

S E C O N D L I N E O F D E F E N S E

Delivering Capabilities to the War Fighter



SHAPING A 21ST CENTURY APPROACH TO TRON WARFARE

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| | |
|--|----|
| Introduction | 2 |
| The Emergence of Tron Warfare | 3 |
| Combat Tactics and Combat Learning: A Key Dimension of Prevailing in Conflict | 9 |
| The F-35 and the Aviation Design Cycle | 12 |
| The Training Challenge for 21st Century Con-Ops | 17 |
| Operating on the Z Axis | 24 |
| The Impact of a Z Axis Air System on Combat | 29 |
| Dealing with the Hypersonic Missile Threat | 32 |
| The S-Cubed Revolution | 36 |
| Conclusions: Laying a Foundation for Crafting a 21st Century Air Combat Approach | 39 |
| Selected Bibliography on Electronic Warfare | 48 |

Introduction

21st century warfare technologies concepts of operations and tactics and training are in evolution and revolution.

At the heart of reshaping US and allied approaches to airpower and its evolution is the emergence of the F-35, the significant impact which a global fleet of F-35s will have on US and allied capabilities and the approaches to leveraging other capabilities in the warfighting tool kit.

There is always the reactive enemy, so that the roll out of new approaches shaped by the impact of the F-35 will see reactions from various competitors and responding to these reactions will part of the re-set of evolving US and allied airpower and combat approaches.

The F-35 is at the heart of change for a very simple reason – it is a revolutionary platform, and when considered in terms of its fleet impact even more so.

The F-35, Lightning II, has a revolutionary sensor fusion cockpit that makes it effective in AA, AG and EW.

US and Allied Combat pilots will evolve and share new tactics and training, and over time this will drive changes that leaders must make for effective command and control to fight future battles.

An issue has been that the F-35 has been labeled a “fifth generation” aircraft, a sensible demarcation when the F-22 was being introduced.

But the evolution of the combat systems on the aircraft, the role of the fusion engine, and the impact of a fleet of integrated F-35s operating as a foundational element will make this term obsolete.

The global fleet of F-35s will be the foundation for a fundamental change in the way air power operates and with it overall combats concepts of operations for the US and allied insertion forces.

It is not an in and of itself platform; it is about what an integrated fleet of F-35s can deliver to TRANSFORM operations.

The decade ahead can be very innovative if what the fleet brings to the fight is learned and applied and the combat warriors leverage what they learn and then the application of those lessons to reshaping the force are applied.

As a senior RAF pilot involved with the F-35 program has put it well: “While much of the world still debates the existence of the F-35, we are moving rapidly forward to figure out how to use the aircraft and leverage it.”

At the heart of the transformation is the combination of two powerful trends: the emergence of Tron warfare and the forging of a combat cloud integrating combat capabilities.

The F-35 fleet operates at the cutting edge of both.

The Emergence of Tron Warfare

The F-35 is known as a 5th generation state-of-the-art combat aircraft with stealth for survivability.

The F-35 Lightning II is often discussed in a performance trend clustering over time with the F-22 Raptor, the Russian Sukhoi PAK FA T 50, and various emerging PLAAF aircraft such as Chengdu J-20 and the just announced J-31.

A 5th Gen well designed stealthy aircraft can operate very effectively in both a Fighter (AA) and Attack (AG) role until it can't.

Yet reducing the F-35 to stealth essentially misses the point of the impact of an F-35 global fleet on reshaping US and allied combat operations.

I highlighted what I think is the key shift in an interview with [Wendell Minnick](#) of *Defense News* in a discussion of the emergence of the J-31:

The physical resemblance between the J-31 and the F-35 — despite the difference in relative size — indicates an effort by China to reproduce the F-35s stealthy external design, Timperlake said.

“If it is a success in being physically stealthy and they build a lot it could be a problem” for our allies in the region, he said.

However, stealth is simply a survivability feature and analysts must learn more about the internal systems. The real combat engagement operational and tactical question is the F-35 fusion cockpit and whether the Chinese actually have anything close to it, Timperlake said.

“Fusion will make all the difference in looking at the J-31 as a real competitor or just a linear generational development aircraft with perhaps enhanced survivability that will still need a hub spoke battle management [concept of operations] — [airborne warning and control system] or [ground-controlled interception] being essential for them,” he said.

The US and Allied fleet of F-35s will also add an “electronic” or “tron” warfare component to the fight, an “E” for electronic.

It is not necessary to designate the F-35 as the F/A/E-35 but that would be more accurate.

Adding the “E” is both an active and passive capability and will changing the entire design dynamic of combat aviation.

Electronic Warfare (EW) was designed inherently into the F-35 airframe and Fusion Cockpit. The revolutionary design of a Fusion Cockpit will as time goes by give the air battle commanders of the US and allies an emerging new strategic command and control way to fight and win.

EW is a complex subject with many discreet but also connected elements. Over time all things electronic in the military took on many dimensions. Electronic Counter-measures (ECM) begat Electronic Counter-Counter (ECCM) measures, Command and Control

(C&C) has grown to C5ISR. Information war in certain applications created a multi-billion dollar domain called “cyber.”

Additionally there has to always be considerations of Electro Magnetic Pulse concerns (EMP) and the counter measures of ‘hardening’ of electronic components. There are a lot of other EW issues in “tron war,” such as Infer-Red Sensing (IR) and always protecting “signals in space” information being transmitted and trying to jam the bad guys “signals in space.”

Tactically, it has been said on the modern battlefield — air, sea or land — if not done correctly, “you emit and you die.”

EW can include offensive operations to identify an opponent’s emissions in order to and fry spoof or jam their systems.

In successful “tron” war, often-kinetic kill weapons can be fired. The kinetic kill shot is usually a high-speed missile designed to HOJ (home on jam). There is also the ability to emit electronic “kill” or spoofing signals i.e. to emit miss signals to an enemy’s incoming weapon sensors.

But what is necessary to succeed in evolving capabilities to fight in the age of “Tron” Warfare?

In taking a lesson from history, pre-WWII AA&T long lines research found that in order to build and keep operational a U.S. phone system, the AT&T visionaries found that the key to success was the need for “robust and redundant” systems.

That lesson of always focusing on robust and redundant systems in combat is extremely critical in the electrical element or “tron” component of the modern way of war.



With a solid interactive structure, the 5th generation aircraft can function as a honeycomb which allows them to follow a distributed air con-ops. This allows them to become a lead element for enabling the entire air combat force to be able to operate in three-dimensional space. (Credit: Bigstock)

Over two human Generations from WW II the F-35, was designed as being both inherently robust and redundant with many sensors and systems built into the airframe structure from the initial airframe stealth design forward. All F-35 systems designed and developed sent “trons” into the aircraft cockpit “Fusion Engine.”

Trusted fusion information generated by inherent aircraft systems queued up electronically by threat will send to the cockpit displays, and the pilot’s helmet, battle ready instantaneous Situational Awareness.

A combat certainty is that “electronic warfare” or as referred to in this Special Report as “tron” warfare will grow in importance and will evolve as a critical component of future combat engagements.

As very briefly described above the issue of all things “EW” or “tron” war is extremely complex because electrical components engage in empowering a nation’s ability to fight and win and covers so many facets of combat.

Because of the growing role of shared situational awareness and shaping of what some are calling the combat cloud, tron warfare is part and parcel of the transition in air war-

fare. Tron warfare is about protecting your ability to operate in shared communication space and to deny your adversary the ability to do so.

As Secretary Wynne has noted: “Whether we call it the combat cloud or the ability to share targets and situation awareness; the bulk of our and allied air fleets will be fourth gen for a long time. Getting max use from this mixed fleet will be the Hallmark of the next few decades. ‘Tron’ warfare should therefore be a prelude to Maximizing Probability of Kill; while minimizing the probability of being killed.”

The specific focus of this Special Report is the F-35 F/A/E and what it means for shaping a new foundation for the way ahead in air combat.

To put it another way, the F-35 fleet allows the air services to shape a new foundation for engaging in Tron Warfare, but because “no platform” fights alone, it is a foundation from which other elements of the airpower and combat capabilities picture are woven in for 21st century operations.



F-22 Raptors from the 94th Fighter Squadron, Joint Base Langley-Eustis, Virginia, and F-35A Lightning IIs from the 58th Fighter Squadron, Eglin Air Force Base, Florida, fly in formation after completing an integration training mission over the Eglin Training Range, Florida, Nov. 5, 2014. The purpose of the training was to improve integrated employment of fifth-generation assets and tactics. The F-35s and F-22s flew offensive counter air, defensive counter air and interdiction missions, maximizing effects by employing fifth-generation capabilities together. (U.S. Air Force photo/Master Sgt. Shane A. Cuomo)

(Please see bibliography at end of the Special Report for most current articles of discussing the many different aspects of electronic warfare.)

One additional notation in this research is that there is an emerging focus on the concept of “Combat Cloud” computing for military operations. It is a debate going in many different directions much like in US “Information War” as initially proposed in “The Revolution of Military Affairs.”

Information War (IW) proposed as part of RMA eventually migrated especially in US forces to a very significant focus on “cyber” or computer empowered systems. The word “cyber” is now covering a multitude of capabilities issues and technological progress.

So perhaps a good place to start to understand the newest item of analysis “cloud computing” could begin by studying both the F-35 individual cockpit inward and the ability of each aircraft to be connect to a network of additional F-35s and other weapon systems.

The “E” in F-35 will eventually change strategic battle management Command & Control (C&C), especially using the military concept of no platform fights alone.

Consequently, the F-35 is an example of both a ‘Cloud’ enabled aircraft cockpit looking inward to enhance pilot information and outward by projecting 360 long range collected information into a fleet of similar F-35 T/M/S.

The F-35A is land based belonging to USAF and some allied nations; the F-35B is V/Stol belonging to USMC, Royal Navy, Italian Navy and others in the coming years, and the F-35C is a large deck USN model

So the F-35 could be a starting point for the never ending process of understanding the next generation of “Cloud” information flowing to all levels of the battle space.

And the “combat cloud” operating within a Tron warfare fleet is a very powerful re-definer of combat capabilities for reshaping 21st century concepts of operations.

Combat Tactics and Combat Learning: A Key Dimension of Prevailing in Conflict

Technological development is a key part of being on the winning edge of combat. Yet the ability to produce the technology in numbers and to train to use it effectively is crucial to success.

During our recent visit to Fallon Naval Air Station, a Top Gun instructor underscored the importance of training:

According to CDR Charles “Chunks” Smith:

I would argue that training is the essential piece, which is necessary to drive combat competence and the ability to get full value out of our platforms.

I’m not a famous admiral in the Pacific, but if you want the Chunk sound bite, I’ll tell you that it is a waste of taxpayer money if you buy a capability that has not been trained to by its aircrew, it’s a waste of tax payers money.

And going back into history, lessons can be learned from looking at the US-USSR air power rivalry.

The lesson for the air power rivalry between the US and USSR is rather straightforward: the technology had to be available but it also had to be successfully understood and employed.

An historical take away from the cold/hot war air battles is that in the air-to-air mission, a country that equips its fighters with airborne radar and sensors allows more autonomous action and actually favors tactical simplicity and operational autonomy—even though the equipment becomes more complex.

In air-to-ground, airborne simplicity indicators are usually smaller formations and allowance to maneuver independently into weapon launch envelopes primarily in a weapons-free environment. Embedding technology into the weapon itself—bombs and rocket-fired weapons—has also made a revolutionary difference.

A key conclusion is always to assume a reactive enemy can develop the necessary technology to try and mitigate any advantages. With the worldwide proliferation of weapons even a second or third world nation might have state-of-the art systems. The air war over the skies of Vietnam was between two peer competitors because of USSR support and constraints by the US national command authority on how the US would fight an air campaign.



F-4D Phantom II marked as 555th TFS 66-7463, flown by Ritchie and DeBellevue for their first of 4 kills together and Ritchie's 5th kill which was DeBellevue's 4th kill. An F-4D owned by the Collings Foundation taxis at Selfridge ANGB, Michigan in May 2005. The plane has the markings of the Steve Ritchie / Chuck DeBellevue fighter from the Vietnam War. Credit: Wikipedia

The peer fight in the air abruptly ended when President Nixon unleashed the full power of US air in the famous Christmas bombing of 1972. The war ended quickly after that. When the North invaded the South in 1975 US air power was not used like the first invasion in 1972, which was a dismal failure for the North Vietnamese.

The lesson on the US-USSR rivalry is that air combat leaders must be able to adjust during the course of an air battle or war by changing strategy and tactics, to achieve exploitation of the enemy's mistakes or weakness.

Aircrews must be adaptable enough to follow changing commands from leadership and also, on their own initiative, to change tactics to achieve local surprise and exploitation. Like the quote in *Animal House*: "knowledge is good." In the cockpit it can be a life-saver and aid in mission accomplished.

An air-to-air engagement totally slaved to a ground controlled radar attack, the USSR model was a colossal failure and deadly to a lot of pilots locked into such a system. A

bottom-up approach with evolving aircraft system capabilities in a competitive airframe makes for adaptive, creative aircrews that will have a large repertoire of tactical moves and a better chance of getting inside an opponent's OODA loop.

This is true for both air-to-air and air-to-ground combat missions.

As the history of war in the air shows it was a constantly evolving process of human factors integrated into technology. The Cold War ended well for humanity and a lot of courageous pilots, bold leaders, and smart technologists deserve a lot of credit for this success.

The great strength of the American way to fight in the air is combat learning and sharing between the USAF, USN and USMC; all can come together to fight learn, train and win.

One very powerful example of US combat learning was cited in an interview with the leading Ace of the Vietnam War, [Col. Chuck DeBelleue](#) USAF (ret).

(I was told that): You're going to the Navy Fighter Symposium at Miramar.

I get to go with my roommate from Southeast Asia. He had three kills and spent 23 days on the ground Hanoi when they got shot down. He was in the class ahead of me.

He flew us out and back in a 237 to Miramar also with his instructor. We got the instructors into all the briefings, which were classified. Bear Lassetter was there (USMC Mig Killer) – Cunningham (USN ACE) was there – Steve and I were there – all talking about our engagements. That's November of '72.

Question: That is '72 – just before the Christmas bombing? They called you guys together to really, really learn from your experiences?

Answer: Right – just before the Christmas one. Cunningham was back in the States – Driscoll (USN RIO ACE) were back in the States and so were we. This was a weapons symposium to discuss tactics it was pretty interesting.

After Vietnam, in 1986, the USAF made an historic raid on Libya, called “El Dorado Canyon.”

The Navy attacked from the sea along with the USAF 12 plane F-111 strike force from a base in England. The entire mission was flown “EMCON.” Electronic emission controlled, and it was reported that there was one “mike” click over the entire route of flight. Libyan defenders knew they were under attack as bombs were falling. Tragically one F-111 was lost.

The importance of both the **joint learning** seen by the F-4 community and **the importance of being able to strike with EMCON capabilities** are two important lessons going forward as the US and its allies shape 21st century concepts of operations to take advantage of the 5th generation aircraft and the associated new tools for combat.

(For a Special Report on the lessons learned from the US versus USSR tac air rivalry see the following:

<http://www.sldinfo.com/download-pdf-the-us-vs-ussr-in-tacair-lessons-learned-from-a-hot-cold-war/>).

These lessons and concepts can now be extended to our allies and coalition partners in unique ways.

The extent of integrated exercises and training provides clear evidence that next generation allied force wants to come up the learning curve towards more effective 21st century air combat approaches and concepts of operations.

(For a look at the role of exercises in Pacific training see the following:

<http://www.sldinfo.com/allied-pacific-exercises-and-training-shaping-a-deterrence-in-depth-strategy/>).

The F-35 and the Aviation Design Cycle

In the opening days of US combat in World War II, extremely courageous Navy and Marine pilots went up against the Imperial Japanese Navy in inferior aircraft. For the

Marines, the F2A Brewster Buffalo was woefully inadequate at the Battle of Midway and an entire Navy torpedo squadron, Torpedo-8 except for a single pilot, was killed in combat.

However, independent of technological aircraft shortcomings, the aircrews of Torpedo-8 did not die in vain, Ensign George Gay was the sole survivor, because all the Japanese fighters were pulled down to sea level.

In searching for the main Japanese Carrier strike force LCdr. Wade McClusky leading the USS Enterprise bombing group at altitude saw the wake of a Japanese Destroyer and followed it to the enemy carriers. USN dive bombers could then concentrate on their targets unimpeded by Japanese fighters.

With the entire world in combat and nations fighting for their very existence, aircraft design teams pressed ahead with all the resources and intellectual vision they could bring to the design table. What the U.S. air forces introduced during those years was a steady introduction of type, model, and series (T/M/S) of always improving airborne killing machines.

From the F2-A Brewster Buffalo to the F4F and F4U to the F6 and at wars end, the F8 Bearcat the Navy had a series of prop driven Fighters that mastered the Japanese Zero. The Army Air Corps went from P-39 to P-38 Lighting, P-47 Thunderbolt to the P-51 Mustang with its wonderful bubble canopy to carry the fight to the heart of Germany.

Along the way emphasis was placed on pilot survivability by putting armor plates in the cockpit and having self-sealing fuel tanks. Since the entire objective was to get first “tally” and then out maneuver the enemy to kill him, the total design focus was to always improve a blend of speed, range, and maneuverability—better engines and smarter airframe designs.

Of course, while the main effort was producing enough “motors and gun sights,” industry and research lab efforts were underway to change yet again the technology of the air fight.

The P-61 “Black Widow” was an early attempt to put radar on a night fighter, and the Germans tried a rocket plane against B-17 formations. The Italians, Germans, Brits and, ultimately, Americans experimented with early jet engines. The German ME-262 changed the dynamics of combat. Although, the Germans employed it in an inefficient manner in following Hitler’s call for it to be committed to an air to ground role.

After WWII, the jet engines started the same dynamic seen in the prop years –improved airframe system performance by improving speed, range and maneuverability.

But two new dynamics were added both related to “payload.”

For a fighter in WWII, the “payload” was simple –what caliber and how many machine guns or cannons fit the design to give the pilot enough “deadly bursts” to kill several of his opponents.

In the jet age, the complexities of adding airborne systems and improving the weapons carried, changed the technology vectors of design considerations and introduced two more synergistic, but relatively independent research and development paths.

Airborne radar and sensors were added to fighters and those systems helped the payload—guns and early IR fire and forget missiles became more efficient with the AIM 9 sidewinder series.

But then, concurrently, independent performance was put into the payload by improving missiles and linking long-range (BVR) missile shots to radar technology. At first, radar guided missiles needed continuous guidance from the fighter but eventually even radar guided missiles became BVR self-contained “fire and forget.”

So unlike WWII research and development, where research on airframes and engines was the mantra, in the jet age there were two other huge design factors at work.

The first was always questing to improve the radar systems in the fighters and, secondly, as technology allowed independent designs could improve the weapons carried. Yet again, the art of aeronautical design had to work in partnership with the science of military R&D.

Along the way survivability shifted from armor, speed, and focusing on a good canopy into the era of Electronic Warfare and now the incorporation of stealth characteristics through both design considerations, composite materials and the wonders of chemistry for paint.

Stealth is a survivability factor and is critically important because it multiplies the effectiveness of the fighter—one doesn't add stealth but incorporates it into the very existence of the fighter. Being a multiplying factor means it is sensitive and can really drive the entire performance of the airframe and system combat performance.



F-35B arrives with two F-18s. The past escorts the present. Credit Photo: Yuma Sun

So ending the 20th Century the complexities of fielding the best fighter was a much bigger challenge because of three synergistic but independent factors — basic airframe performance improvements, internal system R&D and constantly improving weapons.

However, with the very real computer revolution moving with light speed into the 21st Century there is now a forth design dynamic at work —the man-machine interface.

With the very real capability of three-dimensional sensing and being able to distribute information to other warfighters (airborne and on the ground or at sea), the relationship of the individual pilot to knowledge of the bigger air battle is truly revolutionary.

For example, one of the most important capabilities of the F-35 is the distributed information capability. The least experienced fighter pilot to the most experience all are fly-

ing into the air battle in yet to be developed formations are all equally capable of having the same knowledge and situational awareness.

Consequently in the formation if one pilot gets inside the opponents OODA loop (observe orient decide act) all are capable of having that same joint knowledge. The revolutionary point is the enemy can splash an individual F-35, but cannot kill the knowledge gained by all: that aspect of modern warfare is truly unique 21st Century technology brought to an air battle.

Conversely, on the offensive if one F-35 picks up an enemy's airborne vulnerability such as an aircraft system or weapon frequency emission or stealth breakdown it can be sent to all. Thus, another unique aspect of F-35 21st Century capabilities is that every Lightning II is a real time intelligence collection system. The entire engagement is also captured electronically for immediate and direct refinements to tactics and analysis during the air battle.

Fleet wide information sharing among services and allies will be a huge factor in winning an air campaign.

Recognizing and exploiting man-machine three-dimensional knowledge is truly a brave new world.

Consequently, the F-35 is capable of constantly updating this next generation of U.S. fighters but not by building a new airframe but staying inside the F-35 basic airframe and adding the next generation of systems and weapons with soft-ware upgradeable programs.

The learning curve to improve F-35 sensors, systems capabilities and weapons carried compared to building another airframe is a new American way of industrial surging. The American arsenal of democracy is shifting from an industrial production line to a clean room and a computer lab as key shapers of competitive advantage.

The Training Challenge for 21st Century Con-Ops

The challenge at all times is to prepare for the future with the forces available. Just like the evolution of technology for generational clustering of ever improving combat aircraft the training has to be flexible to fight the force as generations shift.

The Navy training with regard to the F-4 at “Top Gun” is a perfect example. While many services and allies were flying the F-4, Top Gun was the place where the ability of the aircraft was really understood. Since the Israeli Air Force had had combat success with the F-4 they very generously shared their flying tactics.

The focus at “Top Gun” was the Air-to-Air Mission, even though the F-4 was also proficient in air-to-ground. The Marines MAWTS process also kept focus on AG by the nature of their requirement to always support ground combat troops.

Over time the Phantom was replaced by the F-14 but the Navy still had an “Attack Community” flying A-6 and A-7 Aircraft. The Marines stayed with F-4 and AV-8 and the Air Force introduced the F-15, F-16 and kept the A-10. Both the F-15 and F-16 were superb AG aircraft.

The most interesting technology training and tactics evolution was in the introduction of the 4th Gen F/A-18. The designation of “F” for fighter and “A” for attack in the same aircraft changed everything as the Navy and Marines adjusted. Since the Marines kept their AV-8 Harriers they still had a designated CAS/GA attack aircraft.

But for the Navy everything changed as the A-7 was phased out and eventually the A-6 and F-14. Consequently the Navy had to adjust during an airframe generational shift to successfully integrating a well designed from its conception multi-mission aircraft, the Hornet.

The History of the [USN “Grim Reapers”](#) shows this progression of type/model/series (TMS).

The F-4, which evolved into a multi-mission platform, began life as an interceptor. The F/A-18 Hornet began life with both an “F” and an “A”, and in a very practical sense the

F/A-18 forced two communities to join together. The Navy “Fighter” community and “Attack Community” were completely different even operating from different Naval Air Stations and only come together in exercises and as part of a Carrier Air Group” when deployed.

Navy leaders figured all this out and created a multi-disciplined curriculum at NAS Fallon. But Fallon is much more than just “Top Gun.” Fallon Naval Air Station is in the desert of Nevada. It is where the Navy trains for the advanced tactics for core air platforms but most importantly shapes its integration of the air wing prior to going to sea for final preparation for combat. Naval Strike and Air Warfare Center (NSAWC) is known in the Navy as “Strike University.” Strike U was set up to deal with combat failures of naval aviation, and to shape better tactics, training and concepts of operations to prevail going forward.

As the head of NSAWC, [Admiral Scott Conn](#), noted in an interview:

The mission we have here started with TOPGUN, 45 years ago. TOPGUN was founded out of failures in combat during the Vietnam War. TOPGUN training led to measurable improvements in Air-to-Air kill ratios.

Additionally, as a result of failures in combat in Lebanon, STRIKE University, now call simply Strike, was stood up in 1984 to target training at the integrated warfighting level. Through the years, other communities have mirrored the TOPGUN model including the EA-18G HAVOC course, the E-2 CAEWWS course, and the H-60S/R SEAWOLF course.

These courses target advanced training at the individual level. We have learned a lot of lessons at Fallon and we have had a lot of time to shape an effective combat learning environment. Bottom line: My job here is to prepare our forward deployed air wings to fight and win in a wide variety of missions across the globe.

With the coming of the F-35 and the evolution of the threat envelope in the next decade, the USN is changing its training approach.



F-35C on the USS Nimitz. November 2014. Credit: USN

And in so doing, they will establish a framework more appropriate to developing, and executing 21st century concepts of operations.

As [Admiral Conn](#) put the challenge:

I think it important to emphasize that adversary A2AD capabilities pose a serious threat not only to Navy, but to our entire Joint ability to fight and win.

I think of A2AD as the proliferation of precision for potential adversaries and how this proliferation of precision effects joint forces ability to maneuver where we need to be and when we need to be there.

For me, it is about expanding the battlespace and training with regard to how to do this.

Training for an expanded battlespace means that the extensive ranges at Fallon are not enough to train to prevail in the evolving battlespace.

This is why the Navy is spearheading a broad effort to expand the envelope of training to combine live training with what is called Live Virtual Constructive training. What is entailed is folding in red and blue assets to shaping an evolving strike integration training process.

As [Captain McLaughlin](#), the outgoing CO of Strike, explained in an interview with Second Line of Defense:

The current Fallon ranges – although large – are too small to train against an advanced threat, which can shoot longer than the ranges. We need to train to a 21st Century Plus type of threat with very long-range missiles in the mix.

It is not about succeeding; it is about how we are going to do this with highest probability of success.

We are rolling in Live Virtual Constructive Training to provide the extenders for our operators to work in that threat environment and to reach out to other assets – Navy and joint – which can allow us to fight in an expanded battlespace.

[Rear Admiral Mike Manazir](#), the Admiral responsible for the future air systems of the US Navy, perfectly describes Live Virtual Constructive Training:

Live, virtual, constructive (LVC) training is a way to put together a representation of the threat baseline where you can train to the very high end using your fifth generation capability. Some of it is live with a kid in the cockpit, some of it is virtual in a simulator, and so “virtual” is actually the simulator environment. And then constructive is a way to use computers to generate a scenario displayed on either or both of the live or simulated cockpit.

You can also combine them to be live-constructive, or virtual-constructive, and by that I mean there are systems out there right now that you can install in the airplane that will give you a constructive radar picture air-to-air and surface-to-air along with the electronics effects right onto your scope.

You’re literally flying your airplane, and through a data link, you can share that information between airplanes, you can share it between dissimilar airplanes.

You could take a set of Navy airplanes, for instance, an E2D and a division of F-18s or F-35s on the Fallon range. And you could have a constructive scenario that is piped into all five of those airplanes.

It's the same scenario, has all the same effects. And then the blue players can act according to that constructive scenario, and react to that constructive scenario in the live environment, but there's nothing real in front of them...the threat is all simulated by computer generation.

Now let's say that through fiber network, you pipe that constructive picture over to a coalition partner...for example, you do so to the RAAF in Australia...it is piped to a live airplane or a simulator over there, and let's say there's two Australian airplane simulators, and they're seeing the same picture as the Americans are fighting.

And let's say that there is a network that goes to the Aegis Cruiser, which is off the coast of Florida, and is going to be their Aegis Cruiser for the training. And you can show them the same picture.

And you can transmit the comms across that. You can easily see the training power in this LVC construct.

There are other systems that will allow you to have a live wingman up in the air in Fallon or on another range, his lead in a simulator, and when the simulator lead looks at his or her visual, he can see a virtual representation of his live wingman doing everything he does in the aircraft, and a link sends the aircraft maneuvers down to the simulator.

And when the simulator or the live person looks through their enhanced Joint Helmet Mounted Queuing System, he can see a virtual airplane on his visor.

When the virtual airplane on the helmet system say, dumps a flare or drops ordnance against the target, you actually see it come off the airplane in your visor.

And you can actually fight a virtual bogey on your visor, and the guy's not there. And you fight it with your airplane, just as if it is a real piece of metal. So that's the live-constructive piece.

If you optimize the networks so that you have a live airplane flying somewhere, a simulator that's exactly what emulates a live airplane, and then a constructive scenario that goes to both you now have the full LVC construct. You can overcome the barriers of geography, if the range is not big enough. You could also overcome the barriers of multilevel security, because if you go up and use

all of your weapons system modes up in the air, live, there are surveillance systems that can pick up what you're doing.

In this way, you can protect high end modes with encryption, and then create an architecture where LVC allows you to train to the complete capability of your fifth generation platform integrated into the advanced air wing and connected to AEGIS and the aircraft carrier as well as operations centers ashore. And that's what we're looking to do.

We realize that the fifth generation platform has now bumped us up against the limits of our training ranges and that we do not quite have the LVC components built yet, so that is where our current focus lies.

And in that interview, the head of N-98 highlighted that recently the USN headed a government wide group looking at the approaches to shaping and implementing VLCT across the combat enterprise.

The F-35 is a key element of shaping Navy thinking about operating in an expanded battlespace.

Aviation leadership is looking forward to the impact of F-35 on the evolution of the strike fleet, much as a leaven for change than the sum and substance of that change.

Again, as Admiral Conn put it:

Looking forward, we need to continue to provide trained and ready aircrew to operate forward. In five years we are going to have JSF in the fleet.

In five years we may have UCLASS on our carriers. In five years, the Super Hornet of today is going to be different. In five years the E-2D capabilities and our networks will have matured. In five years the threat is going to change and competitors will have more capability.

In working with Naval Aviation Leadership, we are on a journey of discovery of how to best create a training environment that replicates potential adversary's capabilities.

Training to operate in the expanded battlespace is a key requirement to deal with the threat and to leverage what the F-35 brings to the force and to an ability to tap into the

entire panoply of joint and coalition warfighting assets to deal with 21st century challenges.

The Marines are experiencing a similar transformation at Yuma MCAS as they bring the F-35B on line and prepare for IOC next year.

According to the Executive Officer of the VMFA-121, Green Knights, [Major Gregory Summa](#):

In the F-35, the fusion engine does a lot of that in the background, while simultaneously, I can be executing an air-to-air mission or an air-to-ground mission, and have an air-to-air track file up, or multiple air-to-air track files, and determine how to flip missions.

Because the fidelity of the data is there right now, which allows me to determine if I need to go back into an air-to-air mindset because I have to deal with this right now as opposed to continuing the CAS mission.

And I have a much broader set of integrated tool sets to draw upon. For example, if I need an electronic warfare tool set, with the F-18 I have to call in a separate aircraft to provide for that capability. With the F-35 I have organic EW capability. The EW capability works well in the aircraft. From the time it is recognized that such a capability is needed to the time that it is used requires a push of a button. It does not require that a supporting asset be deployed.

Question: Obviously your pilots need to be trained to combine the air-to-air and CAS capabilities and to use the new organic tool sets as well?

Major Summa: It does. Now we're going to have a pilot that's versed in doing CAS, if he needs to use the electromagnetic spectrum or exploit it to accomplish his mission, he'll be educated and have the equipment to do so.

If he needs to use it in the air-to-air arena to exploit it, to accomplish his mission, he'll have the training and the equipment needed to use it as well.

In the current situation, I would deploy a Prowler to work with my legacy fighters. The Prowler would have to be sortied and would operate only for a period of time and in a specific operational

area. With the low observability of the F-35 combined with the organic EW capability of the aircraft, the aircraft expands my capabilities for both air-to-air and CAS.

With respect to different but similar pilot cultures Major Suma captures that US way of war and the training for combat:

Working with the other service pilots provides an important window on where we want to go with the concepts of operations of the aircraft.

We have different backgrounds — Harrier, F-18s, F-16s, F-22s and F-15s — but we understand that, given the commonality of the aircraft, these different backgrounds suggest common ways ahead. We are all able to contribute to the way ahead for a common aircraft.

Operating on the Z Axis

The F-35 is known as a 5th generation player in the state-of-the-art for both the Air-to-Air Fighter, and Air-to-Air Attack combat roles. It also adds an “electronic” or “tron” warfare component to the fight—the Z Axis and the “Fusion Engine”

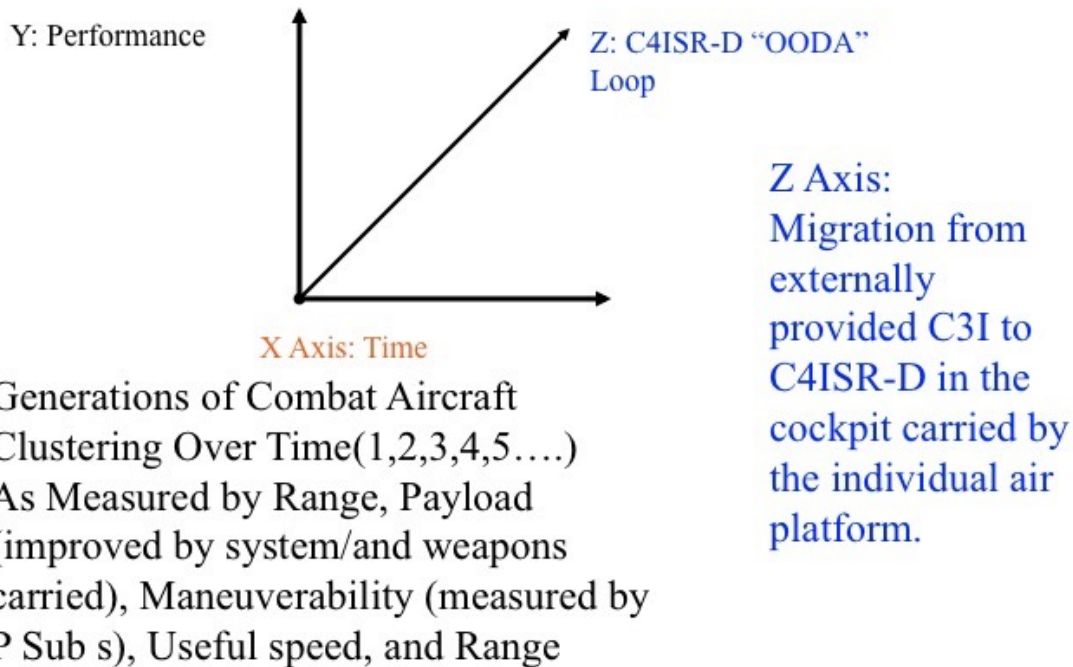
This is the beginning of a combat aircraft design that is building along a new axis—the “Z-axis.” The “Z axis” is a core discriminator.

The F-35 aircraft is not a linear performance enhancement from F/A-18 4th Gen; it has a third performance axis “Z.”

The “Z” axis is the pilot’s cockpit C4ISR-D (for decision) loop axis.

Starting at the beginning air fleet Command and Control from WWI on it has morphed into C5ISR (useful but getting silly) – Command, Control, Communications, Computers, Combat Systems, Intelligence, Surveillance, and Reconnaissance

The Z Axis for Combat Aircraft



Traditionally, in looking at the progression of aircraft a two-dimensional design depiction has been used; the x-axis is time and the y-axis is performance.

That graph captures individual airplanes, but they do tend to cluster in generation improvement. Each aircraft clustered in a "generation" is a combination of improvements.

The aeronautical design "art" of blending together ever improving and evolving technology creates improvements in a linear fashion, if not performance would eventually go asymptotic.

The airframe design characteristics blended together prior to F-35 have been constantly improving range, payload (improved by system/and weapons carried), maneuverability (measured by P Sub s), speed, and range (modified by VSTOL—a basing mobility plus factor).

The F-35 is also designed with inherent survivability factors, redundancy and hardening and stealth. Stealth is usually seen as the 5th Gen improvement.

But reducing the F-35 to a linear x-y axis improvement simply misses the point.

The F-35 is now going to take technology into a revolutionary three-dimensional situational awareness capability. This capability establishes a new vector for TacAir aircraft design.

This can be measured on a “Z” axis.

Historically, Command and Control (C&C) was external to 1,2,3, 4th and some 5th Generations of TacAir. Now known as C5ISR the goal was still enhancing fleet wide combat performance for all Type/Model/Series (T/M/S) of TacAir.

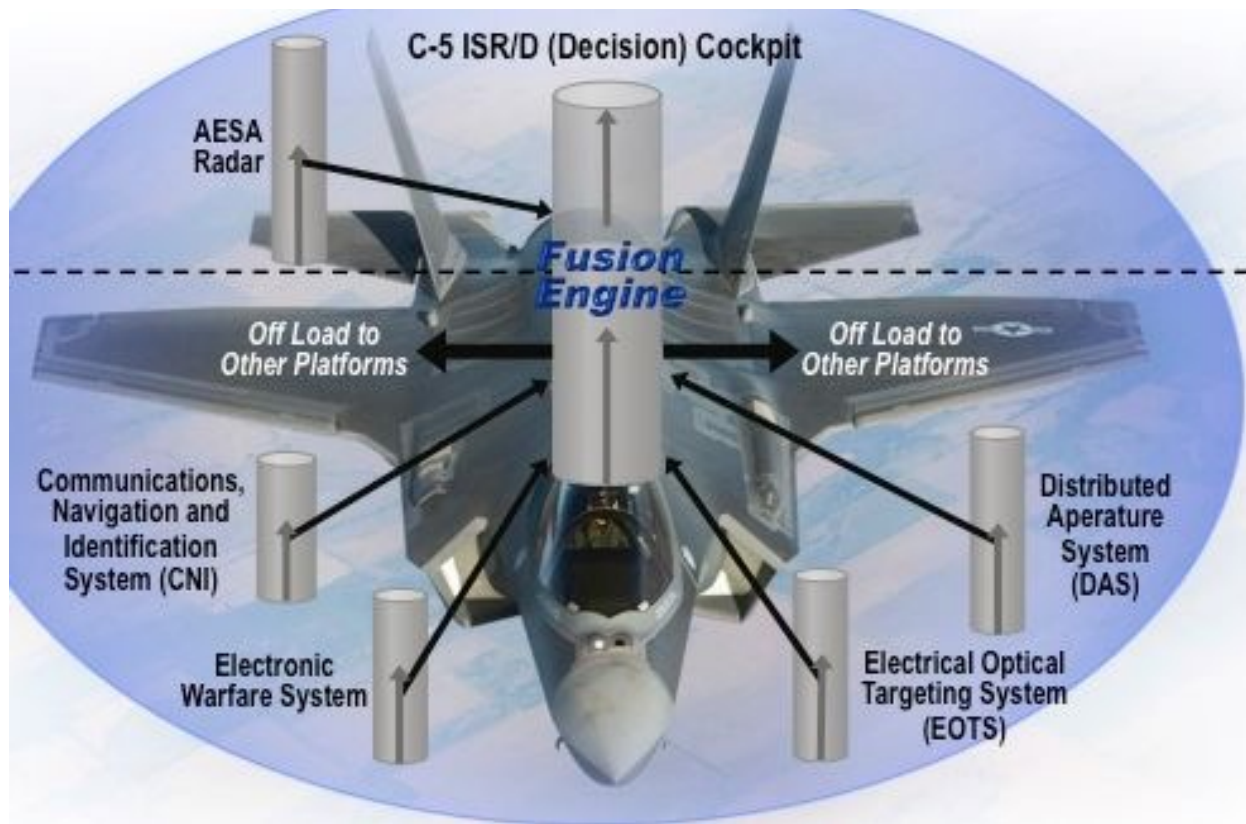
This is the current modern AWACS (hub and spoke) battle management concept. But by using a three-dimensional graph, one can understand that the “Z-axis” takes airpower into a totally different domain.

The shift is from externally provided C5ISR into C5ISR-D for decision into the cockpit. This is the revolutionary step function that breaks the linear progression of previous Generations. The “Z” axis in which the F-35 is the prototype is the first fusion technology with 360 awareness “D” (for decision) cockpit.

A design focus of F-35 is the cockpit, and helmet displays of trusted fused integrated systems.

Enabled with that technology the pilot can also be a distributed information decision-maker.

This is the Z axis in action and the enabler is the trusted “fusion engine.



The engagement process of content in context empowers dynamic situational decisions at all levels and gives the fighting force the best chance of prevailing.

Multi-Function Array (MFA) or the AESA Radar

Distributed Aperture System (DAS)

Electrical Optical Targeting System (EOTS)

Electronic Warfare System.

CNI (Communications, Navigation and Identification System) — connected to the other combat systems via the high-speed data bus is the CNI which is a core and very flexible RF system that enables the aircraft to operate against a variety of threats.

The systems are built upon a physical link, namely a high-speed data bus built upon

Col John Boyd's OODA loop formula was a brilliant insight in merging technology, training and tactics. TacAir development was in a never ending quest to quest to always achieving "SA"—Situational Awareness—the Observe/Orient part of OODA.

And because of the technology limitations of Command and Control battle management was focused on building a better and better “Observe Orient” half of his OODA formula”, AWACS and Navy E-2s are examples of providing “bogy Dope” to a radar empowered fighter.

With the F-35 Cockpit Z-axis the key words are actually now embedded in the second half of Boyd’s OODA –the words “decide, act.”

The quest for US way of war to always fight and win is to now embrace the entire spectrum of Boyd’s OODA by not questing just for Situational Awareness, because that is only half way but rather everything should be now focused on developing technology, training tactics and C&C at all levels to empower “Situational Decisions.”

Consideration has to be taken into account of the F-35 active systems, both radar and DAS but also the combat revolution of attacking in a stealth aircraft using state-of-the-art passive sensing beyond anything ever seen in combat.

This is the true revolutionary step beyond just SA that the “z-axis” F-35 “fusion engine” brings to the fight as a catalyst for a 21st Century refocused way of support equipping and training all Service joint con-ops.

General Mike Hostage, then Commander of the USAF Air Combat Command captures this dynamic of 5th gen and F-35 perfectly:

People focus on stealth as the determining factor or delineator of the fifth generation. It isn’t; it’s fusion. Fusion is what makes that platform so fundamentally different than anything else. And that’s why if anybody tries to tell you hey, I got a 4.5 airplane, a 4.8 airplane, don’t believe them. All that they’re talking about is RCS (Radar Cross Section).

Fusion is the fundamental delineator. And you’re not going to put fusion into a fourth gen airplane because their avionics suites are not set up to be a fused platform. And fusion changes how you use the platform.

The Impact of a Z Axis Air System on Combat

With the F-35 Cockpit Z-axis the key words are actually now embedded in the second half of his OODA –the words “decide, act.”

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I have been trying to formulate a way to express the human/machine evolving action/reaction cycle understanding that everything is always relative. “Beef” (an Air Command and Control Officer then at MAWTS) gave me the insight I needed to complete a year’s worth of research on ways to look at this dynamic.

Based on our discussions with Dean Ebert, (NGCO employee and former USMC EA-6 driver) I have been focused on the combat learning cycle associated with the new cockpit, the sensors in the aircraft and fusion prospects.

I seized on an MIT concept of the “engagement process of content” to understand how learning evolves. Similar to some of the thinking of Piaget, that one’s ability to learn evolves over time with age and learning, we now need to understand that learning in the cockpit powered by the fusion engine is not simply a linear repetitive experience. It is a learning experience and is done so within the fleet, both flying, just returned and about to engage.

<http://ed.ted.com/lessons/deb-roy-the-birth-of-a-word>

In our very robust discussion with “Beef,” he added “in context” to the statement and clarified the approach. We are now not talking about Situational Awareness as the key dynamic but Situational Decisions.

A foundation for “fifth generation” operations realize is built around the notion of learning rapidly in a combat situation and acting on that knowledge.

The engagement process of content in context empowers dynamic situational decisions at all levels and gives the fighting force the best chance of prevailing.

The “engagement process of content in battle context” which empowers dynamic situational decision making at all levels has the best chance of prevailing. It is the foundation of war winning in the 21st century.

And the discussion with “Beef” highlighted an important clarification in another sense. Instead of confusing folks with C5ISR and with situational awareness, we should focus on C2 plus information war.



F-35As being refueled near Eglin AFB. Credit: 33rd Fighter Wing

Pilots in the F-35 are Information Warriors. A fleet of F-35s puts in the air with a 360 degree swath a decision and information warfare grid. This grid is leveraged throughout the battlespace for ground and surface operations throughout the engagement.

Adding “Beef” to MAWTS a 7202 –and going back to using the term “Information War” (I used that term in Red Dragon Rising published in 1999) actually brings more clarity

than just “cyber” which is a critical subset. Combat leaders can now focus on Command and Control plus information war. Pilots in the F-35 are Information Warriors.

A fleet of F-35s puts in the air with a 360 degree swath a decision and information warfare grid.

This grid is leveraged throughout the battlespace for ground and surface operations throughout the engagement.

As [Mike Skaff](#) the father of the F-35 cockpit states:

The Z axis and the fusion engine graphic captures the essence of the change, or the foundation from which change will occur.

It points out the advent of the information age.

We're old enough, and we can remember when there weren't cell phones. There was a time when there wasn't an Internet. We can remember that distinctly.

When these tools show up in the early '90s, there's a paradigm shift that we call 'the information age', and now it arrives in the airplane. With the F-35 we enter into the information age in a new way and we can connect these airplanes just like nodes of the Internet. I'm not saying we're connected to the Internet, but it is like that. I like to think of this as information dominance. When a 5th generation fighter arrives in battle space the pilot has information dominance.

The F-35 was specifically designed to provide the pilot with information dominance through multi-spectral, multi-sensor, distributed processing and advanced fusion – this is the distinction and the difference from the 4th generation. This is the paradigm shift.

Because this is software-defined plane built around evolution over time, we know the future is going to be different. The threats will evolve and everything else.

But initially, these initial airplanes have all of the hardware in place to last for a couple of software upgrades. And so, we can redefine the airplane in its missions and how the sensors work and what they detect. Hypersonic cruise missiles, seeing that the horizon maybe with DAS, who

knows what is the next evolution, but we know it is coming. And the plane is built to anticipate change.

Recently a Marine Corps general underscored that we are not making this airplane for Harrier pilots. In fact, most F-35 pilots haven't been born yet.

You're making it for the next generation. And they're going to jump into the cockpit and they're going to see a Nintendo or a PlayStation or whatever is the deal at that time.

But they're not like us old guys that are looking for air speed, altitude, conventional electro-mechanical gauges. They literally see a video console in front of them, and we've got to make the airplane for them. They can deal with information and they can process it differently than you and I can....

It is also about survivability in an information dominance environment. By reducing the gaggle of aircraft to an interactive air system with other combat assets, we can pursue air dominance against a reactive enemy. It will be a different paradigm leveraging the Z-axis to pursue information dominance.

Dealing with the Hypersonic Missile Threat

An example of how to leverage the Z-axis for a fleet of F-35s will be seen in the game of tracking hypersonic cruise missiles.

The PLA military threat in numbers and quality is growing, PLA is generic for all Army, Navy, AF and missile forces.

So it is now time to accept that a war-changing weapon is in late stages of R&D and it must be accounted for in any battle plan.

Unlike distant "hyper-sonic" R&D efforts such as Global Strategic Strike -a hypersonic cruise missile is a rapid evolving technology, which sooner than later will be demonstrating the art of the possible up close and personal. Such a revolutionary CM in the US arsenal is a very good thing. In the hands of PLA forces it is a very real "wolf at the door."

Consequently when, not if, a hypersonic-Cruise Missile is battle ready the Air/Sea Battle staff will have to figure out both offensive and defensive con-ops. In sufficient numbers a hypersonic Cruise Missile can be a war-tipping asset. Employed by US and Allied forces the capability will greatly enable a deadly combat punch. If it is in the hands of an enemy a hypersonic Cruise Missile is a ship killer.

Since defeating a hyper-sonic cruise missile is the hardest problem focusing on that will have the added benefit of addressing less capable weapons-such as the new PLAAF 5th Gen J-20.

US and allied forces will have the perfect aircraft in the F-35 to play both offensive and defense when hypersonic Cruise Missiles become a combat reality. The C4ISR-D “Z-axis” in the cockpit can lead the way in developing a Pacific “honeycomb” ISR Grid to handle the hyper-sonic Cruise Missile threat and also go on the offensive since Chinese President Hu Jintao has just put the PLAN on combat alert.

Everything will take time to develop and if PRC goes to war at Sea today they will lose. However, time is precious for US and Allies to get the technology for a 21st Century Air/Sea Battle right.

If the F-35 did not exist with it’s revolutionary “Z-axis” 360 umbrella —it would have to be invented to take on directing all current and future weapons, such as ship-board lasers for example against the possibility of PLA hypersonic ship killing cruise missiles and other threats.

Northern Edge validated that the US has developed a flying combat system that is world class and unique—a Fighter/ Attack aircraft with EW/“tron” warfare capability with both AA and AG kinetic weapons in the bay.

American visionary commanders and operators given enough F-35s will have the beginning of a real honeycomb defense. F-35 cockpit enabled sensors linked with other combat systems networked because no platform will fight alone and employing the Wynne Doctrine-“If you are in a fair fight someone failed in planning,” – it s formula for combat success.



A hypersonic rocket launches skyward during a March 22, 2010 test launch from the Woomera Test Range in Australia. The flight was part of the joint U.S.-Australian HiRise project to test and develop hypersonic vehicles for future aircraft transportation. Credit: Australia Defense Science and Technology Organisation

Such new concepts enabled by F-35 A (USAF), B (USMC) and C (USN) as Aegis can be a “wingman” and an SSGN Submarine can be a “fire support ship” is the touchstone for winning an Air/Sea Battle.

The C4ISR-D (for decision) F-35 cockpit should be the R&D focal point for developing the next generation of weapons. Designing electromagnetic hardened (EMP) systems, platforms and weapons to take full advantage of the unique emerging F-35 C4ISR combat capability is the way ahead.

If the F-35 did not exist with its world class “Z-axis” 360 umbrella—it would have to be invented to take on future PLA hypersonic ship killing cruise missiles and other threats.

Northern Edge validated that the US has something world class and unique—a long range 360 search, and sort information system in a Fighter/ Attack aircraft that will has both EW/“tron” warfare capability and kinetic AA and AG weapons in the bay.

A successful Pacific Rim fleet wide “honeycomb” ISR grid can be created with enough USAF/USN/USMC and Allied F-35s flying along the Pacific Rim. F-35’s in the Japanese self-defense Force are extremely important along with Australia, Singapore and South Korea.

US and Allied con-ops can begin to offensively link the DAS capability to hypersonic CMs in the hands of the good guys-. –Imagine an F-35 lights up a threat and then out pops a hypersonic CM from an SSGN or a Zumwalt (DDG-1000) class (all two of them) or an Arleigh Burke (DDG-51) surface combatant, or is launched from many different USAF air platforms both piloted and UCAS.

Equally important the F-35 “Z-axis” mitigates the “wasting asset” argument being made against our Fleet. The Fleet Commander will have tremendous situational awareness (SA) to defend against enemy hypersonic CMs, and also IRBMs end game maneuvering warheads.

In that game instantaneous speed of light information originating from cockpits in a fleet of F-35s is a real game changer. From point of launch to possible impact the Navy Fleet employing a 1600+ diameter DAS capability can begin to figure out how to network all fleet “weapons” to kill, jam, fry or spoof incoming hypersonic CMs and endgame maneuvering IRBM. R&D efforts in directed energy research would add to the mix of weapons to employ.

Essentially, the Commander and all operators will have the best SA knowledge possible to successfully track the flight path from launch to endgame maneuvering. Early detection just like fighting an aggressive cancer is a life savor.

If the F-35 did not exist the Air/Sea Battle Commanders would have to continue to invent or improve a lot of expensive disparate systems to do what one aircraft can accomplish—no platform fights alone is a winning strategy.

The F/A-18 -in fact no system in the world, can do what I just described. The critical point is taking advantage of the “Z-axis” is to build new weapons. The Navy and AF armaments commands now have a combat survivable aircraft that can “tron” track the threat.

Weapons and systems can be developed that enhance EW offensive capabilities against incoming missiles and also target them with kinetic weapons internally carried and from other platforms. Hopefully some day lasers will also come to the fight all to kill the hypersonic threat before it gets close to its end game maneuvering.

The F-35 initially will be network to other systems but realistically the “other systems” should begin to evolve toward taking advantage of F-35 SA potential-not the other way around and over time this will happen.

The S-Cubed Revolution

Inherent in the discussion of dealing with the coming hypersonic missile threat is the ability to being at the cutting edge of the S cubed revolution. Sensors, combined with stealth combined with speed can provide a new paradigm for shaping the Pacific force necessary for the U.S. in working in the Pacific.

At the heart of getting the policy agenda right is to understand that warfare is highly interactive.

Buying, building and deploying yesterday’s technologies against evolving threats is a sure fire way of being in the wrong side of the outcome.

As [Lt. General Walsh](#), then Deputy Commanding General, Marine Corps Combat Development Command, put it succinctly in a presentation:

Some say that the development of modern anti-access, area denial threats make an amphibious assault impossible.

That has been said before and it was not true then and it is not true now.

The challenge is to leverage the asymmetric advantages we have in functions like ISR, precision first, and seabasing.

The challenge is to use the sea as a maneuver space in the context of the modern threat.

We don't need to give up on the capability.

We need to think our way through the challenge.

What Walsh was hinting it is what we would call the S cubed evolution or revolution of capabilities. Sensors, stealth and speed can come together to create a powerful distributed force in the Pacific, which can so complicate Chinese military planning as to enhance deterrence significantly.

A deployed fleet of F-35s – allied and American – in the Pacific lay down a strong stealth and sensor-enabled honeycomb of deployed kinetic and non-kinetic capabilities. The reach of the fleet is such that a 21st century equivalent of the World War II big blue blanket can be created.

The F-35 has been built to be a fleet, not a silver bullet.

As [Lt. General Schmidle](#), the former Deputy Commandant of Aviation commented with regard to the flexibility and coverage, which the Bs can bring to a theater of operation like the Pacific:

I think that we're going to find ourselves in a situation where we, the Marine Corps, are going to be able to offer much more to the joint force in terms of capability.

And as General Hostage put it to me, Marine Corps assets will be considered an integrated part of the joint force, in a way he has not thought of it before.

The Air Force Commander will look at USMC or USN F-35s as part of his F-35 fleet from the perspective of the joint fight.

And [General Hostage](#), the former ACC Commander, underscored the air combat cloud role of the fifth generation aircraft operating as a fleet.

The advantage of the F-35 is the nature of the global fleet. Allied and American F-35s, whether USAF, USN, or USMC, can talk with one another and set up the distributed operational system.

Such a development can allow for significant innovation in shaping the air combat cloud for distributed operations in support of the Joint Force Commander.

Other [sensor capabilities](#) will be provided by evolving robotic capabilities, under the sea, on the sea and in the air.



Another game-changing capability of the F-35 global fleet will be its ability to function within a wolf pack, utilizing all of the deployed assets for control of 360 degree space. One analyst referred to the capability of the fleet to operate as a roving motorcycle gang in disrupting adversary capabilities and responses. (Credit: Bigstock)

The concept of an operating wolf pack whereby robotic elements outside of the fleet and inside the planes themselves will make a stealth-sensors dynamic as a solid foundation for the weapons revolution.

We are currently putting 3rd and 4th generation weapons on 5th generation aircraft.

This makes little sense.

With a plane that can see significantly further than the [weapons](#) it carries can operate, the capabilities of the plane are being limited by the past, rather than enabling a new strike enterprise future.

But the link to the third S – speed – is off-boarding of weapons is what I wish to highlight here.

Offloading of weapons will be a fundamental opportunity posed by the 5th generation aircraft.

The former Chief of Staff of the Air Force, [General Schwartz](#) spoke prior to his departure of F-22s training to guide Tomahawk missiles off of surface ships to their targets.

Our testing last year of an F22 in-flight, retargeting a tomahawk cruise missile that was launched from a U.S. Navy submarine, is an example of how we are moving closer to this joint pre-integration under our Air-Sea Battle concept.

The F-35 has a 360-degree situational awareness and data delivery capability.

This poses the possibility of leveraging the 360-degree space to guide weapons to their targets.

Target acquisition onboard does not have to be married to weapons CARRIED on board.

This means as well that classic distinctions between tactical fighters doing close air support, or air superiority missions or air defense missions are clearly blurred.

The fleet flies and identifies targets for the various mission sets and can guide weapons to a diversity of target sets.

The reach of the fleet is the key to the operation of the fleet, not the range of individual aircraft.

Shaping a new distributed operational capability when added to the coming revolution in speed will provide the US with a range of options to deal with global threats, including any presumed advantages of the Chinese area denial strategy.

Conclusions: Laying a Foundation for Crafting a 21st Century Air Combat Approach

The F-35, Lightning II, has a revolutionary sensor fusion cockpit that makes it effective in AA, AG and EW, consequently, US and Allied Combat pilots will evolve and share

new tactics and training, and over time this will drive changes that leaders must make for effective command and control to fight future battles.

The F-35 adds an “electronic” or “tron” warfare component to the fight, an “E” for electronic. It is not necessary to designate the F-35 as the F/A/E-35 but that would be more accurate. Adding the “E” with both active and passive capabilities is changing the entire strategic and tactical dynamic combat aviation

The F-35 with its “F” “A” and “E” role in same airframe will be a focal point for pulling those elements together for the American way of war that “no platform fights alone.”

Passive capability of F-35 sensors will revolutionize strike operations and force innovative strategic Command and Control thinking.

Imagine squadrons of F-35s in a strike package, F-35As taking off from land, the B model from USS America, F-35C Squadrons from USS Gerald Ford all attacking stealth enabled and relying on passive sensing on an emcon mission. Add allies flying the F-35 and the first time the enemy knows they are under attack is when the bombs and missiles impact.

Stealth enabled “passive” sensing with reach not just range will add a revolutionary step-function in combat effectiveness –both in intelligence gathering and strike–the nexus between reach in collecting identifying and then having a commander prioritize “aim-points” to execute passive integrated attack strike vectors is a joint capability that no other combat force other than US and Allied empower by F-35 A/F/E in the world will have for at least a decade or more–PLAAF and Russian Stealth do not have fusion cockpits J-31 does not have passive capability.

Just like Wade McClusky seeing a Japanese wake as to the position of the targeted Carriers, often signals-in-space have the ability to give away positions, the F-35 may have a battle winning way to avoid giving away its position, along with its basing location, because of both stealth and the very long reach of its passive sensing.



Three F-35B Lightning II Joint Strike Fighters with Marine Fighter Attack Squadron 121, 3rd Marine Aircraft Wing, and two AV-8B Harriers with Marine Attack Squadron 211, 3rd MAW, fly in a “V” formation during fixed-wing aerial refueling training over eastern California, Aug. 27, 2013. The F-35B joint strike fighters practiced refueling with Marine Aerial Refueler Transport Squadron 352. (Photo by Lance Cpl. Michael Thorn)

Just like the F-111 El-Dorado Canyon strike an “emcon” strike, stealth enabled, can come as a complete surprise.

The possibility will exist for the US Intelligence Community to capture information “seen” both active or passive by US and Allied F-35s and all other ISR sensors, to create a dynamic almost real time library of future “aim-points” for attack in the event of hostilities—this building of a library can occur without any opponent knowing what US and its allies know.

The F-35 OODA “DA” fusion cockpit will shift all US combat planning and engagement eventually into a horizontal grid vice reliance on only Hub Spoke battle management—this evolving attribute will change C&C in very profound ways and this is could be a good starting point for any “Combat Cloud” discussion.

If the F-35 did not exist it would either have to be invented or many different technologies would have to be aggregated to even try and achieve what the aircraft can do—and that effort would have exploitable seams, and an increased C&C demand with an increased vulnerability to enemy “tron” counter measures.

Going active F-35 can engage in combat as USAF Secretary [Mike Wynne](#) says empowering another revolutionary capability—a “sensor/shooter” dynamic engaged with legacy

systems. Dynamically using fifth generation aircraft as target location systems may not be seen as satisfying to the traditionally trained pilots, but it can serve a vital role for forward observers in concealed locations.

The F-35 is not in direct competitions with Growler, E-2 and AWACS it will just drive combat innovation especially using its EW capability on the emerging Virtual/Constructive Fallon range-technology, training and tactics will come together in perfect harmony to allow Squadron Pilots and Commanders the environment to innovate dynamically and to “train, train, train,” — no opponent in the world has this capability.

The use of Growler Electronic strike as part of an air wing strike package along with AWACS, E-2s and surface ship enhanced C&C can empower F-35C s in its non-stealth mode. The design factor of ever increasing F-35 airframe payload utility/accuracy can be embraced by taking advantage of the tremendous weapon load carried on F-35 hard points and utilizing the F-35 “fusion” cockpit to identify with precision accuracy hitting all types of ground targets.

The “E” capability of F-35 can augment the Growler “tron” warfare capability.

However, if the tactical situation requires it, the F-35 can attack in stealth/passive mode or after the beginning of air superiority with successful SEAD the F-35 can attack with slung wall-to-wall ordinance relying its “tron” or electronic counter-measure capability. The ability of the Strike Commander to mix and match his con-ops in battle has increased immeasurably. And clearly flying with the F-22 will enhance this overall capability as well.

Just like the example of the Israeli Air Force flying F-4s and attending “Top Gun” the F-35 will allow tactical innovations to take place in many Allied fighting forces and the training and sharing will make all countries combat forces better.

Tracking Hypersonic Cruise Missiles with instantaneous speed of light information originating from cockpits in a fleet of F-35s is a real game changer. From the point of launch to possible impact the Navy Fleet employing a 1600+ miles diameter DAS capability can begin to figure out how to kill, jam, fry or spoof incoming hypersonic CMs

and endgame maneuvering IRBMs. If the F-35 did not exist the US Navy to protect their ships would have to invent it.

The other attribute of an F-35C strike force and especially with the addition of the USS Gerald Ford is not only will the aviation Strike Force be an integrated combat air wing but the air wing and carrier will be uniformly integrated with the entire Navy and Allied assets, air land and sea. This is an additional factor that can be explored on the Fallen Virtual/Constructive Range.

S-cubed airborne considerations with trade-offs between sensors, stealth and speed is a way ahead for new weapons being developed.

By laying a foundation for a strategic transition in the operation of airpower other changes can be facilitated.

As the new head of ACC, and former PACAF chief has highlighted that the F-35 as a fleet in the Pacific can allow his successors as PACAF to think in terms of a CAOC and not simply in terms of flying capabilities to be linked in a CAOC. This means working the 4th to 5th generation concepts of operations, and working various strike and defensive assets into an integrated whole as seen from a C2 perspective.



General Hawk Carlisle, then commander, Air Forces Pacific sits with AFN-Pacific Hawaii News Bureau, to get the general's thoughts and messages on the state of Air Forces in the Pacific. Credit: Defense Media Activity, Hawaii News Bureau, 4/613

For example, in an interview with ["Hawk" Carlisle](#) conducted earlier this year, the then head of the US Pacific AF highlighted this opportunity:

Command and control are two words.

The way ahead is clearly a distributed force integrated through command and control whereby one develops distributed mission tactical orders (with well understood playbooks) reflecting the commander's directions and then to have the ability to control the assets to ensure that the sensors and shooters accomplish their mission.

Shaping an integrated enterprise is not a futuristic mission for the integration of Patriots, Aegis and THAAD is already a work in progress, but General Carlisle sees the approach getting better over time as new systems come to the Pacific, including a fleet of allied and US F-35s.

We need to get better at attack operations to take out the shooter.

How do we do that better?

It is clear that an F-35 fleet coupled with the new long range strike systems will play a key role in that function.

We also need to shape game changers in terms of the missiles used to intercept missiles.

The current generation is expensive and we need to drive down the cost point for interceptors.

SM-6 is coming which is an important asset but DOD is working hard on ways to drive down the cost of future interceptors.

And we are working the passive defense piece of the puzzle as well including hardening, concealment, dispersal of assets, rapid runway repair and support for a fluid force operating in a distributed manner.

Secretary Wynne likened what will be set in motion by deploying an F-35 fleet and the learning curve with regard to Tron Warfare as something akin to the WW I aviators learning how to shoot bullets through the propellers – which was hardly a quick or easy learning path.

It is clear that learning how to leverage the F-35 global fleet to fight and win in the Tron Warfare domain will help lay the foundation for the next generation of weapons as well. As Secretary Wynne commented on an earlier draft of this paper:

“I looked for the likely path of growth in ‘Tron’ warfare and the challenge may well be to bring the Cyber Domain into the fight; and integrating an electronic gun; with laser or microwave style emission into the transmit for sharing; or the fire for effect mechanism for blinding or burning incoming strike assets.”

The technology described exists it just requires the political will to appropriate enough money to both acquire enough and constantly “train train train.” Squadron pilots and Commanders in all communities will learn as they go.

Future combat success has the appropriate building blocks; the US combat philosophy of innovates, train, innovate, repeat, and repeat... is demonstrated in the sky every day. This is how it should be!

But with competitors like the Chinese and Russian clearly committing resources to the 21st century fight – in terms of technology, leadership and political will – the US and its allies can not simply squander away what could prove to be a decisive political advantage – namely building, deploying, training and leveraging a global US and allied F-35 fleet.

Some now are pushing a discussion of a 6th Gen aircraft. It might be prudent to allow the F-35 (F/A/E) to enter all US and Allied combat fleets to see how it evolves the air battle. The Lightning II is not a 5th Gen as defined by stealth it is actually the first generation of the American and Allied scientific, engineering and best military minds producing a new “axis” or design vector in combat aviation. It is the foundation for the next generation of air warfare, rather than simply being a fifth generation aircraft.

And the software upgradeability within the aircraft itself is part of evolving its ability to support the evolution of the “next” generation of warfare.

As the then head of N-98 and now [Vice Admiral Moran](#) put it:

SLD: You will also have the opportunity from the standpoint of 2030 to take advantage of understanding what the impact of the F-35 will be on the fleet.

Rear Admiral Moran: Absolutely. That is a good point.

Joint strike fighter in my view is a revolutionary change to how we're going to operate.

And we will evolve joint strike fighter once we get it in our hands and we learn to operate with it, and we truly understand its full potential. Once we get it out there and we start operating, we're going to find out that we're going to want to evolve this capability.

And the F-35 may be its own successor.

Or as [General Hostage](#), then head of the ACC put it:

Hostage: The fifth generation aircraft will enable the air combat cloud and allow me to use my legacy assets differently.

Many of my 4th Generation fighters can be used to extend the network of linked systems providing reinforcing fires, and I can focus on the fifth generation assets as the core nodes shaping distributed joint capabilities.

And when we come to the evolution of "next" generation systems, the form factor could stay quite similar as we evolve the capabilities within the planes or in terms of how the flying systems can interact and operate together.

Rather than thinking of 6th generation aircraft in form factor terms, we can operate the new air combat cloud and leverage that moving forward.

The 21st USAF Secretary Mike Wynne and former head of DOD Acquisition at the time when the F-35 moved down a path to build out its fusion engine capabilities should have the last word:

The speed of transition for the US and allied forces is very dependent on the resources to both produce the F-35 and then for the subsequent training.

It is encouraging to see this as a top priority for all of the US and allied forces.

With the demanding world, this is an imperative, and thus gratifying to see this response.

If the drums of war are beginning, or if they remain quiescent for a period, fulfilling this imperative will have an impact.

With both Russia and China making ominous moves against America especially with military modernization initiatives and force projection it is time for a deterrence response.

The F-35 production line can be doubled and over a period of time doubled again. If the US can be the WW II Arsenal of Democracy, and then produce thousands of F-4s and then F-16s there is no reason except lack of political will power to increase the production rate of F-35s for the US and its Allies.

And this about getting on with it and making a fundamental transition in the overall approach to air enabled combat power for the US and its allies.

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