired sink, and concurrently evaluated approaches with crosswinds behind the ship out to 7kts.

"At that point in time we began low- and high-energy catapult shots which sought to evaluate how energy effects our rotation off the end of the cat. We didn't expect a lot of rotation with low energy cats: that's one in which the pilot may end up getting into the loop to influence the fly away but done so safely.

"Conversely on high-energy cats we were looking for any undesirable pitch rates. Because of the design of the F-35 there's a lot of stored energy in the nose, so as the shuttle is released from the cat, the nose springs up. Well, on a high-energy cat shot there's a lot of wind catching the nose that can quickly generate a high pitch rate which, from a pilot's perspective, can be undesirable.

"We also evaluated approach handling qualities in low and high wind conditions: low is 10 to 20kt, nominal is 20 to 30kt and high is in excess of 30kt. The team's goal for DT I was to gain as much data with cross winds and various head winds to allow us to start writing our aircraft launch and recovery bulletins."

What Next?

Testing around the carrier gets more complicated with aircraft weight and asymmetry. On subsequent DT events the F-35 ITF will increase aircraft weight and asymmetry by loading stores on one side to create as much asymmetry as possible, which is the complicating factor. Cdr Wilson told *AIR International* that testing on subsequent DT events is going to look very similar but will evaluate heavier weights and asymmetric lateral weight differences.

OUTCOMES FROM DT I

- *Flight test conducted in the operational environment.*
- *The F-35C demonstrated exceptional handling qualities throughout all launch and recovery conditions tested.*
- *All four test pilots rated the F-35C to be very easy to operate from the carrier. Arrested landings were consistent: the aircraft caught the optimal three-wire in the majority of the 102 traps. Pilot comments included: "I noticed the burble, but the aircraft just takes care of it", "It makes flying the ball comfortable" and "This thing is a three-wire machine".*
- *Maintenance and flight operations integrated well with standard carrier procedures onboard the USS Nimitz.*
- *On November 13, Lt Cdr Dyckman piloted CF-03 for the inaugural night flight, launching at 6:01pm Pacific Standard Time. Dyckman conducted a series of touch-and-goes before making an arrested landing at 6:40pm.*

F-35C Carrier Suitability

http://issuu.com/nawcad_pao/docs/striketest2015_single

“The F-35C completed initial sea trials from November 3-14, 2014 aboard USS Nimitz (CVN 68). The at-sea test event was the culmination of a year of shore based test operations at the TC-7 and MK-7 catapult and arresting gear site at NAS Patuxent River as well as at Joint Base McGuire-Dix-Lakehurst. At sea, the F-35C accomplished 124 arrested landings, 222 touch and gos, zero one wires and zero unintentional bolters. (The team conducted two hook-down intentional bolters as part of the DT-I test plan.) The F-35C demonstrated exceptional performance both in the air and on the flight deck, accelerating the team’s progress through the DT-I schedule and achieving 100 percent of the threshold test points three days early. Test pilots flew approaches in three different approach modes (Manual, Approach Power Compensation (APC), and Delta Flight Path (DFP)). Handling qualities in all three approach modes were excellent. DFP is a new approach mode that allows the pilot to directly command a glideslope. The test team characterized the performance of DFP as an enhancing characteristic of the airplane. In fact, test pilots and engineers credited the F-35’s DFP technology with significantly reducing pilot workload during the approach to the carrier, increasing safety margins during carrier approaches and reducing touchdown dispersion. Calling the aircraft a three-wire machine, they noted that the F-35C was very good at flying behind the ship, that the flight control system was precise, stable, responsive and delivered carefree handling in all flight regimes, and they predicted that future Fleet pilots would be able to correct any deviations quickly and accurately.

Since the aircraft flew very well behind the ship, the test team decided to conduct night ops — an unheard of feat during the first at sea period of any naval aircraft since the F-4 era. They conducted multiple approaches, two hook-down passes, and two traps. However, due to the quality of the image in the Helmet Mounted Display (HMD), they delayed further night operations until the second at sea developmental test period (DT-II). The improved image quality of the new GEN III helmet HMD release will enable upcoming night carrier landings during DT-II. Overall, DT-I was an extremely successful effort, proving the sea worthiness of the F-35C & developing a large amount of the initial Aircraft Launch & Recovery Bulletins.”

Navy F-35C Landed So Precisely, It Tore Up a Runway

U.S. Navy photo courtesy of Dane Wiedmann

HOPE HODGE SECK AUGUST 18, 2016

http://www.dodbuzz.com/2016/08/18/navy-f-35c-landed-so-precisely-it-tore-up-a-runway/

Before seven of the Navy's carrier-variant F-35 Joint Strike Fighters embarked aboard the carrier USS George Washington for its third and final round of developmental testing, they completed a required ashore training period, practicing landings at Choctaw Naval Outlying Field near Pensacola, Florida. The landings went well — maybe a little too well.

"They were landing in the same spot on the runway every time, tearing up where the hook touches down," Vice Adm. Mike Shoemaker, head of Naval Air Forces, told an audience at the Center for Strategic and International Studies in Washington, D.C. Thursday. "So we quickly realized, we needed to either fix the runway or adjust, put some variants in the system. So that's how precise this new system is."

The new system in question is called Delta Flight Path, a built-in F-35C technology that controls glide slope and minimizes the number of variables pilots to monitor as they complete arrested carrier landings. A parallel system known as MAGIC CARPET, short for Maritime Augmented Guidance with Integrated Controls for Carrier Approach and Recovery Precision Enabling Technologies, is being developed for use with the Navy's F/A-18 E/F Super Hornets and EA-18G Growlers. Together, these systems may allow carriers to operate with fewer tankers, leaving more room for other aircraft, Shoemaker said.

Military.com reported on the implications of this new landing technology from the carrier George Washington earlier this week, as the first operational pilot-instructors with Strike Fighter Squadron 101, out of Oceana, Virginia, began daytime carrier qualifications on the aircraft. On Thursday, Shoemaker had an update on the ongoing carrier tests.

Of about 100 F-35C arrested landings completed on the carrier, he said, 80 percent engaged the 3-wire, meaning the aircraft had touched down at the ideal spot. As of Monday, there had been zero bolters, when the aircraft misses an arresting wire and must circle the carrier for another attempt.

"I think that's going to give us the ability to look at the way we work up and expand the number of sorties. I think it will change the way we operate around the ship ... in terms of the number of tankers you have to have up, daytime and nighttime," he said. "I think that will give us a lot of flexibility in the air wing in the way we use those strike fighters."

Tankers, or in-air refueling aircraft, come into play because they as required to be at the ready when aircraft make arrested landings in case they run low on fuel during landing attempts. Fewer bolters means, prospectively, a reduced tanker requirement.

"Right now we configure maybe six to eight tankers aboard the ship," Shoemaker said. "I don't think we need to to that many. That will give us flexibility on our strike fighter numbers, increase the Growler numbers, which I know we're going to do, and probably E2D [Advanced Hawkeye carrier-launched radar aircraft] as well."

The F-35C's last developmental testing phase is set to wrap up Aug. 23. MAGIC CARPET is expected to be introduced to the fleet in 2019, officials have said.

US Navy makes F-35C carrier qualification push 17 Aug 2016

Stephen Trimble https://www.flightglobal.com/news/articles/us-navy-makes-f-35c-carrier-qualification-push-428594/

“...The F-35C also is being scrutinized for how its redesigned arresting hook performs the George Washington’s flight deck. In the first round of carrier testing aboard the USS Nimitz in November 2014, the F-35C’s resculpted tailhook performed flawlessly, with no unplanned missed landings in 122 attempts, according to a 2016 report by the Pentagon’s Office of Test Evaluation. Such testing includes some planned missed approaches to evaluate how the aircraft performs during a go-around.

But a follow-up deployment last October aboard the USS Dwight D. Eisenhower resulted in seven “bolters” in 62 attempted carrier landings. Those results may have been skewed, however, because one of the four arresting wires on the Eisenhower’s deck was out of service during the demonstration.

In dozens of attempted landings from 14 August to 17 August on the Washington, the F-35Cs had reported no unplanned missed landings, according to the F-35 joint programme office....”

VX-23 Strike Test News 2014 [02 Sep]

"SHORT TAKEOFF AND VERTICAL LANDING (STOVL)

The F-35B continued sea trials last summer aboard the USS Wasp (LHD 1). Lessons learned from the previous ship trials in 2011 were incorporated and evaluated. Centerline tracking during short takeoffs (STOs) was drastically improved with the combination of an improved NWS schedule and the use of the Three-Bearing Swivel Nozzle (3BSN) for yaw control. BF-1 and BF-5 were utilized for the sea trials to further expand the wind and performance envelope for F-35B STOVL operations on L-class ships. Mission systems testing, to include the Night Vision Camera (NVC) and Distributed Aperture System (DAS) was accomplished by BF-4.

The F-35B STOVL envelope expansion continued last year. The Rolling Vertical Landing (RVL), Creeping Vertical Landing (CVL), Vertical Landing (VL), Slow Landing (SL), Short Take Off (STO) and Vertical Takeoff (VTO) envelopes were all expanded. RVL testing included main runway testing with some crosswind testing. CVL testing began and was completed on both the main runway and the Expeditionary Airfield (EAF). The VL wind envelope was further expanded, with up to 10 knots of tail wind and 15 knots of crosswind. SL and STO testing included crosswind expansion out to 20 knots, completed primarily at Edwards Air Force Base and NAWS China Lake during a wet runway and crosswind detachment. STOVL formation testing began this year, which included formation STOs and SLs. VTO expansion occurred concurrently with **AM2 soft soil pad certification**....

...F-35C CARRIER SUITABILITY

This is a very exciting time for F-35C Carrier Suitability team. We have been busy testing the F-35C at our unique shore-based catapult and arresting gear test facility to ensure it can withstand the punishing forces associated with shipboard flight operations. The TC-7 catapult and Mk-7 arresting gear sites at NAS Patuxent River, Maryland and Naval Air Warfare Center Aircraft Division (NAWCAD) - Lakehurst located aboard Joint Base Mcguire-Dix-Lakehurst, New Jersey, are fleet representative and almost identical to the equipment aboard today's CVNs. In addition to arrested landings, the team has been hard at work validating the current control laws in preparation for initial sea trials, as well as developing a new set of control laws to increase safety margins and boarding rates.

The road to initial sea trials began in December 2013 with the return to flight of CF-3 — the third F-35C aircraft to roll off of the production floor — after receiving a redesigned hook during a major modification period. The first order of business was to ensure the new hook worked. The team traveled to sunny Lakehurst in January to conduct arresting gear roll-ins. During this phase of testing, we targeted an engaging speed and validated loads on the arresting hook. After achieving the maximum engaging speed, we executed off-center engagements to a maximum of 20 feet off-centerline. The team successfully completed more than 35 roll-in engagements with no hook skips. We used the data from the roll-ins to create an interim Aircraft Recovery Bulletin (ARB) for use at the Patuxent River Mk-7 site and during initial sea trials. Having gained confidence in the new hook system, the team returned to Patuxent River to conduct the next phase of testing — structural survey — in which we evaluate the aircraft structural strength to ensure that it is sufficient for shipboard operations. This is accomplished by conducting several series of arrested landings outside of a normal touchdown envelope. The landing series consist of high sink landings, rolled-yawed landings, maximum engaging speed landings and free flight landings. The free flight landing is similar to an in-flight engagement since the hook engages the cross deck pendant prior to the main wheels touching down; however, the aircraft still has a downward vector. The ultimate goal of this testing is to ensure the aircraft can handle the harsh forces it will experience while a nugget is safely executing night CQ.

The F-35C team as a whole is busy developing the next generation of control laws that aim to increase boarding rates and safety margins while operating around the aircraft carrier. A new control scheme called **Delta Flight Path** (DFP) is featured on the F-35C. DFP is a form of autopilot in which a flight path is commanded, nominally 3 degrees. The pilot is then free to make lineup corrections with lateral stick without the need to compensate for lost lift with power or longitudinal stick inputs. If the pilot requires a glideslope correction, the sink rate can be increased or decreased using forward or aft stick until a center ball is achieved and then release the stick input. The control laws will then return the aircraft to the commanded flight path. The pilot will have the ability to change the desired glideslope as required by the environmental conditions for any given day. DFP's goal of increasing boarding rate and safety margin has shown promise during field testing. But, as all good naval aviators know, the boat is the great equalizer and we are eagerly awaiting the opportunity to test DFP during initial sea trials...."

http://www.navair.navy.mil/nawcad/index.cfm?fuseaction=home.download&id=820

VX-23 Strike Test News 2010-14 INDEX:

http://www.navair.navy.mil/nawcad/index.cfm?fuseaction=home.content_detail&key=7DABC751-98E2-4709-B704-F34E8876769E

ADVANCED FLIGHT CONTROLS AND DISPLAYS (MAGIC CARPET)

Project Magic Carpet includes a new set of Powered Approach (PA) flight control laws for the F/A-18E/F Super Hornet, combined with innovative new Head-Up Display (HUD) symbology designed to significantly simplify the carrier landing task. The flight control laws take advantage of advances in the flight control computers and increased hydraulic actuator bandwidth to allow the aircraft to correct glideslope position errors using Integrated Direct Lift Control (IDLC), as opposed to the current method of modulating thrust. This provides the pilot with direct control over glidepath using a single controller (the stick) instead of requiring a multi-part power correction using the throttle, while influencing angle of attack with the stick. Furthermore, this method allows the pilot to correct significant glideslope deviations precisely and instantaneously, without waiting for the engines to spool-up or spool-down. It also reduces the potential of the aircraft becoming dangerously thrust deficient when correcting from a high position during the final phase of the approach.

Combined with the new flight control laws are several new additions to the Head-Up Display, to include a Ship Relative Velocity Vector (SRVV) and a Glideslope Reference line. Together, these two tools allow the pilot to precisely measure not only the magnitude of present errors, but also the magnitude of commanded corrections, completely removing the guesswork currently involved in flying the ball.

These advanced control laws and displays are currently under development and test at the Manned Flight Simulator (MFS) at Patuxent River, Maryland. They are slated to undergo initial flight testing in the Super Hornet later this year, with the goal of testing them at the ship in 2015. If these modes prove as compelling in the aircraft as they do in the simulator, they have the potential to revolutionize the manner in which the U.S. Navy lands aircraft aboard aircraft carriers.

http://www.navair.navy.mil/nawcad/index.cfm?fuseaction=home.download&id=820

First sea trials completed for MAGIC CARPET

07 May 2015 NAWCAD Public Affairs

NAVAL AIR SYSTEMS COMMAND, PATUXENT RIVER, Md. – Naval Air Warfare Center Aircraft Division engineers and test pilots successfully completed the first at-sea testing of the newly-developed F/A-18 flight control software on USS George H. W. Bush (CVN 77) April 20.

The Maritime Augmented Guidance with Integrated Controls for Carrier Approach and Recovery Precision Enabling Technologies, or **MAGIC CARPET**, is designed to make landing on an aircraft carrier easier by incorporating direct lift control, an augmented pilot control mode that maintains a commanded glideslope, and improvements to heads-up display symbology tailored for the shipboard landing task.

Navy test pilot Lt. Brent Robinson hit the two wire as planned when he landed "Salty Dog 100," an F/A-18F Super Hornet assigned to Air Test and Evaluation Squadron (VX) 23.

"This was a huge technology milestone in the history of carrier landings," said Robinson, **MAGIC CARPET** project officer. "What we saw at sea was essentially the same as the land-based testing we did at [Naval Air Station Patuxent River]. We are still analyzing the data, but from the [landing signal officer's] position, the landings looked very good."

NAWCAD engineers and VX-23 test pilots specifically used the two wire for testing because unlike most Nimitz-class carriers, CVN 77 has 3 arresting gear wires and aiming for the number 2 wire is standard operating procedure.

The flight test team, which included engineers from NAWCAD, the Atlantic Test Ranges, and industry partner Boeing, executed more than 180 touch-and-go landings with 16 arrested landings in the advanced control modes during three days of testing. The two F/A-18F test aircraft were flown in both nominal and off-nominal approaches and in varying wind conditions.

The engineering group responsible for developing the flight control software, new heads-up displays, and simulators was encouraged by the sea trials.

"This initial sea trial confirmed that carrier landings can be achieved at lower pilot workload while maintaining or reducing current touchdown dispersions performance," said James "Buddy" Denham, a senior engineer in the aeromechanics division at NAVAIR. "The results from this test clearly show the benefits we expected to achieve with this level of flight control augmentation. The data we have now collected in both the F/A-18E/F Super Hornet and the F-35C Lightning II in the **Delta Flight Path mode** show that the Navy's fleet of tactical aircraft, to include the EA-18G Growler, is well on its way with a safer, more predictable method of accomplishing the unique naval aviation task of shipboard landings."

According to Lt. Cmdr. Daniel Radocaj, carrier suitability testing department head at VX-23, **MAGIC CARPET** reduces touchdown dispersion, which refers to the repeatability of aircrafts' tailhooks to land in approximately the same spot on the carrier deck, and improves the overall success rate for carrier landings.

As an added benefit, **MAGIC CARPET** can help to minimize hard landings, reduce the number of required post-hard landing aircraft inspections, and improve overall aircraft availability. The results from this initial round of testing give good confidence that **MAGIC CARPET** can provide substantial benefits to reduce initial and currency training for pilots and lower the costs of Naval Aviation, said Radocaj.

Test pilots, engineers, and landing signal officers (LSO) from VX-23 will continue to test **MAGIC CARPET** demonstration software on F/A-18E/F aircraft for the remainder of 2015 and early 2016. Production-level software for the Fleet is scheduled to start flight testing in 2017, with general fleet introduction to follow via the F/A-18 and EA-18G program office.

http://www.navair.navy.mil/index.cfm?fuseaction=home.NAVAIRNewsStory&id=5904

Semper Lightning: F-35 Flight Control System Part 1

09 Dec 2015 Dan "Dog" Canin http://www.codeonemagazine.com/article.html?item_id=187

"...Generally, the F-35 tries to keep sideslip near zero, but in some cases it intentionally creates adverse or proverse yaw as necessary to control roll and yaw rates. We'll talk about the use of pedals at high AOA in a later article, but, for general flying around, the best coordination we'll get is with our feet on the floor....

...the CV airplane has three different approach modes, easily selected using buttons on the stick and throttle. Two of these modes – APC and DFP – are autothrottle modes, indicated by a three-letter label on the left side of the HUD. The third mode – manual throttle – is indicated by the absence of a label… arguably not the most compelling indication that you're responsible for the throttle. This interface will probably evolve; in the meantime, we need to be disciplined and to make doubly sure we've got APC engaged before we turn throttle control over to George.

Another area is STOVL landing. The difference between what the power lever (a.k.a. throttle) does on the ground and what it does in the air is profound. On the ground, it acts like a normal throttle: pulling it full aft commands idle thrust. In air, it commands accel/decel rate: pulling it full aft commands a maximum decel. There's plenty of redundancy in the weight-onwheels sensors, but if the airplane ever thought it was still airborne after a vertical landing, and you pulled the throttle full aft, the airplane would go charging backward. This would be "untidy" (as our British friends say), especially on the ship. So we take every STOVL landing to a firm touchdown, and let the airplane itself set the throttle to idle when it determines it's on the ground....

...APC is "approach power compensation" mode, in which the throttle is automatically controlled to maintain the desired AOA during approach. In the C-model, engagement of APC also increases the gain on IDLC (integrated direct lift control), which schedules the flaps in response to stick movements to give very high-gain glideslope response. Another approach mode, DFP (delta flight path), currently in the C-model only, changes the pitch axis CLAW from a pitch-rate system to a glideslope-command system. DFP improves glideslope tracking performance & significantly reduces workload during carrier approaches...."

Semper Lightning: F-35 Flight Control System

Dan "Dog" Canin 9 Dec 2015 CODE ONE: 2016 Vol. 31, No. 1

http://www.codeonemagazine.com/article.html?item_id=187

The inaugural issue of Code One *contained the first of the* Semper Viper *series of articles, in which Joe Bill Dryden, a senior company test pilot, gave an insider's view of the F-16. Joe Bill's passion, insight, and clarity provided a shining light – and a lightning rod, sometimes – for a generation of F-16 pilots.*

Why is a series like this needed? The reason is as valid for the F-35 as it was for the F-16: The flight manual doesn't tell the whole story. It's not intended to. While there is always debate about what should be in a flight manual, the authors, generally, try to keep the document minimal and austere. (You knew you were in trouble when they named the F-35 manual "Flight Series Data," right?) If you're like me, though, you want to know more. You want to know not only how something works but why it works that way. Understanding tradeoffs and design rationale is an important part of learning to use a machine well.

My hope is that these articles, by giving some insight into how the F-35 works and why it was designed that way, will help pilots fly the airplane better, employ it more effectively, and handle emergencies more intuitively. The articles may also help dispel some myths. As Joe Bill put it, "as airplanes become more complex and more capable, the amount of misinformation seems to grow." With your help, we can keep the mythology in check.

Some of this information may seem academic. That's partly because I'm a geek and find the technical details interesting (I hope you do, too). But it's also because design decisions involve tradeoffs, and it's important to understand them. The F-35 systems, training, and tactics will evolve over the next several decades, and fleet pilots will be intimately involved in that evolution. Anything we can do to increase our technical understanding as users will raise the game for everyone involved in this effort, and will ultimately result in a more effective pilot cadre and weapon system.

Feedback is critical to making this series a success. With Code One *online, we can turn what used to be a lecture (the print version) into a conversation. Let us know what you're interested in, and we'll hunt it down. Let us know what you disagree with (be gentle!), and we'll find the best answer and learn together. You can reach us by using the comments section, or by sending an email to the editor. Stay in touch.*

Dan Canin has logged more than 6,000 flight hours in more than eighty types of aircraft, including thirty types of tactical jets and jet trainers. He is a 1978 graduate of California Institute of Technology, a distinguished graduate of the US Naval Test Pilot School (USNTPS), and a former USNTPS instructor. During his nineteen years as a test pilot for Lockheed Martin, his experience includes the developmental testing of the Argentine A-4AR and over 700 hours in the Block 60 F-16, including loads, flutter, weapons integration, store separation, and advanced flight controls development. Currently a member of the Integrated Test Force at Pax River, he has logged more than 500 hours in all three variants of the F-35, performing initial airworthiness, loads, flutter, flying qualities, mission systems, F-35C catapult and arresting gear compatibility, and F-35B engine airstart verification testing. For the past three years, he has led the high AOA test program for the B and C variants, from initial envelope expansion through departure recovery testing.

Photo by Michael D. Jackson

F-35 Flight Control System, Part One

When people think of the "miracle" of flight, they usually think of overcoming gravity. Turns out, that's the easy part – some things overcome gravity even when we don't want them to (think race cars, and roofs in tornadoes). The hard part is control. Indeed, control – not lift or propulsion – was the key to the Wright Brothers' fame and the subject of the years-long patent war that followed. Flight control systems have evolved continuously since the Wrights' first flight, and the F-35 represents a historic step in that evolution.

In his first article for *Code One*, Joe Bill did a great job introducing us to fly-by-wire (FBW) control. The F-16 was the first production fighter to use FBW, so Joe Bill had plenty to talk about. As he said, the F-16 was…different.

In this article, we'll discuss FBW, generally, and focus on some features of the F-35's control laws (CLAW) from the pilot's perspective. In the next article, we'll get into some engineering details and see what's so innovative – and historically significant – about the F-35's approach to FBW.

Why Fly-by-Wire?

Forty years ago, when Harry Hillaker and his design team decided to incorporate FBW control in the YF-16, the decision was hardly a slam-dunk. When asked what he considered the riskiest feature of their design, Mr. Hillaker didn't hesitate: "The fly-by-wire system. If the fly by wire didn't work, our relaxed static stability wasn't going to work." [1] To manage the risk, they had a backup plan to mount the wing further aft, reverting the airplane to a statically stable (albeit draggier and less maneuverable) design that could be flown with a conventional flight control system.

Today, FBW is so accepted, and so beneficial in terms of reduced weight, survivability, design flexibility, and performance, it's hard to imagine a modern fighter controlled any other way.

The F-35, in most of its flight envelope, is unstable in pitch and neutrally stable in yaw. What that means is that if there were a nose-up or nose-down disturbance that the stabs didn't immediately react to counter, the disturbance would grow. RAPIDLY. At normal cruise speeds, the time for an angle of attack (AOA) disturbance to double, if not corrected, would be about a quarter of a second. This instability makes the airplane agile and highly efficient aerodynamically, but it would also make it unflyable were it not for the flight control system – doggedly, eighty times per second – positioning the stabs to keep the nose pointing into the wind. So, as golden-armed as we F-35 pilots are, if we were responsible for positioning the control surfaces ourselves, the airplane would be out of control in seconds.

Static stability isn't the only thing artificially created in a FBW airplane. The dynamic response – the way the airplane responds to our control inputs – is also created artificially. That response can, in fact, be just about anything we want, since it's determined by software…not nature.

What? We Don't Like Nature?

Have you ever known someone who did exactly what you asked? (Okay, me neither, but work with me here.) FBW airplanes are a lot like that guy. Their response is, in a way, too perfect: they do exactly what we tell them. As a result, we have to un-learn some of the compensation we thought was "just part of flying."

For example, when we want a snappy roll in a mechanically controlled airplane, we have to overdrive the stick to get the roll going, then apply a check in the opposite direction to stop it. Not so in our computer-controlled machine. The F-35, as most FBW airplanes, sees our lateral input not as a command to move a surface but as a command to provide a roll rate: it overdrives the surfaces to get the roll going, then backs them off to maintain the rate we've commanded. When we remove the command, it drives the control surfaces against the roll to bring it to a crisp stop. If we check, as we did with basic airplanes, the airplane obediently performs a quick head-fake in the direction of the check. Most of us experienced that in our first flight in a FBW airplane, but the tendency went away quickly as we learned the new response.

Another example is turn coordination, which relates to the amount of sideslip we get during rolls and turns. Automatic coordination isn't unique to FBW: we've had aileron-rudder interconnects (ARIs) for years, and even the Wright Flyer had one[2]. But turn coordination in FBW airplanes can be very sophisticated. Generally, the F-35 tries to keep sideslip near zero, but in some cases it intentionally creates adverse or proverse yaw as necessary to control roll and yaw rates. We'll talk about the use of pedals at high AOA in a later article, but, for general flying around, the best coordination we'll get is with our feet on the floor.

The point is: When we move the stick and pedals, FBW gives us what we actually want – or what the control engineers want us to have – while suppressing the extraneous things nature has always tossed in along with it, things we previously had to compensate for or just learn to live with.

But Wait, There's More!

FBW does more than just stabilize the airplane and clean up its response. It determines the very nature of the response itself. That response can be programmed to be whatever we want, as a function of the airplane's configuration, speed, or whether it's in the air or on the ground. For example, if we make a lateral stick input in CTOL mode, we get a roll rate. But in jetborne mode, we get a bank angle. At high speed, a pitch stick input commands a normal acceleration ("g"); at low speed with the gear up it commands a pitch rate; at low speed with the gear down, it commands an AOA; and in the hover, it commands a rate of climb or descent.

The ability to tailor the airplane's response as a function of its configuration and flight regime is the beauty – and potential curse – of FBW. If control engineers get it right – if they define the modes properly, put the transitions in the right places, and give the pilot the right feedback – then control is intuitive. But if they make the various modes too complicated, or the feedback (visual or tactile) isn't compelling, then modal confusion can set in and bad things can happen.

Some mode changes occur without our knowing, which is fine as long as we don't have to change our control strategy. An example is the blend from pitch rate command at low speed to g-command at high speed. This transition is seamless from the pilot's perspective.

Other changes require us to change our technique, which is okay if we command the changes ourselves and they're accompanied by a compelling change in symbology. Examples are the transitions from gear-up (UA) to gear-down (PA), and from CTOL to STOVL.

There are few areas, though, where a mode change is important but not obvious, which is where pilot discipline and training come in. For example, the CV airplane has three different approach modes, easily selected using buttons on the stick and throttle. Two of these modes – APC and DFP[3] – are autothrottle modes, indicated by a three-letter label on the left side of the HUD. The third mode – manual throttle – is indicated by the absence of a label…arguably not the most compelling indication that you're responsible for the throttle. This interface will probably evolve; in the meantime, we need to be disciplined and to make doubly sure we've got APC engaged before we turn throttle control over to George.

Another area is STOVL landing. The difference between what the power lever (a.k.a. throttle) does on the ground and what it does in the air is profound. On the ground, it acts like a normal throttle: pulling it full aft commands idle thrust. In air, it commands accel/decel rate: pulling it full aft commands a maximum decel. There's plenty of redundancy in the weight-on-wheels sensors, but if the airplane ever thought it was still airborne after a vertical landing, and you pulled the throttle full aft, the airplane would go charging backward. This would be "untidy" (as our British friends say), especially on the ship. So we take every STOVL landing to a firm touchdown, and let the airplane itself set the throttle to idle when it determines it's on the ground.

Protecting Us From Ourselves

The control limiters in the F-35 – love them or hate them – are there to help. They not only make the airplane safer, but also more effective, by allowing us to fly aggressively without worrying about breaking something or losing control.

But flying the F-35 is not completely carefree. The control engineers had to give us some rope in a few places, since doing otherwise would have compromised capability and possibly even safety. So it's important for us to understand what's protected and what isn't.

One of the things CLAW does not protect us from, for example, is overspeed. We can exceed Mach and KCAS limits in nearly every configuration (Mode 4 being the exception), though an OVERSPEED caution alerts us as we approach them.

What about g? We're mostly protected, but not completely. Interestingly, the protection is least where the maneuvering limits are the lowest: in powered approach (PA) and aerial refueling (AR). The limits in those modes are 3g and 2g, respectively, and there's nothing to keep us from exceeding them. Why not? Because, while those limits are more than adequate for normal ops, there might be times when we need to exceed them to avoid hitting something – such as the ground, or the tanker – and our CLAW engineers have wisely decided that running into things would probably be worse than busting the g limit. So they let us bust the limit.

What about high-g maneuvering, up-and-away? For symmetric maneuvers, CLAW's got our back: As long as we're not rolling or yawing, we can slam the stick full aft or (ugh) forward, at any speed, at any loading. CLAW will keep g within NzW limits[4].

Rolling and yawing – so-called "asymmetric maneuvering" (maneuvering using lateral stick or pedal inputs) – is another story. If we don't pull more than 80 percent of the positive NzW limit or push to less than negative 1g, we can roll and yaw to our heart's content. But if we push or pull more than that, we have to abide by a pilot-observed limit of 25 degree/second. (Stick your hand out in front of you and roll it through 90 degrees while counting to three potatoes. Yup, it's slow.) I know what you're thinking: "How do I know when I'm more than 0.8NzW?" You don't – unless you're good at mentally dividing the basic flight design gross weight (BFDGW) by your current gross weight and multiplying it by 0.8 times the basic g-limit for the airplane. (If you can do that, continuously, you're probably in the wrong line of work.) And, "Why 25 deg/sec?" Because that's the loads folks' definition of "zero": if you're rolling less than 25 deg/sec, they consider that not rolling, so symmetric limits apply.

But, mostly, you're thinking: "What's with the pilot-observed limit? Why couldn't the control engineers just protect us with CLAW?" The reason is that the analysis and the design work to handle every asymmetric input, under every flight condition and loading, would be prohibitive. And if they put the 25 deg/sec limit into CLAW, it would be tactically restrictive and possibly unsafe. So they picked the middle ground of telling us not to roll too much while we're on the g-limiter.

So what happens if we make a big roll input at 0.9 NzW? First of all, the CLAW folks haven't completely abandoned us: As g increases, the roll rate is reduced, and, if we're commanding more than 50 deg/sec, the airplane unloads to get us back within the 0.8NzW limit. But there's no guarantee that the unload will be quick enough to prevent an overload.

Does that mean we can break the airplane by pulling and rolling? Not really. The pilot-observed limits were decreed to make sure the airframe delivers its contractually specified life. If we exceed them, the wings won't fall off, but we might reduce some of that life. The bottom line: If you're on the g-limiter and want to roll, back off a little, then roll. This will not only keep you within the rules, it will give you a better roll rate in the bargain. If you can't back off – because, say, you're trying not to hit the ground, or trying not to get shot (and I don't mean by your buddy during BFM) – then do what you need to do! The worst thing that will happen is that you'll trip an OVER G advisory or an overload HRC,[5] and have to explain your heroic act to the maintenance officer when you return. Presumably, the maneuver will be worth the airframe life you expend.

We Don't Need No Stinkin' Limiters

While almost everyone appreciates limiters that prevent overstress, the consensus isn't as strong when it comes to those that limit control, i.e. the limiters on AOA and body rates (pitch/roll/yaw) intended to keep us from departing controlled flight. We won't settle that argument here. Like all design issues, limiter design is a tradeoff between competing requirements – in this case, between agility and departure resistance – and opinions will always differ regarding where that line should be drawn. Some pilots will argue (as some have) that we should get the limiters out of the way, or at least open them up, and leave it to the pilot to learn where the cliffs are. The counter-argument is that, assuming we've got the limiters in a reasonable place now, opening them up would result in more departures, some of which may cause overstress and some (if they happen at low altitude) loss of the aircraft altogether.

The F-35 is an inherently unstable airplane, required to handle a wide range of CG. Its control surfaces are sized to meet the requirements of both maneuverability and low observability. As a result, the combinations of body rates, AOAs, CGs, Machs, and weapon bay door positions that define the controllable envelope of the F-35 are extremely complex – and the boundaries of that envelope are reflected, with all that complexity, in CLAW. If the control engineers opened up the limiters and gave us, instead, "rules of thumb" to maintain control – ones that we had a fighting chance of remembering – the rules would most likely be so restrictive that we'd give up more than we gained. Could we evolve to that in the future? Sure, if we decide it's a positive trade. As the control engineers hate to hear us say, "It's only software."

How Does It Do It?

In this article, we talked about what the FBW system does. But we didn't talk about how it does it, i.e., how it figures out which effectors to move, how much to move them, and how to handle failures. It isn't magic, but it's close. To appreciate the historical significance and engineering brilliance of this machine – and, more importantly, to impress your friends – you'll want to take a peek at what's going on under the hood. The second article will address how FBW works in the F-35, and why it was designed that way.

Dan Canin is a Lockheed Martin test pilot based at the F-35 Integrated Test Force at NAS Patuxent River, Maryland.

Footnotes

[1] *Code One* (Vol 6, No 1, April 1991) [return]

[2] The Wright brothers incorporated automatic rudder coordination because they had no choice. Laying prone and controlling the aircraft's roll with their hips, there was no practical way to control the rudder independently, so they linked the rudder wires to the wing-warp hip cradle. Interestingly, the Wrights deleted the interconnect in their later models, preferring to have direct control of sideslip and to rely on pilot skill for coordination. It was decades before airplanes incorporated both: automatic coordination with roll, with additional yaw command available via the pedals. [return]

[3] We'll talk more about these in a later article on advanced control laws, but for now: APC is "approach power compensation" mode, in which the throttle is automatically controlled to maintain the desired AOA during approach. In the C-model, engagement of APC also increases the gain on IDLC (integrated direct lift control), which schedules the flaps in response to stick movements to give very high-gain glideslope response. Another approach mode, DFP (delta flight path), currently in the C-model only, changes the pitch axis CLAW from a pitch-rate system to a glideslope-command system. DFP improves glideslope tracking performance and significantly reduces workload during carrier approaches. [return]

[4] What's NzW? The airframe structural limit isn't just a function of g – which the pilot can sense – but the actual lift force imposed on the airframe, which is the product of gross weight (W) and g (also known as Nz, the normal acceleration in the z direction). At light weight (low W) we can pull more Nz with the same structural load (Nz*W). That said, there's still a maximum g the F-35 is allowed (9g for the F-35A, 7g for the B, and 7.5g for the C), and CLAW will let us pull that anytime the weight is less than the Basic Flight Design Gross Weight (BFDGW). Above that weight, the allowable g decreases to keep the total lift – Nz*W – constant. . Fortunately, CLAW figures that out for us. [return]

[5] An OVER G advisory will trip if you exceed the book symmetric or asymmetric maneuvering limits by more than 0.5g. For the purposes of this ICAW, the airplane defines as "asymmetric" any roll rate over 50 deg/sec, so there's a 25 deg/sec buffer there as well. So if you stick to the flight manual roll rate limit, you should never see this ICAW. What you might trip, though, is an "overload" HRC, which has a much more sophisticated algorithm behind it and will only trip when you've exceeded an actual limit on some component of the structure. CLAW should in all cases prevent actual overload to failure, but during rolling maneuvers it may allow one of these indications to trip, requiring a maintenance inspection. [return]

"...for general flying around, the best coordination we'll get is with our feet on the floor...

...Rolling and yawing – so-called "asymmetric maneuvering" (maneuvering using lateral stick or pedal inputs) – is another story. If we don't pull more than 80 percent of the positive NzW limit or push to less than negative 1g, we can roll & yaw to our heart's content...."

Navy F-35C pilot gears up for testing on carrier Ike

04 Oct 2015 Lance M. Bacon

Do you want to know what it is like to fly the Navy's F-35C Joint Strike Fighter?

Well, that's too bad, because "there are no words to describe it," Lt. Cmdr. "Anoya" Hess said. He has been a JSF driver for two years and is still at a loss for words.

"It is an amazing piece of machinery," he said.

The Navy's next big JSF test is set for mid-October, if weather permits. Two F-35Cs, the Navy's carrier-landing variant, are set to spend 10 days training with carrier Dwight D. Eisenhower off the Virginia coast. The pair will conduct day and night carrier qualifications, night operations with the Generation III Helmet Mounted Display, Delta Flight Path testing, and F-35 Joint Precision Approach and Landing System testing.

Hess, who served as a landing signal officer when JSF made its first carrier landing aboard the carrier Nimitz in November 2014, will pilot one of the two test birds. Countless simulator landings and practice at the JSF's home base of Eglin Air Force Base, Florida, has given Hess confidence as the date draws near. Still, he admits that he is "really excited to see what it can do behind the boat."

The former F-14 Tomcat pilot, who went on to fly F/A-18 Super Hornets, described the JSF as a combination of current technologies and lessons learned from previous fighters.

"It takes that entire operational picture and gives you complete [situational awareness] as to what is going on in the battle space at all times and enables you to share with other assets in the fight with you," said the 14-year vet, who asked Navy Times to withhold his first name out of concern for his security.

Despite the jet's leap-ahead technology, the learning curve is not as steep as one might expect, he said.

Much of that is due to the $600,000 helmet, which Hess identified as the hardest thing to leave behind if he were to return to flying Super Hornets. Its visor replaces the traditional Heads-up Display. Every detail the pilot needs, from flight data to targeting information, is displayed in the helmet.

Then you add in the Distributed Aperture System, which streams real-time imagery from six infrared cameras. This allows pilots to "look through" the airframe.

Second only to the helmet on Hess' list is the ease of flight controls. It is "very simple to handle whenever tasks are going on from a mission standpoint," he said.

Cool as it may be, the JSF is not without challenges. Its delays have been many and the cost has soared to $400 billion. Worse yet, the fighter was on the losing end of a July dogfight with the more maneuverable (and much older) Air Force F-16 Fighting Falcon. That same month, Marine Commandant Gen. Joseph Dunford — who is now chairman of the Joint Chiefs of Staff — declared the Marines' jump-jet variant as operationally sound. That was countered by J. Michael Gilmore, the Pentagon's top weapons tester, who took issue with the evaluation rather than the fighter's capabilities, and said the event "did not — and could not — demonstrate that Block 2B F-35B is operationally effective or suitable for use in any type of limited combat operation, or that it was ready for real-world operational deployments, given the way the event was structured."

In August, testers discovered concerns that pilots who weigh less than 136 pounds have an increased risk of injury during a low-speed ejection.

Strike Fighter Squadron 101, the "Grim Reapers," will welcome its first pilots from the operational test community in November. Hess is one of the squadron's 15 pilots. The Grim Reapers was the last F-14 Fleet Replacement Squadron. It was disestablished in 2005 but rose again one month short of its 60th anniversary in 2012. The squadron is tasked with training JSF pilots and maintainers, and development of its tactics and the training syllabus.

http://www.navytimes.com/story/military/2015/10/04/navy-f-35c-pilot-gears-up-testing-carrier-ike/73106716/

F-35C completes carrier tests aboard the Ike

17 Oct 2015 Lance M. Bacon

ABOARD CARRIER DWIGHT D. EISENHOWER IN THE ATLANTIC — Across the board success was how the test pilots scored the second carrier testing run for the Navy's F-35C Joint Strike Fighter, which wrapped up Oct. 9 aboard the carrier Dwight D. Eisenhower.

The multifaceted two-week flight test was used to develop launch and recovery bulletins. The former focused on 55,000 and 60,000-pound catapult shots at military, the catapult shot with standard jet thrust, and maximum power. The launches included internal stores such as simulated 2,000 pound Joint Direct Attack Munitions and AIM-120 Advanced Medium-Range Air-to-Air Missiles.

Test pilots found the jet's slowest airspeed cat shot. Officials were not ready to reveal that number, but there were launches in which the F-35C dipped well below the flight deck. The Navy typically sets the standard launch speed at 15 knots above the minimum.

Development of recovery bulletins saw multiple wind scenarios — some as high as 40 knots over deck. Cmdr. Christian "Wilson" Sewell, the flight test director, lauded "Delta flight path," in which flight controls capture the glide slope once the pilot has a center ball on their flight deck approach. The pilot then adjusts with minor tweaks via the stick.

"Easy," Sewell said. "We put it on the deck exactly where we want just about every time."

Sewell, who started off in F/A-18 Hornets, has been flying 16 years. He has roughly 40 shots and traps in the JSF, and another 230 in the Hornet.

"It's a dream to fly," he said of the F-35C, built to fire off a flattop's catapult and catch its tailhook on the arresting cable upon return. "The mission systems, the flight controls, everything has a little more capability and a little more precision to it."

The flight deck was equally impressed. A number of specific parameters were necessary — **for example, two jet blast deflectors were modified so that the salt water flows through at a higher rate, a necessity for the heat produced when JSF hits afterburners.**

Capt. Steve Koehler, Ike's commanding officer, said the event was a challenge to the air and navigation departments, as well as bridge watch standers, but nothing his team couldn't handle. After 23 months in the yard, his crew was ready for any challenge — as long as it was at sea.

Yellow shirts said the JSF taxis and maneuvers well on the flight deck. Sailors found it to be similar to the F/A-18 Super Hornet — it uses the same repeatable release holdback bar, the Catapult Capacity Selector Valve is set the same, and suspend procedures are the same. The one difference is location of the intakes.

"Our hold back operators and topside safety petty officers have to approach the aircraft similar to the way they would approach a EA-6B Prowler or A-6 Intruder," said Lt. Cmdr. Karl Murray, V-2 division officer and senior catapult and arresting gear officer, a.k.a.

"Top Cat." "The intakes are closer to the nose launch bar, and some of these sailors aren't used to seeing that."

The flight deck saw about 20 shots per day, with flight ops running about seven hours each day. The two test birds were then used for logistics testing in the hangar bay.

"We are a single engine, but we are a single huge engine," Sewell said. **"A 10,000-pound engine** presents some unique logistical considerations: how to get it aboard the ship, how to unpack it and move it around, where can maintenance be done, etc."

The team did not do an engine swap, but simulated a swap of the power module, which is the largest component. The team also tested the integrated power package that provides electrical power to start the engine. While such gear is nothing new, the exhaust in this IPP points upward. The team ran the IPP for 20 minutes to ensure the hangar bay ceiling didn't get too hot.

This also marked the first carrier operations for the $600,000 Generation 3 helmet, and it was a huge hit. Its visor replaces the traditional Heads-up Display. Every detail the pilot needs, from flight data to targeting information, is displayed.

While the ship's crew and JSF's pilots put a future jet fighter to the test, one two-star pilot was engaged in a different kind of battle. Many media outlets reported earlier this year that the stealth fighter had lost in a dogfight with the Air Force's F-16 Falcon earlier this summer. Is the JSF inferior? Is it a waste of money? Did the designers fail to build a better plane?

Such assertions "makes me cringe," said Rear Adm. John Haley, the head of Naval Air Force Atlantic. "It makes me think the people that are looking at this don't understand what the future holds for us."

"If you wanted us to design an airplane that optimized going out and beating an F-16 or F-15, we could do that. It wouldn't be this airplane. If you tell me to optimize an airplane that's going to do the mission we need to do, which is power projection and force protection, in a modern cyber and threat environment, this airplane does that without sacrificing your capabilities to do a close-in fight."

Haley reiterated the JSF's stand-off capabilities, unmatched situational awareness, and the fact that it won't travel into the battlespace alone.

"With this airplane and how were going to fight with it, [a close-in dogfight] will not be typical," he said. "I'm pretty confident I'm not going to have that happen. However, if it happens, we're not just going to stop training guys on [air combat maneuvering].

"I'm not saying that there aren't airplanes out there that can beat this thing if you put it in a bad position. I'm saying that the airplane had such great situational awareness, the chances of getting in that position are slim. An adversary coming off aspect would be identified long before he could recognize you."

Final carrier tests are scheduled for late summer of 2016. This will include external weapons and the full joint precision aircraft landing system.

http://www.navytimes.com/story/military/2015/10/17/f-35c-completes-carrier-tests-aboard-ike/74015774/

THE FUTURE OF NAVAL AVIATION ABOARD THE USS GEORGE WASHINGTON **2016-08-21 Todd Miller**

http://www.sldinfo.com/the-future-of-naval-aviation-aboard-the-uss-george-washington/

The USS George Washington (CVN-73) is hosting the F-35C in its final Developmental Testing cycle (DT-III) Aug. 14-23. However, for a few of those days the two VX-23 “Salty Dogs” F-35Cs from NAS Patuxent River were joined by 5 F-35Cs from VFA-101 “Grim Reapers” out of Eglin AFB.

The 7 F-35Cs gathered on the deck of the USS George Washington represented the largest carrier contingent of F-35Cs onboard a large deck aircraft carrier to date.

Media were hosted on the USS George Washington August 15 to observe the carrier qualifications at the onset of DT-III. All pilots embarking must perform a number of “cats” and “traps” prior to executing the specific tests involved with DT-III.

DT-III is focused on a number of issues:

- Validation of the aircraft’s flying capabilities with full inert internal and external stores (up to 4 GBU-12s and two AIM-9X on external hardpoints);
- Handling tests with asymmetrical loads;
- Testing for maximum weight launches at minimum power; evaluating all of these in a variety of wind and sea conditions.

As explained by Tom “Briggo” Briggs ITF (Integrated Test Force) Chief Test Engineer, there were additional minor tests to run through, such as ship borne evaluation of minor adjustments made to control laws (based on previous DT testing), and night launches to verify the Gen 3 helmet performed as desired.

Briggs made clear that the testing is to prepare the aircraft launch and recovery bulletins (ALB/ARB). These are the operating guides the Navy will utilize to determine the appropriate launch and recovery parameters for the aircraft given weights and conditions. These bulletins will ensure the aircraft can safely launch with the desired loads to complete assigned missions.

Complete ALB/ARBs will enable the F-35Cs to be very combat capable as they reach IOC utilizing the Block 3F software.

DT-III is a significant milestone for the F-35C program and represents the progression towards US Navy IOC somewhere between August 2018 and Feb 2019.

It was all business as planned. Media probed for human-interest stories from the cadre of pilots on board: “What was it like, after all the simulator hours and practice landings at the airfield to actually land on the ship?

From pilots who had 50 traps with the F-35C to those who had just realized their first – they struggled to provide any other answer; “no drama, no surprise, performed as expected, very vanilla, pretty straightforward.”

No news.

“Any issues moving 7 F-35Cs around the deck at once, or reliability issues?”

No news.

Though not officially part of DT-III, the Grim Reapers of VFA-101 put the state of the F-35C program in context – and made news of their own. VFA-101 represents a cadre of instructors and strike fighter tactics specialists who took this opportunity to carrier qualify so they can prepare the instructor syllabus for the F-35C.

12 VFA-101 pilots with 5 F-35Cs completed their carrier qualifications (CQs) in just over 1.5 days. That is, as Capt. James Christie of VFA-101 described, 10 landings and 2 touch and goes each – 120 cats, 120 traps and 24 touch and goes.

As U.S. Navy Commander Ryan “Flopper” Murphy, F-35 ITF Lead said: “the greatest satisfaction was to watch the fleet (VFA-101) start to utilize the aircraft.

After all, that is the point of everything we are doing, all the years of work; to equip and empower the Fleet with the F-35C.”

After observing VFA-101 for a few hours, it is clear the equipping and empowering are well underway.

Simultaneously the 5 VX-23 pilots performed their CQs.

Suffice it to say, the F-35Cs on board were very busy, and from an observer’s perspective, landing and launches were very frequent. There were instances of hot refueling, with pilot changes during refuel and the aircraft cycling back for more CQs.

As VX-23 F-35C pilot Ted “Dutch” Dyckman explained, everybody completed their CQs faster than with the Hornet. The additional fuel on the F-35C, the ease of landing due to Delta Flight Path mode, along with the aircrafts reliability all played a part in the accelerated CQs.

The innovative “Delta Flight Path” mode that is engaged on approach alters the control laws, setting auto throttles and maintaining the optimal 3-degree glide slope to landing. This approach makes the pilots job landing on the carrier much easier, and they were hitting the desired 3 wire almost 100% of the time.

Any wave-offs were driven by deck activities – not derived from within the aircraft. Delta Flight Path utilizes the flaps to add or decrease lift during approach so as to maintain the glide slope. Observers can see tremendous amounts of flap adjustments on aircraft approach to the deck – these are all controlled by the computer to provide the pilot what they want – glideslope to the deck.

The Super Hornet and Growler control laws are being modified to feature the same Delta Flight Path in an initiative called “Magic Carpet.”

http://www.sldinfo.com/navair-magic-carpet-innovation-for-the-f-18-fleet/

Once Delta Flight Path is fully integrated on the F-35C, F/A-18E/F & EA-18G the efficiencies created will make a profound, operational impact on naval aviation. Numerous pilots identified the benefits provided by Delta Flight Path; safer, less stressful landings on board; pre-embark training cut by as high as 50%; more time available to focus on tactics and missions; reduced wear and tear on aircraft; fuel savings; fewer “tankers” required in the air during recoveries and more.

USMC Major Elroy Northam, a pilot with VX-23 extoled the value of the F-35 in the battlespace as a stealth platform with an advanced sensor suite that will push its way to the forefront of the battlespace, gather all kinds of information as to what is out there, quickly identify “red or blue,” and push it out throughout the force including to legacy aircraft.

The information will provide an unparalleled situational awareness (SA), and the guy with the best SA usually wins.

Recently appointed to the new position, Director of Joint Strike Fighter Fleet Integration, Rear Admiral Roy “Trigger” Kelley was on the USS George Washington for DT-III. Kelley will direct the F-35C program towards IOC.

Given 70% of the world is covered by water, the US Navy-Marine Corps team can expect to be on the frontlines of any potential battle.

Kelley is excited about the capability the F-35C will bring to the Fleet; first day access into contested areas that host sophisticated air defense systems; the ability to utilize stealth and sensors to define the battlespace combined with advanced command and control capabilities that will empower the entire fleet.

The F-35C and associated technologies (Delta Flight Path) will revolutionize Fleet capabilities, particularly when seen in context of the evolving US Navy “kill web” approach. The information gathering and sharing network consisting of the F-35C, P-8A, MQ-4C, Aegis and others will be a foundation for the maritime services operating in the extended battlespace.

Once DT-III is finished the ITF will look forward to DT-III with the F-35B in October, and then close the loop on additional verification of structural load testing on the aircraft. It is expected that their work in this capacity will wrap up the summer of 2017.

For Briggs, (recognized as the 2015 Test and Evaluation Lead Tester) it is hard to put into perspective an effort that has spanned over a decade and a half. One can feel the professional sense of pride he takes in what is being accomplished by the team including the ITF, Lockheed Martin, the USS George Washington, USMC, US Navy and others.

170 personnel from Pax were on the carrier to support the testing, and many more back on land that have been working tirelessly for many years to make it all happen.

DT-III is a significant milestone, and it is clear the US Navy is now tracking very quickly and methodically to a very capable IOC.

Second Line of Defense would like to thank the following for their support: Sylvia Pierson, F-35 ITF/JPO PA; CDR Dave Hecht, Naval Air Force Atlantic PAO; Capt. Timothy Kuehhas, CO USS George Washington; and the many supporting PAOs on and off shore, pilots, engineers, and C-2 Greyhound crews. The entire US Navy team performed as professional, gracious hosts.

Editor’s Note: The Marines have been operating the B for more than a year after IOC and are getting ready to take their first combat squadron to the Pacific next year.

According to one senior Naval aviator, although the Navy has been perceived to be slow on the uptake on F-35, he believed that a rapid learning curve will be driven by the integrated air wing.

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.”

We would add as well that Marines are naval aviators and are flying the C as well as the B.

This point is often not realized outside of the naval aviation community but is a key plank in shaping capabilities necessary to prevail in the extended battlespace.

https://farm9.staticflickr.com/8533/29182351665_3d637e8eb8_o_d.jpg
An F-35C Lightning II comes in for a landing on USS George Washington (CVN-73) while carrying external stores during F-35C Development Test III. Lockheed Martin photo by Michael D. Jackson. https://www.flickr.com/photos/lockheedmartin/29182351665/

First Fleet F35-C Carrier Qualifications, Final Round of Testing Conducted at Sea

Story Number: NNS160826-12: 8/26/2016 By Donna Cipolloni, Naval Air Station Patuxent River Public Affairs

http://www.navy.mil/submit/display.asp?story_id=96397

ATLANTIC OCEAN (NNS) -- The jet blast from seven F-35C Lightning II Joint Strike Fighter aircraft only added to the already intense summer heat and humidity on the flight deck of USS George Washington (CVN 73), Aug. 15, where the third and final round of at-sea developmental testing, or DT-III, was underway about 100 miles offshore from Virginia.

During the 20-day testing period, which is set to conclude Sept. 1, objectives included external symmetric and asymmetric weapons loadings; launches and recoveries at maximum weight; approach handling qualities; landing systems certification; and engine logistics.

In addition to phase three of shipboard developmental testing, jet after jet thundered on and off the deck as 12 instructors and pilots from Strike Fighter Squadron (VFA) 101, out of Eglin AFB in Florida, completed the Navy's first fleet carrier qualifications, with each pilot knocking out two touch-and-goes and 10 arrested landings.

"The work we did [during the two previous testing phases at sea] directly fed what VFA-101 was able to come out and do today," explained Tom Briggs, lead flight test engineer with the F-35 Lightning II Integrated Test Force (ITF) at Naval Air Station Patuxent River and recipient of the 2015 Department of the Navy Lead Tester of the Year award. "For those of us involved in the program for quite a while, it was incredibly gratifying to see them come out and use that work to start making this aircraft real and get it out to the fleet."

Cmdr. Ted "Dutch" Dyckman, Air Test and Evaluation Squadron (VX) 23 test pilot, landing signal officer, and squadron operations officer at Pax River, started out flying F/A-18 Hornets, moved to F/A-18 Super Hornets, and now flies the F-35C. This was his third ship trip and 50th trap -- and he has a definite favorite.

"I prefer the F-35," he said. "It's easy to fly, autopilot is nice, cockpit has good visibility, and mission systems make it easy to do your task."

One of the most difficult and hazardous tasks in naval aviation is landing on the deck of an aircraft carrier, something now made simpler by Delta Flight Path. Developed by Lockheed Martin after a lot of crosstalk and technology sharing with NAVAIR personnel, the semi-automated landing mode significantly helps lower a pilot's workload task.

"The control laws allow aircraft to fly a commanded glide slope," Dyckman said. "Before, you had to manually fly that path through the air. Now, at the push of a button, the airplane will tip over and fly that path. If I have a good approach behind ship, I can push one button. If there are deviations, I can make a correction. Other than that, I may not touch the stick at all during the approach, from the start until touchdown. Coming to the ship is as easy as landing on an airfield now and that enables us to spend less time training guys to land on the ship."

Other testing involved improved nighttime visibility for the aircraft's third generation helmet, which displays symbology right on the pilot's visor.

"I don't have to look down for a piece of info on one display, then to another display and correlate it all in my head; everything appears in the helmet," Dyckman said. "When I look out, even if I'm looking away from where I'm going, I can see my target information, airspeed, altitude, threats. With this airplane, I basically have a display with my aircraft in the center and it presents information for situational awareness."

Test pilot Lt. Cmdr. Daniel "Tonto" Kitts, officer in charge of the VX-23 test detachment, noted three things about the F-35C that excite him.

"The ability to bring the aircraft back aboard the ship safely the first time, every time for the most junior pilot to the most senior is one of its major advantages," Kitts said. "Also, the incorporation of its mission systems to the pilot and the fusion of that information is really going to make it a lethal tactical platform. Lastly, its ability to share that information with other assets in the fleet is going to help build the picture for the whole carrier strike group. Not to mention, we're bringing a stealthy airplane to the carrier decks for the first time."

DT-III was an incremental buildup on five years of work from the Pax River ITF team, beginning with the first aircraft's initial onshore catapult and arresting gear testing and ending with the hundreds of operational cats and traps that recently took place aboard Washington. Having completed the gross weights and load up testing necessary to provide the fleet with a full launch and recovery bulletin, it was the final phase of testing.

"This is the last time we're coming to a carrier for F-35 testing and support for Navy IOC (initial operational capability)," explained Cmdr. J. Ryan Murphy, director of Test and Evaluation/F-35 Naval Variants. "It was satisfying to watch [VFA-101] start to utilize the aircraft. After all, that's the point of all the years of work -- to equip and empower the fleet with the F-35C."

The F-35C, the Navy carrier variant of the Joint Strike Fighter, conducted its first shipboard test flights in November 2014 aboard USS Nimitz and follow-on developmental testing aboard USS Dwight D. Eisenhower in October 2015. Engineered for a carrier, its 51-foot wingspan is larger than the Air Force's F-35A and Marine Corps' F-35B short take-off-and-landing variants.

"It's going to be a viable aircraft that's going to do what it's been designed to do," Briggs said.

It is expected the Navy will declare initial operational capability in 2018.

F-35C Development Test III 16 Aug 2016
LM Flickr **"Four F-35Cs from VFA-101**
depart USS George Washington (CVN-73).
Lockheed Martin photo by Todd R. McQueen."

https://farm9.staticflickr.com/8353/28470455733_e460367bb8_o_d.jpg

Navy's F-35C Takes Historic Step Forward Following Budgetary Turmoil

14 Nov 2014 Kris Osborn

ABOARD THE USS NIMITZ IN THE PACIFIC OCEAN — With smoke rising from the deck of the carrier and moderate winds churning up the seas, the Navy's F-35C took off from the aircraft carrier Nimitz as part of a historic series of test flights marking a major milestone in the service's first carrier-launched stealth fighter.

Following the first landing of the F-35C on Nov. 3, test pilots have conducted more than 100 approaches, landings and takeoffs on the Nimitz's flight deck. Last week's successful landing offered both history and relief for a Joint Strike Fighter program that Pentagon leaders say will revolutionize airpower, but has also been plagued by countless delays and budget overruns.

The Navy's variant of the fifth-generation fighter is arguably the most complex because it must execute catapult shots and landings from the flight deck. And it's also the one facing the most questions as many defense analysts have questioned the Navy's commitment to the Joint Strike Fighter program.

The ongoing maneuvers on the Nimitz are part of a 14-day developmental test period designed to gather data and assess the F-35C's ability to achieve the proper "glide slope," handle catapult takeoffs, and land on the flight deck under a variety of wind conditions.

"If you look across the inventory at where we have stealth technology, it is all ground based. Now we have sea-based stealth technology. That provides us capabilities that we currently do not have," said Rear Adm. Dee Mewbourne, commander of Carrier Strike Group 11.

Navy leaders, pilots and engineers said the initial testing has gone well. Ultimately, the Navy and Marine Corps plan to acquire 680 F-35Cs and F-35Bs — the Marine Corps' short-take-off-and-landing variant of the aircraft.

"Our job is to identify the issues and report on them. All the issues that we have been finding are very minor," said Navy Cmdr. Tony Wilson, an F-35C test pilot. "The main focus of the test has been catapult shots and landings. We did do shore-based testing to make sure we were ready to come out here. However, the big difference is you can't simulate rolling off the edge of an aircraft carrier when you are shore based."

Success Amidst Budget Problems

Successful test flights on the F-35C program could be seen as a welcome development for a program that experienced budget cutbacks earlier this year. The Navy's five-year budget plans outlined in the service's 2015 budget request cut the planned buy of F-35C aircraft almost in half, from 69 to 36.

Although service officials at the time said the numbers would be made up in future years, some observers questioned if the reduction indicated hesitations about the program overall.

A second round of developmental testing is slated for next summer to study the aircraft's ability to operate on a carrier while carrying weapons internally, Wilson said. A third period of testing with external weapons on board is also slated, all designed to bring the aircraft to operational status by 2018, Navy officials said.

"In this main round of testing, we're looking at the basic aircraft. We're looking at the approach and handling qualities. We're looking at high headwinds, low headwinds, crosswinds and a bunch of different wind variations as well," said Chris Karapostoles, an F-35C test pilot.

Being engineered for a carrier, the F-35C's 51-foot wingspan is larger than the Air Force's F-35A and Marine Corps' F-35B. An empty F-35C weighs 34,800 pounds, carries up to 19,000 pounds of fuel and 18,000 pounds of weapons. It is configured to fire two AIM-120C air-to-air missiles and two 2,000-pound guided bombs, or Joint Direct Attack Munitions. It can reach speeds up to Mach 1.6 and travel more than 1,200 nautical miles.

Landing a Stealth Fighter at Sea

As part of the testing, pilots practice maintaining their glide slope by watching a yellow light on the flight deck called the Fresnel Lens. It includes a vertical row of yellow lights between two horizontal rows of green lights. Using a series of lights and mirrors, a pilot's approach is reflected by the position of the yellow light in relation to the green lights above and below, displaying whether the aircraft is on the right "center line" or "glide slope," Karapostoles said.

"If he [the pilot] is on glide slope, he will see a centered amber ball in between the horizontal green lights. If he goes high on glide slope, he will see the ball rise above the green lights. If he goes below glide slope, he will see the ball fall below the green lights," he explained.

The F-35C is also engineered with a technology referred to as Delta Flight Path, a system that uses software to help the flight control computer automatically correct course and adjust the aircraft's flight path as needed.

"Instead of manually controlling thrust and pitch attitude, our flight control engineers have cut out the middle work so the flight path is controlled directly. It gives us spare capacity to monitor the other systems on the jet. We are landing the jet almost exactly where we want almost every time," said Cmdr. Christian Sewell, a F-35C test pilot.

Pilots try to land the F-35C in between the second and third of four cables arranged on the landing deck, Sewell explained.

In order to properly align for an approach to the flight deck about three-quarters of a mile away, pilots make a sharp, descending 180-degree turn to slow the aircraft and begin descending from about 600 feet, Wilson said.

"Once we arrive on center line and on glide slope, that is where the precision comes in because your runway is essentially moving sideways on you," he explained.

The testing is also assessing how the F-35C catapults off the deck. The steam catapult on board the Nimitz is thrusting the aircraft off the deck at a range of speeds in order to test the slowest and fastest potential takeoff speeds, said Lt. Eric Ryziu, catapult arresting gear officer.

Aircraft are able to reach speeds up to 160 knots in about 2.5 seconds as a result of being thrust forward by the steam catapult, which stretches about 300 feet. The steam catapult generates 520 PSI (pounds per square inch) of pressure pushing pistons forward. The pistons push cylinders connected to a shuttle attached to a launch bar, which pulls the aircraft forward, Ryziu explained.

http://www.military.com/daily-news/2014/11/14/navy-f35c-takes-historic-step-forward-after-budgetary-turmoil.html

F-35C Development Test III 20 Aug 2016
https://farm9.staticflickr.com/8017/29286032426_82886f72af_o_d.jpg

“An F-35C Lightning II on USS George Washington (CVN-73) during F-35C Development Test III.
Lockheed Martin photo by Michael D. Jackson.”
https://www.flickr.com/photos/lockheedmartin/29286032426/in/album-72157669446446264/

Back to the Boat Oct 2016 James Deboer Combat Aircraft Magazine Oct 2016 Vol 17 No. 10

"The US Navy's F-35C Lightning II began its third and final developmental test (DT) carrier embark, known as DT-III, on August 14 aboard USS George Washington (CVN-73) of the coast of Virginia. Combat Aircraft was afforded a look at the testing on the second day of the three-week phase....

...August's DT-III takes it all a step further, with more than 600 test points being conducted and the bulk of the flights focusing on launch and recovery with external stores such as GBU-12 laser-guided bombs and AIM-9X Sidewinders. This will include approach handling qualities with symmetric and asymmetric external stores, so-called delta flight path testing, joint precision approach and landing system trials, crosswind and maximum-weight launches, and military-/maximum power launches.

Leading DT-III is LCDR Daniel 'Tonto' Kitts, who is part of the Integrated Test Force (ITF) with VX-23 'Salty Dogs' at NAS Patuxent River, Maryland. Kitts told Combat Aircraft: 'This third trip to the boat is about creating a complete set of launch and recovery bulletins for fleet use, so that when the [F-35C achieves] IOC [initial operating capability] the fleet has everything that they need to launch the aircraft in all its IOC configurations on the ship. We are getting up to the heaviest gross weights with external stores and will also clear out the full crosswind envelope for launching and recovering. We can launch with up to a 15kt crosswind & we can recover with up to a 10kt crosswind.

'The objective test points are ones that we have to get done. They number about 315, and the other threshold test points we will look to do as long as we have the time and the asset support. This trip is about verifying the testing we have already done shore-based.'"

Clean Sweep: F-35 Fighter Confounds Critics With Perfect Performance In First Tests At Sea

21 Nov 2014 Loren Thompson

There's a tradition in the U.S. Navy that when missions are a complete success, a broom gets raised up the mast to signal a "clean sweep." That's what happened on November 14 when the F-35C Lightning II completed its first series of developmental tests on the U.S.S. Nimitz aircraft carrier. Sailors sent a broom up the mast below the flag to signal the tests had gone very well.

How well? For starters, the two weeks of scheduled tests were completed three days early with 100% of threshold test points accomplished. For the first time ever, a new carrier-based aircraft conducted night operations during its initial round of testing at sea — operations that are usually performed in later rounds. As one Navy test pilot observed in an official news release, **"It's unheard of to conduct night ops on the first det,"** meaning developmental test.

To say that carrier-based air operations are challenging is an understatement. Jets designed to fly faster than the speed of sound must take off and land on a short runway while the ship is pitching in the sea and wind is blowing across the decks. The catapults that provide the initial push to get airborne accelerate the planes from zero to 170 miles per hour in two seconds. The arresting wires that trap the planes when they land bring them to a dead stop in two seconds. And since there's always a chance the plane could miss the arresting wires while attempting to land, the thrust can't be cut too much because a pilot might have to get his or her jet back into the air real quick. So the risks are high and the physical forces at work are extreme.

In this harrowing environment, two F-35C fighters managed to accomplish **124 catapults and arrestments, 222 touch-and-go landings**, and a host of other operations without a hitch. On their first try. It was a world-class performance for the carrier version of what used to be called the Joint Strike Fighter, and a vindication for prime contractor Lockheed Martin. As the Navy news release put it, "The aircraft demonstrated exceptional performance throughout its initial sea trials." Two follow-on sets of tests are scheduled in 2015 and 2016, but the Navy can now be confident that the F-35C will be ready for its first scheduled fielding with the fleet in 2018.

The success of the tests has important implications for the whole joint force. Pentagon leaders are warning that other countries have begun closing the technology gap with U.S. warfighters, and the fighters the Navy operates today won't be able to survive in contested air space indefinitely. The F-35 program was conceived to replace the Cold War tactical aircraft of three U.S. military services and over a dozen allies with affordable multi-role fighters that not only can survive, but will sweep the skies of enemy aircraft while destroying well-defended ground targets. The F-35 accomplishes this with an integrated stealth design that makes it nearly invisible to enemy radar and an advanced sensor package that provides comprehensive situational awareness to the pilot. Precision-guided munitions give it pinpoint accuracy in attacking surface targets, while its electronic-warfare suite can defeat a wide array of hostile emitters.

When these features are combined with the speed and maneuverability afforded by Pratt & Whitney's revolutionary F135 engine, the result is what military experts call a "fifth-generation" fighter. Developing such an aircraft in multiple variants for three different services may well be the most challenging military-technology project ever. The Air Force variant needed to be cheap enough for overseas allies to afford, the Marine version needed a mid-fuselage lift-fan and vectored thrust for vertical takeoffs and landings, and the Navy version needed to be sufficiently rugged to withstand the stresses of carrier catapults and arresting wires.

The F-35C — the carrier version — may be the most challenging variant to build. It has bigger wings, stronger landing gear, and greater fuel-carrying capacity than the other variants to meet the Navy's unique operating requirements. Those features make it possible for the plane to fly farther with a larger payload, while being able to conduct its final carrier approach at a slow enough speed for safe landings. **One key feature on the naval variant that performed well in the recent tests was a system called Delta Flight Path that enables the F-35C to automatically capture and maintain the optimum glidepath on final approach to the carrier — reducing the pilot workload, increasing safety, and making F-35C, in the words of the Navy's testing team leader, "a carefree aircraft from the pilot's perspective."**

This may be the first time ever that the word "carefree" has been used by a Navy tester to describe the performance of a new carrier-based aircraft. Adjectives like "arduous" and "challenging" are far more commonly used. So the F-35C has set a high standard for all naval aircraft to come in the maturity and sophistication of its design. Perhaps there is a lesson to be learned about our culture from the fact that the Navy's very positive experience with its F-35 variant this month has gone largely unnoticed in the general media, even though every supposed problem with the plane up to this point has gotten headlines. The Navy and its industry partners have just demonstrated that when it comes to aerospace technology, America still leads the world by a healthy margin. So let's get that plane into the fleet, where it can start making a difference in maintaining global security.

http://www.forbes.com/sites/lorenthompson/2014/11/21/clean-sweep-f-35-fighter-confounds-critics-with-perfect-performance-in-first-tests-at-sea/

Glad to be Back!

Oct 2016 James DeBoer
AirForces Monthly

"After a ten-year gap, the 'Grim Reapers' of VFA-101 recently returned to the aircraft carrier. Its mission, as James DeBoer witnessed, was to complete the third phase of F-35C development testing....

...To conduct the daytime CQs, the squadron took five aircraft, 12 pilots and more than 80 maintainers including enlisted sailors and contractors. The squadron was joined by two F-35Cs from the experimental test squadron, VX-23, which, along with the Integrated Test Force (ITF), were working on the final Developmental Test (DT) period known as DT-III. To qualify for daytime carrier landings, each pilot at VFA-101 needed ten traps and two touch-and-goes, the same number needed for Hornet carrier qualifications. This could be reduced though, due to newer technologies such as the Delta Flight Path incorporated in the F-35C. This piece of kit helps improve safety during landing on a carrier deck. The first three aircraft took off from Eglin AFB on the morning of August 14 for the 90-minute flight to the ship. Each of the pilots conducted a touch-and-go before catching the wire. Once on board, the pilots were quickly positioned for another catapult launch, they would then repeat the landing sequence nine more times. Two more F-35Cs from the squadron followed the same day.

"We're out here developing a syllabus," said Capt James 'Cruiser' Christie, the Commanding Officer of VFA-101. "The carrier qualifications went really well for us. One of our big 'takeaways' was that Delta Flight Path is clearly going to be the new standard for precision landing modes (PLM). The PLMs are a remarkable change to how we fly around the ship. This technology will make the average fleet pilots approaches to the ship safer as well as improve their boarding rate".

The squadron logged 154 approaches to the ship with a 100% boarding rate, with not a single 'bolter' or 'wave-off', which is when the pilot goes around again.

Additionally, the pilots did not catch a single 1-Wire, the wire furthest aft and considered on the low side of the glide slope. "It's a pretty big statement to say we had a 100% boarding rate, with no bolters. This all means the [jet's] hook was touching down where we wanted it to almost all of the time. Over 80% of our landings caught the

3-Wire so that statistic is pretty remarkable" said Capt Christie....

...The squadron helped with DT-III while out at sea. One of its test points was the removal of the engine from an F-35C in the hangar bay while under way.

Capt Christie said: "When the test point came out, we realised there were resources in the fleet that could perform this and that there would be a benefit to all parties involved. An agreement between the head of test and the ship's Air Boss to have VFA- 101, led to the test being conducted. We had the VX-23 Integrated Test Force out with us to make sure we were capturing what the test guys wanted us to do and for them to properly document all the test points. Our team at VFA-101 is extremely experienced at changing engines on shore, so we were up to the job. I think we exceeded all expectations on how quickly and efficiently we were able to accomplish the task. Many observers were thinking it would take about 72 hours and the team did it in under 20 maintenance hours. That's a great success"....

...The LSO

Lt Graham Cleveland was serving as a landing signal officer (LSO) with VFA-101 during the carrier qualifications. Lt Cleveland has been part of all three DTs as an LSO.

He said: "So far, the data looks good. In this round of testing, there have so far been no bolters, when an aircraft unintentionally misses the wire, and no landing wave-offs attributed to aircraft performance or safety issues".

Lt Cleveland added that all the new technology that helps pilots safely operate around the ship reduces the pilot workload, so the Navy may be able to cut FCLPs from the current 16 to 18 practices to as little as four to six. When it comes to carrier qualification requirements, Lt Cleveland envisages the possibility of reducing the number of needed traps from ten to six. All these reductions would result in huge savings to the Navy: "That's going to save money, that's going to save fuel, that's going to save aircraft life, basically."...

...The former F/A-18C pilot

Lt Nicholas 'Fila' Rezendes flew his F-35C call sign 'DASH-3' on to the ship directly from Eglin AFB. With a background in F/A-18Cs, Lt Rezendes is enjoying his F-35 assignment. "Before going to the USS George Washington, we did a two-week period of FCLPs, but they don't usually compare very well to the ship. We also did some simulator work at Eglin, which, along with the FCLP, helped prepare us very well for the day we actually landed. "Once we got to there we quickly realised that the precision landing capabilities of the F-35 almost made landing administrative-like in nature. It makes the task of landing on a carrier less demanding, and helps the pilot focus on other things, such as being more tactical in the air."

When asked about his first landing, Lt Rezendes recalled: "Taking off from Eglin we had about a 90-minute flight, so I had plenty of time to think about landing on the ship. I was thinking about general safety. Even though I may have done it a couple of hundred times, landing on a carrier always makes people feel nervous. Most of us were dumbstruck with the first few passes because of how easy it was compared with our experiences in the Hornet."...

...Pilot's Landing Workload Reduced

Capt Mark 'Gerbs' Weisgerber was one of the 12 instructors chosen to conduct the first round of carrier qualifications. He has flown every model of the Hornet and now serves as the vice commander of the 33rd Fighter Wing, Air Education and Training Command at Eglin AFB. The Wing serves as the home to the F-35 Lightning II Integrated Training Center (ITC), providing flying and maintenance training for the Marine Corps, Navy, Air Force as well as eight international partners.

Asked about his first day on the ship, Capt Weisgerber said: "After the five guys arrived with the jets on the first day and took care of their work, I hot-seated into one of the airplanes. I had enough time to get seven of the ten arrested landings in before the sun set and we shut down for the day".

He added: "I have about 875 arrested landings in the legacy Hornet and Super Hornet, but I was really pleasantly surprised by how much the pilot workload was reduced compared with the Hornet. Historically, senior pilots like myself, get better and better as you do more because you can anticipate the conditions behind the ship. Pilots that can anticipate get better grades than the pilots that react, but with the new flight Delta Flight Path control mode, you really don't have to anticipate."

Delta Flight Path gives the aircraft the ability to stay on glide slope automatically and minimise the number of corrections the pilot must make and was used on all of the carrier qualifications landings conducted by VFA-101.

Capt Weisgerber continued: "That easiness translates to a better boarding rate, which means not having to practice as often, which is important because we spent a lot of training dollars preparing for landing on the ship. We probably won't need as much emergency fuel operating over blue water, so hats off to the engineers who designed this thing."

"Historically we carrier aviators pride ourselves on how well we land behind the boat. 'Greenie boards' on the ship display the pilot's landing grades, for everyone to see. It is a matter of pride [to get a good grade] to be up there at top and if you are not you want to improve, which in turn makes people safer. Now, with the pilot workload minimised when landing, you can still take pride in great grades, but everyone is going to have them, so we will have to find something else to hang our hats on to boost our reputation around the ship." When asked about the first catapult shot and landing on a carrier, he said: "With the training we got back on land at Eglin, each of us receiving five or six turns practising at the FCLP [Field Carrier Landing Practice fields at Choctaw, near NAS Pensacola, [Florida] and the other one near NAS Meridian, [Mississippi], we all felt up to the task".

Field carrier landing practices are a series of touch-and-goes, which are observed by a landing signal officer who grades and critiques each landing. "I first experienced the catapult shot on board a C-2 Greyhound. It's a little different than the Hornet in that it's a bit more of a violent ride down the catapult," Capt Weisgerber explained.

VFA 101 currently has 23 F-35Cs assigned to it and recently started training several pilots who will soon stand up a second fleet replacement squadron, VFA-125, on the west coast at NAS Lemoore, California. Although slated for only 15 aircraft, VFA-101 continues to receive aircraft off the production line until the other squadrons, such as VX-9 and VFA-125, become operational with the C model. The aircraft are currently waiting to receive the Block 3F software now in developmental testing, which will provide the air-to-air and air-to-ground mission capabilities. VFA-101 has started training personnel for the first fleet squadron, VFA-97 which should reach IOC by 2018."

[Now VFA-147 is slated first]

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Navy F-35C Prepares for Ship Trials, Faces Headwinds

17 Feb 2014 Sandra I. Erwin

Naval aviators plan to fly the F-35 Joint Strike Fighter from an aircraft carrier at sea this fall. Pilots who have operated the aircraft say they are cautiously optimistic about its future despite a string of technical setbacks.

During carrier tests scheduled for October, officials will have an opportunity to examine the performance of the airplane following a recent redesign of the arresting hook that catches the airplane when it lands on the carrier deck. Aviation commanders also hope the tests will provide early answers to questions about the role of the F-35C as part of an air wing.

The F-35C faces several more years of tests before it is ready to join carrier air wings. Whereas the Marine Corps is determined to start operations with its vertical-takeoff F-35B as early as 2016, the Navy is in less of a hurry. At the earliest, the Navy has said the F-35C would be operational in 2019, although that goal appears to be in flux.

"We are only half way through the initial development plan," says Navy Lt. Cmdr. Michael Burks, a test pilot with 150 hours in the cockpit of the F-35C and B.

Flight tests are planned through 2017, and operational-level trials would begin later. The $400 billion Joint Strike Fighter program includes three variants: one for the Air Force, one for the Marine Corps and one for the Navy.

The priorities for the Navy's F-35C are to finish software development and to fix glitches in the helmet-mounted displays, Burks says during a recent industry conference in San Diego. Then the Navy will have to decide how to incorporate the F-35C into an already crowded air wing.

"There will be some challenges integrating the F-35 on the carrier. Most have been identified," he says. A carrier air wing typically has anywhere from 44 to 54 fighter jets. The Navy expects that for the foreseeable future, most of the fighters in the air wing will be Super Hornets, and that the F-35C will have a niche role as an airborne intelligence nerve center.

The F-35C will be predominantly an "information collector and distributor in the air wing," says Burks. As the Navy's only "stealth" aircraft that can fly undetected by radar, it will be prepared to "go alone into highly contested areas," he adds. But most of the time it will serve as the hub of a "network centric" air wing.

"It may not matter what weapon we have on board," Burks says. F-35 pilots will pass information over the network that would allow other aircraft to engage targets. "I may pull the trigger in the cockpit but the weapon may come from a different platform," he explains.

Routine aircraft operations and maintenance aboard the carrier will change dramatically when the F-35C joins the fleet, says Burks. The high-tech materials that give the F-35 stealth properties require special care. "There will have to be a paradigm shift… in the grimy flight deck environment," he says. "Maintainers are going to have to come into the 21st century when it comes to maintaining these technologies," says Burks. "No longer can we allow our aircraft to get grubby and grimy from wear and tear, and wash them once a month. They will require daily support, the effort of the entire squadron, especially on cruise," he says. "That's different from the current mindset when we let the airplanes get dirty because of the operational environment." In test squadrons, aircraft are kept indoors and in hangars, so maintenance problems at sea have yet to be experienced.

Another issue will be coping with louder than usual engines. "It is a very noisy jet," Burks says of the F-35C. "We are looking at having to use noise-cancellation headsets for maintainers" and other operators.

The Pentagon's Director of Test and Evaluation Michael Gilmore says in his 2014 annual report that engine noise is a "potential risk to personnel on the flight deck and one level below the flight deck." Projected noise levels one level below the flight deck will require at least single hearing protection, he says. On most carriers this is a berthing area, but on the new carrier CVN-78 this is a mission planning space, Gilmore says. "Personnel wearing hearing protection in mission planning areas will find it difficult to perform their duties."

A more significant concern is the performance of the redesigned tail hook, which has been tested six times so far. "It's a bit early to say we have definitely nailed this problem," says Burks. "The tail hook has been a major issue for the development of this airplane. It was unexpected until it was discovered in 2011." The first problem was not being able to catching the arresting wire. There was also a structural flaw that caused excessive stress to the bulkhead where the tail hook attaches to the airframe. The redesign took a year and a half. Manufacturer Lockheed Martin Corp. has so far delivered one F-35C with the new tail hook at the Navy's test site at Patuxent River, Md.

Gilmore says the arresting hook system "remains an integration risk as the JSF development schedule leaves no time for new discoveries." He cautions about the "potential for gouging of the flight deck after a missed cable engagement due to an increase in weight of 139 pounds and the potential for sparking from the tail hook across the flight deck because of the increased weight and sharper geometry of the redesigned hook."

One of the most anticipated features of the F-35C is an automated landing system called "delta flight path" that would take the pressure off aviators to nail landings on moving ships. "The delta flight path for the F-35C will make carrier landing so easy," Burks says. "It will be a new era of carrier aviation. ... Night landings will not be the number one task to focus on." The system has been tested ashore but has yet to be tried at sea.

The glitches of the $500,000 F-35 pilot helmet have been well documented, but problems have yet to be fixed. Having a helmet-mounted display is central to how air warfare will be conduced with the F-35 because it eliminates the heads-up display in the cockpit, and everything is projected on the visor of the helmet.

"When it gets to the fleet and it's working right, it will provide a great capability," says Burks. It would allow for a smooth transition from day to night, with no need for night vision goggles. The pilot would have a 360-degree view of his surroundings from the cameras around the aircraft. The helmet, though, has been plagued by the jitters. When the display is fixed to the aircraft, it is easy for the human eye to compensate for head motion. "It so happens now that your head is bobbing around when you're pulling G's, it's not quite as easy to stabilize the symbology on the visor," he says. "We've been through many fixes." The contractor built a tiny electronic device to sense aircraft vibration and buffeting. "It turns on filters in different regimes of flight to filter out the noise we're seeing in the display," says Burks.

The redesigned helmet is now undergoing tests. The helmet's night camera also will require major changes. "It continues to be a show stopper at night," he says. One problem is that it leaks light at night when the pilot is trying to dim the display down. "You get a lot of leakage of light in the optics around the eyes. It's distracting," says Burks. **He predicts the transition from cockpit to helmet-mounted displays will be hard for most pilots. "It took me about 50 flying hours to adjust."**

William Gigliotti, F-35 test pilot at Lockheed Martin Corp., says glitches are to be expected in any major weapon development. During a panel discussion at the Navy's West 2014 conference in San Diego, Gigliotti suggests that "nits" in the F-35 program get blown out of proportion. "It's the most scrutinized program around," he says. "We can't afford to hide anything."

Being in the middle of the flight test program, he says, "our job is to stress the aircraft, find problems and fix them."

He says Lockheed engineers have come up with novel ideas for how to maintain sensitive stealth aircraft at sea. "When we go to the carrier this year, we have to see the normal wear and tear."

A potential weakness of the F-35 is not the aircraft but its weapons, Gigliotti says. He worries about future conflicts where U.S. aviators may have to engage in dogfights against well-equipped enemies. "We have air-to-air missiles. But it's important we acknowledge that in the United States we need a new AIM 120," he says referring to the newest air-to-air weapon used by the U.S. military. "We need a longer range air-to-air weapon. … As an industry, we need to get active in supplying a longer and more kinematic air-to-air weapon," Gigliotti says. "That is a current limitation under some scenarios. … It is the Achilles' heel across the U.S. Fighter fleet. We need better kinematics."

The Pentagon plans to buy nearly 100 F-35s of the three variants by 2018. When the program's schedule collapsed in 2009 and its costs started to soar, Pentagon officials halted development and directed all branches of the military to beef up the testing program to ensure problems were fixed before more airframes were produced.

The projected price tag of $391.2 billion for an eventual fleet of 2,443 F-35s is a 68 percent increase from the estimate in 2001. The officer in charge of the F-35, Air Force Lt. Gen. Christopher Bogdan, says in a 60 Minutes interview that the price tag of at least $115 million per aircraft is too high, but the Pentagon intends to stick with the plan. "I don't see any scenario where we're walking back away from this program."

http://www.nationaldefensemagazine.org/blog/Lists/Posts/Post.aspx?List=7c996cd7%2Dcbb4%2D4018%2Dbaf8%2D8825eada7aa2&ID=1415

Lightning II ground

As the F-35 Lightning II completes a raft of flight test trials, Aerospace Testing International takes an exclusive look at the involvement of the Integrated Test Force (ITF) in this stage of the fighter's complex multirole development

http://www.aerospacetestinginternational.com/articles.php?ArticleID=1189

Since December 2006, the F-35 Lightning II has surpassed 25,000 combined flight hours with 16,200 hours in F-35 military fleet aircraft and 8,950 hours of system development and demonstration testing. Much of that testing has been conducted by the F-35 Lightning II Integrated Test Force (ITF) assigned to Air Test and Evaluation Squadron (VX) 23, based at Naval Air Station Patuxent River, Maryland.

Operating at a high tempo is routine for the Pax River ITF's cadre of military, government and contractor testers. In the span of less than six months, they successfully conducted two high-profile test evalutions on opposite coasts of the USA and began preparations for additional high-visibility testing, yet again on both sides of the country.

On September 29, 2014, the ITF deployed a team of 40 testers to the McKinley Climatic Laboratory (MCL), the world's largest environmental testing chamber. The 96th Test Wing, a US Air Force Materiel Command unit, operates the MCL at Eglin Air Force Base in Fort Walton Beach, Florida. For six months, the Pax River ITF Climatic Test team and key members of the Edwards ITF have capitalized upon the MCL's proven capability to recreate nearly every weather condition on Earth as they assessed the performance of aircraft BF-05, the short take-off/vertical landing (STOVL) variant, in a wide array of temperatures and meteorological conditions. Testers put the aircraft through extremes such as -40°F/C up to 120°F (48.8°C) and featured wind, solar radiation, fog, humidity, rain intrusion/ingestion, freezing rain, icing cloud, icing build-up, vortex icing and snow.

By placing BF-05 onto a purpose-built frame, test pilots were able to 'fly' a standard profile in accordance with defined test sequences. This profile featured a normal start-up, a VSBIT (vehicle systems built-in test) to check the onboard systems, a simulated short take-off, a climb out, full afterburner runs in conventional mode, and a simulated vertical landing. Each meteorological condition was fully tested and featured 60% ground operations and 40% flying, including engine runs and simulated flight in both conventional and STOVL modes. Testers also ensured the collection of accurate and representative data during the icing evaluation by installing additional F-35A and F-35C icing detector probes according to each variant's design.

"This type of testing doesn't happen every day," says US Navy test pilot Cdr Tony 'Brick' Wilson. "What the McKinley team has pulled off at Eglin is a real feat of engineering; it's been a very surreal experience to walk from normal Florida weather into the hangar where it's like the Arctic and test the F-35. We'll complete our testing at the end of March 2015 and I'm pleased to say that the findings have been very positive to date."

Opp: An F-35B Lightning II short take-off/vertical-landing (STOVL) variant of the Joint Strike Fighter is currently undergoing climatic testing at McKinley Climatic Laboratory (MCL) at Eglin AFB. An icing cloud test calibration fixture has been installed within the climatic chamber

Above: CF-05 lands aboard the USS Nimitz during the initial shipboard trials. The F-35C performed its first set of arrested landings and catapult launches

Onboard trials

While some of their teammates were in Florida, an ITF detachment traveled to Naval Air Station North Island in Coronado, California, to board the USS Nimitz (CVN 68) in November 2014. Led by Cdr Wilson and Thomas Briggs, the ITF's lead flight test engineer for DT-I, their test objective was to conduct a three-week initial shipboard developmental test (DT-I) trial of the F-35C Lightning II, the carrier variant of the Joint Strike Fighter (JSF).

During DT-I, F-35C test pilots and engineers tested both the suitability and integration of the aircraft with carrier air and deck operations in an at-sea environment. The F-35C demonstrated exceptional performance both in the air and on the flight deck, accelerating the team's progress through the DT-I schedule and achieving 100% of the threshold test points three days early. Test pilots and engineers credited the F-35C's Delta Flight Path (DFP) technology with significantly reducing pilot workload during the approach to the carrier, increasing safety margins during carrier approaches and reducing touchdown dispersion.

"The engineers responsible for the aircraft's control laws did a phenomenal job designing this aircraft from the pilot's perspective," Wilson explains. "The control schemes of the F-35C provide a tool for the below-average ball flyer to compete for top hook."

"My major takeaway was that the F-35C is very good at flying behind the ship," notes Lt Cdr Ted Dyckman, a VX-23 test pilot at the ITF. "Any deviation that someone gets themselves into, they can correct fairly quickly and accurately. In fact, it's a three-wire machine," he added, referring to the optimal arresting wire aboard an aircraft carrier.

The DFP capability allowed for 124 arrested landings with zero unintentional hook-down missed attempts to catch an arresting wire on the flight deck, otherwise known as 'bolters'. (Two hook-down intentional bolters were conducted as part of the DT-I test plan.)

"The flight control system is precise, stable and responsive, and provides carefree handling in all flight regimes," says Cdr Christian Sewell, the VX-23 F-35 operational test liaison officer/ITF operations officer. "We've tested right up to the edge of the envelope and the aircraft handles amazingly. In general, the pilot workload required to fly the F-35 is less when compared with legacy aircraft, which allows the pilot to focus on the operational mission."

Above: The F-35 Lightning II Pax River Integrated Test Force from Air Test and Evaluation Squadron (VX) 23 has ferried aircraft BF-05 to Eglin AFB to undergo climatic testing

Tailhook design

The three-wire landings during DT-I also demonstrated the successful redesign of the F-35C's tailhook and supporting structural interfaces. The joint contractor and government team consisted of engineers from NAVAIR's Systems Engineering, Air Vehicle Engineering and Support Equipment & Aircraft Launch & Recovery Equipment departments, the Atlantic Test Range (ATR) and Pax River ITF, and Lockheed Martin Aero, Northrop Grumman, and Fokker Landing Gear.

The tailhook redesign effort, like the flight control system, is an example of the power of collaboration between government and industry engineers. In both cases, industry was able to leverage NAVAIR's decades of experience in carrier-based aircraft design to build an outstanding product for the warfighter.

"Since beginning shore-based carrier suitability testing in January 2014 with the redesigned hook system, test results have been positive, with the ultimate proof coming in the success of DT-I," says Bryan Racine, F-35 ship suitability team lead.

"We had stricter weather requirements when we were here. As we got into testing, the weather started coming down," Dyckman says. "We had such confidence in how the airplane was flying that we lowered the weather minimums to what the fleet is actually using, knowing that when I lower my hook and come into the groove, I'm going to trap."

Dyckman adds that the test team's confidence level in the aircraft was so high that they were ready to evaluate the aircraft for night operations. "It flew very well behind the ship, even on the darkest night," he says. "Two hook-down passes and two traps: that says it all right there. It's unheard of to conduct night ops on the first test detail."

During DT-I, F-35C maintenance and ground operations integrated well with standard Navy carrier procedures aboard Nimitz.

"All of the flight deck crew members involved in DT-I were assigned to Nimitz, some of whom went to NAS Patuxent River in mid-October for training," Wilson explains. "They returned to the ship and prepared the remainder of their crew for the arrival of the F-35C. The initial ship trials of the F-35C would not have been possible without the cooperation of Nimitz."

After all test points are collected, analyzed and assessed, the DT-I data will be used to advise the Navy of any adjustments necessary to ensure the fifth-generation fighter is fully capable and ready to deploy to the fleet.

"Our main testing points were to verify that the approach handling qualities were satisfactory across a variety of wind conditions; to determine the launch characteristic and performance from the ship's catapults across a variety of wind conditions; to look at the integration of the aircraft with the ship, both on the flight deck and in the hangar bay; and to test the ability of the F-35C to use other ships' flight systems to perform inertial alignments, instrument approaches, and basic navigation to and from the ship," says Cdr Shawn Kern,

The F-35C Lightning II carrier variant conducted its first carrier-based night flight operations aboard a US Navy aircraft carrier in November 2014

the director of test and evaluation for F-35 naval variants. "We also performed some aircraft functions in and around the shipboard environment, including use of various sensors and fuel dump testing."

Runway trials

As team members returned to the ITF from their highly successful detachment aboard the Nimitz, they began to finalize preparations for wet runway and crosswind testing at Edwards Air Force Base and Naval Air Weapons Station China Lake in March 2015; and ski jump testing at Pax River in May 2015.

To date, 158 F-35 pilots and more than 1,650 maintainers have graduated from training at Eglin AFB, while the F-35 has completed multiple weapons tests as well as F-35B and F-35C first-life durability testing.

Additionally, the program has conducted two F-35B DT shipboard trials aboard the USS Wasp (LHD 1) and two more shipboard trials are anticipated in 2015 – the F-35B will conduct its first operational test and the F-35C will conduct its second DT event. As the F-35 progresses through all of these test events, the initial operational capability (IOC) milestone dates published in 2013 continue to be on target. The F-35A is set to reach its IOC milestone by December 2016; the F-35B is expected to reach its IOC milestone by July 2015; and the F-35C is anticipated to reach its IOC milestone by February 2019.

Sylvia Pierson is the F-35 Lightning II Patuxent River Integrated Test Force (ITF) public affairs officer