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.

Delta Flight Path F-35C JSF Roundtable West Feb 2014

https://www.youtube.com/watch?v=bc0mDcWEpKQ

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

Boeing helps test software that makes carrier landings easier and safer https://www.youtube.com/watch?v=YrnkfCQ3pSI

The U.S. Navy and Boeing recently tested the technology during successful sea trials onboard the USS George H.W. Bush aircraft carrier. It's called MAGIC CARPET, Maritime Augmented Guidance with Integrated Controls for Carrier Approach and Recovery Precision Enabling Technologies, and it helps guide pilots to the carrier deck. Published on **Jul 20, 2015** Boeing

Super Hornet Magic Carpet 2015 Tailhook LSO 'Magic Legs' Brief

https://www.youtube.com/watch?v=v_Mp8uUZeCY

VADM Dunaway Remarks Magic Carpet Benefits TailHOOK 2015

https://www.youtube.com/watch?v=htRvkyTrogM

WHO Introduces VX-23 HOOK14

This squadron does the fixed wing carrier suitability trials with obvious stress testing of the aircraft in all kinds of odd landing situations to try to mimic on land what may happen out at sea:

https://www.youtube.com/watch?v=TDUmNUCm29Y

Magic Carpet for F/A-18EnF&G EMALS AAG X-47B Hook14
https://www.youtube.com/watch?v=q8Bn2GZuQCc

Magic Carpet DLC Super Hornet Explanation Hook 14

Another OPNAV N-98 magic carpet explanation DLC for the Super Hornet (the F-35C will use something similar called IDLC). There are differences (TWO) with the CARPET for how things are done. I'll guess when testing is finished there will be good explanations about it all.

https://www.youtube.com/watch?v=X-pWG4T65f0

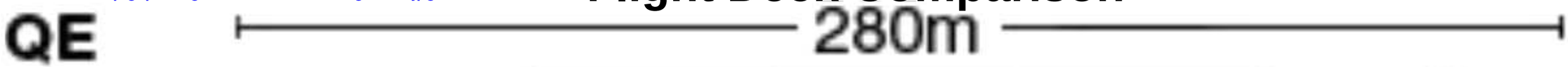
Carrier Suitability F-35C SR&R Hook14

https://www.youtube.com/watch?v=AKE0s0i-6xc

QUEEN ELIZABETH CLASS (CVF) & NIMTIZ CLASS (CVN)

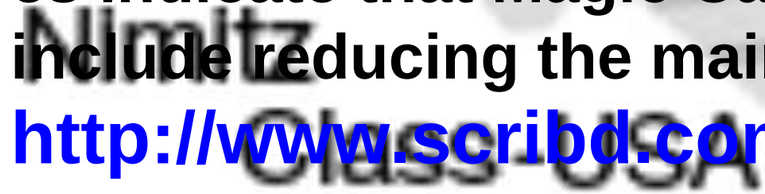
http://www.bbc.co.uk/news/special/uk/11/aircraft_carrier_pig_pic/img/aircraft_carrier_design_976.jpg

Flight Deck Comparison



Naval Aviation Vision 2014-2025

"...Magic Carpet: Magic Carpet is an acronym for Maritime Augmented Guidance with Integrated Controls for Carrier Approach and Recovery Precision Enabling Technologies. It is a cockpit system that makes carrier approaches and landings easier and safer for Navy and Marine Corps pilots by reducing the vulnerabilities associated with fully-automated systems that are susceptible to jamming, poor reliability, and electronic failure. Magic Carpet's integrated direct lift improves short-term flightpath response, which is critical to final glide slope corrections prior to landing. This system is currently flown in the F-35C and being retrofitted for testing in the F/A-18E/F. The potential cost-saving impacts of Magic Carpet are significant. Millions of dollars are spent yearly on landing practices ashore and actual carrier qualifications while underway. The money saved could be repurposed to train pilots to employ the weapon systems of their aircraft, dramatically changing their priorities from landing proficiency to warfighting proficiency. Conservative estimates indicate that Magic Carpet could save tens of millions of dollars per year, which include reducing the maintenance and repairs after hard landings aboard ship...."



http://www.scribd.com/doc/218758281/Naval-Aviation-Vision#download

http://www.onr.navy.mil/Science-Technology/Directorates/office-innovation/~/media/Files/03I/News-Sept13-Vol10.ashx

Figure 1. Carrier landing area as seen through the HUD. Pilots need to monitor glideslope using the Fresnel Lens, angle of attack (speed), and lineup simultaneously.
(*background photo*: U.S. Navy photo by Petty Officer 3rd Class Kenneth Abbate)

A BREAKTHROUGH IN CARRIER AIRCRAFT LANDING

Mr. John Kinzer, *Program Officer, Air Vehicle Technology, Office of Naval Research*

Landing a jet aircraft on an aircraft carrier is very difficult on a good day, and when you add in darkness, bad weather, a heaving, pitching deck, and pilot fatigue from an extended combat mission, it is one of the most demanding challenges faced by Naval Aviators. And the consequences of failure are severe. Because of this challenge, the costs of training Naval Aviators are very high. Aircraft carrier qualification training is conducted during intense pilot undergraduate training, fleet replacement squadron training, and refresher training prior to deployment.

It's no surprise, then, that the idea of automating carrier landings has been around for some time. In fact, the first automated aircraft landing on an aircraft carrier was performed by an F-3D Skyknight in 1957 on the USS Antietam (*Figure 2*). So why aren't we routinely relying on this capability today? The answer is that because piloted landing skill is so difficult to develop and maintain almost all the landings a pilot performs are needed to make sure he or she is ready when challenging conditions occur. If an automated landing system cannot be 99.9999% reliable under the worst case scenario, then the pilot always has to be ready. There are a number of reasons why automated landing systems have insufficient reliability even today. Many of them have been addressed by steadily advancing reliability of the aircraft themselves. One is the need for a precision navigation system that can provide high quality information to the aircraft as to exactly where it is relative to the landing point, all the way to touchdown. This technology is still in development.

The real breakthrough then is to change the way pilots fly aircraft to landing. Traditionally, pilots control rate of descent with power (left hand on the throttles), airspeed with pitch attitude (forward/aft stick), and heading with roll (left/right stick). It's hard enough to do these three things at once, but complicating the problem is that these control axes are cross-coupled and only indirectly influence what is really intended: glideslope and lineup. The pilot is required to integrate the disparate control problems and anticipate the need for adjustments. The change that is being developed is to reduce the number of controls, eliminate control cross-coupling, and provide direct control of glideslope and lineup (*Figure 1*).

Figure 2. An F-3D Seaknight conducts the first automated landing, aboard USS Antietam, using the radar equipment in the foreground.

Figure 3. F/A-18F engages the arresting wire during a carrier landing.

At the Naval Air Warfare Center, Aircraft Division, Patuxent River, engineers under the leadership of James "Buddy" Denham, and with partial Office of Naval Research (ONR) sponsorship, this breakthrough change is becoming reality in a program called MAGIC CARPET. First, they incorporated the use of reliable automated approach power control to allow the pilot to control the entire landing with just the right hand on the stick. Second, they developed flight control laws which did two things: (1) utilized wing flaps and ailerons to instantly adjust lift on the wing, and (2) augmented aircraft stability to allow the pilot forward and aft stick inputs to directly control glideslope angle. Third, they provided displays to the pilot on the Head Up Display (HUD) with desired glideslope reference and actual glideslope flight path vector. The task for maintaining glideslope then becomes greatly simplified: fly level until the ship comes under the desired glide slope reference and push the stick forward until the actual glide slope vector matches the glideslope, and release the control. Slight adjustments high or low can be accomplished in a similar manner.

These breakthroughs have been tested and demonstrated in simulators with two different aircraft. In flight simulator evaluations in a Joint Strike Fighter configuration at BAE Wharton, the workload for carrier landing was reduced from a Handling Qualities Rating (HQR) 6 (extensive pilot workload), to 2 (minimal pilot workload)—a dramatic reduction! These results were confirmed in an F/A-18E/F simulator at Patuxent River in late 2012, in which landing touchdown performance was improved by over 50% (*Figure 3*).

MAGIC CARPET technology development is continuing. Flight control augmentation for lineup is being developed and tested in the flight simulator, and HUD displays are being refined. Planning is underway to conduct testing of the control laws and displays in both the F/A–18E/F and the F-35C.

Since training cost reduction as well as landing performance enhancement is needed, an ONR interdepartmental Air Warfare and Warfighter Performance collaboration has commenced. Experiments are being developed to assess the pilot's learning curve using these advanced controls and displays as well as performance. This will help to establish a basis for potential reduction of the amount of dedicated training needed to ensure continued operational effectiveness without compromising efficiency or safety. It is possible that integration of MAGIC CARPET technology in F/A-18 and F-35 could save hundreds of millions in training costs per year—that would be the real breakthrough. Of course, we may someday see the day when all aircraft landings aboard ship are fully automated and pilots no longer have to train for this part of the mission at all. Navigation systems and automated capability to enable this are already in work, but significant challenges remain. But that's another story. ■

http://www.onr.navy.mil/Science-Technology/Directorates/office-innovation/~/media/Files/03I/News-Sept13-Vol10.ashx

Boeing helps test software that makes carrier landings easier and safer

https://www.youtube.com/watch?v=YrnkfCQ3pSI

SAME story over page

Flight-Control Advances Promise Big Savings

New U.S./U.K.-developed flight-control technology might make carrier landings easier

03 Jul 2014 Bill Sweetman
Aviation Week & Space Technology

New flight-control and guidance technology developed by the U.S. Navy and British researchers has been shown to allow carrier fighter pilots to land more accurately and consistently, and will be applied to both the Boeing Super Hornet/Growler and the Lockheed Martin F-35C Joint Strike Fighter.

Developers of the technology predict it will reduce the number of training landings needed to qualify pilots for carrier operations and reduce fatigue on airframes.

Magic Carpet could sharply reduce the number of FLCPs needed to keep pilots qualified for carrier ops.

In the case of the F-35C, the new system—known as Maritime Augmented Guidance with Integrated Controls for Carrier Approach and Recovery Precision Enabling Technologies, or Magic Carpet—was shown in simulator tests to reduce pilot workload from borderline-acceptable levels to "minimal," and it will be installed for the fighter's long-delayed carrier trials later this year. Magic Carpet has been installed and tested without any hardware changes.

In a conventional carrier landing, the pilot follows an optical glideslope guidance from the ship, with flaps deflected to a preset angle. If the aircraft descends below the glideslope, the pilot has to pull the stick back and pitch the nose up to increase lift. This increases drag, so the pilot has to add power to maintain speed, then recover the original angle of attack (alpha), and throttle back to avoid over-speeding.

In a Magic Carpet approach, the pilot can engage a "Delta Path" law once the aircraft is on the glideslope. The flight-control system commands a reference flightpath, in combination with pilot-entered ship speed, which corresponds to the optical signal from the carrier. The aircraft will follow this path automatically, with the pilot correcting for any excursions. A ship-relative velocity vector is projected on the head-up display.

A major difference in the Magic Carpet approach is that the flaps are not fully deflected, and the flight control system uses them to add or reduce lift. If the aircraft falls below the glideslope, the pilot still pulls the stick back, but the control system deflects the flaps downward, reducing descent rate at a constant alpha. Once the aircraft regains the glideslope, Magic Carpet uses the flaps to readjust the vertical speed, again with no change in alpha. The auto-throttle—which on the Super Hornet is set to hold a constant alpha at an airspeed proportional to aircraft weight—will make necessary adjustments.

Both the basic F/A-18E/F and F-35C flight-control systems had provision for direct lift control, but the innovation in Magic Carpet is to add the Delta Path mode. In simulator tests at BAE Systems' Warton, England, site, the workload for an F-35C carrier landing was reduced from a Cooper-Harper handling qualities rating of 6 (extensive pilot workload), to 2 (minimal pilot workload), according to a Navy document.

A second element of Magic Carpet will help pilots fly through the "burble" of turbulent air behind a moving carrier. The inertial reference system and attitude sensors can be used to provide micro-corrections before the pilot can react—responding to a 0.1g departure in as little as 0.4 sec.

Magic Carpet originated at the U.S. Naval Air Warfare Center's aircraft division (Nawcad) at the Patuxent River, Maryland, flight-test center. Team leader James Denham, a senior engineer at Nawcad, tells Aviation Week that the idea stemmed from tests of the **Qinetiq-modified Vectored-thrust Aircraft Advanced Control (VAAC) Harrier aboard the U.K.'s aircraft carrier Illustrious, aimed at developing a shipboard rolling vertical landing mode for the F-35B**.

Denham proposed a system that would give other aircraft the same rate-command flight-control capability demonstrated on the VAAC Harrier, and obtained some "seed money" from the Office of Naval Research to conduct some simulation research. The results justified follow-on funds from ONR to develop control laws for the Super Hornet, leading to flight tests in 2012.

Simulated and flight tests have shown that pilots using Magic Carpet land more consistently than pilots using conventional controls, with less variability (in terms of touchdown dispersion) between different pilots and across multiple landings. Improvements are sustained in turbulence and high sea states.

ONR predicts Magic Carpet will reduce the number of field carrier landing practice approaches that are required to requalify pilots before each cruise, reducing both direct flight hour costs and the consumption of airframe life, and estimates that Magic Carpet could save the Navy $1 billion per year.

Boeing is under contract to build Magic Carpet functions into the Super Hornet/Growler operational flight program (OFP) with the goal of making it available to the fleet in 2018. The first phase is to build a fully certifiable OFP modification, which will start tests at Patuxent River in the fall of 2014 and undergo sea trials in early 2015. That is to be followed by a second phase that adds the "anti-burble" stabilization mode head-up display symbology and integrates the air data and inertial systems more fully.

http://aviationweek.com/defense/flight-control-advances-promise-big-savings

Magic Carpet Meets The Fleet

Victor Chen NAWCAD Public Affairs
30 Oct 2014 Publication : Tester

In early September, a team of NAVAIR engineers and test pilots took an example of an emerging NAVAIR innovation to the fleet.

Magic Carpet, an advanced software aid aimed at landing aircraft aboard heaving carrier decks, made its Tailhook Association reunion debut through a NAVAIR-built, high-fidelity flight simulator.

Heavily attended by current fleet pilots, the Tailhook reunion enabled test pilots and landing signal officers (LSOs) from the Carrier Suitability Department of Air Test and Evaluation Squadron (VX) 23 to collect feedback from more than 500 fellow pilots.

"The overall response from the fleet was exceptionally positive," said Lt. Cmdr. Patrick Bookey, department head for Carrier Suitability at VX-23. "I thought most fleet aviators were very receptive, even enthusiastic about [Magic Carpet] and its potential impact on the carrier landing task. Most people were asking, 'When are we getting this?'"

Carrier landings are inherently dangerous because of the large number of inputs that pilots must simultaneously absorb, understand and react to in order to safely land on a runway moving through the ocean. Magic Carpet alleviates pilot workload during the carrier landing process by automatically flying a set rate-of-descent based on pilot input, allowing the pilot to focus more attention on maintaining line-up while the aircraft flight controls maintain the proper glideslope.

At Tailhook, pilots — including air wing commanders and strike group commanders — waited in line well past official closing time to try their hand at NAVAIR's prototype.

Courtesy photo Magic Carpet, also known as Advanced Flight Controls and Displays, was the center of attention at NAVAIR's presence at the 2014 Tailhook Association reunion. Magic Carpet features a new set of powered approach flight control laws for the F/A-18 E/F Super Hornet including new, innovative symbology for the Head-Up Display (HUD) to significantly simplify the carrier landing task. Magic Carpet will make its first test in a live, at-sea environment on the F/A-18 platform early next year.

"The ability of the team at Manned Flight Simulator (MFS) to pull this together on short notice was incredible," Bookey said. "It was an extremely effective tool to get the feedback we were looking for and demonstrate NAVAIR capabilities to the fleet."

http://www.dcmilitary.com/article/20141030/NEWS14/141039966/magic-carpet-meets-the-fleet

According to the MFS team, creating the simulator was a group effort.

"The demonstrator is indicative of the 'we can do that' mentality of the simulator engineers and flight control software developers in the MFS facility," said Christian Riddle, a lab architect at MFS. "With a very short deadline, we created an amazing demonstrator. It not only looked impressive but, more importantly, it conveyed the true power of Magic Carpet and it how it will help naval aviation."

Even with only a few weeks with which to work, the MFS team had to scale back their ideas for the simulator.

"Given the time compression we were working with, we had to focus on the art of the possible. Our pilots from VX-23 were instrumental in helping us focus on what was important to get the message across to the fleet," Riddle said. "We used near 'off-the-shelf' solutions when more elegant answers were calling to us. Engineers always strive for perfection and, at some point, you have to bound your design and produce something on time, within budget."

Magic Carpet will make its first test in a live, at-sea environment on the F/A-18 platform early next year.

Semi-autonomous aviation controls coming to the fleet

05 Feb 2015 Meghann Myers

They say the most stressful job in the world is landing on an aircraft carrier at night in rough weather. On Thursday, Navy aviation officials are **carrying out another round of tests** on a control system that promises to take the edge off that sometimes harrowing experience.

Meanwhile, showgoers at the Naval Future Force Science and Technology Expo in Washington, D.C., got a chance to sit in a faux cockpit and try out the Naval Air Warfare Center Aircraft Division's system.

Maritime Augmented Guidance with Integrated Controls for Carrier Approach and Recovery Precision Enabling Technologies, or **MAGIC CARPET**, is already integrated into the F-35Cs that pilots from Air Test and Evaluation Squadron will take for a spin, NAWCAD aerospace engineer Steve Moss told Navy Times on Wednesday.

MAGIC CARPET allows a jet to self-correct its altitude, Moss said, as opposed to the constant pushing and pulling pilots do now to stay on course while approaching a carrier.

"You're constantly moving the throttles, because a jet's engine is always lagging," Moss said. "So you're doing a three-part power correction: You add the power to go forward, pull power off because it's always too much, then add power because you've overcorrected."

With the other hand, Moss added, the pilot is steering the jet left or right to line up with the carrier. But with every lateral movement, the plane tilts and loses altitude, so the pilot has to balance every movement with another shot from the throttle.

"It's very complicated and very hard to do, and hard to keep that currency up," Moss said. "So you have to keep training for it, keep taking training life off of our jets to do that."

With **MAGIC CARPET**, pilots are able to steer the jet to the carrier without losing lift, because self-adjusting flaps in the jet's wings compensate for any path changes, without having to hit the throttle.

"So let's have the flight controls do the hard part, do the integration part," Moss said. "Instead of fixed flaps, raise the flaps up a few degrees so you have authority, so the longitudinal stick is now commanding symmetric flaps.

"You're not fighting it, you're just flying," Moss said.

To make things even easier, the cockpit's heads-up display show's the carrier's relative velocity, taking into account its horizontal movement, to help pilots aim at the flight deck.

The Navy's F-35Cs come with **MAGIC CARPET**, Moss said, while the fleet's F/A-18 Hornets will get an upgrade in the 2017-18 time frame.

The integration will be purposely slow, he added. First-tour pilots won't be flying with **MAGIC CARPET**, he said, but second-tour pilots who've mastered the old system will upgrade.

But the question is, will they want to? Navy fighter pilots have a notoriously difficult job, and are well known for the pride they take in mastering it.

"Every single pilot that's flown in this has come in with the hairy eyeball like,' Are you kidding me? You can't change this. You can't change the way we fly the aircraft — it's supposed to be hard,' " Moss said.

Their attitudes quickly changed to, **"Why don't we have this already?" he added.**

http://hrana.org/news/2015/02/semi-autonomous-aviation-controls-coming-to-the-fleet/

First airborne flights completed for MAGIC CARPET

16 Mar 2015 Naval Air Warfare Center Aircraft Division (NAWCAD)

NAVAL AIR SYSTEMS COMMAND, PATUXENT RIVER, Md. – Recently, engineers and test pilots at the Naval Air Warfare Center Aircraft Division successfully transitioned the newly-developed F/A-18 flight control software called **MAGIC CARPET** from the virtual world of the simulator to the blue skies above the Chesapeake Bay.

MAGIC CARPET is an acronym for Maritime Augmented Guidance with Integrated Controls for Carrier Approach and Recovery Precision Enabling Technologies. The software is designed to make landing on an aircraft carrier easier by maintaining a commanded glideslope and angle of attack, giving the pilot the opportunity to focus more attention on maintaining a proper line-up.

On Feb. 6, Navy test pilot Lt. Cmdr. Tyler Hurst flew the first flight in "Salty Dog 222," an F/A-18F Super Hornet assigned to Air Test and Evaluation Squadron (VX) 23. On Feb. 11, Navy test pilot Lt. Brent Robinson flew a follow-on test flight to expand the **MAGIC CARPET**'s flight envelope.

"With the initial set of flights, we were able to confirm that these new flight control laws performed very much in line with our predictions from the simulators," said Robinson, **MAGIC CARPET** project officer. "The initial airborne response characteristics observed in both Path and Rate modes with both Full and Half flaps are very encouraging."

Test pilots from VX-23, working closely with engineers manning the control rooms of the Atlantic Test Ranges, will put the flight control system "through its paces over the next few weeks with myriad of approaches and touch-and-go landings in preparation for the initial shipboard testing," Robinson said.

The engineering group responsible for developing the flight control software, new heads-up displays, and simulators was encouraged by the first initial flights, which included practice field carrier landings.

"After the first test flights, we needed only minor tweaking of a few feedback gains which showed good correlations with our aerodynamic models and flight response predictions," said James "Buddy" Denham, a senior engineer in the aeromechanics division at NAVAIR. "We also received very positive feedback on the enhanced heads-up displays, we are now completing much of the off-nominal work, and the initial results and pilot feedback are favorable."

Test pilots, engineers, and landing signal officers (LSO) from VX-23 will continue to test **MAGIC CARPET** on F/A-18E/F aircraft through nominal and off-nominal approaches in the coming weeks, leading up to an at-sea testing period scheduled for later this year.

http://www.navair.navy.mil/index.cfm?fuseaction=home.NAVAIRNewsStory&id=5864

Safer Approach MAGIC CARPET Delta Flight Path

Easier, more accurate & repeatable carrier landings promise improvements

Graham Warwick Washington

AVIATION WEEK & SPACE TECHNOLOGY/APRIL 13-26, 2015

New flight-control and guidance software for carrier landings will require a culture change within the naval aviation community if it is to deliver on its promise of easier, safer and more repeatable recoveries that reduce pilot workload and wear and tear on the aircraft.

U.S. Naval Air Systems Command (Navair) has completed land-based testing of the Magic Carpet software in the Boeing F/A-18E/F at NAS Patuxent River, Maryland, and shortly will begin at-sea evaluations on an aircraft carrier off the U.S. East Coast.

Tests show the new flight-control laws and head-up display (HUD) symbology provide the reductions in pilot workload that were predicted in simulations. The Magic Carpet software upgrades are slated to be fielded on the F/A-18E/F in 2018.

In a carrier approach, the pilot must maintain a glideslope angle to clear the stern of the ship and stay aligned with the centerline of the flight deck to keep the wings clear of the superstructure, but also control the angle of attack to within 1 deg. to ensure the lowered arrestor hook catches the wire.

The pilot manually follows optical glideslope guidance from the ship, controlling descent rate with power, airspeed with pitch attitude and heading with roll. But these control axes are cross-coupled, and maintaining glideslope, lineup and angle of attack requires constant throttle and stick inputs.

"If I make a small power correction, I change angle of attack, which affects glideslope, and at the same time I can drift off lineup. There are a lot of things going on," says Lt. Brent Robinson, test pilot with U.S. Navy evaluation squadron VX-23 at Patuxent River.

The F/A-18E/F also has an autothrottle approach mode, which attempts to maintain angle of attack. "When you make an aft-stick correction, the throttle will see the aircraft's nose come up and add power to maintain angle of attack, but fairly loosely," he explains.

The workload is a "little less," allowing the pilot to focus on lateral stick control to maintain lineup, but Robinson says only senior naval pilots are allowed to use the autothrottle mode. More-junior pilots are required to fly approaches manually to hone their baseline skills.

"I am primarily trying to hold glideslope, but to have the glideslope accurate I have to be on speed [angle of attack]. I focus so much on glideslope and angle of attack that my lineup ends up drifting. It takes a lot of practice to build up the muscle memory to do the corrections," Robinson notes.

In Magic Carpet, gains and settings in the digital flight-control computer are fine-tuned to hold angle of attack tightly while longitudinal and lateral stick inputs are decoupled. "The primary factor in glideslope is longitudinal stick and in lineup it is lateral stick," he says.

The control system melds aileron, stabilator and rudder control to maintain attitude. Then the flaps are raised a few degrees from their nominal half or fully deployed position. This gives the control system a few degrees of flap movement to use for direct lift control.

"With aft stick, the flaps lower slightly to increase lift, the stabilator balances pitch, and I get almost pure vertical movement because angle of attack is being held for me. Near-pure lift increase or decrease gives me very high-fidelity control over glideslope," Robinson says.

The flight-control computer also calculates and maintains the ideal glideslope—3.5 deg.—using sensed windspeed and ship speed, either estimated by the pilot from the carrier's wake or called out by the landing signal officer on deck.

If high or low, the pilot can make a longitudinal stick input, hold it until centered on the optical guidance "meatball," then release the stick, and the aircraft will return to the ideal glideslope. "Now I have fine control available. I need to make much less input," he says.

The new glideslope-holding flight-control law is called Delta Path. Magic Carpet also includes a "Rate" mode, which holds flightpath command and not glideslope. This is for use in the pattern and holds bank angle and pitch attitude in the turn to intercept the glideslope.

The other part of Magic Carpet is new HUD symbology that ties the flight control changes together. This includes a horizontal line drawn 3.5 deg. down from the horizon. If this is close to the optical guidance cue from the ship, Robinson explains, the aircraft will be near the required glideslope.

The bigger piece of the new symbology is the ship-referenced velocity vector. "This is referenced to the ship by basic geometry from the ship speed, and if I put it on the centerline and hold 3.5-deg. glideslope, I will land on the centerline," Robinson says.

Simulator and flight tests indicate that, of the decrease in pilot workload and increase in the accuracy and repeatability of landings from using Magic Carpet, three-quarters come from the flight-control changes and a quarter from the HUD symbology, he continues.

Navair has completed land-based testing of Magic Carpet, flying carrier approaches from nominal to extreme off-nominal to a shore-based field with the aid of an optical guidance system and landing signal officer.

"We have tested and refined the gains and feel they are as good as we can get them," says Robinson. Six pilots were involved, only two of whom had experience with Magic Carpet. "The real-life performance is very close to the simulator, which shows our models are correct and the design is holding up."

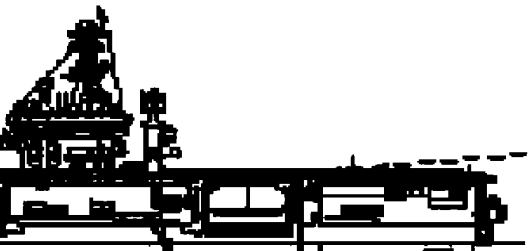
Land-based testing involved some "pretty extreme cases we will not perform at the ship, where we will run a bunch of nominal approaches to build up a touchdown dispersion database" as well as some less-extreme off-nominal approaches, Robinson notes.

"When Magic Carpet comes to the fleet in the next few years, there has to be a large cultural change for pilots," says Robinson. "We are attempting to make this the primary mode of landing and to make manual and autothrottle approaches obsolete."

Presently, competition between pilots is a major factor in improving their manual-approach flying skills. "We make it competitive. It's part of the learning curve, of staying sharp. Everyone wants a better score," he adds.

"With Magic Carpet we will lose that competitive edge, but it will be far more safe and repeatable and will make it easier on maintaining the jets and the aircraft carriers," Robinson concludes. "But it will be hard to change the mindset. I expect it will start out slow and be phased into the fleet."

F/A-18E/F pilots must maintain an 8.1-deg. angle of attack to ensure that a tailhook catches deck wires.



"...the flaps are raised a few degrees from their nominal half or fully deployed position. This gives the control system a few degrees of flap movement to use for direct lift control..."

Navy Starts Sea Testing New Carrier Landing Software for Fighter Jets

24 Apr 2015 Kris Osborn

The Navy is preparing for its first at-sea test of a new software program for F-18s designed to make it easier for the multi-role fighters to land on carriers.

"We're going to take it to the ship this month," Rear Adm. Michael Manazir, Director of Air Warfare, told Military.com in an interview.

The Navy will test the automated landing software system at sea following a string of recent successful land-based tests at Naval Air Systems Command, Patuxent River, Md.

The software is called Magic Carpet, an acronym for Maritime Augmented Guidance with Integrated Controls for Carrier Approach and Recovery Precision Enabling Technologies.

The technology is slated to deploy by 2019 on F/A-18E/F Super Hornets and E/A-18G Growler electronic jamming aircraft.

It is designed to make landing on an aircraft carrier easier by maintaining a commanded glideslope and angle of attack, giving the pilot the opportunity to focus more attention on maintaining a proper line-up, a Navy statement said.

"A pilot can take symbology on the HUD (heads up display) and he can move it to a symbol or a place on the flight deck and let go of the controls. The airplane knows with that symbol that is where I want to land. It will continually land on that spot," Manazir explained.

The software helps the approaching aircraft lock in on the correct landing approach, removing the need for the pilot to continuously adjust the aircraft. Landing on a carrier requires the pilot to account for the aircraft's speed, the speed of the ship along with wind and weather considerations. Pilots seek to maintain the proper glide slope as they approach the carrier deck.

"When we land an aircraft on an aircraft carrier, it is kind of a three connection thing. You see the deviation, you correct, you re-correct and then you correct one more time as you go so there you are kind of chasing the parameters," Manazir said.

"With magic carpet, the pilot can move the stick and move reference point and the stick does not have to re-correct. That is where the airplane is going to go. It is control law software – and it actually moves the flight control surfaces to make that work — to where the aircraft is going to go. It is not just symbology," Manazir said.

Navy test pilot Lt. Brent Robinson said the recent land-based flight and landing of Magic Carpet showed the technology could perform as was demonstrated in simulations.

"With the initial set of flights, we were able to confirm that these new flight control laws performed very much in line with our predictions from the simulators," said Robinson, a Magic Carpet project officer. **"The initial airborne response characteristics observed in both Path and Rate modes with both Full and Half flaps are very encouraging."**

The flight control algorithms for Magic Carpet were developed by Naval Air Systems Command and the Office of Naval Research.

If Magic Carpet becomes widely used throughout the Navy and emerges as a new standard for landing aircraft on carriers, pilots could then use more of their valuable training time working on weapons systems and other key avionics issues instead of practicing as much on how to land the plane on a carrier, Navy officials said.

http://www.dodbuzz.com/2015/04/24/navy-starts-sea-testing-new-carrier-landing-software-for-fighter-jets/

“Salty Dog 100,” an F/A-18F Super Hornet assigned to Air Test & Evaluation Squadron (VX) 23 at Naval Air Station Patuxent River, Md., lands on USS George H. W. Bush (CVN 77) 20 Apr 2015. The landing was part of the first sea trials for MAGIC CARPET, new flight control software & display symbology for F/A-18 aircraft designed to make carrier landings less demanding for Navy pilots.”

http://www.navair.navy.mil/img/uploads/150420-N-YL257-047-crop.jpg

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

Blog: Naval Aviation Focuses on Information Technology 11 Feb 2015

Robert K. Ackerman http://www.afcea.org/content/?q=naval-aviation-focuses-information-technology

“Software is vying with hardware for upgrade priorities. Information technology systems, elements & methodologies are becoming more of a factor in U.S. naval aviation. Virtual capabilities are supplanting physical training, & new architectures may allow faster incorporation of new technologies.

Some of these approaches were outlined in a panel discussion at West 2015, being held in San Diego, February 10-12. Vice Adm. David A. Dunaway, USN, commander, Naval Air Systems Command (NAVAIR), was blunt in his assessment of the current NAVAIR budget environment. “The current cost profile is prohibitive,” he declared. “It’s a going-out-of-business profile.” He called for an open architecture, which he described as the key to NAVAIR modernization. When it is achieved—in both a hardware and software perspective—NAVAIR will be able to modernize more quickly. Having an open architecture processor will allow information technology companies to plug into it and demonstrate their products.

NAVAIR already has incorporated an automated carrier landing system that simplifies the process for pilots. As a result, they do not need to practice carrier landings ashore as much as they used to. And, NAVAIR is working to introduce simulated enemy aircraft into a cockpit situational awareness system, so pilots could train for air combat without having to face actual aggressor aircraft.

Above all, NAVAIR must not develop its systems using a stovepipe mentality. The admiral noted that it builds platforms along the lines of program silos. But the Navy does not fight like an F-18, he said, offering instead that it fights like a carrier strike force. It needs to proceed along those lines, and he said his office is hard at work writing technical standards for warfighting capabilities.”

“An F/A-18E Hornet, assigned to the Salty Dogs of Strike Aircraft Test Squadron (VX)23, tests the Joint Precision Approach Landing System (JPALS) aboard the aircraft carrier USS Theodore Roosevelt (CVN-71). US Navy Photo”

http://i2.wp.com/news.usni.org/wp-content/uploads/2013/11/JPALS.jpg

Delivery of first fleet F-35C starts countdown to debut (NAVY TIMES 08 JUL 13) Mark D. Faram http://hrana.org/news/2013/07/navy-jsf-arriving/

...'Flies Beautifully'

Tabert, a test pilot, is one of the Navy's most experienced pilots in the JSF, with more than 130 hours of stick time to date. He was the first military pilot to fly all three F-35 variants—Air Force, Marine Corps and Navy — and was involved in the initial tests of the Navy and Marine versions at Patuxent River, Md., before reporting to VFA-101 in February. As the Navy's most experienced F-35 pilot, it's his job to get the squadron's other pilots — nearly all with 3,000-plus hours flying F/A-18s off carrier decks — up to speed as instructor pilots.

"It's not a difficult airplane to fly," Tabert said. "The systems and the sensors are very new and state of the art." One main difference between the Lightning II & previous Navy fighters is the placement of the control stick, used to steer the aircraft. "This is the first 'side stick' control [carrier-based] aircraft the Navy has," he said. "That's a little bit different than the center-stick Hornet we came from. They did a great job aligning it & the aircraft flies beautifully."

Another improvement, he said, is the helmet-integrated head-up display, or HUD, which gives pilots their most critical information such as speed and altitude without requiring them to look down. The F/A-18 Hornet's HUD rests on top of the cockpit's front panel. Though Tabert said it took a little getting used to, having the display in the helmet "saves you time in making important decisions that in legacy airplanes you may have to take a second to look down," he said. "It makes flying better and makes you a more lethal war fighter."..."

NAVAIR Flight Ready: Magic Carpet [video transcript]

https://www.youtube.com/watch?v=FMTf_Z9rMh0

The broader idea of MAGIC CARPET [Maritime Augmented Guidance with Integrated Controls for Carrier Approach and Recovery Precision Enabling Technologies] is simply to make landing at the ship easier; to make it repeatable, to make it safer and just in general less work or easier for the pilots to do a very difficult task, to do that repeatedly.

Magic carpet is kind of a two-part program; it is a change to the flight controls on the Super Hornet so it adds direct lift control and then the other part is the HUD symbology, it gives us some ships cueing that makes it easier to land on the boat.

What we are doing differently here is we are really providing the pilot direct control of what he is trying to do which is to control the flight path; so the flight control computer is controlling and closing the loops around flight path, which is important for landing on the carrier and is something we don't do today.

As you are trying to land on the boat, the boat is moving away from you, [and to the] right, so you have to continuously chase after the boat to get to it. All of the symbology we have right now in the HUD, or in our heads up display, is kind of in reference to the actual airplane, so what is the airplane doing? Well, this new HUD symbology, you actually input the speed of the boat and it takes into account the winds, so now, it accounts for that movement of the boat, so I don't have to worry about that, so I don't have to lead, I don't have to have that experience to figure out what is the boat doing, I just put the velocity vector now in the landing area of the boat and that is exactly where the airplane goes because it already compensates for the movement of the boat.

It is going to reduce the workload so we can focus on maintaining the proper glide slope and proper approach so we don't get too low and we don't get too high and it will be easier for day and night and we can take that reduction in workload and stress overall throughout the flight and maybe apply that to other areas, to tactics or whatever. So they can focus more on that and make the ship landing a more administrative task.

It definitely makes it a lot safer. I flew about 30 touch and gos in a 2-hour period, and I don't think I would have had the mental capacity to be able to do that safely if it wasn't for this technology. And I think that is just going to make it safer when guys are coming back from long missions, six to seven hours over Iraq or Afghanistan or whatever and they come back to the boat, and they are tired and exhausted and this is just going to make it a no-brainer to land at the boat.

Another perspective is from the LSO perspective, the landing signal officer, the guys on the ship that are helping the planes land, safety is their number one concern, so (cut) the LSO knows, that the jet hopefully the throttle is linked up and the altitude of the jet is constant, so he is not worried as much about the new pilot, (cut) pulling the throttles back to idle and possible crashing into the back of the ship.

So to date, we are really getting very good correlation with our simulation results to what we are seeing in the airplane, so in terms of lowering the pilots workload, in terms of performance on the flight path, holding and controlling the meatball for landing is all there.

So the overall result has been much more repeatable, much more consistent between pilots even with different techniques and that is the goal with taking this to the fleet between new guys and very old Salty guys that have been around for 25-30 years, the deviations that you should expect are now going to be much smaller across the board.

It is awesome to be able to be in one of the first landings in Magic Carpet to experience this technology, and you know, I just want to tell everyone in the fleet that it is awesome and the first time anyone gets to fly it they are going to be like, "this is wow, this is what I want, this is what I need."

http://www.navair.navy.mil/index.cfm?fuseaction=home.download&key=C2D4B2A4-9FD4-47BD-9CF2-3D18A15E6C76

First Sea Trials Completed for MAGIC CARPET

NAN Summer 2015 Jennifer Neal

"The Maritime Augmented Guidance with Integrated Controls for Carrier Approach and Recovery Precision Enabling Technologies, or MAGIC CARPET, automatically adjusts the jet's speed and angle of attack in relation to the intended landing surface and includes improvements to the heads-up display, making it easier to land on an aircraft carrier. Initial tests of the system took place in early February at Naval Air Systems Command, Patuxent River, Maryland.

"This was a huge technology milestone in the history of carrier landings," said Navy test pilot Lt. Brent Robinson, MAGIC CARPET project officer. "What we saw at sea was essentially the same as the land-based testing we did at [Patuxent River]."

The flight test team, which included engineers from Naval Air Warfare Center Aircraft Division, 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. Two aircraft, an F/A-18E and an F/A-18F, were flown in ideal- and less-than-ideal approaches and in varying wind conditions.

"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. Touchdown dispersions refer to the differences between the actual and ideal landing points.

The idea for MAGIC CARPET started with a desire to simplify carrier-based air operations and pilots' carrier qualifications (CQ). Landing F/A-18s with current flight-computer software requires adjusting multiple, interconnected variables simultaneously.

"Normally when a pilot is attempting to manage glideslope, lineup and angle-of- attack all at the same time, a change in one of those parameters affects the other two," Robinson said. **"MAGIC CARPET lets us unlink those parameters, so when a pilot wants to change glideslope, all he has to do is push or pull on the stick. The system can essentially hold the ideal glideslope for the pilot, so he doesn't have to make very large corrections. When he wants to make lineup changes, all he has to do is move the stick left or right."**

The new heads-up display design aided this process, which includes symbols tailored for the shipboard landing task. This effectively enhances the pilot's situational awareness and inputs needed to capture and track those approach parameters, Denham said.

Traditionally, landing an F/A-18 on a moving aircraft carrier requires months of training and hours of qualifications. MAGIC CARPET greatly reduces the amount of time required to qualify a pilot.

"CQs train pilots to learn how to effectively address and adjust each aspect of landing the aircraft," said Denham. "It's like learning how to juggle — you start slowly and work your way up to proficiency. Now, we can let the computer do the work. With this software and 15 minutes in a simulator, we can teach anybody to safely land on a ship."

Test pilots, engineers and landing signal officers (LSO) from Air Test and Evaluation Squadron (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.

Jennifer Neal, Naval Aviation News contributing editor, compiled the articles by Mass Communication Specialist 3rd Class Patrick Ian Crimmins, USS George H.W. Bush Public Affairs; and Victor Chen is director of Corporate Communication, Naval Air Warfare Center Aircraft Division at Patuxent River Naval Air Station, Md."

http://navalaviationnews.navylive.dodlive.mil/files/2015/07/NAN-Summer-2015-web1.pdf

Magic Carpet F/A-18EnF&G EMALS AAG X-47B Hook14

https://www.youtube.com/watch?v=q8Bn2GZuQCc

“An F/A-18E Super Hornet is on a night field carrier landing practice (FLCP) at Iwo To, Japan. Magic Carpet could sharply reduce the number of FLCPs needed to keep pilots qualified for carrier ops. Credit: U.S. Navy Mass Communication Specialist Trevor Walsh” http://aviationweek.com/site-files/aviationweek.com/files/uploads/2014/06/AW_06_30_2014_2210L.jpg

Enhanced HUD Symbology

Ship Relative Velocity Vector and Glideslope Reference Line

Lockheed Martin [F-35C] Update: http://livestream.com/wab/tailhook2015/videos/98909598

FPAH – Flight Path Rate Command
-DP- – Delta Flight Path Command

HOTAS Select Enabled

Ship Speed

SRVV

Glideslope Reference

Magic Carpet briefing by VX-23 at Tailhook 2015:

http://livestream.com/wab/tailhook2015; or http://livestream.com/wab/tailhook2015/videos

VX-23 Magic Carpet — Carrier Landing Brief

http://livestream.com/wab/tailhook2015/videos/98951655

Sep 2015 STRIKE TEST NEWS VX-23 LT Brent “ROTC” Robinson

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

“Project Magic Carpet is an innovative set of flight control laws combined with enhanced Head-Up Display (HUD) symbology for the F/A-18 E/F/G designed to significantly simplify the carrier landing task. The improvement to the flight control laws is twofold. First, we introduce Integrated Direct Lift Control (IDLC), and second we let the flight control computers compute and then maintain the desired ‘ideal’ glideslope. IDLC uses combined trailing edge flap and aileron movements to affect lift directly with an improved auto-throttle function. This allows the pilot extremely precise glidepath control using a single controller (the stick) to affect lift, vice the traditional method of artfully balancing AoA, manual throttle manipulations, and stick inputs. Furthermore, because most of the glideslope deviations will now come from lift, the engines remain in a much tighter RPM band; thus, waiting for engine spool-up/down is no longer a factor. To make this whole ‘landing on a moving boat’ task even easier, the system can now maintain itself on the ideal glideslope with little to no inputs from the pilot. The glideslope reference angle and ship speed is selected by the pilot prior to the approach turn (or during, in cases of the SHB!). Then, with a subsequent depression of a single button, the aircraft will rotate, capture, and maintain the glideslope…hands off!

The enhanced HUD includes a new Ship Relative Velocity Vector (SRVV) and a Glideslope Reference line while removing the normal velocity vector and E-bracket. Together, these two tools allow the pilot to precisely view not only the magnitude of deviations, but also the magnitude of commanded corrections, completely removing the guesswork currently involved in flying the ball. Additionally, the SRVV acts as a novel lineup aid by allowing the pilot to simply place the symbol on the landing area centerline in order to maintain sufficient lineup to avoid a call from the Air Boss…essentially just ‘put the thing on the thing!”

After successful shore based testing, we took two jets to the mighty USS G.H.W. Bush to truly put MAGIC CARPET through her paces. After 181 approaches of intentional (and some un-intentional) ‘underline’ high, low, & overshooting starts, the data were eye-watering. With a significant decrease in pilot workload ratings, an increase in handling qualities ratings, and a reduction of over 50% in average touchdown dispersion the team believes they are on the cusp of revolutionizing the most stressful and dangerous part of daily operations of pointy-nose aircraft aboard carriers! Over the next two years, we will be further refining MAGIC CARPET to make the system more robust and useable in any F/A-18E/F/G configuration including asymmetric loadouts, half flaps, and single engine. MAGIC CARPET is expected to hit the fleet at the same time as the H12 SCS release.”

New carrier landing software will smooth out the ride

12 Sep 2015 Meghann Myers

"SPARKS, Nev. — They say the world's most stressful job is landing on an aircraft carrier at night in bad weather.

That may be true, but the task is going to get significantly easier when MAGIC CARPET starts making its way to the fleet next year.

The goal is to get the latest version of the Maritime Augmented Guidance with Integrated Controls for Carrier Approach and Recovery Precision Enabling Technologies software to the fleet to start testing in 2016, F/A-18 Hornet program manager Capt. David Kindley told Navy Times on Friday at the annual Tailhook Reunion near Reno, Nevada.

From there, they're looking ahead to a 2018 total availability to the fleet's Hornet and E-18G Growler Squadrons, in addition to the F-35C Lightning II jets that will come standard with MAGIC CARPET, which will automate more of the approach so pilots need to make fewer adjustments.

Landing an aircraft on a carrier now is a delicate dance of shifting left, right, up and down while adjusting the plane's throttle to make up for the tiny losses in speed and altitude for every movement of the nose.

When you do it right, you keep a little ball on the heads-up display just above the flight deck to glide down and catch your tailhook on the wires.

It takes an immense amount of focus and skill, but Naval Air Systems Command's MAGIC CARPET software aims to make it much easier.

"It's this admin task, where they should be focusing on the projection of power that should be our primary mission," Lt. William Dann said at a NAVAIR presentation Friday.

The difference with MAGIC CARPET is that a pilot can change direction without losing speed or altitude. The software simply self-adjusts to maintain a flight path.

"What this does is makes the longitudinal stick into a flight path rate controller, so when you pull aft on the stick a certain amount, it commands a rate of change of flight path, and when you release the stick, you get zero flight path rate," he said.

When F-35Cs are delivered to the fleet in 2018, they will come with MAGIC CARPET. The challenge now, Kindley said, is to start loading the software into older airframes.

It's a two-part process, he said, which involves updating an aircraft's flight and mission computers. Flight computers can be updated at any time, but mission computer updates are on a set schedule.

At the request of Naval Air Forces boss Vice Adm. Mike Shoemaker, Kindley said, he's looking into how soon they can start pushing the latest version of the software to Hornet mission computers, which looks like next summer right now.

That will give squadrons the chance to test out how the software works before a 2018 roll-out goal, he added.

The goal of MAGIC CARPET isn't simply to make carrier landings easier, Rear Adm. Mike Manazir, the Navy's director of air warfare, told Navy Times.

Pilots spend a significant amount of their training just working on safe carrier landings, and then a significant amount of their time in the fleet requalifying for landings.

MAGIC CARPET will cut down drastically on the amount of time they spend training to land and pass that savings on to more time training for missions, Manazir said.

"We're looking forward to not having to practice as much, while reducing costs of training and repairs," he said.

Every time a pilot has a hard landing, it takes time to investigate the damage and then significant time and money to repair it. MAGIC CARPET will reduce all of that.

And for the Super Hornets, nicknamed "Rhinos," which have decades left of scheduled service, fewer hard landings and repairs is a huge plus.

"We're concerned about the life of the airframe," Kindley said.

Though pilots in the fleet will be landing aircraft with MAGIC CARPET in the next few years, Dann said that for now, they'll continue to train the old way, on T-45 Goshawk jets that don't use the system.

The question of changing that comes up often, he added.

"Do we not train guys to be the classic manual ball flyers that we always have? And we're not suggesting that at any point right now," he said. "But we do believe that in the future we will get to a point when this is the only way to fly the Rhino and the Growler, and so we don't necessarily need to train to anything else."

http://www.13newsnow.com/story/news/2015/09/12/new-carrier-landing-software-smooth-out-ride/72149060/

Benefit of IDLC for F-35 (& 'Magic Carpet') 14 Jun 2014

'johnwill': 14 Jun 2014: http://www.f-16.net/forum/viewtopic.php?f=60&t=25627&p=273289

“A couple of points to be made about IDLC. First, note in the video that the flaps and tails are both operating to maintain flight path. The preceding discussion has mentioned the flap movement to control incremental lift to adjust flight path. However, as the flaps are providing lift changes, they are also changing airplane pitch moment, which would change angle of attack (and lift) in the wrong direction. Say the flap goes down a few degrees, increasing lift. But the lift is aft of the CG (negative pitch moment), so the AoA goes down, reducing lift, not what you want. Trailing edge up tail movement is needed to provide a positive pitch moment, to maintain AoA and get the desired positive lift increment.

Second point is that this is nothing new, as in 1982 (!) the AFTI F-16 demonstrated this same capability, plus other similar capabilities in both vertical and lateral axes. The airplane could move vertically without AoA change, could point the nose up or down without flight path change. could move laterally without any sideslip, and could point the nose left or right without changing the flight path. These new control modes were for up and away flight, not landing as the Navy uses the F-35C. So give the Navy credit for using old technology in a new application.

Even further back in time, the F-111B (1966) and F-14 (1972) used wing spoilers to provide partial direct lift control. The spoilers were closer to the CG, so did not provide much pitch moment effect. However, the spoilers could provide only down direct lift, not upward.

Note that Leading Edge Flap is not used for IDLC, probably because it is not as effective as the TEF and its surface rate is too slow to give the necessary response. Which brings up another point - the LEF is not a control surface. Flaps, ailerons, tails, and rudders are control surfaces since their deflections provide the forces and moments to change the airplane flight path. But the LEF deflection is a response to airplane motion (AoA, g, etc).”

'quicksilver' 14 Jun 2014: “To add to what JW said, from a pilot perspective the IDLC allows the pilot to affect 'glide slope transfer' with the application of one inceptor (control) input. Glide slope transfer is also referred to in some places as the pop-up maneuver. A pilot flying on-speed, but a ball or more low has to move the jet from the low ball to a centered ball while staying on-speed, and needs to do so with minimal down-range travel and without changing aircraft attitude (which would alter the hook geometry relative to the wire) or speed. The control inputs and pilot skills necessary to successfully do so in the past were very complex and varied greatly from aircraft to aircraft.

Not so in more recent times. Hornet very good. SH better. F-35C HQs looking like the best ever but yet to prove same at the ship.”

https://www.dvidshub.net/download/image/1932112 150420-N-YL257-101

ATLANTIC OCEAN (April 20, 2015) An F/A-18E Super Hornet attached to the "Salty Dogs" of Air Test & Evaluation Squadron (VX) 23 prepares to land on the flight deck of the aircraft carrier USS George H.W. Bush (CVN 77) as part of the at-sea testing of Maritime Augmented Guidance with Integrated Controls for Carrier Approach (Magic Carpet). Magic Carpet is designed to make landing on an aircraft carrier easier by maintaining a commanded glideslope and angle of attack, giving the pilot the opportunity to focus more attention on maintaining a proper line-up. George H.W. Bush is conducting training exercises in the Atlantic Ocean.
(U.S. Navy photo by Mass Communication Specialist Seaman Christopher D. Gaines/Released) https://www.dvidshub.net/image/1932112/uss-george-hw-bush

First sea trials completed for MAGIC CARPET

Naval Air Warfare Center Aircraft Division Story by William Couch **Date:** 05.07.2015 **Posted:** 05.13.2015 16:07 **News ID:** 163211

https://www.dvidshub.net/news/163211/first-sea-trials-completed-magic-carpet

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 three 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.

ABOUT NAWCAD

The Naval Air Warfare Center Aircraft Division (NAWCAD) employs more than 8,000 scientists, engineers, and other experts who perform cutting-edge research, development, test and evaluation of aircraft systems for the Navy and Marine Corps. NAWCAD has three primary locations: Patuxent River, Maryland, Lakehurst, New Jersey, and Orlando, Florida.

VIDEO: Airwaves: 9 July 2013

http://www.youtube.com/watch?v=165cQsfxNzw

"On this edition of Airwaves... a "magic carpet" makes carrier landings safer for pilots.... & (Transcript)

A new landing system aims at making carrier landings safer.

"Engineers at manned flight simulator are testing magic carpet – a landing system designed to reduce the workload of pilots and improve carrier touch-down performance. By using manned flight simulator, engineers can test the system under normal and adverse conditions, giving them a better idea of how the system will respond at sea. The goal is to reduce landing variability allowing pilots to focus more on the mission."

-James Denham / Senior Engineer, Aeromechanics Division 4.3.2

"Airplanes today have very good computer systems, redundant and reliable flight control computers. We are capitalizing on those systems and then providing augmentation in the flight path access for the airplanes. So we are taking a lot of the tasks that the pilot has to do manually and letting the computer take care of those tasks and give him direct control of what he is trying to do which is fly the flight path and line up the touchdown." In addition to increasing safety, the system is expected to save on training costs for carrier landing signal officers. Engineers are currently testing the system for use on the Hornet and F-35C."

http://www.navair.navy.mil/index.cfm?fuseaction=home.VideoPlay&key=F9AB80BB-FB66-4047-B436-0A36B1E3C033

Redesigned Tailhook Tests Well In F-35 Sea Trials

Smooth sailing for initial F-35C sea trials may boost U.S. Navy's visible support of JSF Amy Butler and Guy Norris | *Aviation Week & Space Technology* Nov 17, 2014

http://aviationweek.com/defense/redesigned-tailhook-tests-well-f-35-sea-trials

A pair of Lockheed Martin F-35Cs have completed their first series of arrested landings and catapult takeoffs from the carrier USS Nimitz this month, marking the start of the developmental test program for the U.S. Navy's first stealthy piloted aircraft.

The seaborne takeoffs and landings mark a historic achievement for the $400 billion project after a summer marred with disappointments—a Pratt & Whitney F135 engine fire prompted an emergency egress from an F-35A in June that then caused the program to scrap plans for its international debut in the U.K. and put flight-testing 45 days behind schedule.

The apparent success of these carrier trials will also likely bring more visible support from the Navy, which has historically been conservative in planning for the F-35 purchases while continuing to advocate for more buys of Boeing F/A-18E/Fs.

Testing began on Nov. 3, when the first F-35C, CF-03 from Navy Air Test and Evaluation Sqdn. VX-23, touched down at 12:18 p.m. local time after flying to the carrier from MCAS Yuma, Arizona. Flown by Navy test pilot Cmdr. Tony "Brick" Wilson, the aircraft first made a low approach and overshoot, followed by a touch-and-go with the tailhook retracted. Finally, with an F/A-18F as chase, Wilson brought the F-35C in for the first arrested landing. A second aircraft, CF-05 flown by Lt. Cmdr. Ted "Dutch" Dyckman, arrived less than 1 hr. later and landed successfully at 13:11 p.m.

With media and senior defense officials watching from the ship's Vulture's Row, both aircraft made highly stable approaches and trapped firmly on the third of the Nimitz's four arrestor wires. Touchdown between the second and third wires is considered the optimum for carrier landings. With no "bolters" in the first week of testing, a redesign of the F-35C's tailhook, which failed repeatedly in ground testing three years ago, appears to be sound. A bolter is when a pilot touches down on the deck with the hook deployed, but has to accelerate and fly off again after it fails to snag the arresting wire. The redesign added stronger dampening to the hook to keep it from bouncing on deck upon touchdown. It also sharpened the hook for a better scoop under the wire. Having contributed to the delayed start of carrier trials, the performance of the redesigned hook was a significant watch item. "It's a little bit different of a design, and obviously it works," says U.S. Pacific Fleet, Naval Air Forces Cmdr., Vice Adm. David Buss.

"...This flight control system mode, called Delta Path, is unique to the F-35 though it is nearly identical in functionality to the Magic Carpet system recently flight tested by F/A-18E/F pilots, says Eric Van Camp, director of domestic F-35 business development for Lockheed Martin. "The way we used to do it was this choreography between your right and left hand. Delta Path and Magic Carpet eliminate that." Magic Carpet is due to be tested at sea on the Super Hornet in early 2015...."

Although calm seas and light winds from the northwest contributed to the benign conditions and trouble-free landings, both pilots partly attributed the precision touchdowns and stable approaches to the F-35C's integrated direct lift control feature. While all three Joint Strike Fighter variants have it, Wilson says direct lift's greatly improved glide slope control on approach is especially useful for the F-35C.

Unlike conventional carrier aircraft, in which the pilot approaches the carrier with flaps set at a fixed position and adjusts power and pitch attitude to stay on the glideslope, the F-35 system controls power through an "auto-thrust" function and alters the position of the trailing edge flap in response to pilot inputs.

So the stick becomes my glideslope controller," says Dyckman, the second F-35C test pilot to make a carrier landing. "If I pull back, the flap adds lift; if I push forward, it commands a steeper approach." The nominal flap position for a carrier approach is 15 deg., or half-flap, providing ample margin for additional flap movement to add or reduce lift. Wilson says the effect is to "change the 'heave' of the aircraft, rather than the pitch."

"I was watching the angle-of-attack indicators," Senior Chief Petty Officer Alistair McIntyre says. "As they came in [to land] from the break, it was perfect ~~green~~ [ORANGE is the 'Optimum AoA Airspeed Indication - 'green' for?] all the way in. It was stable all the way in for both approaches. I was amazed for that, being their first time landing on the carrier, as it looked like both pilots were old pros at landing F-35s. They came in on the glideslope and landed with no problems. It felt like we'd been doing this for a long time."

This flight control system mode, called Delta Path, is unique to the F-35 though it is nearly identical in functionality to the Magic Carpet system recently flight tested by F/A-18E/F pilots, says Eric Van Camp, director of domestic F-35 business development for Lockheed Martin. "The way we used to do it was this choreography between your right and left hand. Delta Path and Magic Carpet eliminate that." Magic Carpet is due to be tested at sea on the Super Hornet in early 2015.

The landings marked the start of a two-week Developmental Testing 1 (DT-1) phase for the F-35C; there are three such phases planned. The primary objectives are launch-and-recovery handling as well as aircraft support operations on the ship, including chocking and chaining the aircraft, tractor tow movement and placement of the aircraft on deck. Landings are limited to crosswinds below 7 kt. and day arrestments only. Basic navigation, radar and other mission systems are also being tested, says Thomas Halley, Lockheed Martin F-35 business development director.

Two follow-on DT periods will gradually expand the crosswind conditions to 15 kt., Halley says. DT-2 will incorporate internal weapon stores, and DT-3 will add external stores to the mix. Both follow-on periods will include testing of the F-35's distributed aperture system and Link 16 communications. DT-2 is slated for September 2015, with DT-3 to follow by April of 2016. Testing during DT-1, however, has been smooth, prompting officials to consider starting night operations before departing the ship Nov. 16.

The Navy objective is to declare initial operational capability (IOC) with a squadron of 10 aircraft in August 2018 or no later than February 2019.

Meanwhile, the U.S. Air Force plan to declare IOC with 12-24 aircraft in August 2016 is in jeopardy, says USAF Lt. Gen. Christopher Bogdan, program executive officer for the F-35, due to a shortage of available personnel to become trained in maintaining the jet. The Air Force had planned to pull staff from the A-10 program, which was to begin retiring jets in fiscal 2015. But Congress has yet to pass spending and authorization bills and has balked at the proposal. August 2016 is going to be "really hard to get to, [and] I am very worried that my promise to them to give them all the things in 2016, I may not be able to keep," Bogdan says. Roughly 800 of 1,100 maintainers needed for F-35s were to come from the A-10, he says. Also perturbing plans are unforeseen commitments for sorties against Islamic State targets in Syria and Iraq, according to an Air Force official.

Air Force officials have not said when it will be realistic to declare IOC.

Though less severe a delay, the Marine Corps plan for IOC July 1, 2015, with 10- 16 F-35Bs also in jeopardy due to availability of mission data files and a tight schedule to deliver all the jets in the same, war-ready configuration (see page 41). The service should make its objective by the end of next year, Bogdan says: "There is no way in the world we are missing that by months."

As the U.S. services near their F-35 operational debuts, the program office and Lockheed Martin are planning to propose a discounted price for international partners willing to participate in a "block buy" of the jets from low-rate, initial production lots 11-13, which will deliver aircraft beginning in 2019. This will be key to stabilizing the supply chain, says Lorraine Martin, executive vice president of F-35 for Lockheed. Notionally, it would include about 50 international aircraft per year for three years; deliveries would be spread across three years, but the commitment would come upfront. "We will expect that block buy to yield them savings," Bogdan says. "It is a motivation to keep people stable in the program."

Lockheed officials project foreign military sales of about 750 aircraft, with another 612 going to partner nations: the U.K., Italy, Australia, Norway, the Netherlands, Denmark, Turkey and Canada. Japan and Israel, which is negotiating its second buy, are Foreign Military Sales buyers. South Korea has also selected the F-35A.

Martin and Bogdan continue to say they will achieve a price of $80-85 million per F-35, including engines, in fiscal 2019. The latest F-35 delivered, from low-rate, initial production lot 6, cost $103 million without engines (though an A model F135 is about $14 mil.).

Courtesy of NAVAIR

First airborne flights completed for MAGIC CARPET

U.S. Navy photo by Photographer's Mate 1st Class James Foehl

An F-A-18 Super Hornet assigned to Air Test and Evaluation Squadron (VX) 23 prepares to launch from one of four stream driven catapults on the flight deck aboard USS Theodore Roosevelt. Recently, engineers and test pilots at the NAWCAD successfully transitioned the newly-developed F/A-18 flight control software called MAGIC CARPET.

Recently, engineers and test pilots at the NAWCAD successfully transitioned the newly-developed F/A-18 flight control software called MAGIC CARPET from the virtual world of the simulator to the blue skies above the Chesapeake Bay.

MAGIC CARPET is an acronym for Maritime Augmented Guidance with Integrated Controls for Carrier Approach and Recovery Precision Enabling Technologies. The software is designed to make landing on an aircraft carrier easier by maintaining a commanded glideslope and angle of attack, giving the pilot the opportunity to focus more attention on maintaining a proper line-up.

On Feb. 6, Navy test pilot Lt. Cmdr. Tyler Hurst flew the first flight in "Salty Dog 222," an F/A-18F Super Hornet assigned to Air Test and Evaluation Squadron (VX) 23. On Feb. 11, Navy test pilot Lt. Brent Robinson flew a follow-on test flight to expand the MAGIC CARPET's flight envelope.

"With the initial set of flights, we were able to confirm that these new flight control laws performed very much in line with our predictions from the simulators," said Robinson, MAGIC CARPET project officer. "The initial airborne response characteristics observed in both Path and Rate modes with both Full and Half flaps are very encouraging."

Test pilots from VX-23, working closely with engineers manning the control rooms of the Atlantic Test Ranges, will put the flight control system "through its paces over the next few weeks with myriad of approaches and touch-and-go landings in preparation for the initial shipboard testing," Robinson said.

The engineering group responsible for developing the flight control software, new heads-up displays, and simulators was encouraged by the first initial flights, which included practice field carrier landings.

"After the first test flights, we needed only minor tweaking of a few feedback gains which showed good correlations with our aerodynamic models and flight response predictions," said James "Buddy" Denham, a senior engineer in the aeromechanics division at NAVAIR. "We also received very positive feedback on the enhanced heads-up displays, we are now completing much of the off-nominal work, and the initial results and pilot feedback are favorable."

Test pilots, engineers, and landing signal officers (LSO) from VX-23 will continue to test MAGIC CARPET on F/A-18E/F aircraft through nominal and off-nominal approaches in the coming weeks, leading up to an at-sea testing period scheduled for later this year.

MAGIC CARPET

http://www.navy.mil/management/photodb/photos/101106-N-0000X-001.jpg

“Magic Carpet” software may mean fewer touch-and-gos on Whidbey Island 15 Sep 2015

Joe Kunzler http://whidbeydailynews.com/2015/09/magic-carpet-software-may-mean-fewer-touch-and-gos-on-whidbey-island/

“Software due for integration by the Navy in 2018 aims to reduce the number of touch-and-go training operations necessary for EA-18G Growler pilots. The training is conducted primarily on Whidbey Island at Ault Field in Oak Harbor and Outlying Field Coupeville. The “Magic Carpet” software, as planned for the Boeing EA-18G of the Navy’s Electronic Attack Wing, will put the aircraft into a mode for a constant, safe rate of descent toward an aircraft carrier and help the pilot line up for landing.

“What I anticipate is that you will have a reduction in your Field Carrier Landing Practice requirements, your currency requirements at the carrier so you can focus rather on your real missions rather than this admin task,” according to test-pilot Lt. William Dann during an online question-and-answer session during the 2015 Tailhook convention Sept. 10-13. “It is making everything safer.” However, Dann said his test pilots are unable to say specifically to what extent “Magic Carpet” will replace the need for FCLPs.

The noise levels of the Navy’s latest electronic attack aircraft, the EA-18G Growler, has been an ongoing point of contention for residents living near the Navy’s airfields on Whidbey Island. Some residents claim the noise associated with the FCLPs decreases quality of life and has harmful health effects. An Environmental Impact Statement on the Growlers and their basing at Whidbey Island Naval Air Station was initiated in late 2013. Vice Admiral Shoemaker, commander of U.S. Naval Air Forces, said he’s “hopeful as we work through that process we’ll get the necessary relief we need and be able to conduct our operations at Coupeville.”

“We have current limits as to what we can do every year in terms of the number of landings,” Shoemaker said. “The EIS will look to expand that. I won’t tell you the numbers there but it will be more realistic and reflective of what we need to do from a bouncing and FCLP perspective for the growing force up at Whidbey Island.””

The Tailhook Association, which holds the annual networking convention, is an independent, non-profit organization known as the premier supporter of the aircraft carrier and other sea-based aviation.