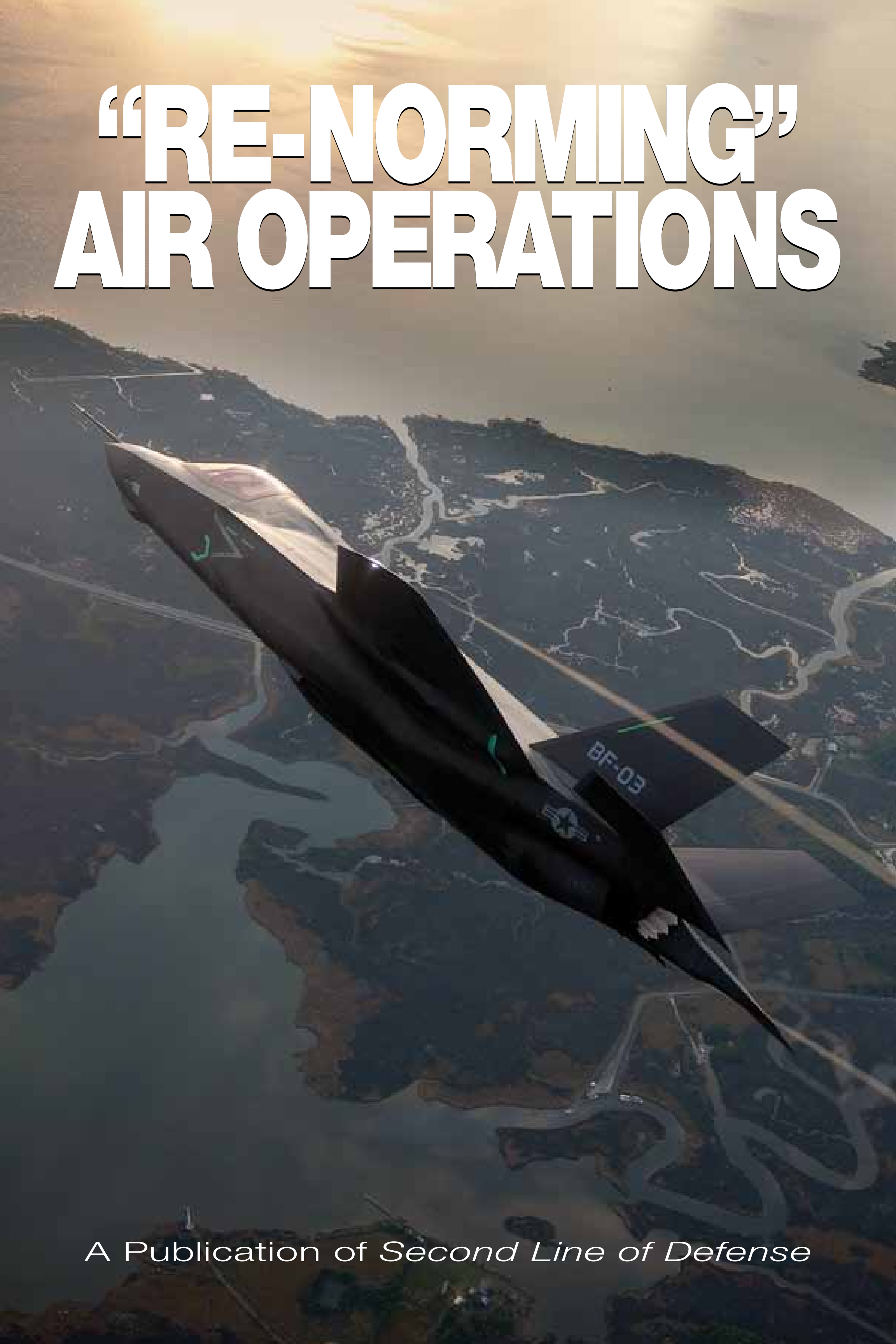
“RE-NORMING” AIR OPERATIONS



A Publication of *Second Line of Defense*

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FOREWORD

Most of the interviews and essays in this booklet have appeared in earlier versions on the web site *Second Line of Defense* (http://www.sldinfo.com/). SLDinfo.com focuses on the creation and sustainment of military and security capability and the crucial role of the support community (logistics community, industrial players, civilian contractors, etc.) along with evolving public-private partnerships among democracies and partners in crafting real military and security capabilities. On SLDinfo.com, articles, videos and photo slideshows on military and security issues are posted on a weekly basis.

Some of the articles and interviews in *Re-norming Air Operations* are excerpted from the longer pieces on SLDinfo.com as indicated at the beginning of the article. The original pieces on the web site often include photos and graphics, which are not included in this publication.

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PREFACE

The title of this book could have been *The Future of Air Power*. But today, the meaning of air power has been clouded by the Iraqi and Afghan operations, with the result that some think that an Army Air Corps would suffice, rather than a combat air force deployed on land and at sea.

For many, the historic dominance established by U.S. air power is a given, with no real "peer competitors" in sight. The unfortunate result is an assumption that the U.S. and its allies can simply rest on their laurels, keep building traditional aircraft, and build new so-called unmanned aircraft in order to solve the challenges. There is also an assumption that the numbers of U.S. and allied aircraft are sufficiently high, and that the United States and its allies have a decade to begin a new effort to restock the force.

These assumptions are seriously flawed.

But the air dominance requirement is not answered simply by increasing the quantity of aircraft, the measure by which bean counters tend to respond to the air dominance challenge. Air dominance is the *sine qua non* for any effective military operation worldwide. And worldwide is the problem. The numbers of aircraft and ships available to the United States and its allies has dropped significantly over the past decade. The U.S. Air Force has reached the point where it increasingly faces the same dilemma as the U.S. Coast Guard — where the service can surge to a problem but only by stripping itself of many of its available assets. The tanker crisis has made it evident that in situations like Korea, the ability of the United States to surge air power is questionable over a sustained period of time.

The historical pattern of U.S. air dominance is not the practical reality of today's escalating and sophisticated adversarial air challenge.

The United States has cut its air power inventory in half in the past 15 years, and the trend will continue unless there is a real commitment to manufacturing the F-35. Unless the United States invests in the aircraft, the technological promise of the fifth-generation aircraft will never be realized. And U.S. air power will become a haunting memory.

Commitment without construction will simply create the chimera of innovation.

The term "fifth-generation aircraft" is also part of the problem facing the future of air power. The term suggests a linear relationship to preceding aircraft, so that one can argue that F-18s and F-16s can be upgraded and become 4.8-generation aircraft. This is simply not the case. The fifth-generation aircraft are a benchmark for a new approach to air power, which is why this book is titled *The "Re-norming" of Air Operations*.

This can clearly be seen in the F-35 combat system enterprise.

Classic aircraft development simply adds systems to the aircraft to provide new capabilities. The pilot has to then manage each added system. Not so with the F-35. The F-35 has five major combat systems which interact with each other. Functional capabilities emerge from the interaction of the systems handled by the machine, and are not simply correlated with a single system. For example, jamming can be done by several systems aboard the aircraft. The machine determines which one is used through interaction among all of the systems. The entire system rests on a common architecture with broadband capabilities.

If air power leaders simply mimic the operations of older aircraft with the fifth-generation aircraft, the promise of the new air operations will not be realized. The United States and its allies would simply be mimicking the mistake of the French when facing the Germans in World War II, where they had superior tanks but outmoded tactics and command structures.

The new aircraft simply do not function like the old.

The F-22, in the real world, has already demonstrated this promise. We have interviewed F-22 pilots whose firsthand experience underscores the true value of the aircraft; unfortunately the F-22 has been put into a political ghetto, so the ability to leverage the capabilities of this aircraft in transforming air operations is often outside the comprehension of political players. Only the Russians and Chinese seem to be carefully studying the impact of the new aircraft — Russia is actually celebrating the opportunity to generate exports of their new aircraft that is mimicking some of the fifth-generation capabilities.

The fifth-generation aircraft are at the heart of a potential new air combat system enterprise. The F-22s have been the harbinger, but for full participation, the F-22 needs to be modernized with some of the air combat systems present on the F-35.

The F-35 is a flying combat system able to operate across the spectrum of warfare. It is the first plane which can manage 360-degree space, and has the combat system to manage that space. Deployed as a force, it enables distributed air operations, an approach crucial to the survival of our pilots in the many challenges that lie ahead.

Distributed operations are the cultural shift associated with the fifth-generation aircraft, along with investments in new weapons, remotely piloted aircraft, and the crafting of simultaneous rather than sequential operations.

Unfortunately, the debate about fifth-generation aircraft continues as if these are simply aircraft, not nodes that are driving significant cultural changes in operational capabilities. And they are essential tools in executing difficult missions such as missile defense as well.

The pilots we have interviewed are "living" this transition. As Colonel Berke, the USMC pilot of the F-22 put it:

> *The joint operational role for the* Raptor *is significant…. Maritime Interdiction Integration is a key element of what we're doing. Virtually all of our tests are about how to make the airplane value-added to the conventional fleet.*

Berke underscored the new decision-making role for the combat pilot enabled by the new aircraft:

> Raptor*…is…how you think….With the F-22, as will be the case with the F-35, you're operating at a level where you perform several functions of classic air battle management.*

Berke added:

> *SA (situational awareness) is extremely high in the F-22, as it will be in the JSF. So it's very easy for the pilot to process the SA…. The best SA I ever had in the* Hornet *pales in comparison to what the JSF will do for me.*

F-22 pilots at Langley AFB further clarified the changes possible with the new aircraft:

"Bean" Akers:

> *One of the key things today is the need for an AWACS. We practice our training for times when the AWACS is hundreds of miles behind us. As we move forward with the systems and sensors that are on both the F-22 and F-35, there will no need for that requirement anymore.*

"Shotgun" Anthony:

> *With the sensors on the fourth-generation jet, I have an active radar that is continuously transmitting a picture off my nose. In order to build a coherent picture in front of our noses, we had to communicate verbally on our radio. In a three-dimensional battlespace we would communicate with what we were seeing with our individual jets. We parse out sections of airspace to sanitize in front of us. And we build a picture from close end from the nose all the way out.*

And a significant cultural shift will be necessary with the new aircraft:

> *The mission commander or the flight lead was always clamoring for sufficient information to make appropriate tactical decisions. From the operator's perspective, it will be like the difference between stumbling around a dark room and turning the*

> *lights on. The combat situation will be instantaneously transparent. All of those high-processing-time tasks that the pilot used to spend his time on, with the objective of knowing what was going on so that he can then take an appropriate action are now done by the airplane.*
>
> *I think the most difficult and the most painful set of shifts will be organizational. They will relate to the people who will be forced to relinquish operational strategic decisions. So that speaks to an entirely different — not just physical architecture, also personnel architecture, but more importantly leadership paradigm and approach to solving a problem. You now are far more able to remove fat layers of intermediate data processing and you're able to focus a force of very capable assets on an objective. Now we can send folks with the idea of an outcome we hope for. And they now have the information to take that kind of action. And they have the capacity to go where other assets couldn't go previously.*

The shift from the older aircraft and operational paradigm to new aircraft and the new operational paradigm can be envisaged as the network versus the honeycomb or of spears being launched against targets versus 360-degree decision-making systems organizing the air ground operational space.

In the classic aircraft operations of the past thirty years, the lead aircraft strike enemy targets and are organized by AWACS and the CAOC to shape the air operations combat space. *Wild Weasels* or F-117s would lead the attack with tactical aircraft and strategic bombers that were part of the initial assault or providing follow-on attack capability. The large aircraft, such as AWACS, are key command elements.

This approach is increasingly suspect. The large aircraft are targets of the adversary, the initial attack is against increasingly sophisticated air defenses or has to cope with significant numbers of missile launches. States like China are introducing significant numbers of unmanned aircraft to complicate the air attack. The network of aircraft is targeted as a major vulnerability, with the goal of disrupting the pace and rhythm of the attack. And the significant reductions in the numbers of aircraft mean that follow-on force attacks, so crucial in the presence of mobile targets, are undercut in their efficacy.

With the new aircraft, air operations are conceived of differently. The F-35s operate in 360-degree space, with systems able to see hundreds of miles away. They could work with other multi-mission systems like Aegis to operate in a very different manner.

The classic systems are used sequentially, with different capabilities shaping either a signaling function or operational capability. In contrast, the new systems operate simultaneously. The F-35s and Aegis, for example, are deployed. Period. They could be used to defend, to attack, to do kinetic or non-kinetic attack. It is really up to the national command authority.

And the F-35s and F-22s will operate in a honeycomb, not a network. The planes operating as a fleet will function as separable decision makers, with joint operational missions.

An adversary can destroy parts of the honeycomb but they cannot destroy the ability of the combat air force to operate against remaining adversary forces. The fleet is not simply a combat air arm but embodies deployed and distributed decision-making capabilities.

	Classical Operational Paradigm	New Operational Paradigm
Foci	Sequential	Simultaneous
Connectivity	Network	Honeycomb
Decision-Making	Centralized	Distributed
Capabilities for Core Combat Platforms	Linear	360-Degree
Combat Systems	Additive and Managed by Pilot	Integrated and Managed by the Machines with Pilot as Decision Maker
Fleet Operations	Networked and Sequential Exposed to Ground-Attack Missile Defense Systems	Distributed Decision Makers with Stealth-Enabled Operational Capabilities

The "re-norming" of air operations will provide the foundation for building new equipment to shape enhanced capability. If the focus remains on building the older systems, one is investing in the past, not the future.

As Vince Martinez warned in a recent posting on the SLD website:

> *How do you create opportunities for martial advantage in the future? Fund technological innovation or foster growth on a production-level scale.*
>
> *If we can't collectively see the tactical, operational and strategic advantages that the MV-22 and the JSF bring to bear because we have been trained to focus on the distracters, then maybe we should try looking at those programs from a different angle; the MV-22 and the JSF are the martial enterprise's best incubators for the future — plain and simple.*
>
> *Often, you can run across military and former military people telling jokes along the lines of "…congratulations, you just managed to kill the MV-22 Program! What now, Lieutenant?" Unfortunately, this joke is now more reality than satire.*

The greatest disappointment in this whole dilemma, however, is that we likely don't have an answer to that very simple question that isn't an evolutionary step backward.

This is the time where leaders must lead, and those in the positions to do so need to ensure they are looking out long and far enough to be able to differentiate the forest from the trees.

An additional aspect in developing joint or coalition CONOPS for the F-35 will revolve around its interaction with other manned and unmanned assets. With regard to manned assets, a key challenge will be to work an effective connectivity battlespace with other manned aircraft, such as the Eurofighter *Typhoon* and legacy U.S. aircraft. Here, the advantages of each platform in contributing to the air battle and to the type of flexible military force packages that 21st-century air capabilities provide will be the focus of a joint concept of operations.

In addition to the core dynamic of working with a variety of manned aircraft across the joint and coalition battlespace, the F-35 will be highly interactive with the evolution of robotic elements. Unmanned Aerial Vehicles (UAV) are not well designed for self-defense. For early-entry UAVs to stay alive, they need to be part of a wolf pack built around the protective functions of the manned aircraft.

As air dominance and air superiority operations succeed, their significance can recede during an operation, allowing the role of unmanned aircraft to increase significantly and, over the course of the operation, supplant manned aircraft in ISR and C2 roles.

The man-machine attributes and computational capabilities of the F-35 provide a significant opportunity to evolve the robotic elements within airspace to provide for data storage, transmission, collection, weapon emplacement, and loitering strike elements, all of which can be directed by the manned aircraft as the centerpiece of a manned/robotic strike or situational awareness wolf pack.

Rather than focusing on robotic vehicles as self-contained units with proprietary interfaces and ground stations, the F-35 can be useful in generating common linkages and solutions to combine all into a core wolf pack capability.

In short, a number of key elements of innovation can be generated moving forward, ranging from new missiles, to new remotely piloted vehicles, and to new long-range strike capabilities which can leverage the new combat aircraft's ability to penetrate and operate in contested air space.

But to move forward, one needs to recognize that the new combat aircraft are not simply an iteration of change but a potential driver for new paradigms of combat operations, in the air, at sea, and in air-ground CONOPS. The old system of sequential air operations built around legacy aircraft, AWACS, and multiple assets needs to be replaced in a timely manner by a well-resourced distributed operations enterprise.

THE UNITED STATES VS. USSR: TACAIR LESSONS LEARNED FROM A "HOT" COLD WAR

http://www.sldinfo.com/?p=13410

The Honorable Ed Timperlake

The complexities of the design of U.S. and USSR tactical combat aircraft that were developed during the Cold War offer a perfect case study of an action/reaction cycle tested in combat between technology-savvy and capable enemies. Tactical aviation in the Cold War consisted of aircraft and crews that could fight, and win or die, just below a threshold that could have started a nuclear war. It was an up-close and personal battle waged by fighters and attack aircraft around the globe.[1]

The synergistic mix of technology, airborne flying skills, and the vision of national leadership made the difference. It was never simply technology alone. President Reagan's unwavering commitment to win the military modernization race against the Russians was evidenced by his famous statement, "Mr. Gorbachev, tear down this wall." Also important were the skill and leadership of both U.S. and USSR combat aviators in shaping the technological competition.

The United States and USSR had competing views on how to fight the air battle and thus used different training and tactics in support of their airborne engagement doctrine. These different approaches to CONOPS, in turn, interacted with the technological agendas and approaches.

In order to understand the complete story of Cold War aviation, senior leadership decisions to achieve combat success must be considered. Both sides tried to exploit rapidly developing and constantly changing airborne technological capabilities, but the United States prevailed and won in this race.

The Great Jet Age Rivalry: Combining Technological Advantage with Effective Employment Strategies

The advent of the jet engine as World War II ended, combined with significant improvements in radar, meant that tactical combat aircraft and airborne technology experienced a quantum leap in capability. Design bureaus in both the United States and the USSR enhanced both airframe and system performance in essentially a wartime cycle of designing and testing new combat aircraft. The goal was to secure a wartime winning edge with the results determined by success in combat.

From the MIG-Ally fights between the F-86 and MiG-15s during the Korean war… to the Israeli Air Force sweeping the sky of Arab opponents in the Six-Day War in 1997 and Yum Kippur in 1973… to the U.S. air campaigns during Vietnam, history has shown that the technological advantage shapes the life and death outcome. The Cold "hot" War in the air was an unforgiving story of success and failure.

It may have been called a "cold war," but for many combat pilots it became very hot in combat. The U.S. and USSR jet-age rivalry was a constant race to fly the best aircraft to kill your opponent.

Along with airborne engagements between fighters, there were many duels to the death by attack aircraft against surface-to-air missiles, anti-aircraft batteries, and enemy fighters. Airborne combat was a conflict between deployed offensive and defensive capabilities. It was never merely offense versus offense.

In retrospect, it now looks like the absolute determinant was actually each nation's leadership and vision, not a simple technological one-upmanship. Victory was shaped by many factors: the ability to improve airframe performance with both onboard and externally carried weapons system enhancements, combined with embracing and instilling proper command and control, as well as engaging in realistic training and tactics to exploit the best use of the entire aircraft.

With U.S. and USSR technology leapfrogging in capability it was the evolution of combat doctrine and the commensurate training and tactics successfully to fight the air battle that tipped the balance.

The lesson for the air power rivalry between the United States and USSR is rather straight forward: the technology had to be available, but it also had to be understood and successfully employed.

A fundamental rule of aviation design is that combat aircraft design features are always relative in both airframe and system performance between reactive enemies.

Understanding the design attributes of combat aircraft is simple. A tactical aircraft has basic airframe performance characteristics measured by payload, range (which can be enhanced by vertical and short takeoff and landing basing modes), maneuverability, and speed.

The system performance for an airframe can add quality considerations. For example, target acquisition capability and target engagement capability enhances an airframe's payload. Survivability enhances the entire capability of both airframe and systems.

At all times, design teams must recognize and adjust system performance because of a reactive enemy, as there is an ever-present obsolescence factor. The inventory level of fielded aircraft has a quality all its own.

Drivers for Military Modernization

Modernization of a military force can be carried out for any one or combination of three reasons:

1. To gain some new capabilities not previously available;
2. To add new components which provide for enhanced or more reliable operation of existing equipment; or
3. Simply to replace worn-out equipment that is no longer militarily useful.

Of course, modernization can also include the capital investment in facilities used for the production and modification of existing weapons or support systems. In looking at the modernization of tactical aviation inventory by type/model/series, measurement should be made only in terms of the fielded inventory.

Several inventory caveats must be acknowledged because simple comparisons of total inventories (bean counting) may not take into consideration that varying requirements exist for different regional deployments. Elemental hardware counts also overlook such intangibles as command and control, training and tactics, and logistical support. Static comparisons thus can often overlook important trends in quality and modernization.

To complicate matters a tactical aircraft can be designed for various missions and roles. TacAir is a very broad and varied category; thus sub-missions such as air-to-air (AA) and air-to-ground (AG) become very important in design.

During the Cold War some U.S. aircraft focused on one mission (air-to-air, the F-104 and F-106; air-to-ground, A-4, A-7, and A-10), while other aircraft were accomplished in all missions and were thus dubbed "multi-mission" aircraft (the F-4, F-15, F-16, and F-18).

The Soviets had the same design philosophy and some of their very successful MiGs and Sukhois were air-to-air fighters while others specialized in ground attack or were multi-mission. The great rivalry between the United States and USSR was an action/reaction cycle of design, fly, test, build, fight, and modernize. This cycle lasted for more than four decades.

One example of this action/reaction cycle is demonstrated by the MiG-21J, which evolved to become a more capable performance fighter aircraft than the F-4J. The

MiG-21J achieved higher maneuverability and top-end speed even though the F-4B started as a superior aircraft when compared to earlier MiG-21 designs. More than 5,000 F-4 *Phantom IIs* were built for U.S. and allied air forces, and the Soviets diligently worked to take away the F-4's advantage in thrust to weight. They were finally successful with the MiG-21J.

As the F-86 vs. MiG-15 or F-4 vs. MiG-21 shows, the United States and USSR tactical combat aircraft were in a design race of competing airframe and system trade-offs, and it was not until the F-15 mastered the skies in a 100+ to zero exchange rate that the U.S. fighter technology finally reigned supreme — for the time being.

Air-to-air benchmarks of success measured during the Cold War were easily expressed in kill ratios. However, the effectiveness of air-to-ground missions is a different order of magnitude and a very difficult benchmark to measure to this day.

The Human Factor: The Challenge of Shaping Effective Engagement Capabilities

Looking at combat engagements between Russian aircraft in the hands of their surrogate forces and the U.S. Air Force (USAF), Navy, and Marine aviators, during hot periods in the Cold War, sheds light with regard to the evolution of 21st-century aircraft technology.

In Vietnam, the U.S. Navy recognized that it was up against air-to-air engagements with well-designed and skillfully flown aircraft as well as a significant threat from evolving air defenses. The Navy's visionary response was to create their fighter weapons school, nicknamed TOPGUN. This bold leadership decision was a stroke of genius that made all the difference.

USAF leaders then created Red Flag to simulate, as close as possible, an environment with the complexities of a multi-plane air battle. It took strong leadership in both the Navy and Air Force to accept training losses, because TOPGUN and Red Flag came with a price — higher accident rates.

Understanding that the past is prologue, this jet-age rivalry to the death provides insights into the future of air combat in this new century.

Below the nuclear threshold, the ultimate killing machine in the world is the best fighter. The number-one fighter flown competently can kill all opposing weapons — every other weapon is dimensionally limited. The best fighter can kill everything that flies including a B-2 — if it sees it, it will kill it. The best fighter if modified or designed for multi-mission ground attack can also kill tanks, artillery batteries, infantry, ships, missile silos, and the opponent's command and control centers. To be fair, the best fighter may have trouble killing a submarine, but if a submarine is detected then airborne-dropped weapons will kill it. Finally, fighters combined with onboard missiles can even engage in anti-satellite missions, although not a preferred mission.

The lesson of the great jet-age rivalry is that both the United States and USSR were capable of producing exceptional tactical aircraft and at times exceptional pilots. Although to be fair, both sides had their share of design disappointments — the U.S. F-102 and A-5, and the USSR MiG-23 and MiG-25, for example.

However, from a pure technology viewpoint the MiG-15 versus F-86 in Korea was not an unfair fight, although the F-86 Saber did have a better gunsight.

The next hot period of U.S. versus Soviet designs was in the skies over Vietnam. The MiG-21 engagements against the F-4 in Vietnam matched two very well-designed fighters.

Finally, everything came together for America just as the wall was coming down. The air campaign in Desert Storm was a tremendous validation of U.S. air doctrine, and the greatest fighter ever built to date measured by kills-to-losses is the USAF F-15 Eagle. The F-15 has more than a 100-to-zero loss rate in aerial combat.

Embedded in American success is a strong appreciation for the complexities of success in the air in relation to the "fog of war." Although this term, coined by Carl von Clausewitz, was used for land campaigns, it is now equally important in the air.

In the air-to-air (AA) mission, killing a friendly in the confusion or "fog" is of great concern; thus tactics and technology evolved with a constant focus on avoiding this. In the air-to-ground (AG) mission, if the focus is close air support (CAS) — an air attack called in close to ground troops — avoiding friendly casualties is paramount. If reaching beyond the CAS and the AG mission to interdict opposing forces or other targets such as bridges, ammo dumps, factories, or airfields, a U.S. air campaign tries to avoid collateral damage as much as possible. Avoiding the killing of innocent civilian targets is a tactical goal of U.S. air power.

The difficulty is measuring success.

- There is a huge difference in a measure of merit (MOM) for AA success and AG success. In AA it is simply the kill ratio between fighters.

- The dilemma in measuring AG effectiveness transcends the Cold War and is still a huge problem today. In the air-to-ground mission the measure of merit is usually bomb damage assessment (BDA); sometimes damage is visible with great clarity, and other times it is very opaque and murky. It is much harder to judge the results of TacAir modernization, tactics, and training in the AG mission.

For the AG interdiction mission during the Cold War, there was a major technology shift to rely upon enhanced weapons. The U.S. attempts to destroy the Paul Doumer Bridge over the Red River in Vietnam captured this dynamic. The Paul Doumer Bridge was essential to the Vietnamese war effort because it connected Hanoi to the port of Haiphong.

Many courageous attacks were made against the bridge during the Vietnam War. Correspondingly, the determination of the Vietnamese to defend and rebuild was also evident. Many bombs were dropped and planes lost over the course of the war.

Finally, in May 1972 everything changed. USAF F-4s armed with laser-guided bombs made an attack with pinpoint accuracy. This was really the first indication that AG performance had shifted from the aircraft to an integrated marriage of an airframe, with internal systems and technology embedded in the weapon itself.

In the CAS mission, the same trend of an airframe, internal systems, and improved externally carried weapons also evolved, as demonstrated in an interdiction raid in May 1972 over the Red River. This AG trend is ongoing and still one of the most difficult problems in combat aviation well into the 21st-century.

Unlike a kill in AA, AG battle damage can be very difficult to assess. To further complicate the issue a reactive enemy on the ground can be very clever at camouflage. Destroying a bridge is a highly-visible "kill." The effects of a CAS strike are easy to measure, if the enemy stops firing. Other targets further away from the edge of the battlefield are much more difficult to count as destroyed, assuming that they are even viable military targets… the camouflage issue.

One additional and very important aspect of winning the air battle is the need to concentrate on suppressing enemy air defenses (SEAD). From bombing and strafing WWII "flack" batteries to today's air campaign, a lot of technology, training, and tactics have evolved. American lessons learned from Vietnam were acted on because an entire generation of U.S. combat pilots vowed to not be Tom Wolfe's famous characterization "human skeet."

In combat, the losses mount up.

During the Vietnam War, approximately 2,251 Air Force aircraft were shot down with an additional 514 lost in operational accidents. The Navy flyers in the "Tonkin Gulf Yacht Club" lost 530 planes and an additional 329 in accidents. The Marines, operating mostly from land bases, lost 193 fixed-wing aircraft and 270 helicopters. The Army pilots reportedly lost 5,086 helicopters including more than 1,000 Air America CIA helicopters.

High-intensity modern combat against even what Secretary Gates has called "non-peer competitors" can chew up and destroy the most advanced aircraft.

Doctrine, Tactics, and Training: Fundamental Differences

Since the end of the great Cold War rivalry, there was a moment in time when there was one huge difference between the super powers in their approach to fighting an air battle. The planes were essentially relatively equal and the pilots were trained as well as possible. But the tactics and command and control philosophy between the United

States and USSR were totally different, and that is the real lesson for a 21st-century air campaign.

The first and most paramount goal of the U.S. Air Force, Navy, and Marine aviators is to establish air dominance. If the aviation units attacking ground targets are free from concern of being shot down by an opposing fighter they will ultimately accomplish their mission.

With air crew skill, competent leadership, and a national will that ensures adequate resources, tactical aircraft flying with extremely accurate standoff weapons complemented by cruise missiles can pick apart ground defensives. A U.S. air campaign might be costly, but without an enemy fighter threat a smart air campaign will currently always beat ground defensives and then ultimately destroy the enemies' combat forces on the ground.

The real element of achieving air dominance is the person Tom Wolfe, in his great book *The Right Stuff*, identified at the top of the aviation pyramid – the fighter pilot. However, measuring the quality (and success) of fighter pilots, especially in aerial combat, is an extensively researched, modestly understood, and fundamentally complex phenomenon. Innumerable psychological and physiological factors — along with opportunity and chance — contribute to the effectiveness of pilots in air warfare.

Combat training for aviators is more than acquiring the skills of flying and delivering weapons. Preparations must also include tactics and training. But tactics are much more difficult to assess. Even assuming one can accomplish the difficult task of finding out what tactics a force is actually learning — a challenge made even harder in peacetime — the real difficulty comes when trying to compare one set of tactics to another.

Who can say with confidence that flexibility, a strong American trait, will win out over dogma, or that simple tactics are always better in actual combat than complex tactics? However, the task is not hopeless because there is an historical difference between the United States and USSR prior to the Berlin Wall coming down.

There appears to have been three criteria to judge the effectiveness of the U.S. and USSR air campaign tactics:

1. Level of Authority — The level in the chain of command that has the authority for promulgating tactics. There are two extremes: one in which the highest command dictates tactics, and the other a bottom-up scenario where the pilots are totally free to innovate.

2. Simplicity/Complexity of Applied Tactics — Taking into account the Clauswitzian concepts of the "fog of war" and the "friction of battle" which might suggest complex tactics are inherently unstable in actual combat.

3. Flexibility of Leaders/Adaptability of Aircrews — Flexibility refers to the capacity and willingness of leaders to adjust in the face of a dynamic war with

an adaptive enemy and the skill of aircrews to adapt readily to the required changes. This is what the late Colonel John Boyd, USAF has described as the capacity to get inside an enemy's "OODA Loop" (the observe, orient, decide, act cycle).

When the level of authority for promulgating tactics lies in the high levels of command hierarchy, tactics usually evolve through a formal process and tend to be rigid. The USSR embraced this top-down solution. Their doctrine allowed little deviation from "the school solution." Since the fall of the Berlin Wall all this became obvious.

The USSR was rigid on having a ground control intercept doctrine. Air Marshal-approved tactics were published and were rigorously enforced. The acceptable size and nature of formations, in-flight procedures, attack patterns, philosophy of engagement, and weapon firing and communications procedures were all spelled out in detail.

Until the Americans caught on in Vietnam, a Soviet surrogate, the North Vietnamese Air Force, had some success with rigid ground-controlled, vectored fighters. But after TOPGUN, the ratio of U.S. airborne kills to losses shifted dramatically in favor of the United States.

Additionally, the Israeli Air Force had remarkable success in the Middle East going against their Arab opponents who were utilizing Soviet equipment and tactics.

When authority lies in the lower levels of command down to the pilots themselves, there is a tactical manual, but its contents serve more as guidelines than regulations. Thus, aircrews have both the freedom and responsibility to test the recommended tactics and develop better ones. Individual creativity and initiative are encouraged.

Pure top-down or bottom-up approaches are extremes. The USSR ground control intercept doctrine was very rigid, and their allies were also very top-down. While the United States and its allies fostered a bottom-up philosophy.

Air-to-air and air-to-ground combat are inherently complicated and demanding tasks.

- In air combat maneuvering, a pilot must be able to project the paths of several objects moving in three-dimensional space, and do so more quickly than his opponent in a life or death situation.

- No less demanding and dangerous is air-to-ground combat where pilots must meet daunting ingress/egress requirements, evade air defense missiles and "the golden BB" from triple-A fire (anti-aircraft artillery), while attacking moving and camouflaged targets.

In actual combat, U.S. combat leaders have determined that simple aerial tactics have an inherent advantage over complex ones. Simple tactics are easier to commit to second-nature responses and are, therefore, less likely to break down in stressful situations.

A historical take away from the "hot" Cold 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 is more complex.

In air-to-ground, airborne simplicity indicators are usually smaller formations with 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.

Role of Leadership, Technology, and the Future

A reactive enemy can always develop the necessary technology to try and mitigate any advantages. With the worldwide proliferation of weapons, even a second- or third-world nation could 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 U.S. national command authority on how the United States would fight an air campaign.

The peer fight in the air abruptly ended when President Nixon unleashed the full power of U.S. air forces in the famous Christmas bombing of 1972. The war ended quickly after that. When North Vietnam invaded South Vietnam in 1975, U.S. air power was not used like it was in the 1972 invasion, and the result was a dismal failure.

The lesson learned from the U.S.-USSR rivalry is that air combat leaders must be able to change strategy and tactics during an air battle or a war in order to exploit 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 surprise and exploitation. In the cockpit "knowledge is good" — it can be a life saver and aid in mission accomplished.

The USSR's model, where the air-to-air engagement was enslaved to a ground-controlled radar attack, 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, there has been a constantly evolving process whereby human factors are integrated with technology. The Cold War ended well for humanity. A lot of courageous pilots, bold leaders, and smart technologists deserve credit for this victory.

The United States would be wise to remember the lessons learned and the devoted pilots who paid in blood in order for America to have the best technology flown by the world's best Air Force, Navy, and Marine aviators. More importantly, it is an imperative that America wisely shape its concepts of operations to take full advantage of the fifth-generation aircraft and the associated new tools of combat.

Author's note:

In 1981, as President Reagan was just taking office, the CIA Theater Forces Division Office of Strategic Research hired me to develop a methodology for estimating Comparative Aircrew Proficiency. This effort built on previous research sponsored by Andrew Marshall, Director Net Assessment, Office of the Secretary of Defense who had supported research to measure comparative force modernization of U.S. and USSR aircraft, trying to balance the "quality" of a country's tactical aviation assets with the "quantity."

Combining both analytical approaches gives a fairly good snapshot of the great rivalry between the U.S. and NATO allies against the Soviet Union and Warsaw Pact nations. Each side had varied and unique approaches to establishing air dominance using their own design concepts while focusing on the great "intangible" — aircrew selection, training, tactics, the command and control of the force, and finally actual combat engagements.

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[1] Before proceeding it must be recognized that Tactical Aviation actually was a second-order technology imperative during the height of the Cold War because of the issue of global nuclear war and strategic bombers being an important part of what the United States identified as a Triad — bombers, ICBMs, and submarines with nuke warhead missiles.

To stop the bombers both the United States and USSR built point-defense interceptors and an extensive network of ground-based radar and command and control centers to vector interceptors toward penetrating strategic bombers. Interceptors would be controlled from a ground-based radar center, following a "ground control intercept" (GCI).

As airborne system technology improved, many interceptors were designed with airborne radar (F-4 was a success story) so they could independently acquire, lock-on and shoot down a bomber with a missile or cannon/machine guns. The United States did tend to favor offensive strike, while USSR designs tended to favor point defense. Hence over time, some stellar United States air-to-air fighters became also multi-mission standouts, such as the F-15 becoming an air-to-ground Strike Eagle. This article is only up to the Fall of the Wall and at that time the USSR was finally also beginning to develop some very capable multi-mission aircraft — the SU-27 family type/model/series progression is an excellent example.

To further complicate the TacAir picture strategic bombers were also used tactically, and the most successful example in history was the B-52. The B-52 was successfully modified and employed as a conventional bomber— for example, the term "Arc Light" was used in Vietnam when B-52s were used as conventional air-to-ground interdiction bombers.

Both the United States and USSR had specific interceptor commands to focus on developing the best technology and tactics to address the strategic bomber threat. This article will show over time that American Air Generals were ultimately much more flexible to change and adapt in the combat employment of all air power assets — bombers, interceptors, GCI sites — from the strategic deterrence mission to the much more deadly mission of actually fighting tactically.

Part One

The Strategic Shift to Distributed Operations

COMBAT AIR POWER: THE NEED FOR A NEW PATH

http://www.sldinfo.com/?p=11608

An Interview with General John D. W. Corley, USAF (Ret.)

General John D.W. Corley, USAF retired November 2009 as the four-star commander of the Air Combat Command, with headquarters at Langley Air Force Base, Virginia, and Air Component Commander (ACC) for U.S. Joint Forces Command. ACC operates more than 1,200 aircraft, 27 wings, 17 bases, and more than 200 operating locations worldwide.

General Corley is a widely respected air power thinker and joint force commander. In this interview, he provides us with a *tour de horizon* on air power and national security strategy with an emphasis on how to leverage the new capabilities for the future joint and coalition forces.

SLD: Why do we have a combat air force and what is the role of that force within the U.S. Air Force and the joint forces?

GEN Corley: The U.S. Air Force is historically associated with *global* vigilance, *global* power, and *global* reach. I think it's with good reason that we start with global, because if you spin the globe and park your finger at any point on the globe, the Combat Air Force (CAF) will be able to influence operations at that point.

Traditionally the CAF was combat air power, but today the CAF is more than just fighters and bombers operating in the air. It incorporates our air, space, and cyberspace, airmen, organizations, and capabilities to deliver global power and to provide for global vigilance.

USAF global tool sets are necessary to underpin a national military or a national defense strategy, which, in turn, underpins a national security strategy. Global power and global vigilance are where I would start as we discuss the role of the CAF.

SLD: What are the enduring contributions such a force must provide?

GEN Corley: I think the enduring capabilities for a CAF are, first, the ability to dissuade, deter, and reassure. We are missing the point if we don't have an ability to dissuade an adversary, to deter an adversary, or to reassure an ally. Another key enduring contribution is decision superiority. How do I make a more fact-based or more informed-based decision than does my adversary? Whether my adversary is someone regular or irregular, nation state, near peer, new peer, or some extremist, how do I make decisions that are better in a shorter period of time than the adversary can make?

SLD: A term we use in place of C4ISR is C4ISRD. Can you discuss C4ISR as the tools that can either get in your way or facilitate good decision making?

GEN Corley: We seem so magnetized to start each conversation or punctuate the conversation at only a platform level. We want to talk about an MQ9, or we want to talk about a *Predator*. Such an approach totally misses the point. We need to be looking at how information flows from sensors on board a platform (whether air based or space based), and how that is used. How is that information assessed, analyzed, distributed, and used, and for what purpose? Ultimately, what we want is to make better-informed decisions. So, dissuade, deter, and reassure come first, then decision superiority is our second enduring end. I would argue whether it's today in Afghanistan or in some other future operation, what you call C4ISRD is crucial for mission success.

SLD: What you're describing are persistent requirements throughout different spectrums of warfare operating in a variety of scenarios. Are these constants which are necessary to achieve mission success?

GEN Corley: They are ends. Another enduring end, and a theme that is pulled through the JOE or the joint operating environment, plus pulled through the Capstone Concept for Joint Operations, is the necessity for operational freedom of action. I believe that the ability to deliver on freedom of action is again, an enduring end for a CAF. Whether it's a maritime domain, an air domain, a cyber-domain, or a space domain, the desire to obtain and maintain freedom of action is a necessity; it's an end that you have to deliver on.

SLD: We have a number of regional partners, and few of them have global reach. If the United States doesn't bring global reach to the party, then it's going to be very difficult to give allies freedom of action, because their freedom of action is constrained within the region in which they operate.

GEN Corley: All true. Otherwise, deterrence theory does not work. There's another word I would throw out for consideration, and that's the word credibility. If we do not have the tools to underpin the global precision attack concept of operations, then we can't deliver on the enduring capability to dissuade and deter. If we can't deliver on dissuade and deter then allies are not reassured, and those allies could make choices to proliferate a family of capabilities not consistent with U.S. strategic interests.

The CAF needs a flexible set of tools that friend and foe alike can credibly believe might be used. Use of them, in turn, would imply that even more powerful tools would be used, if they don't accept my interpretation of the situation. If I don't have the "front game" tools that I can employ rapidly to facilitate accurate, rapid decision making, the other guy may misunderstand my longer-term intent. Ironically, the more you reduce effective deployable tools, the more you risk creating a WWI situation in which sides start mobilizing capabilities without a sense of the end game.

SLD: So if you're absent the proper tools, you're absent the credibility.

GEN Corley: To that point, this week twelve F-22s and six B-52s are rolling into Guam for the purpose of supporting a continuous bomber presence in Guam. In my mind this feeds into the dissuade, deter, and reassure aspect that needs to be underpinned; but if you are absent flexible tools or you're unwilling to use those tools, then your ability to underpin that enduring capability begins to disappear.

SLD: Are there other enduring capabilities which you would consider important?

GEN Corley: I have talked about dissuade, deter, and reassure. Then we talked about decision superiority. We also briefly discussed operational freedom of action. A last enduring end that I would like to emphasize is persistent pressure. Persistent pressure provides the joint force coercive pressure in the form of multidimensional, distributed, coordinated, lethal, and non-lethal effects. This locks down areas of interest and denies an enemy freedom of action. By the way, all these enduring ends are not mutually exclusive. They have inter-dependencies across them.

The enduring goals or objectives of the CAF are underpinned by a set of concepts of operations. For the air domain, air superiority is a service core competency of the Air Force, bolstered by collaborative competencies from other services that also contribute to air superiority. This is a constant of operations that underpins operational freedom of action.

If you don't underpin operational freedom of action, then again, your freedom from attack, freedom to attack, and freedom to maneuver vanishes. If that vanishes for the joint force, then I don't think you have an effective fighting joint force. I also think your ability to dissuade and deter is called into question.

An example of that is the global precision attack I discussed earlier. If we can no longer hold targets at risk because we no longer have credible assets to be able to strike targets, whether those are lethal or non-lethal ways to strike those targets, then we are no longer credible.

For example, when the 509th bomb wing's 20-year-old B-2 platform no longer possesses the ability to penetrate anti-access environments, even with the finest aviators, maintainers, and logisticians, then the global precision attack concept of operations is called into question. If it's called into question, can you credibly dissuade and deter? And so the enduring capabilities begin to come apart.

SLD: How do we maximize the air superiority effort in our current constrained fiscal environment?

GEN Corley: The approach is to leverage extant legacy assets, building upon the foundation provided by F-22s and F-35s. For example, if I've got a fleet of F-15s, how can I leverage those F-15s in a potential future environment at the challenging end of the scale with the range of military operations? Today F-15s, F-18s, or F-16s do not possess the needed survivability to operate inside an anti-access environment. You can say what you will, argue all you want, but they will not be survivable.

From a CONOPS point of view, they're being pushed further and further out due to terminal defenses or countrywide or regional defenses that exist. And this diminishes their utility, but they can still be effectively used.

For example, you may take an existing platform, like an F-15, from the Air Force and begin to apply a pod to provide for infrared search tracking, so that it could basically begin to detect assets and then feed that information back to other assets. Or, by providing for connectivity with some advanced tactical data link, that platform, in turn, could be directed to launch weapons from it.

Even if we have the capabilities of platforms like the F-35, F-22, B-2, or a follow-on long-range strike platform, they ultimately will be limited. Limited by what? Limited by things such as their capacity to carry weapons.

In order for us to apply persistent pressure we need to have some capacity to employ others' weapons.

If I eventually run my F-35s out of SDBs, or out of JDAMs, is there a way for them to still contribute to the fight because they're inside of that anti-access bubble, still using their sensors, still communicating? Can I contribute to weapons employment from other platforms, outside the anti-access bubble to enable the concept of operations and apply persistent pressure?

SLD: What you're describing is when the F-35, for example, or the F-22 is in the anti-access environment, it will carry less weapons because they're internal to the aircraft.

GEN Corley: A CAF aerial vehicle needs to be lethal; it needs to be survivable; it needs to be supportable, and design traits have to enhance survivability. They have a limitation in terms of lethality capacity from a weapons metric due to the design for enhanced survivability.

The weapons are inherently limited because of internal carriages, which were demanded in a design trade to enhance the survivability aspect of the platform itself. We have four weapons bays in an F-22, two weapons bays in an F-35, and three weapons bays in a B-1. You can try to optimize the different types of weapons that you carry, but, of course, once you take off with that set of weapons, functionally it is in fact limited. I only have so many weapons I will carry inside the aircraft.

SLD: What do you see ahead for the next-generation weapons for the F-35?

GEN Corley: We should not simply extrapolate an evolutionary path where we go from what was a 2,000 pound JDAM, a small-diameter bomb, and a small-diameter bomb that's launched at 1.6 MACH… that has this kind of range or that arrives at a range. Or tailor the number of weapons carried on a B-2 by the use of a 500-pound-class weapon and assuming it will hit an equally larger number of targets. It doesn't necessarily translate that the results will be increased by this process. You could determine if there are other weapons that are not necessarily yielding blast-frag effects but still yield a different effect on a target. It doesn't just necessarily have to be a size and weight determination.

SLD: If you add another trend line — innovative thinking about small UAVs — you could be dumping a small fleet of UAVs out of a bomb bay for various uses and various effects. Circa 2010 judgments about the value of the internal base of the F-35 and F-22 are certainly not going to be accurate 10, 20, 30 years from now.

GEN Corley: Any development of a major weapons program that I'm aware of in the Department of Defense that's going to have three decades' plus worth of military utility is going to have a growth associated with those three decades; it's not just going to be stagnant unless someone makes a conscious decision, and a foolish decision in my mind, to stop this development.

SLD: When you are talking about modernization of the assets, there are two ways that you can look at this. One is you've introduced the F-35/F-22 as a new baseline. You're reaching back to modernize the extant fleet; what you're not doing is buying newly manufactured versions of legacy aircraft.

GEN Corley: In fact I'm advocating against that. When we talk about modernizing legacy assets, we're talking about modernization of those legacy assets to try to yield the greatest degree of combat capability across the entire fleet. But the risk I talk about can be measured as risk of failure of the concept of operations. Even if I modernize them with the new data links so that they can communicate with platforms inside of an anti-access bubble, there are inherent limitations. What if an adversary in the strategic process winds up with a new weapon to push them further out, therefore yielding their weapons carriage capacity as moot, because now their new weapons don't in fact reach back inside that anti-access environment?

SLD: Another key element, which the new assets introduce, is enhanced reliability rooted in viable supply chains.

GEN Corley: It's an essential element. For example, if you take a look across the F-15 platform, there are some hundred and fifty plus single-point structural failures alone. We really don't have insight into what the structural viability of those platforms is, so as you're investing in modernization in new systems, advanced tactical data links, and other things to leverage the ability of those legacy platforms, it's not without risk. Until you complete teardowns, you won't have a sufficient understanding of the real service life of a platform. If we invest those modernization dollars in structurally unsound legacy platforms, we need to ask if those modernization dollars could have been better spent some place else. They certainly would not be better spent in trying to buy a new one of those same platforms whose military utility today is being called into question.

SLD: What are some of the ways you can shape new capabilities leveraging the new F-35/F-22 "re-norming" baseline?

GEN Corley: Let us go back to the global precision attack requirement. If you're not credible — and we're beginning to worry about the future credibility of even the B-2s and their ability to penetrate anti-access environments — that sets the stage for an argument for other capabilities could help us underpin that global precision attack concept of operations. We need to make sure that remains a viable concept of operations.

One way might be to enable an existing set of platforms, and those existing sets of platforms could in fact be the launch vehicles for things like the MALD (Miniature Air Launched Decoy) or MALDJ (Miniature Air Launched Decoy Jammer). One would be used to stimulate a set of air defenses, causing the adversary to question what is in fact real versus what is a non-real threat. If an adversary can't discern what's real from what's not, then they're going to have to target everything. This causes obvious problems for your adversary!

Then of course, you would like to have some sense of whether or not that's working. I remember Greg Gonyea, who flew one of the first 117s in the first night of our Gulf environment. He was the one who coined the phrase, "Gee, I hope this stuff works."

SLD: Can you discuss the synergy between the new tactical aircraft and a new longer-range platform?

GEN Corley: Folks are looking at not just a platform but also a family of systems. This family will need to provide long-range strike capabilities that still allow us to be credible — to hold targets at risk. The system will need to be able to underpin the enduring capabilities of dissuade, deter, and reassure.

Is it long-range strike the platform, and what does that mean? Is it long-range strike the weapon? Is it long-range strike defined as some conventional prompt global strike asset? That appears to be a divergent set of families that are being considered.

Long-range strike (the platform) is not just useful in terms of its ability to deliver a kinetic weapon against target to hold it at risk; it's also a long-range strike penetrating platform because that allows the sensors to be closer to the areas of interest.

SLD: Another key consideration is the nature of the likely adversary against which you would build such a target set. Can you discuss how you would deal with adversaries who have enhanced mobility and mobile defense systems?

GEN Corley: I have to have penetrating capability in a local and fluid environment. With modern air defenses, modern defenses, semi-submersible, small ships, different kinds of missiles, anti-access missiles, as we call them, or simply S300s, you're shaping a very different and more complicated environment in which to project power and penetrate defenses.

SLD: It sounds like decentralized execution where the individual making that decentralized decision needs to have a robust way of gaining more confidence in the decision that he or she is going to make.

GEN Corley: Sometimes point solutions yield very bad information into a network. Even if you drill down, you wouldn't want to assume you have information that suggests this is in fact not a friendly asset. What if that friendly asset had some component on board a platform operating in the maritime that was malfunctioning, and you made your decision to attack based purely on the fact that it is not emanating some positive "I am a friendly blue-force entity"?

I'm going to circle back to the robust nature of the F-22 and F-35 platforms. I'm going to come at it from a couple of different approaches. Number one, to the individual decision maker, to the operator, whether that operator is remotely operating or physically operating, they're just looking for enhanced credibility of information, and since this war business is inherently a human endeavor, the human beings are looking for it to be additive bits of information. When I talk about robustness, I like the thought process that something could be pulled out of a system and not cause the ultimate collapse of the system itself. I do not want to be in a situation whereby if I lose a single entity or a single critical node, I have lost the ability of that system to function and therefore my ability to execute the concept of operations is destroyed.

SLD: You don't want the node to be a linchpin; you want it to be a modular element which is replicable.

GEN Corley: Right. Also in terms of the new norm in some of these platforms, like F-35, I like the digital aspect of them as opposed to waiting two years to get the next OFP (operational flight program) updated. I'd like to be able to have an ability to update things in a more rapid fashion. I don't want to wait for an added capability when that added capability is necessitated by what's occurring in front of me today. I like the digital aspect of being able to upgrade the aircraft and its systems rapidly. I love to have digital interfaces because I would like to be able to bring on board a new weapon and not go through many months of examination — designing the next Rapid Prototype (RP), getting the control panel to talk to the central computer, getting the central computer to display a different weapons engagement zone in terms of a head-up display, and then ultimately trying to discern what is sensor suite A telling me, or sensor A telling me via sensor B, and trying to resolve the anomalies between them, and then trying to bring those together.

SLD: Another aspect of the digital character of these aircraft is the ability to enhance the reliability and maintainability of the new aircraft.

GEN Corley: How could you ever argue against this digital world? It yields more identification of fault, if a fault does exist, and helps you isolate where that fault is. It helps you identify what maintenance is required. Pooling that information in a carefully protected manner so that it can be interpreted and acted upon is critical. Not to mention that the individual operator can understand the impact of the fault. What are the ramifications? Operators would begin to understand they still have viability in the conduct of a mission that they're currently performing.

SLD: What have we learned from the F-22 to date?

GEN Corley: A lesson learned is that people failed to understand the importance to the joint force of operational freedom of action. They started with the argument over the F-22, when they should have started the argument over how the joint force is underpinned by, supported by, and is critically enabled by operational freedom of action.

Operational freedom of action can only be delivered inside an air domain through a concept of operations, which is air superiority. That yields what capabilities you need, including the F-22. So instead of starting with a discussion of the pros and cons of the F-22, I think the discussion should start with an analysis of what the joint force necessitates — what the maritime, on land, and air need to ensure operational freedom of action. That is resident inside that capstone concept of joint operations and inside of the JOE, and that is necessary to underpin national security.

That's one of the first lessons.

SLD: I think the F-22 has been viewed as the F-15's successor, and largely as an enhanced classic air superiority fighter. What does the F-22 bring to the core structure to allow the force to move forward?

GEN Corley: Earlier, I talked about the ability to dissuade and deter. I talked about decision superiority; I talked about operational freedom of action; I talked about persistent pressure. In my mind, the capabilities resident inside of an F-22 can actually, through multiple concepts of operations, yield contributions in all of those simultaneously.

It doesn't just simply go out, kick down the door inside of an anti-access environment and establish, obtain, and maintain air superiority. At the same time it is yielding decision superiority because of the sensors that are on board. That's why in increment 3.1 there are enhancements in geo-locating targets on the ground with the synthetic aperture radar. That's why it's able to pour information off board in increment 3.2 from F-22 to other F-35s and to other B-2s. That's why you can deploy F-22s to Guam in a continuous package to dissuade and deter. That's why you can use it as a power tool deployed into a regional area. Those are all threads and all stories about the F-22 which have not been told and which I hope people begin to understand so that other assets aren't compromised.

SLD: We have historically talked about sequential escalation, and that's been rooted in the nature of the structure of the tools we have. What's interesting about the nature of the new tools, whether it is F-22, F-35, or Aegis, is that I can deploy this kit and it's not an escalation; it's a deployment. I could be using it for defense, I could be doing it for security ops, I could be doing it for strike, or I could be working with allies. The simultaneous quality of being able to strike, to provide data on targets distributed to assets in other regions, doing some air battle management, able to work in a distributive environment, operating in a distributive environment simultaneously is what's new.

GEN Corley: Excellent point. In earlier decades we bought more of one new type of capability in a given month than the United States Air Force buys in an entire year. That fiscal environment allowed us to buy very specialized platforms in sizable quantities, platforms that were focused solely on a specific capability — specialized capability like air superiority, or specialized air surface capability like an F-117. Those fiscal and industrial environments don't exist today. Now, because of the birth of technology, the age of the digital world, the enhanced sensors, and kill chains associated with weapons, and enhancements in terms of survivability with the new aircraft — we need to pursue another path. This path is to build upon the F-22/F-35 foundation.

"RE-NORMING" THE ASYMMETRIC ADVANTAGE IN AIR DOMINANCE: "GOING TO WAR WITH THE AIR FORCE YOU HAVE"

http://www.sldinfo.com/?p=11959

The Honorable Michael W. Wynne, 21st Secretary of the U.S. Air Force

Secretary Rumsfeld, in one of his philosophic comments, said, "You go to war with the Army you have, not the Army you want." I would suggest a similar approach to understanding our capabilities for future concepts of air operations and making modifications to accommodate them.

A realistic look at the future of air operations must take into account the size of the force, the capabilities of the force and the evolving construct of the future weapons available; then we can place this template of available forces against what technologies would or could maximize their utility to a combatant commander. There has been steady erosion in the quantity of aircraft being made available to allied air forces around the world. For the past several generations of development, we have substituted combat qualities for enhanced quantities within each platform.

To deal with declining numbers ("quantity has a quality all of its own") calls for imagination and innovation in thinking about future investments and concepts of joint operations. We need to leverage technology trends and pick strategies that our ground combat commanders have used historically — to restore the unfair fight and ensure that we have superiority at the point of the spear.

At the same time, we must focus on ways to minimize the probability for failure, while we maximize our probability of success. We may be longing for the days of large numbers of combat platforms, but now must consider where we are and what are the real, not desired, trends affecting deployable capability.

We cannot rely on the ability quickly to accelerate our industrial capacity, as we have in the past. We must consider the fact that the speed of war has increased, and that the time necessary to field new technology marvels has increased. We must take to heart Secretary Rumsfeld's comment and begin to design a future plan that allows for erosion in our "asymmetric" advantage.

Building such CONOPS is rooted in more data sharing and more integrated tactics. We need to reach into the ground commander's kit and shape air versions of forward observers, weapons teams and spotters to assist with targeting. We need to provide for layered offenses to match layered defenses.

In other words, as we shift from older notions of our capabilities for air superiority, how do we shape dominance on the battlefield? What must be understood, as General Corley has forcefully underlined in the previous article, is that, without air superiority, it is impossible for the joint warfighter to operate at all or effectively in projecting global power.

Realists point out that if you want to know the capability of the armed forces ten years from now, you must look around today. Even Germany's Blitzkrieg capability was minimal in 1940; in many ways it was an aspiring template relative to the bulk of their deployed forces, some of which were still horse drawn and supplied. Indeed, if one looks carefully at Leni Riefenstahl's masterpiece *The Triumph of the Will*, one sees as many horses as tanks in the propaganda film.

Unless actions are quickly taken, the structure of America's capability to provide air dominance in a future fight will decline dramatically. And with this decline will come reduced freedom of action for our allies as well.

The size of the air arms of the U.S. forces is clearly going down. Current Air Force plans call for standing down 250 fourth-generation tactical fighters as the transition to the complement of 185 F-22s. This represents a total inventory and not an operational inventory that is closer to 150. Added to this is the emerging, but undetermined and as yet undeployed, F-35 fighter.

Fifth-generation air will slowly grow with deliveries, and the Marines will push the AV-8 out of their inventory as the STOVL F-35 sparks their imagination regarding CONOPS. Navy has asked to invest further into fourth-generation fighters, as their F-35 CV version goes through the testing phase and they worry about the viability of their aging carrier Air Fleet and see the need to populate the carrier decks. Clearly, the resultant structure of U.S. air power will be a mixed fleet of fifth-generation and fourth-generation fighter aircraft for an indefinite period. Meanwhile, several specialized capabilities central to past successes will be rapidly aging or altogether eliminated. Among the aircraft that the American military used to penetrate the air defenses in Iraq in 2003 are the F-117s that have been grounded and the B-2, which continues to age with its reduced capability to penetrate increasingly sophisticated air defenses.

Adversary defenses have not remained static; integrated air defenses are now becoming much more effective and much more mobile. The strategic trajectory is to update defenses with regard both to range and maneuverability. Competitors have complemented these defenses with upgrades of their own air fleet using a mixture of calibrated 4.5-generation technologies.

Competitors are introducing near fifth-generation capabilities, such as the new Russian fighters, and others are shaping new-generation missiles for their own use and export. The Chinese will be able to project power simply by exporting missiles to various developing states, and can up the ante in any Middle East confrontation.

The mission concerning air dominance is unyielding and will continue to call on our brave pilots to hold hostage targets anywhere in the world: to do so requires an ability to penetrate integrated air defenses, and along the way to deter or defeat enemy air.

This puts CONOPS pressure on the other elements of the combat air force. The refuelers or tankers become essential to power projection. But they are not being replaced in a timely fashion. Other approaches may be necessary, such as developing the concept of drop tanks for fifth-generation aircraft as they sortie to the battle zone, thus allowing tankers added discretion. But compensating for missing tanker platforms by such means is not optimal.

We need to take a hardheaded look at what we have to execute the air dominance mission, and therefore complement the ability of the combatant commander to succeed by extending well into the 21st century America's control of the skies. We cannot continue to assume a dominance, which has been built by past investments, absent a robust engagement to shape capabilities for the future.

We need to look into the benefits of the current investment and the technologies, which are or can be brought to bear seriously to level the fight. I have a philosophy that if America is ever in a fair fight, we have suffered from bad planning.

Though this stems from the clear asymmetric advantage that has been whittled away, coupled with the Clausewitzian advantage always granted to defenders. What then are the available platforms and technologies that we have invested in to date? And how can we shape effective Concepts of Operations for a Joint and Combined Air Strike Force, which leverage these capabilities?

I define joint as involving all available American Air Forces that would have an intrinsic advantage of interoperability. The first recommendation would be to expand the limited tactical cross training that currently occurs and expand the limited set of advanced fighters; this could be a singular mission. I define "combined" as a coalition of the willing, which for our allies might well mean acquiring their version of the Joint Strike Fighter.

In defining tactics, one might recall how even in the Battle of Britain true integration was far more likely in a tattered set of infantry units than in air units. Assuming such integrative capability is a major leap of faith, but may be mandatory. As the current Chairman of the Joint Chiefs admitted, future navies may need to operate together as he witnessed the decline of the U.S. "blue water" Navy and called for a global 1000-ship navy.

Combined forces must train together for maximum result. This puts pressure on diplomats to assemble a combined force, as it puts pressure on the Joint Staff and the combatant commander to allow the air component commander to execute this part of the mission with full joint assets and to have an interoperable force.

Though the design engineers and the human factors professionals combine their talents to make fifth-generation or advanced fighters "easy" to operate, the book *The Outliers* underscored the need for concentrated operator time in order to truly exploit the enormous capacity we are in the process of fielding with these new systems and technologies.

The capacity we are fielding can allow the force application designers to devolve more authority to the pilots; the F-35 becomes then the first-generation air combat battle management system. The information age has granted to the computational system all the benefits that the intelligence agencies once husbanded for fusing sensor-received information, and the sensor capabilities have offered to the pilot an unprecedented view of the three-dimensional battlespace.

On top of what the individual fighter asset will be able to do, the ability to interchange information among platforms is a significant bedrock for change in CONOPS. Such a capability will allow the pilot to be a node on the net with an internal router able to receive and transmit information to air operation centers, air operation commanders and combatant commanders.

Such interactive, distributed capability was once planned for later generations of the F-22, which can play a similar role. The interaction between the F-35 and the F-22 in terms of onboard systems is a key dynamic for reshaping air capability, and as the next generation of remotely piloted aircraft gets added to the mix we will have a strong baseline for "re-norming" air operations. The technology for this is widely known and available for incorporation.

But several key questions need to be resolved and challenges met to leverage the new capabilities inherent in the new technologies:

- Now that the nation has minimized the quantity requirement, will it maximize interconnectivity and, therefore, the quality of the force?
- What will be the training opportunity for the interconnected air fleet, with the Navy model of three months to interconnect a battle group?
- Will the interconnects include our allies to get in the air what the JCS Chairman once quested for the sea… a 1000-ship navy?

Such shared and congruent capability truly assists in managing sensory overload, as the system can establish "chats" and the displays automatically integrate inputted targeting information. What is available is target cataloguing such that the air operations center can optimize the available shooters to fulfill target opportunities.

The sensors can be easily extrapolated to "see" moving targets versus stationary, but the system must off board and discard these so that the principal mission set is executed. Air operation commanders can reset the mission set, but this must be accomplished as well in the pilot's seat — as if all the participants are acting together. In past engagements, there has been a debate as to how to best penetrate enemy airspace. Stealth was considered by some a "silver bullet" strike system sufficient for executing such a mission. But, as historians have noted over the decades, the enemy has a vote in the development of the battle. They too are shaping the battle to fit their designed response.

Under current thinking, American planners have called for increasing the quantity of penetrators to meet global competitors, and for co-opting the integrated air defenses. Given the current forecasts for platform numbers, this will not be achievable. Different strategies and different tactics will be required to deal with integrated air defenses, such as capabilities to expose these defenses in ways that allow the penetrators to shape the battlespace.

During past conflicts and even into the more modern era, "reconnaissance by fire" was a method to draw out enemy positions by convincing them they had been discovered and were being killed; therefore they would strike back and reveal themselves. During the Vietnam era, the air battle became precarious for the slower AC-130 aircraft, which became targets as they performed their nightly missions — lighting up when they commenced firing and thus being shot at by enemy anti-air batteries.

A technique they developed to silence or slow the response was to fly a two-ship circle where one ship would light up and intentionally draw fire from the ground units. This allowed the other to target the battery before it could silence and move. We are extrapolating this on/off technique from the AC-130 Gunships to induce elements of the modern integrated air defense mechanism to reveal itself and its tentacles by offering a ripe target so as to trap an air defense system into giving up its location, or sensor; or communications system to sensors, and ultimately to shooters.

An advantage that the AC-130 aircraft brings to the fight is the closed-form "kill cycle," which when operating in a free-fire zone allows the OODA loop to be milliseconds in length. Tacticians and strategists need to keep this in mind as they lay traps for integrated air defenses, hidden in locations which will give pause to central commanders.

From such a perspective, we can see great utility for unmanned or remotely piloted systems. The carriage of weapons in fifth-generation aircraft is both limited and limiting. Pilots who are the first to launch expose themselves in a dramatic way, and one must presume that once exposed the probability of survival diminishes.

Again, one must see stealth as shelter from the enemy, prolonging the exfiltration of intelligence and reducing the probability of mission failure, not as a medium to enhance the probability of success for the individual fight. We need to think in fleet terms operating in a distributed battlespace. Once we make the mental leap, the air battle manager construct can move into the cockpit where the pilots are part of a team that can become the closed-form "kill cycle" and turn the weapons to target time within the enemy's cycle.

Planners need to turn their attention to providing support to the air battle manager that has taken up a position of control, and has managed to maintain concealment at the same time. Therefore, we need to consider how to absorb and catalogue appropriate targets to achieve the mission and then exhaust the missile load of an unmanned vehicle.

Survival rates in that class are expected to mimic the 8th Air Force in the Second World War, wherein the losses were so traumatic that they actually exceeded the Marine losses in the Pacific. If they are used in this manner, we will need a lot of them. The good news is that the embedded technology can be minimized, and we have a good chance that our industry can produce great quantities. This would be very different if America owned the skies, and thus could exploit the domain at will.

Recent activity indicates that Israeli pilots and accompanying *Heron* UAVs have intelligence and targeting capability that can frustrate defenders. The Israeli pilots were not faced with an integrated air defense system but did take the opportunity to extend the tactical envelope to combined vehicle operations, essentially extending the sensor suite of the fighters.

The concept of having your best sensors be the last to shoot will be a key to victory. The distributed battlespace can be populated by nodes in the network that are able to provide strike or suppression assets, and have the capability for forward deployed sensors to identify core fleeting or mobile targets. The ability for the best sensors to then be available over target areas to strike last — to eliminate residual targets in the battlespace — is the key to victory.

The on-again, off-again long-range "recce" strike platform has bomber capability for which technology programs should come together for a planned operating capability in mid-2020's. Here is a case where DoD can put the concept of "good enough" to the test as requirements continue to arrive for this bomber design that will be in use for the next fifty years.

But if it does arrive — and can be seen to be unmanned in the "recce" role and manned in the bomber role — the advantages of having an over-watch platform will be enhanced. Because of the size, and by extending the sensor capability technology trend, the long-range strike and loiter asset will become the best sensor on the battlefield and take the last place in line to actually strike targets.

Such a concept will be a difficult one as it goes against many years of training to be a first-strike asset. Such is the concept of knowledge as an asset in warfare that must be embedded in our penetration planning. Space assets will form a high-level sensor and command grid above the battlespace, presuming they survive the opening events of any future engagement. Space assets provide invaluable early intelligence and can continue to be useful. But once there are alternative data paths available to the battle commander, the less valuable it will be to single out space assets for attack. Exercises like "a day without space" highlight the need for the "'node on the net" construct for communications. This can only happen with compatibility among space, air, maritime and land C4ISR assets.

A CONOPS that looks for "first to fiber" as a risk reducer should be a backbone of the communications and cyber plan.

Given the "re-normed" knowledge-based battle management system shaped by the F-22 and F-35, we need to consider how to best use the legacy assets. Let's consider bringing fourth generation to the forward edge of the battle to act as functional "throw weight" in the advanced missile sphere.

At first blush this would seem unnerving, but might be highly effective as an "over the shoulder" launch — picked up and retargeted by the lead fifth-generation aircraft. This would allow the stealth asset to remain "cloaked" while allowing the fourth-generation shooter to exit safely after being exposed. It is anticipated that, sooner than later, all sides will have developed the "shooter track" capability that is currently applied to ground missiles but will be adapted for the air fight.

We could also use legacy fighters as a protective curtain for the tanker operation, allowing the tanker to double as a router system for exfiltration of battlefield information.

The phrase "every shooter a sensor and some sensors a shooter" accurately frames the notion of leverage in the interoperability space. This in turn leads to a required weapons management plan for any and all available shooters that can reach the battlespace that must be imposed, as a target-rich environment can easily exhaust and thus waste the "see deep" capability. Spreading the assets across the sky is imperative to effectively employ the weapons, both in terms of legacy aircraft and RPAs or UAVs.

Such a concept of operations was first exploited in an Alaskan exercise when an undisciplined F-22 pilot expended all of his available ordnance and expected an exit plan. The battle manager advised him to become the air battle manager and off-board his acquired targets to other friendly forces. In a similar vein, an F-15 pilot found himself directing the indirect fire from his vantage point in order to save an embattled ground commander guiding UAV and higher altitude release (e.g., bombers).

This type of CONOPS needs to be honed so as to impose ground commander command experience of battle management into aircraft commanders who are not trained as air battle managers, but are now being afforded the tools of the trade. And, as mentioned, they now become the best sensors and fusing mechanisms on the battlefield.

Eventually, fighter pilots will need to act like ground commanders: organizing the ingressing command and making sure that the central air operations center is distributing targets to other shooters, but protecting his area of operation; keeping his fire teams progressing to the objectives while saving the best shooters for the end game mission; then organizing the withdrawal with covering fire from other now ingressing command cells.

As ground troops are introduced into the fight, the air battle manager becomes the area battle manager. This operation can be transitioned to a legacy aircraft and heavied-up (e.g., full external weapons load) F-35s to maintain the air dominant position attained. The ground units can then be forced into a protected zone, entering the fight to truly secure deep and hardened targets.

The Marine Corps concept of operations comes closest to the shift in operational focus, although they will transition to provide high cover to the F-18 and tactical UAV fleet to maintain area control. Here we see maneuver teams dropped behind or beside the enemy — maximizing survival at entry with specific mission links to protect the air assets from buried emplacements and then suppressing enemy maneuvers. It is highly likely that coordinated close air support facilitated by the new air operations approach can curtail enemy maneuvers.

America has enjoyed the real benefit of bypassing the tediously heavily defended enemy. It has become almost a planning dictum that within 72 hours, we are into the logistics of resupply. Here we should postulate and relearn the more difficult strategy and tactics of maneuver warfare and resupply on the move that we have accomplished to some degree in the present engagements: attacking in maneuver and defending in place, essentially maximizing our capability; as well as the Clausewitzian multipliers that have been known throughout the age of warfare.

One can extrapolate such an approach to classic over-the-beach operations. Once a breach has been accomplished, the game then truly is logistics and resupply. But as at Normandy, the enemy gets a vote, and there can be progress mixed with problems.

With concepts like sea basing, vertical logistics and GPS on pallets, the air arm is well versed in picking up this mission and will be able to lead to envelopment and leap frog capabilities which complicate the strategies of an enemy expecting to defeat a hierarchically organized enemy. The new distributed air operations allow U.S. forces to conduct distributed assaults and distributed defenses, and to operate like a "regular" guerilla force.

As a fighting force, we have "chosen well" regarding where to operate these past 40 years; two generations of warriors have never been exposed to an air dominance shortfall. In three generations ground commanders have not had to cope with strafing and enemy interdiction from the air of their supply lines.

With the advent of advanced integrated air defense, coupled with deep, hardened and highly mobile targets, we will have to rethink and train differently. We cannot assume air dominance; indeed we can expect that denial capabilities might well grow faster than traditional air superiority capabilities.

Such an expectation coupled with a hard-nosed realistic view of where we are and where the trends are taking us should encourage the serious investigation of the technologies that are becoming available with the F-22/F-35, and the fully integrated tactics they involve. Training to be a totally different force will be an imperative.

Tomorrow's pilots must become strategists in the cockpit, directing the fight from their position as air battle managers, as if they are Civil War generals — observing and aggressively acting only when they become the last line for success or failure.

To realize such capability will require both training and discipline. Our Air Force command and staff and Air War College need to better integrate the air operations center together with the deep sensor-strike capability to build the capability America will need to continue to have the air dominance mission fulfilled in the coming days of declining numbers of air assets.

A new CONOPS that leverages the new aircraft and incorporates legacy platforms — and shapes new investments that enhance the joint effect — is crucial to success. Declining numbers, coupled with a refusal to recognize the "re-norming challenge," will lead to a needless and dangerous loss of capability.

We need, as well, to invest in the future, not just modernize the past. We need to step back and consider which tactics techniques and procedures have current technology trends been guiding for the future fight; we need to also consider the training needed to perfect our capabilities. We need to retool and to rethink. This march towards the future must begin in our imagination as we cannot assume that historical success will be replicated in the future without innovative thinking and serious planning.

Part Two

Experiencing the Transition

FIFTH-GENERATION AIRCRAFT: A VIEW FROM THE COCKPIT

http://www.sldinfo.com/?p=11395

An Interview with Lieutenant Colonel "Chip" Berke, USMC

Lieutenant Colonel "Chip" Berke has been an F-18 pilot, an F-16 pilot, and a TOPGUN instructor and served as ground Forward Air Controller with the U.S. Army. He gained his *Viper* experience in an F-16A, flying aggressor tactics at TOPGUN — a Marine *Hornet* driver flying "foreign tactics" in a Navy training squadron in an Air Force fighter. He is currently flying the *Raptor* and shaping tactics for the plane in its joint force role. He will become the second squadron commander at Eglin for the U.S. Marine Corps version of the F-35.

SLD: First, why is a USMC pilot flying the *Raptor*?

LtCol Berke: The decision was made a few years ago to put joint pilots into the *Raptor.* The Navy did it in 2006, and the Marine Corps wanted to as well. For the USMC, the transition to the JSF is a critical issue. We can learn from the operational experiences of the Air Force F-22 transition. So an exchange billet with the Air Force at Nellis was created in the Operational Test squadron to give a Marine exposure to the process. The intent was to get someone into the fifth-gen world — to see what the Air Force has done with the F-22 for the last few years and thereby get some fifth-gen perspective. Then that pilot would hopefully be value-added to the Transition Task Force and the JSF team at Headquarters, Marine Corps. Also, it's important to get some perspective on what the Air Force lessons learned have been with the introduction of the *Raptor* and to learn some of their roadblocks in moving from legacy to fifth gen. We (USMC) are the lead for the IOC for the JSF and have a lot to gain from that experience. I have been selected to Command our JSF Squadron, VMFAT-501 at Eglin AFB. I will replace the first Marine JSF Skipper who is there now.

SLD: Obviously there are two advantages to this. First, to begin to understand that the whole capability of this aircraft is not really an F series but a flying combat system. Second, you get operational experience working the fifth-generation capability with legacy aircraft.

LtCol Berke: You're hitting the nail on the head with what the JSF is going to do, but it's also what the *Raptor* mission has already morphed into. The concept of *Raptor* employment covers two basic concepts. We've got an anti-access/global strike mission and the integration mission as well. The bottom line is that the integration mission is our bread and butter. When I say "us" I'm talking about the Air Force and the F-22. Most of our expected operating environments are going to be integrated, and success depends on how we play with other four-gen assets.

The joint operational role for the *Raptor* is significant. I'd say 80 percent of our funded testing involves integration, whether it's integration with other airplanes like F-18s, F-15s, and 16s or integration with Aegis. Maritime Interdiction Integration is a key element of what we're doing. Virtually all of our tests are about how to make the airplane value-added to the conventional fleet.

SLD: What's it like to fly an F/A-18 and shift to an F-22?

LtCol Berke: It's a major evolution. There's no question about it. My career has been in F-18s, but I also flew F-16s for three years. I was dual operational in the *Hornet* and the *Viper* when I was a TOPGUN instructor. I am now coming up on three years flying *Raptors*. I was also on carriers for four years, so I've done a lot of integration with the Navy and a lot of integration with the Air Force. Three years flying with the Air Force has been enlightening.

It's a great experience to see the similarities and differences between the two services. Navy and Marine aviation are very similar. USAF aviation is very different. I was with the Army for a year as FAC in Iraq, as well. I've got a lot of tactical operator experience with all three services — Navy, Army, and the Air Force. It has been illuminating for me to have the experience with all of the services in tactical operations. Obviously I will draw upon that experience when I fully engage with the JSF. But flying a *Raptor* — the left, right, up, down — is just flying. Flying is flying. So getting in an airplane and flying around really is not that cosmic no matter what type of airplane you're sitting in.

But the difference between a *Hornet* or a *Viper* and the *Raptor* isn't just the way you turn or which way you move the jet or what is the best way to attack a particular problem. The difference is in how you think. You work in a totally different way to garner situational awareness and make decisions; it's all different in the F-22. With the F-22, as will be the case with the F-35, you're operating at a level where you perform several functions of classic air battle management. That's a whole different experience that requires a different kind of training.

SLD: With the F-22 and the F-35, you're really moving from a classic air battle management approach, a very different experience.

LtCol Berke: Absolutely. The irony is that when you talk about distributed battle management it is based on how the F-22 and F-35 provide for situational awareness. With an F-18 or F-16, you have federated sensor systems; the information is stovepiped and the pilot must fuse the information in his own mind. You receive a lot of data and you try to shape that data into usable information. In the *Raptor*, the data is already fused into information, thereby providing the situational awareness (SA). SA is extremely high in the F-22, as it will be in the JSF. So it's very easy for the pilot to process the SA. The processing of data is key to having high SA and key to making smart decisions. There's virtually no data in the F-22 that you have to process. There's a small amount, but it is presented to you clearly and requires very little effort to process what's going on. The fused data is so easy to absorb and it's so easy to use. A huge amount of brain cells, a huge amount of pilot effort is necessary to do that in the *Hornet*. You just don't have to do it anymore in the *Raptor* and the JSF. Ironically, that takes some getting used to. The SA in a fused cockpit is so incredible that it takes time to adjust from a legacy mindset, but once you do, the payback is exponential. The best SA I ever had in the *Hornet* pales in comparison to what the JSF will do for me.

SLD: What is the impact of being able to share that fused data with other assets?

LtCol Berke: The impact of sharing data will be profound with JSF using MADL (Multifunctional Advanced Data Link) as a gateway. Currently the *Raptor* requires an off-board gateway, but will eventually get MADL as well. As a matter of fact, we just completed a test on IFDL (Intra-flight Data Link) distribution through to BACN (Battlefield Airborne Communications Nodes) to get *Raptor* data into Marine F-18s with great success. The F-22, especially when we get that data off board, gives tremendous SA to legacy assets. Eventually, when we can pipe the data either through a gateway or when we get MADL, those methodologies will make the aircraft a fused sensor for fourth-gen fighters. The beauty of the F-22 is that it's basically a big flying sensor providing information to our integrated assets. The way we perceive our role as a big flying sensor allows us to be a facilitator for another force to execute their mission more effectively, more efficiently, and with less risk. We quantify everything with the metrics of survivability and lethality. The goal is always to increase survivability and increase lethality. We want to be more deadly while taking less risk.

SLD: I think of the *Raptor* as the tip of a three-dimensional grid, flying at 60,000 feet or more in a maritime environment. Over time, adding F-35s and F-22s and other unmanned assets will result in a sea change in distributed operations.

LtCol Berke: The idea that we're going to attack a cruise missile problem without the use of tactical aircraft surprises me from an analytical perspective, especially considering how often we do it and how much we consider it. It's hard to train to counter-missile operations, but it's certainly a mission set that we investigate routinely. The *Raptor* and JSF and their expanded sensor sets will play a key role. Working the relationship between Aegis and fifth-gen is central to the capability to kill missiles attacking the fleet or in dealing with longer-range targets.

SLD: Could you highlight the changing role of the combat pilot in the fifth-generation aircraft?

LtCol Berke: In the sensor-fused cockpit of the *Raptor*, two things happen. It simplifies the information and presents it more accurately and more quickly. It also provides the information in a 360-degree sphere. That allows a *Raptor* pilot to just make decisions nearly 100 percent of the time. So he does not need to spend his time interpreting and determining the best way to attack a problem. That allows the pilot to decide what's best for him and for all the airborne forces, whether it's other *Raptors* or F-18 strikers that you're supporting or F-15 *Eagles* on a sweep, or any integrated mission. You don't have the luxury of doing that in a legacy airplane. The fused sensors enable all of this. The JSF will only expand this capability with its newer and expanded sensor array. As a flying sensor, you can accurately decide the best way to attack a particular problem for everyone else who is flying. A *Raptor* flight lead (and a fifth-gen fighter is far more effective than a flight leader in another airplane) with the amount of SA that he has can help guide the other aircraft that don't have that level of SA.

SLD: So will this new role for the combat pilot, with new fused sensors and related capabilities, make this new aircraft a game changer?

LtCol Berke: People throw out those terms all the time — "the paradigm shift," "a game changer," "an evolutionary leap" — but it's all true. It's all accurate. I can tell you from the perspective of a guy who has flown over 2,000 hours in a *Hornet*. I was a TOPGUN instructor. I was really at the top of my game. I was as competent as the Marine Corps could've taught me to be. In spite of this background, it was a challenge and a major mental leap for me to go to the F-22. It takes time to turn the corner with fifth-gen thinking. But once you do, there's no going back. Your SA and your ability increase dramatically. Truth be told, you're always going to have limits in any legacy platform, for many reasons. There's not a pilot in the Air Force that's flying *Raptors* right now that will not tell you the exact same thing. But what they'll also tell you is that the first class that flew the *Raptor* straight from flight school was exceptional. They were surprised at how good they were at optimizing the airplane as a sensor. The guys with no experience did extremely well, and I think a huge part of that has to do with their not bringing old habits with them. Changing the way you physically move is one thing, but changing the way you think is very difficult to do and it takes time. When the concepts just don't apply anymore and you've leveraged those concepts for 15 years, it's not an easy thing. This will be a challenge for all pilots transitioning to the JSF because it's going to force them to think differently than they have ever thought before. But doing so is crucial to the shift in air operations. Once the mindset shift occurs, the true capability will be understood. As I said before, once that happens the results are exponential. In just a few years, we're going to have STOVL JSF operating from forward bases. Aside from all the operational and strategic implications, the tactical significance is huge. A single F-35B pilot will have more SA than anyone flying a Marine aircraft has ever had. And he's going to be directly connected to the entire supported force. When you consider the fused cockpit of a JSF, you begin to understand just why all those descriptors are really accurate. It's an evolutionary leap. It's a paradigm shift. It really is a game changer.

CULTURE CHANGE IN SHAPING A NEW CONOPS

http://www.sldinfo.com/?p=12255

In September 2010, *Second Line of Defense* sat down with three experienced USAF pilots at Langley AFB to discuss the impact of the new aircraft on concepts of operations. The pilots have significant experience with F-15s and F-22s, and with shaping the F-35 for introduction into the U.S. Air Force. The three pilots — Lieutenant Colonel Damon "Shotgun" Anthony, Major James "Bean" Akers and Lieutenant Colonel Steve "Rowdy" Pieper — provided an understanding of how classic combat operations built around the use of AWACS (Airborne Warning and Control System) and the CAOC (Combine Air Operations Center) will be modified as new aircraft reshape operational capabilities.

SLD: With the new aircraft, can you see a future where you will not need an AWACS in the same way?

"Bean" Akers: I have 1,200 hours in the F-15C model and then flew the *Raptor* for three years. I showed up at Langley right before I went operational, and then was on all the first deployments — Kadina, Alaska, you name it. I have done just about everything in the jet other than shoot something off the jet in anger.

One of the key things is that there may not be a need for an AWACS. But there also may not be the ability for that AWACS to be there, because of the survivability challenges being posed by the threat systems that are being developed to remove them from the fight. The enemy always has a vote. In training we assume that there may be times where it is just us over the horizon, with the AWACS hundreds of miles behind us and not doing a whole lot for us. I've seen that at Red Flag where AWACS is trying to build a picture and the systems just can't keep up with the mass of the enemy coming from, say, the west. We have to tell them that we've got the picture much better than they do. The legacy way of fighting with the fourth-generation assets relying on reach back is a critical part of the way they employ. As we move forward with the systems and sensors that are on both the F-22 and F-35, I really don't demand or need that requirement anymore. Do they add to my battlespace awareness? Yes, they do. But there are times where AWACS is not needed and may not be available due to the threat.

"Shotgun" Anthony: I'd like to discuss the difference between the current fight and what we're moving to with fifth-generation aircraft. And of course that doesn't mean that legacy aircraft, the fourth-generation aircraft are not in the play. When it was only fourth-generation aircraft, the sensors on the fourth-generation jet were structured so that they are federated solutions to different pieces of the RF spectrum. I have an active radar that is continuously transmitting a picture off my nose. In other words, seeing what is in front of me is the focus of the classic approach. And that's a federated system on the aircraft — an individual aircraft. In order to build a coherent picture in front of our noses, we had to communicate verbally on our radio. I am painting a picture of a three-dimensional battlespace with words. We communicate what we are seeing with our individual jets, because we don't necessarily see the whole airspace in front of us. We parse out sections of airspace to sanitize in front of us. And we build a picture from close end — from the nose all the way out.

SLD: So you built an operational culture tied to a specific technological capability?

"Bean" Akers: That's exactly right. And that was one federated system that's on the jet. And then you have to multiply that times the four or five different federated systems. When you talk about 15C, you've got a radar-warning receiver. That has low accuracy, DF capability and pretty much no ranging. Then I have an electronic attack suite that is tied in with the radar warning receiver; if it sees something and it thinks it's hostile and it sees enough power, it decides autonomously whether to jam it or not. You have targeting pods to deal with the guided weapons. And then later, we learned they had other applications for non-traditional ISR, i.e., following high-value targets in Afghanistan and adding to the picture that the *Predator* and *Reaper* are getting. So there are several independent federated technologies on legacy aircraft that we have to decipher and figure out how to use, create work-arounds, and create a concept of operations. It requires a systems integration approach, outside of the aircraft, in order to be effective.

SLD: A systems approach outside of the individual aircraft?

"Bean" Akers: That's exactly right. As a pilot, you're looking at the entire suite of sensors, and this approach dates back to World War I.

"Shotgun" Anthony: With legacy aircraft we try to take in all the information and create a picture. In the F-22, the data is fused together into a nice single presentation. I don't have to do a lot of federated management or systems management within my own aircraft, other than making sure they're on and they're working. The F-22 display is much like a battle manager, giving me almost everything he has. As a result I can manage assets or manage my flow or my attack… or whatever is demanded by the situation.

SLD: Are the new technologies and capabilities driving a shift in the culture of the CONOPS?

"Rowdy" Pieper: The mission commander or the flight lead was always clamoring for sufficient information to make appropriate tactical decisions, which are really only one very short step removed from operational decisions. From the operator's perspective, it will be like the difference between stumbling around a dark room and turning the lights on. The combat situation will be instantaneously transparent. All of those high-processing-time tasks that the pilot used to spend his time on with the objective of knowing what was going on so that he can then take an appropriate action—you know, point the jet in the right direction, herd the cats in the right direction — are now done by the airplane. All of those activities are now completely overcome by events. He doesn't need to do them anymore; he now sees what he needs to see to make those decisions. So from an operator's perspective, it will feel very natural. And it will feel like you're now able to breathe, whereas before, you were always struggling for breath. You're no longer at the top of Everest trying to breathe; you're down at sea level. You get what you need. I think the most difficult and the most painful set of shifts will be organizational. They will relate to the people who are now forced to relinquish operational strategic decisions to folks like us in the room. Tactical decisions have always had operational strategic and national impact. The difference is that, organizationally, we'll be forced to reconcile that notion and understand that the individual who's charged with those tactical decisions will now have the kind of information that was previously only available nearly fused and imperfectly fused in the CAOC. That information will now be distributed in the battlespace. So that speaks to an entirely different way of operating that is driven not just by the physical architecture, but also by the personnel architecture, with a major shift in the leadership paradigm and the approach to solving a problem. We will now be far more able to remove fat layers of intermediate data processing and able to sic a force of very capable assets on an objective. We're able to adapt dynamically in the middle of that process and make appropriate decisions in support of the objective far more effectively than if we had just sent planes out on a specific task. "Go perform this task, because we back here in the building think that this collection of individuals performing these tasks will result in the amalgamative outcome that we were hoping for." Now we can send pilots out with a clear idea of an outcome, as the pilot now has the information to take action… and the capacity to go where other assets couldn't go previously.

SLD: In other words, distributed battle management is inherent in the technology of the new systems.

"Rowdy" Pieper: The battle manager's job of pushing information to the deployed strike assets can now shift to true battle management. They are no longer integral to providing those snippets of information that are required for the folks in front to go perform what they were supposed to be performing. Now they are truly in a position to manage the battle.

SLD: The F-22 is then a lead element in shaping a new culture?

"Shotgun" Anthony: The F-22 broke the mold and is able to digitally fuse information, to free up the pilot to be a decision maker and actually apply the information. I really like what Rowdy was saying that we always went out the door with objectives. But our objectives in the legacy aircraft are singular or plural in nature and have a tactical effect. Today, my mission is to protect this lane for 20 minutes, and don't let anybody through. My mission today is to go hit this target with a weapon. We've had missiles as our priorities and missed our threat. With the F-22 and the F-35 — and the information capabilities which come with them — you can take an objective designed for a specific result.

SPLITTING THE MEU AND PREPARING FOR THE F-35B

http://www.sldinfo.com/?p=11992

An Interview with Captain Matthew Dwyer, USMC

In an October 2010 SLD interview with Captain Matthew Dwyer, an *Osprey* pilot, discussed his time with the MEU (Marine Expeditionary Unit) after leaving Haiti. Captain Dwyer was deployed on the USS *Nassau* when it first went to Haiti and then left for the Gulf of Aden after the Haiti engagement. During his time on board the USS *Nassau*, the Marine Expeditionary Group executed some new tactical opportunities associated with the use of the *Osprey*. The speed of the *Osprey* allows it to work more effectively with fast jets, which allowed the commander to split the MEU into a rotorcraft-supported fleet and a fast jet- and *Osprey*-supported fleet.

By splitting the MEU, the commander gained significant operational flexibility without loss of the integrity of the operation. This provides a solid bedrock in preparation for the inclusion of the F-35B with the fleet, anticipating a time when the *Osprey* and F-35B will operate together, enabling the three-dimensional warrior.

Capt Dwyer: After Haiti, we went to the Gulf of Aden where we were operating out of Djibouti. We actually split the MEU, the entire MEU, which I don't believe had been done before in specific type model series. So all of the skids, the *Hueys* and *Cobras* were on one ship, and they were almost autonomous. They got to do different things than the ones they were scheduled to do with different countries under the umbrella of the 24^{th} MEU, without impacting our actual operations. The 53s that were grounded in Djibouti hopped off the *Nassau* as soon as we got in there, so it was really an AV-8 and V-22 show for four and a half to five months.

SLD: Because you have operated solely flying the *Osprey*, you come at the question of the potential with a fresh eye. Is there an opportunity to shape a new relationship with fast jets and to reshape CONOPS?

Capt Dwyer: I saw so much potential for the short take-off vertical landing attack aircraft, fixed-wing aircraft and the V-22 working together. In the future, I would have those two, the V-22 and F-35, working very closely together—even for extended operations when you add the refueling piece. The pairing of these two aircraft is far better than pairing the V-22 with any of the helicopters.

SLD: Is it because of speed?

Captain Dwyer: Because of speed and range. And not only that. It's the endurance of the aircraft itself. Once it's flying, it's flying. And we had a lot of missions that required flight times above six hours, which is very taxing for the jet guys and for us as well, but not as bad because we can trade off in the cockpit. The fact is that you can have airborne assets, both as a package as well as a trap for sensitive site exploitations — being airborne all at the same time for hours at a time to respond to something that happens in the AOR (area of responsibility). It offers the the maximum flexibility for response time down to something like thirty minutes, depending on where it is. Then you can sanitize the scene from there, after which everybody returns home. It's a capability that hasn't been utilized like that.

SLD: Does this affect the capability to insert and withdraw airborne and ground forces?

Captain Dwyer: We didn't even have that capability before, especially for the longer ranges and in a short response time. By marrying these two with the fixed-wing aviation asset we can do operations differently. We could neutralize a target and then immediately have a strike team insert to confirm what happened, and then deliver whatever materials they need, get back on an aircraft and leave in under thirty minutes in any location on a 600-mile radius. This is amazing.

FACILITATING JOINT AND COALITION TRAINING: A NEW COMBAT CAPABILITY

http://www.sldinfo.com/?p=12819

An Interview with Colonel Arthur Tomassetti, USMC

In October 2010, *Second Line of Defense* followed up on its January 2010 visit to the F-35 training facility located at Eglin Air Force Base. SLD spoke with Colonel Arthur "Turbo" Tomassetti, vice commander of the 33rd Fighter Wing, home to the Joint Strike Fighter Integrated Training Center that is providing pilot and maintenance training for nine international partners.

SLD: After the foreign partners buy planes can they join the Integrated Training Center?

Col Tomassetti: What we would expect shortly after an airplane agreement is finalized is a discussion of what part of this training operation they would want to buy. Do they want to buy pilot training here at Eglin? Do they want to buy maintenance training here at Eglin? Do they want to buy Lockheed support, in home country for some period of time, until they're up and running? The foreign partners are being allowed to answer the questions for themselves and decide what they want. We are open right now for all possibilities since we have to have the capability to train pilots and maintainers for all three F-35 variants, regardless.

SLD: Are you preparing the infrastructure for a standup capability when the planes arrive?

Col Tomassetti: We have a number of pilots and maintainers to produce, so we are aiming to produce to that number. What gets done with them after they are trained is outside of our scope. We're sensitive to what people are going to do with those groups of trained pilots and maintainers, but again, at the end of the day, we are tasked to produce a certain number. We produce a certain number of pilots and maintainers on the designated timeline and to the level of optimum training that is enabled at the time, and then the services take it from there. Eventually — in the 2015/2016 time frame — when we are performing sustained production, the services will shape their demand equation. The services will come to us with something that will look like a fairly repetitive, recurring requirement of a certain number of pilots and maintainers per year.

SLD: After the planes get mated to the training process and the services determine their training requirements, will you then build a business plan?

Colonel Tomassetti: Absolutely. I think what we'll find is that folks will look to leverage what we're doing here at Eglin against what will happen at the other pilot training centers across the United States. Right now, no one has said anything about any other maintenance training centers for the F-35, but anybody who is going to set up an F-35 training school, wherever that may be, in the beginning, the only reference point they'll have is what's happening here at Eglin. We will establish the template for other pilot training facilities for the F-35.

SLD: Are these joint processes?

Col Tomassetti: The processes are another challenge because this is one case where, if left to their own devices, each individual service could do this very well. They could develop a syllabus for pilots and maintainers. They could develop ways that you do maintenance on the airplane and the procedures that you follow, because they would just apply what they do in their legacy airplanes, add in the F-35 differences, and go forward. Well, that's great if we were going to train in isolation, and not take advantage of the commonality that the weapon system has, and not take advantage of being co-located here at Eglin. We keep striving towards an integrated training approach in order to take advantage of the commonality, but there's still resistance to that. It's still much easier, in some people's minds, to just do things the way they've always done it. But that would sustain the old mindset of not interacting, even though you are co-located.

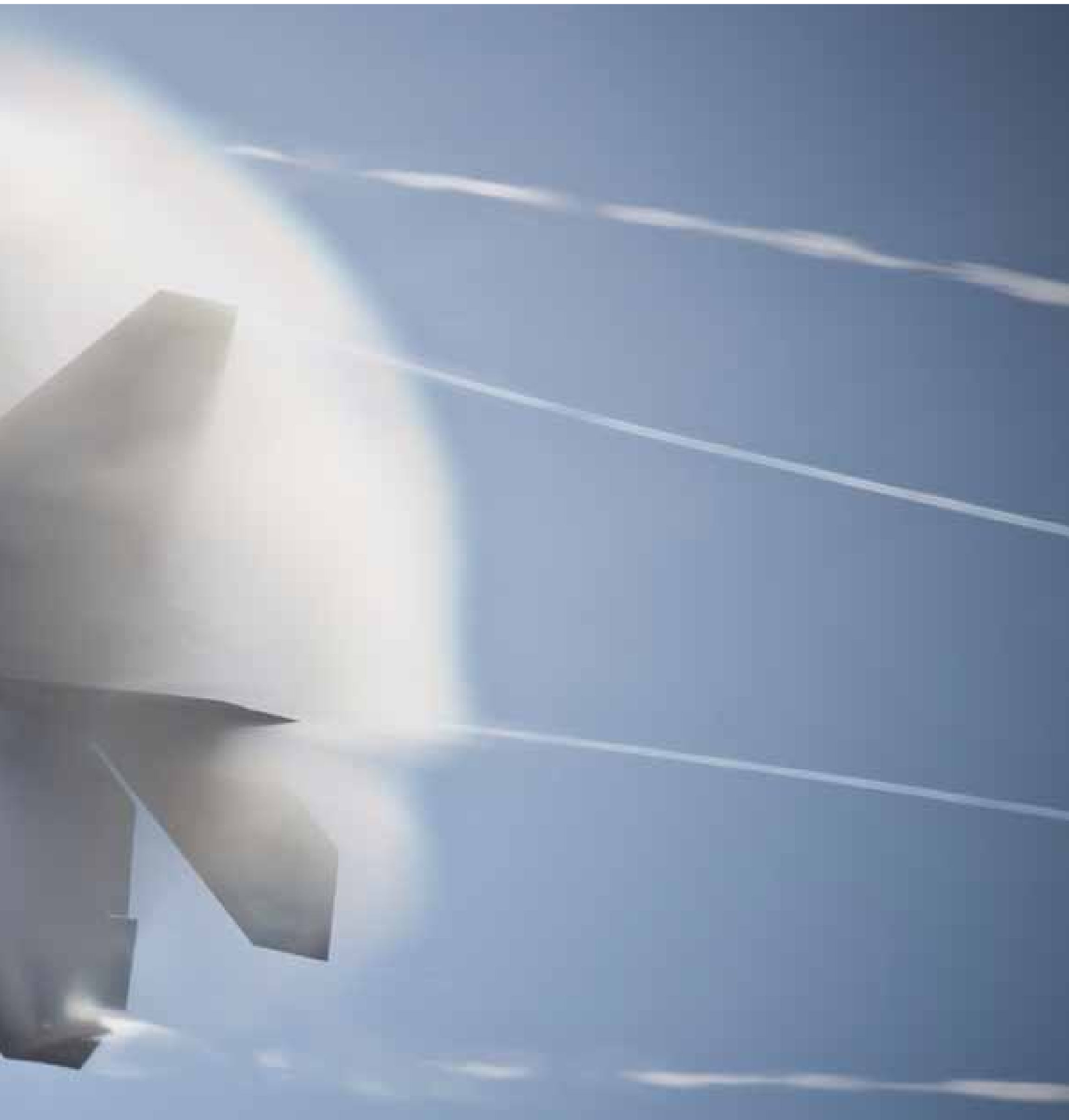
SLD: Is the core advantage of integration crucial to the program and to the savings inherent in co-located training facilities?

Col Tomassetti: There is so much potential that comes from integration. It's more than just saving money. It's the potential interaction of students at this early level in their career with this new weapon system and all of the ideas and opportunities that can come from that. For organizations that are going to go fight jointly, no matter where our pilots go, it

Shaping a New Operational Paradigm

- Pilots as Air Battle Managers
- Distributed Decision Makers
- Best Sensors Last to Shoot
- Weapons Management on Fleet-Wide Basis
- New Maneuver Concepts
- 360 Degree Engagement


RF-02



would be ludicrous not to start the training process off with a joint and coalition setup. We will look for new opportunities to get cross-service interaction. We will look for new opportunities to get some cross-service buy-in, and we start small. We can find one thing that commonality allows us to do with this airplane that legacy airplanes wouldn't allow us to do. Then we can ask, "Hey, would you all be in agreement if we did this very small thing the same way?" We start with something small, get people to agree, and then build on that foundation. As we have communicated to anyone who will listen, we believe that interoperability could start here at Eglin. Take advantage of the weapon system commonality and adopt best practices available. The interoperability that we want on the battlefield of tomorrow or in the disaster relief response of tomorrow — that interoperability could begin here with integrated F-35 training.

SLD: I assume you can bring in aircraft ASAP for the maintainers?

Col Tomassetti: At whatever point aircraft can be brought to Eglin, we will determine the minimum kind of airplane we could have to start some basic training. What we tell people is that even if the airplanes can't do pilot training, if you put them here at Eglin, we'll start maintenance training because the maintainers have to touch those airplanes for their training as well. We'll get the maintainers out there to practice refueling and practice removing and replacing panels. We can start building those maintainers that will have to go out and take care of these airplanes wherever they go. We expect to train about 100 pilots a year, here at Eglin, when we're up and running. We expect to train close to 2,000 maintainers a year, when we're up and running. Getting a start on either one of those requirements will be beneficial.

SLD: So you are shaping the operational concepts and approaches that you're going to use on day one?

Col Tomassetti: Absolutely, because we want to be able to hit the ground running when the airplanes arrive. Eglin will be unique. It'll be the only place where you can see pilots and maintainers training on all three versions of the airplane, from both the United States and the foreign partners who are buying the airplane right now. Our goal remains to take advantage of the commonality that exists in this weapon system.

It seems foolish to set up, as an example, on any given day, airplane class teaching and aircraft refueling in three different classrooms.
We'd have to have an Air Force classroom, where there's an Airman standing in front of Airmen,

teaching; and a Marine classroom where there's a Marine standing in front of Marines, teaching; and a Navy classroom where there is a Sailor standing in front of Sailors teaching. All teaching a process that is done the same exact way on all three F-35 variants. And imagine, in each of those classes, there are three empty seats because you don't have enough people who need that class that day. How horribly inefficient would that be if that's the way we went forward. What a waste of resources it would be if that's the way we have to go forward. But again, it's an uphill challenge because our systems today aren't really set up to be integrated.

We don't do things in legacy airplanes, necessarily, the same way. But as much as we want to take advantage of that commonality, we want to make sure we preserve whatever unique requirements there are, and then beyond that, preserve unique customs and traditions as well. We want the Marines to feel that they are getting to do everything they need to do as Marines, while they're here at an Air Force Base. We want the folks from the U.K. or other customers to feel that they get to do things that are important to them, in their operational culture. We want to make sure that we can accommodate service- and country-unique requirements as best we can.

Effectively sharing resources is another key to success. There are shared resources out on the flight line because we didn't buy three sets of everything. We didn't buy one for the Navy, one for the Marine Corps, and one for the Air Force. For some support items we bought one, and we're all going to have to share that, one tool. We have to share airspace, here at Eglin, with everybody else who's trying to use the airspace. And we have to be effective at that and that means that we need to look at things that haven't been done here before, e.g., a day where two users use the airspace at the same time because we can de-conflict.

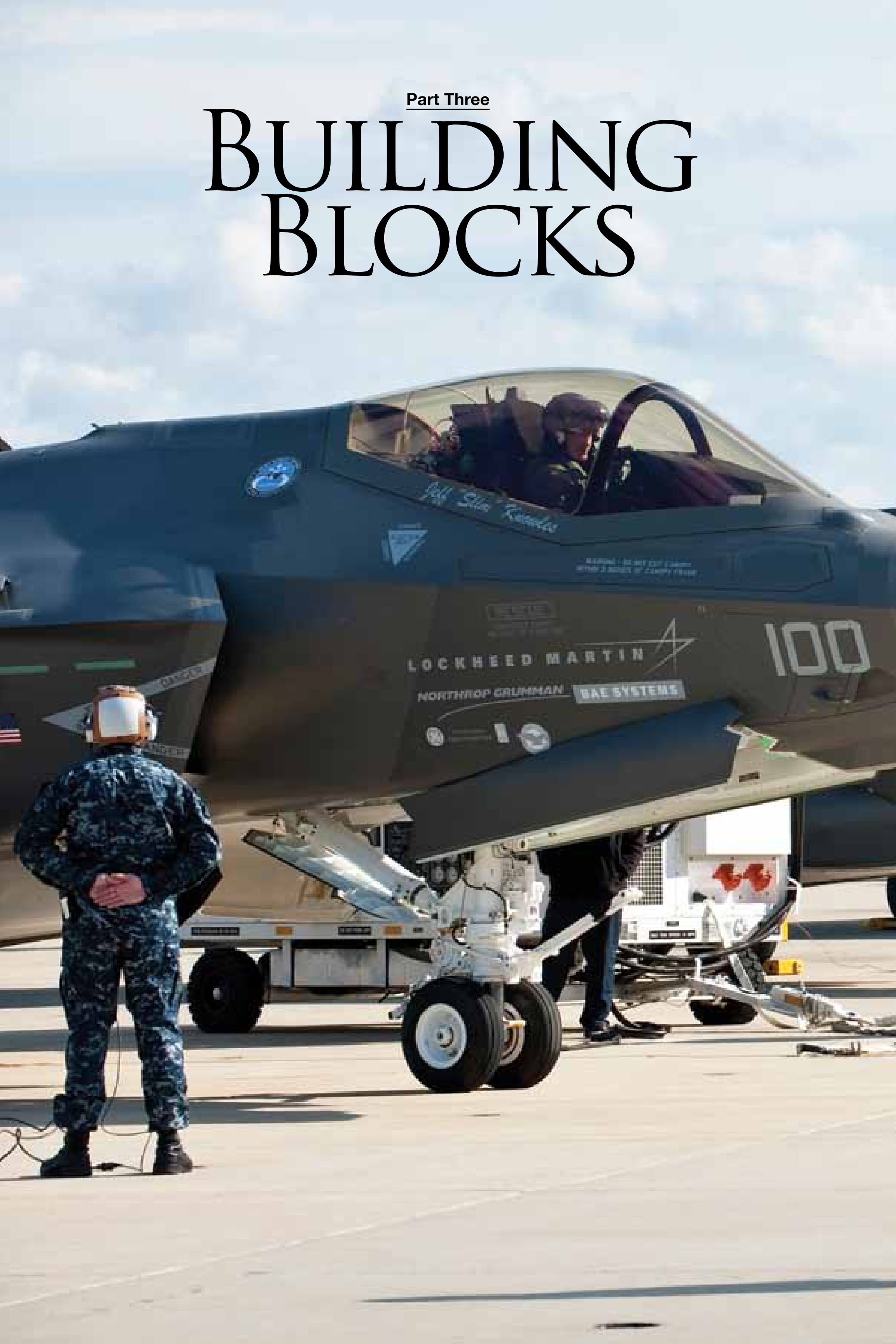
If someone is doing something at five thousand feet and below, and someone else is doing something at ten thousand feet and above, we can go out there on the same day, at the same time, and use that airspace and not get in each other's way — so both get training. What if the Special Forces soldiers from the Seventh Special Forces Group need to learn how to call in close air support?

Wouldn't it be nice if there is a young soldier who, to get the check in the block for training, has to learn how to call an airplane in for close air support, and on the same day, we have a young student who, to get the check in the block, has to learn how to go deliver close air support to a forward air controller on the ground? Imagine if we could both go out to the same range, at the same time, on the same day, and we get an "x" in the box for their folks, an "x" in the for our folks — without stepping on each other's toes. At the end of the day we had a young soldier call in a Marine airplane or a Navy airplane, and work what would look like a joint CAS mission, at the very beginning of their training, at the very beginning of their career. That is how true interoperability needs to start. We have a weapon system available to us that has enough commonality to enable joint operations.

We have a training center in development at Eglin AFB that can capitalize on that commonality and build strong foundations for Joint operations. Taking advantage of what is available to us with the F-35 weapon system can and will move us closer towards true interoperability for Joint and Coalition operations. That is how true interoperability needs to start.

Part Three

BUILDING BLOCKS



A KEY FOUNDATIONAL ELEMENT FOR "RE-NORMING": THE F-35 COMBAT SYSTEM ENTERPRISE

Dr. Robbin Laird

The F-35 is the first combat aircraft which gives the pilot a 360-degree view around the entire aircraft. The Distributed Aperture System is what allows this to happen, and allows the operator or the fleet managers to see hundreds of miles away… on a 360-degree basis. The combat system enterprise allows the aircraft to manage the battlespace within this 360-degree space.

Unlike legacy aircraft, which simply add systems which then have to be managed by the pilot, the F-35 creates a synergy workspace where the core combat systems work interactively to create functional outcomes. For example, jamming can be performed by the overall system, not just by a dedicated electronic warfare system.

The F-35 in many ways is a "flying combat system" and is in a different epoch than F-15s, F-18s and F-16s. The 360-degree capability coupled with the combat system enterprise explains these historic differences on a per-plane basis; the ability of the new aircraft to shape distributed air operations collectively is another historic change, one which the United States and its allies need to accomplish in light of the growing missile, air defense and offensive air capabilities in the global marketspace.

The legacy combat aircraft have added new combat systems over a period of 30 years. These systems are additive, iterative and sequential. They were built over a core foundation that was crafted more than 30 years ago.

As one pilot put it: "On a traditional aircraft, you're going to build your core processor and you may integrate the radar, typically, it's pretty well integrated into the processor. But then, somebody will come along and say hey, I've got a great idea, I need a targeting pod. I'm going to slap this baby on, it's got a lot of neat features, but it is not integrated with the earlier additions."

The F-35 system was built from a clean slate, with a foundation that allows interactivity across the combat systems, and allows the creation of a combat system enterprise that is managed by the computer on the aircraft. The core combat systems are interactive with one another, creating a synergistic outcome and capability, rather than simply providing an additive-segmented tool.

The systems are built upon a physical link, namely a high-speed data bus built upon high-speed fiber optical systems. To provide a rough comparison, legacy aircraft are communicating over a dial-up modem compared to the F-35 system, which is equivalent to a high-speed broadband system. The new data bus and the high-speed broadband are the facilitators of the enterprise.

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

The other core combat systems which interact to create the combat systems enterprise, are the AESA radar, the DAS, the Electrical Optical Targeting System (EOTS) and the Electronic Warfare system.

As one analyst underscored,

> *When this plane was designed, the avionics suite was designed from the ground up; the designers looked at the different elements that can be mutually supporting as one of the integration tenets. For example, the radar didn't have to do everything; the Electrical Optical Targeting System (EOTS) didn't have to do everything. And they were designed together.*
>
> *Fusion is the way to leverage the other sensors' strengths. To make up for any weaknesses, perhaps in the field of regard or a certain mode, a certain spectrum, with each of the sensors as building blocks, they were all designed to be multifunction avionics.*
>
> *For example, the AESA (advanced electronically scanned array) is an MFA (multi-function array). It has, of course, the standard air-to-air modes and the standard air-to-ground modes. But in addition, it's built to be an EW aperture for electronic protection, electronic support, which is sensing, passive ops, and electronic attack.*

A way to look at the cross-functionality of the combat systems is simply to think past the narrow focus of additive systems, where a system is added to do a specific task and the pilot then needs to use that system to manage the task. With the F-35 interactive systems, the pilot will perform a function without caring which system is actually executing the mission. For example, for electronic warfare, including cyber, he could be using the ETOPS, the EW system or the AESA radar.

The pilot really does not care, and the interactivity among the systems creates a future evolution whereby synergy among the systems enables new options and possibilities. And of course, the system rests on an upgradable computer with chip replacement allowing generational leaps in computational power.

- The F-35 combat system allows the F-35 to leverage its ability to operate in 360-degree space;
- The five core combat systems are highly interactive and synergistic — the whole is greater than the sum of its parts;
- Functional capabilities are delivered by the enterprise, not simply by stovedpiped elements;
- And the entire system is enabled by a high-speed fiber optic data bus.

With the legacy aircraft, the legacy system is an additive structure, more like a cell phone than a smart phone with many applications available to the pilot. With the F-35, one is building a flexible architecture that allows one to operate like a smart phone. With the F-35, a synergy space allows the pilot to draw upon a menu of applications.

The F-35 combat systems are built to permit an open-ended growing capability. In mathematical analogies, one is describing something that can create battlespace fractals, notably with a fleet able to execute distributed operations.

THE DISTRIBUTED APERTURE SYSTEM

http://www.sldinfo.com/?p=12819http://www.sldinfo.com/?p=10198

Second Line of Defense talked with Northrop Grumman Electronic Systems' Mark Rossi about the Distributed Aperture System (DAS) on the F-35, which together with the helmet provides 360-degree situational awareness for the F-35 pilot. Mark has served as the Director of the AN/AAQ-37 Electro-Optical Distributed Aperture System (EO DAS) for the F-35 platform, having management responsibility for the product development and production of the EO DAS hardware and software. He joined Northrop Grumman in 1984 and has held numerous positions of increasing responsibility in Technical Subcontract Management, Business Development and Program Management.

SLD: The Distributed Aperture System (DAS) is one of the reasons why the development of the F-35 is about the next 30 years of military aviation, not the past 30 years. Yet folks have not really wrapped their heads around what DAS is or can and will do for the warfighter.

Rossi: The biggest problem facing DAS is the fact that it is a complete unknown to most people. But as they become more familiar with its value, they will realize just how revolutionary this system will be for the warfighter. DAS changes the game. If you consider radars for instance, the utility that radar brings to the fight has been fundamental to the mission of our armed forces for decades. Practically everything since WWII has been equipped with radar, and our radars just keep getting better and more capable. The technology is evolving with the advances in electronics. We just keep building on prior capability.

The capability DAS brings to the fight, however, is new and will significantly change the way the game is played. The services have never experienced anything like the unprecedented capability provided by DAS. While pilots who have witnessed demonstrations of our capability are typically wowed by our imagery and performance metrics, few have any real idea of the magnitude of the capability they are actually receiving with the DAS system.

The key discriminator that DAS brings to JSF is full, 360-degree spherical situational awareness.

We create this bubble around the airplane where we see everything of interest, all the time, simultaneously. Spherical situational awareness will significantly change the game.

SLD: Is this a man-machine interface we're talking about?

Rossi: Yes, but we make it easy for him. From a situational awareness point of view, the pilot does absolutely nothing. We are monitoring the world around him all the time and then differentiating and reporting things that occur in that global scene that are important to the pilot. It's only when we determine that something important has occurred that he'll even know anything's going on — except, of course, for day/night imagery that is presented to him continually on his Helmet-Mounted Display (HMD) and on his panoramic cockpit display.

SLD: Can the pilot on the F-35 take that fused data and share it?

Rossi: There's no reason we couldn't share DAS data short of any limitations of the current data links in the aircraft.

SLD: But the point is that you're standing up a basic capability on the first production aircraft and there's the opportunity to take this capability, which is unprecedented, and figure out new ways to share data and new ways to battle manage. In other words, you're investing in the future by buying this capability.

Rossi: There is no telling how the services will want to use or potentially enhance DAS functionality in the future — on or off-board a single JSF — as the users become more familiar with the capability DAS has to offer.

SLD: Can the pilot declutter the battlespace and focus on the most important priorities?

Rossi: We declutter it for him, automatically. We classify the world into things that the pilot would care about, such as air-to-air and surface-to-air missiles as well as airborne objects like aircraft within range, and only present to him those things that he should focus on.

SLD: Why is the DAS so misunderstood or underestimated?

Rossi: First of all, the users don't really understand what DAS is going to do for them. They have no real point of reference. This capability is truly revolutionary. More importantly, many currently fielded missile warning systems are fraught with error, producing high false alarm rates. The reliability and accuracy of the DAS ensures a whole new level of trust and confidence in the capability we provide to the warfighter.

SLD: How does the new helmet for the F-35 interact with the DAS?

Rossi: The DAS provides a 360-degree NavFLIR (Navigation Forward Looking Infrared) capability that is projected on the helmet display. FLIR is an archaic term because FLIR stands for forward looking infrared. We're not forward looking; we're everywhere looking. But it's a term that people are familiar with so we stick with it.

So if you think about it, all the information is already being collected as part of the situational awareness and missile warning modes. We simply determine the line of sight of the pilot based on his head position and process the raw image data for enhanced display on the HMD. He can basically see anywhere he turns his head — even if he is looking right through the floor of the plane because we see everything in 360-degree spherical space!

We also provide a separate video feed to the Panoramic Cockpit Display that displays a pilot-selected line of sight, at his discretion. All of this functionality replaces bulky night vision goggles that are significantly challenged in urban lighting situations. When we have demonstrated our NavFLIR capability to Navy pilots, they tend to be awestruck at the possibility of even seeing the horizon clearly, let alone seeing the carrier and its wake.

DAS is going to revolutionize night landings on aircraft carriers.

SLD: Can you discuss the advantage that fusion brings?

Rossi: The fusion that we do at our level is relative to the integration of the six sensors installed throughout the aircraft. It's fused into a singular unit that does not lose track of things across sector or camera boundaries, and provides seamless imagery between sensors regardless of line of sight. Being able to stitch the seams to the point that we don't lose a track across a boundary in inertial space is critical to meeting our performance requirements.

THE F-35'S LOW OBSERVABILITY: LIFELONG SUSTAINABILITY

http://www.sldinfo.com/?p=6065

In January 2010, *Second Line of Defense* sat down with Bill Grant, Lockheed Martin's F-35 Supportable Low Observables Integrated Product Team Lead at a joint Lockheed Martin–Northrop Grumman facility in Fort Worth, Texas, to discuss the facility as well as the F-35 approach to LO maintenance.

Everyone knows that the F-35 is a stealth aircraft. This is one element of what makes it a fifth-generation aircraft. But what is not widely known is that the stealth or low observable (LO) character of the aircraft is significantly different from other stealth aircraft, like the F-22. The F-35 LO capability is significantly more robust than legacy stealth, if one might call it that. The F-35 stealth is designed to leave the factory and to be maintained in the field, rather than having to come back to depot or the Fort Worth factory. In addition, the training of the maintainers for the LO repairs is being done at the partner level. That is, if a coalition partner buys an F-35 it will be able to maintain it with the proper training (such as the one to be received at the Eglin AFB facility) and to do so in the field. Although a significant aspect of the F-35 program, the LO repair facility has received scant attention in the vast literature commenting on the F-35.

SLD: Would you explain the background of setting up the LO facility?

Grant: We had the privilege of being able to work with complete access to data and experience of historic stealth programs, including the F-22. Our perspective was simply that LO was an afterthought from the standpoint of manufacturing, whereby stealth was added on to the aircraft.

In our program, stealth is manufactured into the aircraft. The program recognized the LO repair needed to be focused on as an effort by itself. The repair development center was an early invention of the program and was given the resources to go out there and experiment with different material systems and to help refine them and then to incorporate them into a system-level approach. We have developed repairs for each of the materials themselves and then as an entire system.

SLD: How would you describe the stealth LO capability of the F-35 compared to legacy systems?

Grant: Performance-wise, it is a very aggressive capability. From a design standpoint, it is a radical change from legacy systems. In legacy stealth, the stealth in effect is a parasitic application of a multiple stack-up of material systems done in final finish after the actual airframe is built and completed. In the case of the F-35, we've incorporated much of the LO system directly into the airframe itself. The materials have been manufactured right into the structure, so they have the durability and lifetime qualities. It makes them much more impervious to damage. It is a much simpler system with fewer materials to contend with.

SLD: Does this have a significant impact on maritime operations?

Grant: Absolutely. The Navy and Marine Corps have set the benchmark for the LO repair facility program and approach. They work in the worst maintenance environments. It was the challenge we had to meet. So our material development effort and material qualification program were predicated and populated by requirements that were specifically suited for the Navy and Marine Corps.

We have the most extensive and aggressive material qualification in our history, probably in industry history. We have as many as ten times more coupons per material being tested. We have engaged in a very aggressive approach to testing which has been developed with the military labs and the program office. We have worked with them to shape the most aggressive and most challenging test regimen from all of their different programs and their experience, and thereby compiled those experiences into our test matrix.

And the testing process has led to changes in the repair approach as well as the manufacturing approach for the program. Obviously, when we found deficiencies, we suggested changes to the manufacturing processes, which in turn were adopted. Indeed, the interaction between maintainers and designers has been followed throughout the F-35 program in shaping the manufacturing approach.

SLD: You've mentioned "ten times the coupons being tested." What exactly does that mean?

Grant: Well, we use little mechanical coupons. They are then used to do mechanical testing in corrosion and twisting and pulling, and those are representatives of all of the structural integrations of panels and substructure, and the material systems that span gaps in the panels and substructure. We test those coupons in those mechanical situations in both hot and cold extremes, and we've yet to see any of those gaps open up. Naturally, if you can keep the gaps from opening up and introducing contaminants, the potential for corrosion is much lower.

We also have a large selection of similar types of coupons representative of various elements of the structure that are in exposure environments. These environments are either in the laboratory, in our salt bog, exposed to acid rains, or stack gas type of environment — a very, very aggressive environment where they're out on exposure racks or at Battelle's corrosion test facilities out in Daytona Beach, which is considered by the Air Force to be the most corrosion-prone area in the continental 48.

Those coupons being tested, by the way, are in both pristine and in deliberately damaged conditions, to introduce damage that either the maintenance environment or manufacturing anomalies could represent, so that we have a good test of what all the materials do in that environment.

SLD: One of the unique aspects of the F-35 program is how the Systems Development and Demonstration (SDD) phase has been shaped to front-load many manufacturing and maintenance capabilities prior to the full production run of the aircraft. Isn't the LO lab part of this process?

Grant: Absolutely. There has been tremendous investment both on our part and the government in the way that they configured the plan and the entire program to address these issues. Supportability, in general, and supportability of the LO system, specifically, was a highlight of the program. It's one of the pillar elements of the program to ensure aircraft availability and affordability. Obviously, the issues of the past and the expense of maintaining LO on an airplane was of paramount concern to a fleet like the F-35, where there'll be thousands of the airplanes flying that need to be globally operational and maintainable.

SLD: The program inherited a significant LO legacy capability given that Northrop Grumman and Lockheed Martin are key partners in the program. Could you elaborate on this heritage and how it has been leveraged?

Grant: The legacy stealth programs — which to lesser or greater degrees had to invent the technology in a stovepipe fashion — were on their own, and they all essentially had to reinvent the wheel. In the F-35 program, we are partnered with Northrop Grumman and, as such, our team represents 100 percent of the operational stealth experience in the industry in the world. My team and the LO sustainment area is comprised of half Lockheed Martin and half Northrop Grumman employees.

Most of the Northrop Grumman employees are actually retired Air Force LO maintainers who collectively have experience on all of the previous jets currently flying out there. And those who are retired have brought a tremendous wealth of innovation and experience so that they can improve on the conditions markedly for the maintainers of the F-35.

We are not starting from zero. Leveraging this experience is allowing us to build a sustainable LO capability. We're all about providing the maintainers weekends off by giving them systems that are durable and then easily maintained.

SLD: I understand that a core feature of the LO repair effort has been to shape approaches to sustainment that, in turn, have influenced design and manufacturing approaches to the aircraft. In other words, there has been a highly interactive process between the maintenance side and the manufacturing sides of the house.

Grant: From day one, the supportable LO has been a key entity on the program and has had a profound influence on the very design of the airplane. In fact, the element that is manufactured into the skin was an initiative brought about by our LO maintenance discipline. We've also had a profound influence on the selection of the materials and then, once they were decided upon, we helped refine the properties to make them more workable for field use. In addition, we've used the innovation of our team members to create tools and processes that are very easy and reduced the training burden so that they can be easily done in a unit-level environment.

SLD: The F-35 program is built around global partnerships and a globally deployed capability. What is the role of partners in the LO repair facility?

Grant: The partners weren't involved from the very beginning because our technology transfer agreements didn't permit that for a while. But as of November 2008, they have participated in what has become a real institution here. We have quarterly two-day hands-on familiarization courses where maintainers from all of the services and several partners come in and get some experience with the tools and the processes affecting the restorations and the repairs. That's been a tremendous plus in terms of their input and shaping our understanding of what works and what doesn't work, and we've modified our designs and our concepts accordingly. But mostly, they've provided a high-level validation that these tools and processes do, in fact, work for them, for both experienced and inexperienced LO maintainers, and that it's doable in their environment.

SLD: So a lot of the LO maintenance will be done by the services and partners in the field?

Grant: Yes indeed: we have no recognized need for any kind of return to depot or return to manufacturer for doing any type of LO maintenance. Our system requirement was for end of life, which means that throughout the 8,000-hour service life of the jet, it is to remain fully mission-capable. We anticipated the amount of maintenance that would be done over the life of the airplane, and anticipated that in the design.

So when we deliver the jet, it's delivered with a significant margin of degradation that's allowed for all of these types of repairs over the life of the airplane, again, without having to return to the depot for refurbishment. There may be some cosmetic-based reasons why the jet might go back to a facility to get its appearance improved, but from a performance standpoint, there will be no need to do that. The unit-level maintenance will be adequate for maintaining the full-mission capability of the jet.

SLD: In entering the facility, I noticed you have a "door mat" of stealth that's been there for some time. Can you comment on this "door mat"?

Grant: Oh, the slab of stealth? That's our welcome mat. Yes, we actually have one of the test panels that we use for assessing the stealth of the various materials. It represents a stack-up that's consistent with the upper surface or the outer surface of the jet. It has the exact same structure and the primer and the topcoat system that you'll find on the operational jets. And that gets walked upon every time somebody comes in or out of our lab area out there, the repair development center.

Occasionally, we take it up to test to see if there's any electrical or mechanical degradation to the system. With around 25,000 steps across that system, we have not seen any degradation whatsoever. So we have a great deal of confidence, however anecdotal that may be, that we have a very robust system.

UPDATE ON THE F-35 MANUFACTURING APPROACH

http://www.sldinfo.com/?p=9577

Second Line of Defense visited the Fort Worth assembly plant for the F-35 in April 2010. During the visit, the focus was upon the transformation of the outer wing box assembly production approach. During the System Development and Demonstration (SDD) phase, wings have been built in the more traditional military aircraft assembly approach of building around stations. The parts and components come to the station, and the wing is assembled over a period of months at the station. The plant is undergoing change as overhead rail track systems are being installed, after which the outer wing boxes will be assembled using a flow process, rather than a station process. The wing will be assembled by going through two broad flow lines for each side of the wing, with stops along the way at 34 individual stations. Each station does "an individual statement of work" on the wing, after which the wing is moved to the next station for the next "statement of work." Each station within the flow is organized around a work team, which standardizes the effort for that statement of work.

The shift from focus on the stations to flow will enhance production rates and efficiency of the manufactured aircraft, and this is supported by significant capital investment in advanced technologies such as the automated drilling machines seen in the production process today.

The tour and interview were conducted by Don Kinard, Technical Deputy for JSF Global Production Operations and lead for Development of the F-35 Fighter Production System. The Fighter Production System was established to facilitate transition from a current one-aircraft-per-month production rate to a 20-aircraft-per-month production rate in seven years. Prior to this assignment, Don was Director of F-35 Production Engineering and held various positions in both Engineering and Manufacturing during his 18 years on the F-22 Program.

What follows are some excerpts from the discussion during the plant visit, which highlights some of the key elements of the shift from the static station to the flow process.

SLD: How would you describe the basic difference between the wing assembly approach under SDD and under the production approach?

Kinard: I think the basic difference is flows. We are trying to move the product in the wing areas everywhere we can…. For instance, when we produce one aircraft per day, we want to move the wings from station to station each day. We want to create rhythm in the factory so that everything flows, everything moves at a standard pace all through the factory. That's the number-one thing. So everywhere we can we'll be moving it with overhead rail systems to get flow on the parts.

SLD: What's the difference between station and flow?

Kinard: Station build is when I move a wing to a station and it stays there for the entire span time of that build. For example, if I had 20 days of span I'd move to a station and stay there 20 days. When I use flow, I have 20 stations but each one of them is doing a standard set of work. The product moves from one station to another in a standard time span.

The advantage is that the mechanics perform standard tasks in a standard time. They learn much more quickly. They do the same thing every day. All the parts and tools they need are right there delivered to that point of use for that particular station, so everything is optimized all the way down the line. Ultimately, you will find that you don't need 20 stations because the work is performed more efficiently. Bottom line is that you save labor and facilities costs.

SLD: We are looking at an auto-drilling machine. Tell me the advantage of being able to use this machine in the manufacturing process?

Kinard: Here's a wing auto drill; it drills about 3,500 holes per side of the wing, upper and lower wing. So, 7,000-plus holes, and it drills, reams, and countersinks the wing and substructure in one step, with perfection. The yield on auto drilling is about 99.8 percent, which is amazing compared to manual drilling. So, for example, the forward fuselage we are looking at takes about two shifts to drill the subassembly. It takes about two weeks to accomplish the same thing on a legacy aircraft. The wing is very much the same thing. If we didn't use an auto drill, I'd have all these manual tools (drill templates) that I have to locate on each wing, I'd have to drill them up, then take the wings off, and manually countersink them. This automated equipment does all that in one step. It's almost a ten-to-one difference in timespan, plus the added benefit of the perfect quality.

SLD: We are at a substation where the technician is preparing drawings for the wing subassembly work. Tell me how the digital thread process helps precision and savings of time in this process.

Kinard: You've heard us talk about digital thread before and this is a perfect example. Again, we take the bulkheads and first thing we do before we load them in the assembly tools is to do as much work at a subcomponent level as we can. So this is an example. The wing has about 2,000 brackets, which hold tubes, wires, and systems. With legacy technology, we would have built individual locating tools for each of these brackets. The tools would have bumped against a flange of the bulkhead in a particular location to position the bracket.

Using the digital thread, what we do now and what we started doing on F-22 — that we transitioned out to F-35 — is these bulkheads go to a machine that marks the position of the brackets directly on them using the digital thread. It puts an inkjet mark where these brackets go; it gives you a little outline. I, as the mechanic, take the bracket, apply double-back tape, and stick it to the bulkhead using the inkjet marks. The brackets have pilot (undersized) holes for the fasteners. I just transfer those holes into the structure then install the bracket. So, using the digital thread, I eliminate 6,000 tools, or 2,000 per variant, plus all the time it takes to do configuration management on those tools, plus finding them and getting them to the mechanic. Once again, because of the digital thread, I also eliminate mistakes positioning and locating brackets, which is normally one of our high drivers for quality.

SLD: The composite machine we are standing in front of also suggests an interesting approach to manufacturing which shapes a new way to build a composite wing. Could you describe the approach being followed here?

Kinard: I mentioned the key to what we call supportable LO, meaning that the aircraft can go and be Very Low Observable (stealthy) and also very supportable, meaning low maintenance hours for every flight hour. The magic is here in controlling the thickness of the skins. By controlling the thickness of the skins, we're controlling the mismatch from one skin to the other across the joint. Eliminating those mismatches means less radar reflectivity, which is what a stealth fighter is all about. The composite machine is maybe one of the cleverest things that I've ever seen in composites — I mean I started in the composites world, and the Holy Grail has always been to build composites to a precisely controlled thickness. One way we do it on most of the other components (forward fuselage, aft fuselage, and empennage) is to add sacrificial material to the skins, and then we machine it to a nominal thickness with a high-tolerance machine because we're trying to control thickness plus or minus a particular tolerance, which is tremendously better control than we've ever had. For our wings, we invented and patented a process where we measure the cured wing thickness using a laser radar system, calculate where we need to add material to compensate for the thickness, transfer this data to an automated ply cutter, and then transfer this data to a laser projector, which tells the mechanic where to add the plies. The main benefit is lower capital and facilities cost.

SLD: We are standing in front of a wing-skin machine. I see the technician is using the digital thread technology. Could you describe what he is doing and how the technology impacts on the time necessary to do the task, as well the precision of the task?

Kinard: This is a wing skin — the outer surface of the wing — and this wing skin would normally require three drawings to install fasteners on the wing skin. Because it's all digital technology, he is using a laser to mark down on the wing skin where the engineering fastener goes in each hole. Before we were using the lasers it would take us about four days to do this. Now it is much faster. Everything marked on here goes to the final installation area, and the guys don't look at drawings, they just put in fasteners. Now, at some point we may end up doing this real-time, fully integrated within production flow, but today it's much better to do everything off critical path. Now this is only the beginning — you can also do it optically, you don't have to use lasers. But we can do this in one shift now, when it used to take us about four days.

Part Four

Building Future Capabilities

BUILDING THE WEAPONS ENTERPRISE

http://www.sldinfo.com/?p=13846

An Interview with Major General Charles R. Davis, USAF

In October 2010, *Second Line of Defense* visited Eglin AFB and the Air Armaments Center. During the visit, SLD spoke with Major General Charles R. Davis, USAF, who is finishing his tour at Air Armament Center (AAC) and has been nominated for his third star and the command at the Electronic Systems Center at Hanscom AFB.

SLD: What are the most important achievements during your time here, especially in supporting the warfighters in Iraq and Afghanistan?

MajGen Davis: I came here with this perceived notion that we — the U.S. Air Force — had gotten behind in our weapons planning and development activities compared to our platform development. I guess in some ways this turned out to be true. For the operations the Air Force and coalition forces are conducting today — there is hardly a weapon being used today that hasn't been significantly modified in some way. In many cases, the weapons we are using today are being employed in a very different scenario than they were originally designed for. The Air Armament Center team has been very good at adapting something that was believed to be the perfect solution five years ago to an entirely new solution for today's combat. They've demonstrated an inherent flexibility, engineering-wise, test-wise, and production-wise to be able to take some of these weapons and give the folks who are in Afghanistan what they need. In a couple of these cases — one in the Afghanistan AOR, one in another part of the world — we probably could not have anticipated how the weapons were going to be used. But we have other situations where I think if we had followed the right disciplined approach, we could have anticipated needing the weapon that we're now working in a quick reaction mode to deliver ASAP. We could have anticipated that this weapon was going to be needed now, or very close to now, if we had done things differently five or six years ago. This process must start with future target set playing a key role in leading the design process. The process must not start with a set of constraints defined by specific legacy platform dimensions. As we go forward with limited budgets, our challenge is to do a much better job of anticipating what the next need is going to be. How we get adequate funding for what the next weapon requirement will be — a requirement that probably is not part of today's battle — will be a real big challenge in the very constrained budget future.

SLD: How can we be smarter in anticipating future needs as we lay down new baselines for new weapons?

MajGen Davis: We've got to do a couple of things. First, we absolutely have to realize that the weapons we're going to build today have to anticipate tomorrow's battles — in other words, they will be used differently than originally designed and they must be flexible enough to adjust. Today we're building a weapon that is in essence a very small sensor and attack platform that's got to go find its own target and, in some cases, delineate the target from various confusers. It's got to be able to do its mission often without GPS and in all weather.

Tomorrow's weapons must be flexible enough to be effective in a constantly changing threat environment. The threats are getting very, very intelligent. What used to be considered an acceptable level of investment for weapons may not provide what we need in the future. Yesterday's weapon investment levels may not give us the capability to counter the threats that are growing out there today. This is the challenging part.

Some of the threats that we have to deal with today — using very interesting and creative methods — are already appearing on operational threat systems. It is not just a future concern. Five years from now, they're going to be evolved even further into the next generation, particularly in the air-to-air jamming systems. We are already behind the timeline that we need to track be able to counter some threats.

So it's hard for most folks in this day and age to appreciate the level of investment that's got to go into a new weapons program — because that weapon is now essentially a small airframe with a complete radar system, a complete sensor system, a complete guidance system, and autonomous targeting capability. It's no longer just a missile or a bomb.

Our challenge is to meet these needs with a level or decreasing investment budget. It's interesting to see that when the Russians started building their new aircraft, touted as a fifth-generation aircraft, they also simultaneously started to develop the new weapons that would go with it. We're not quite there yet in our airframe/weapons development processes. Our weapons often have to play catch-up after the airframe gets built — in other words, the bay size and the dimensions you have to fit into are fixed. This makes it difficult to optimize a weapon for a mission. We have an opportunity to do better as we look into what's on the horizon in this thing called a "family" of long-range strike systems. We have an opportunity to drive synergy from the start — and really, if you did this the right way, instead of defining your platforms and what platforms you need, you go figure out what your target set is, which would help define what the effect you need is, and could quite possibly define the size and shape of the platform. That would help define the weapon. That would help define what the platform size needed to be and what the platform characteristics would be. The process must start with target set and work its way to the platform bay design. This is a hard concept for most of us engineer and pilot types to accept. If we can shape that process now, as we're getting into new systems like the next-gen platform, or the next-generation bomber — if we can do this a little bit more effectively then maybe, maybe, sometime in the future, senior leadership won't have to ask, "How come we didn't anticipate this five or ten years ago?"

SLD: As we were about to build the F-35, and we have the F-22 in small, but significant numbers, where are the weapons for these platforms? Is there an opportunity to build a weapons enterprise that could be highly synergistic with this stealth platform?

MajGen Davis: I think there's a lot of opportunity now because, as I mentioned, in the past we've had to build weapons to match the hard confines of existing aircraft weapons bays. We are doing that today with the F-22 and the F-35. Or there are other cases where we built the aircraft around existing operational weapons. The F-35 was built around weapons like the JDAM and AMRAAM. In the future, the networks and interactions between an airplane or manned aircraft and UAVs, or aircraft/UAVs and ships on the sea, will determine what weapons you are going to use and how they will be controlled. The weapons could be launched from a wide variety of airplanes and controlled through a variety of different nodes along the way; this will be a major factor in the kill chain of the future. We're already started on what would be considered the next generation of weapons for both the F-22 and the F-35, and the only thing that we're really constrained with now is still weapons bay size.

A NEW PARADIGM FOR MANNED AND UNMANNED SYSTEMS

http://www.sldinfo.com/?p=10222

An Interview with Lieutenant General David A. Deptula, USAF

In May 2010, *Second Line of Defense* continued the conversation with Lieutenant General Deptula with regard to the impact of remotely piloted aircraft on the shifting paradigms for air operations.

SLD: You have talked about a shift in paradigms for air operations associated with remotely piloted aircraft. Could you clarify your thinking about the shift?

LtGen Deptula: We are moving into an era that is much different than the one we just left. Now, that might seem obvious, but moving from the 20th to the 21st century was not just a convenient break point. We are moving away from the industrial age of conducting warfare into an information age to a degree that is only going to accelerate. There are people who have spent their entire careers employing weapon systems in a linear fashion to execute warfare.

Today we are faced with a different set of security conditions. Accordingly, we have to change our thinking on how to effectively accomplish our security objectives, adapting them to the flatness of the way information is collected, analyzed and distributed. We can either capitalize on the technologies that the F-22s, F-35s and Remotely Piloted Aircraft (RPAs) bring to the table or not. We can move further into the information age or we can apply old concepts of operation to new equipment. Such a failure to adapt will prohibit us from exploiting the potential of the manned-remotely piloted aircraft interface.

SLD: Are you talking about a paradigm shift in air operations that is facilitated by the technology but can only be realized by a shift in CONOPS as well?

LtGen Deptula: That gets us into the issue of how are we're using remotely piloted aircraft, and how they may be used in the future. Currently, we are using or applying remotely piloted aircraft in a fashion that resembles the use of segregated ISR platforms in the past. The RPAs have an advantage of providing persistence in this role, even if segregated in CONOPS. Ninety-seven percent of the remotely piloted aircraft today are used to acquire intelligence, surveillance and reconnaissance. The MQ-1 and the MQ-9 do have force application capability, and when their capability is used it dramatically shrinks the ISR strike equation to a matter of single-digit minutes. Their predominate use today is to acquire information.

So while that information is used in conjunction with other force operations, whether they be surface-based or air-based, we still have a long way to go to really achieve seamless integration between remotely piloted and manned vehicles.

SLD: Will there have to be as much boldness in re-designing CONOPS as developing technology?

LtGen Deptula: In the past we let imagination drive technology. Today, technology is driving our imagination. We need to get back to where our imagination drives the technology and permits CONOPS breakthroughs. We need to have imagination driving technology instead of just taking technologies that are handed to us and applying them in old ways. That's letting technology drive us.

And that's where we are with remotely piloted aircraft today. We're trying to figure out how we can plug them into conventional concepts of operation. We are today with remotely piloted aircraft about where we were in 1918-1920 with manned aircraft. Who was the first organizational crowd that brought in the airplane? It was the signal corps — the U.S. Army Signal Corps. They applied it in a fashion that matched what they were used to doing.

SLD: Instead of balloons.

LtGen Deptula: They wanted to see further. They wanted to be able to communicate. Well, that's great, but they're not the ones that came up with the construct of strategic application of force to directly achieve security objectives. The other question is, what are the forces for change? What will allow this new paradigm to be built? It is a combination of imagination that we ought to use to lead technology. In the instance of remotely piloted aircraft, where are we going?

What I'm trying to drive is a concept for MQ-X that is not just a better version of the MQ-9. The MQ-9 is a better version of the MQ-1. It flies twice as high and twice as fast, and carries six times as much payload. There are some people out there who just want to build a bigger, better, higher, faster, greater-payload-capacity remotely piloted aircraft. However, what we really need to do, and what I've tried to accomplish in building this remotely piloted aircraft flight plan, is not simply build a remotely piloted aircraft because it's a remotely piloted aircraft, but address how we can take new technologies that enable remote operations and apply them to our entire set of Air Force core function areas. Where can that technology be best applied across the core function areas to increase effectiveness for air operations? And then you look at the kind of design that you might want to pursue.

SLD: You talked earlier about modularity; how might that drive a new paradigm?

LtGen Deptula: Resource constraints are driving us to fewer and fewer aircraft types, which then drives the idea of something we haven't done in the aviation arena yet. The whole notion of modularity suggests that you can accomplish different mission sets by changing the configuration of the aircraft itself. This may require an approach different from conventional aircraft design.

Imagine a common fuselage, but the wing structure can be changed based on how fast or how survivable or how low observable the overall aircraft needs to be for a particular threat environment — or maybe change the empennage. Or we change out the payload structure.

We need to build the next generation RPA to perform more than just one function. That's one of the key drivers of MQ-X as we design it — modularly. Survivability is also absolutely key as we look to the future. We do not need any more aircraft that can only operate in uncontested airspace. We have plenty of those. This is going to be a challenge.

SLD: Are you focusing on the CONOPS as well as the technology?

LtGen Deptula: We tend to channel ourselves into stealth, which is good, but it's also expensive. We need to be able to produce sufficient numbers to make them cost-efficient. This is what I talked about earlier— the notion of a fractionated set of systems. You have sufficient quantity of systems so that if you lose some you can still achieve your overall degree of effectiveness by those that are remaining.

The other part of the equation from an RPA perspective is the need to move towards greater degrees of autonomous operation to avoid the vulnerabilities associated with current command and control arrangements. A greater degree of autonomy brings with it a completely different set of concepts where you can use remotely piloted aircraft to enhance or extend the influence that is brought to the fight by an F-35 or an F-22.

Pairing up remotely piloted aircraft with manned aircraft enables seamless operations between the two that we have yet to achieve. It is something that I believe we should aspire to so that we can leverage manned aircraft to a degree we have yet to achieve because we have not had the RPA capabilities to match up with them before. That's the direction we need to move in, and that's the kind of leverage or potential that the F-35 and F-22 bring to the equation. We need to apply this kind of conceptual planning for the integration of RPAs with our next-generation, long-range ISR strike aircraft as well.

THE CHALLENGE OF CRAFTING INTEGRATED MISSILE DEFENSE IN NATO AND OTHER ALLIED REGIONS

Ambassador (Ret.) Jon D. Glassman,
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The views expressed are those of the author and do not necessarily reflect those of either the Northrop Grumman Corporation or the U.S. Government.

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The transition to operations draws in a new set of decision makers — national political leaders and military commanders — each with priorities going beyond simple physical functionality of systems.

The priorities of these decision makers in each theater need to coalesce in regional or parallel bilateral understandings on the objectives of missile defense and the means of its execution. If the political leaders and military operators do not create collective or synergistic approaches, the inadequate weight of the theater missile defense effort may render it futile — leaving only pre-emptive offensive action as an option. Regional missile defense architecture—in the hoped-for world of political and military concord — will have to embody more than wire-diagram connectivity of systems.

Additionally, a consensus must emerge that will stimulate self-sustaining growth and transformation of missile defense in the face of evolving threats through mutually reinforcing investment and cost savings produced by coordinated and parallel operations. For the last 45 years, debate has centered on the physical practicality of missile defense: could a bullet hit a bullet? Mercifully, that debate has ended and, in the face of looming threats from Iran and North Korea and uncertainties in Eurasia, real investments are now being made by the United States and other nations to provide a rudimentary and, eventually, more robust homeland and regional defense against missile attack.

As missile defense goes operational, architectural and engineering studies are underway within regions to knit together U.S. sensors and shooters — and, in the future, those of partners — in networks allowing command-and-control. These networks and directive capabilities will be stressed in some regional contexts because of short timelines between launch and impact and the weight of incoming numbers.

The need to create an effective response to voluminous challenges within rigid time constraints makes investment, operational, and policy planning/coordination imperative; yet this vital need is only beginning to be recognized in regional missile defense discussions.

Integrated air and missile defense is but a part of the needed integral defense of regions embracing:

- Defeat of the full range of threats, both ballistic and air-breathing: rockets, artillery, and mortars (RAMs) to theater ballistic missiles, powered glide bombs and UAVs to long-range air-to-ground missiles and cruise missiles;
- Effective cooperation across time: from threat gestation (pre-launch indications and warning) through detection/tracking/engagement, offensive action, and consequence management/reconstitution;
- Achievement of optimal defensive effect through efficient allocation of defensive resources and offensive-defensive fusion;
- Enabling of coordinated investment strategy and political-military policy determination and execution.

The forthcoming global deployment of large unmanned aerial vehicles (UAVs) such as Global Hawk, BAMS, and Euro Hawk, joined with existing manned air-to-ground surveillance (AGS) platforms such as Joint STARS and ASTOR, and Airborne Early Warning (AEW) aircraft such as AWACS, 737 MESA, and E2C/D, could be used to enhance regional ballistic and cruise missile tracking — given an appropriate sensor and networking strategy.

This could come from building out from the U.S. Missile Defense Agency's ABIRS (Airborne Infra-Red System) concept of UAV-mounted infra-red sensors and the future overseas deployment of U.S. and allied/partner F-35 stealth fighters equipped with advanced AESA (Active Electronically-Scanned Array) radar and the Distributed Aperture System (DAS).

With a demonstrated range exceeding 800 miles with full spherical coverage, multiple DAS on F-35s and U.S. and allied Global Hawk, Euro Hawk, BAMS, and other UAVs, fighters, and AEW/AGS aircraft, could be meshed together in ad hoc networks through secure data links using software being developed in the Missile Defense Agency's EC2BMC (Enhanced C2BMC) program. This would allow allies/partners to leverage already committed investments to increase missile defense performance and validate its utility against threats in the ascent and terminal phases.

F-35B:
NOT JUST GAS AND GO

http://www.sldinfo.com/?p=13294

The Honorable Ed Timperlake

In the not too distant future the U.S. Navy, Marine Corps and Air Force may have to establish presence from the sea in a potential combat theater. The threat will be great: friendly forces can be intermixed with opponents who will do whatever it takes to win. From placing IEDs, to employing small unit ambushes, to spotting for artillery and Multiple Launch Rockets… the enemy will be unforgiving and aggressive. In addition there is a large land army with armor and land-based precision weapons nearby to attack.

The opposing forces also have a tactical aviation component of fighters and attack aircraft, along with unmanned aerial systems and some proficiency in offensive "cyber war"… ready to engage. To make it even more difficult, the enemy has located and identified potential airfields that could be occupied and has targeted them to be destroyed by terminally guided cruise and intermediate-range ballistic missiles.

Finally, the fleet off shore is vulnerable to ship-killing missiles. The problem for U.S. war planners is to secure a "beachhead" and build to victory. Traditionally, the "beachhead" was just that, on a beach. But now it can involve seizing inland first and attacking from the back door toward the sea to take a port and or airfield.

The U.S. Air Force (USAF)—flying high cover after being launched from bases far enough away to be safe from attack — can establish air superiority, and the Navy fighters can go on CAP (Combat Air Patrol) to protect the fleet. Both services can launch offensive weapons from their TacAir and from B-2s, surface ships and subs. UAS can go into battle for ISR and offense "cyber" can be engaged. U.S. "smart munitions" can attack enemy offensive rockets and missile launch sites. There will be significant casualties on both sides.

But the Marines do the unexpected and land where the enemy does not have ease of access—a natural barrier or the back side of urban sprawl. Once established, logistical resupply is a battle-tipping requirement.

Once ashore, one asset that can tip the battle and keep tactical aviation engaged in support of ground combat operations, if runways are created. It is the F-35B… because every hard-surface road can be a landing strip, and resupply can quickly arrive from Navy Amphibious ships via MV-22s and CH-53Ks.

The F-35B is a fifth-generation airborne stealth fighter with its own distributed intelligence center. Each aircraft has a total 360-degree knowledge. If the enemy launches an attack from the air or ground, airborne sensors can instantaneously pick up the launch. The battle information displayed in each F-35B can be linked to UAS drivers as well as ground and airborne command centers to coordinate both offensive and defensive operations.

The sortie rate of the aircraft is more than just rearm and "gas and go": it is continuity of operations with each aircraft linking in and out as they turn and burn — without losing situational awareness. This can all be done in locations that can come as a tactical surprise. The F-35B sortie rate action-reaction cycle has an added dimension of unique and unexpected basing, thus getting inside an opponent's OODA (Observe, Orient, Decide and Act) loop.

Now imagine, it is only the Israeli Defense Force fighting for the survival of the free state of Israel. Israel is a nation surrounded by hostile forces. All of the threats mentioned above, instead of being directed against U.S. forces, are life and death problems for Israeli defense planners. Consequently, it is not a surprise that the Israeli Air Force (IAF) is considering the F-35B. The Lightning II V/Stol version's combat potential is nowhere near fully understood and exploited.

It is a perfect aircraft for the Marines: think not only Israel, but other contingencies. Think Korea or Taiwan in a major incident… or the USMC being used to keep the promise with allies that trusted America's Marines to save an Iraqi town of innocents from being overrun or stop the Taliban from attacking a village.

For the citizens of Israel, the IDF is fully capable of making informed and appropriate choices for their survival. However, the F-35B may be a perfect aircraft for their combat situation. If Israel has to fight for their very existence, the V/Stol capability may become invaluable. Debating funding such a valuable resource for both the USMC and others is unthinkable, as the F-35 can be the tipping point for an entire war effort.

CRAFTING THE TRANSITION

http://www.sldinfo.com/?p=13601

An Interview with Major General Herzl Bodinger, Israeli Air Force (Ret.)

In November 2010, *Second Line of Defense* met with Major General Herzl Bodinger, the former Commander in Chief of the Israeli Air Force (January 1992 to July 1996). Major General Bodinger is a noted air power thinker, and during our discussion provided some insights into the evolution of air power and its role in the defense of Israel. He is the President-elect of the He is the President-elect of the Israeli Air Force Association and is President of RADA Electronic Industries. During his 35-year career, General Bodinger accumulated 6,000 flight hours and conducted 451 aerial sorties.

SLD: What role has air power played in the defense of Israel?

MajGen Bodinger: From the beginning, air power has been essential to the survival of Israel. We have developed the Israel Air Force (IAF) at the maximum size possible with our resources. The IAF needs to cover the whole Middle East, and be able to strike any target that the government of Israel will decide is necessary for the defense of Israel. The goal is to be able to convince adversaries that you cannot stop us, and you cannot retaliate in the same manner. We have had total air superiority for a considerable period of time. But air superiority is not a given. We live in a dangerous neighborhood with new weapons, missiles and capabilities. Today's challenge of air dominance is against significant numbers of missiles and defensive systems, primarily not delivered from aircraft. Ensuring air dominance against a polyvalent threat is crucial to the defense of Israel.

SLD: The new approach to take away air dominance is to augment defenses and to proliferate missiles?

MajGen Bodinger: The adversary's efforts are to provide new capabilities against our aircraft and to do so by using various means including ground-to-air missiles of different kinds… challenging the ability of Israel to retaliate, attacking this very small country, a country with no strategic depth. Our adversaries are relying on the proliferation of missiles, both surface-to-air and the ground-to-ground, to prevail.

SLD: So how do you respond to this new threat environment?

MajGen Bodinger: You can simply upgrade existing systems to deal with the new threats. There are some gaps that you can't overcome just by making a small minor change either by changing the tactics or simply upgrading the aircraft. There comes a time though that you have to leap forward in combat capability. We plan to do so with the F-35.

SLD: Do you need to introduce a different type of combat system to deal with the new threat environment?

MajGen Bodinger: A different kind. We went to robotic systems or UAVs of various kinds. We were the first to use them in numbers in 1982. So this was one solution. And this is also a solution for staying over the battlefield for a long time. I call it a satellite in the atmosphere.

SLD: It gives you persistence.

MajGen Bodinger: Yes, it stays there for hours, and provides information and can attack. But it's a robot with the limitations of a robot. You need to shape the correct mix between manned and unmanned aircraft, which is an evolutionary process. But you clearly need to deal with the threat from the defensive systems for both the manned and unmanned systems. You need the ability to overcome all these threats, which are being developed against it, like the S-300 and S-400.

SLD: So you need to craft effective capability to deal with the new defensive systems and missile proliferation, which threaten both manned and unmanned systems?

MajGen Bodinger: The correct way to go, which we watched very carefully, was what the F-117 introduced at first. The idea of low observable and low radar cross section, and it really looks a newer way to go. Of course, all the avionics that come with it make these machines very expensive. But to keep buying the old aircraft simply creates targets for the new defensive systems and is a much more expensive approach.

For us, air power is a spearhead force, which can be used as an icebreaker. It will open the way for the rest of the aircraft to come. This will be the F-35. Because it can lead the way and it can reach the targets. It can fly over any point over the Middle East and strike any target. The surface-to-surface missiles are also a big problem here because of the range and because of the size of the country. We don't have strategic depth. So, we have to bear in mind that all our assets are at risk from missiles. Whether it's the military assets or it's the civilian assets. From electric power stations, airports, and refineries and factories, and airbases, the entire infrastructure is at risk.

SLD: So offensive and defensive systems need to be available to Israel to deal with the new threat environment?

MajGen Bodinger: Clearly you can take some points of interest and defend them better. And if worse comes to worse, and there is such a bombardment, you can put the civilians into shelters and you can even evacuate for a period of time. We don't know what our adversaries will do.

What we've seen since 1991 is that they bombed two towns, two big cities in Israel. Forty missiles launched, twenty on each town… one or two a day. So, it shows the ability to inflict a lot of damage to our nation. We cannot simply sit back and take strikes. We have to defend our offensive assets so that we can strike back. We can put aside the defense against surface-to-surface, there are different means and layers, there's a whole theory here in development of weapons.

But we need time to get better results and better integration. And our defense forces always have to think like that. We have to prepare for the worst; defense spending is like insurance. How much you invest in insurance is an equation that considers the value of the assets that you want to insure and the probability they will be damaged. So this time, the asset is a country. It's invaluable. And the probability that it will be damaged is not low enough. So we have to invest wherever we have to invest. Even if at the end at the day, maybe we have seen the dark side of the cloud and we're pessimistic, one could say, and nothing happened. No alarm and disagreements. Everything is flourishing; it's like Europe here. So, we hope, but hopes are not a plan.

SLD: But what we do know on the defense technology side is the defense is getting better; the missile technology is getting better. So all of that could be bundled into different threat environments that could be very, very difficult if you cannot manage the battlespace.

MajGen Bodinger: That's why we need the new aircraft. One would say we need better tanks; we need better everything. But when we talk about the ranges and the value of air power, not as a partner of the ground forces, but as a lead, this brings me to the F-35. As I look back on the development of the Israeli Air Force, certain aircraft gave us an opportunity to make a leap forward. The F-35 fits into that tradition. Looking back, one quality leap was provided by the *Mirage*, the other by the F-15.

I remind people that in the late '50s and the beginning of the '60s, there were arguments here in the government, in the military and in the Air Force regarding whether or not we needed the *Mirage*. We discussed upgrading the aircraft that we had. Many officers and pilots in the Air Force supported this, thinking we could make do with upgrades and carry the advanced weapons, and be better off. Why do we need to spend a lot of money with something, which could be a little better? But the problem with those who cannot envision the future is that they cannot understand the leap which a new platform can provide. It's another kind of aircraft; another kind of capability.

The *Mirage* was the first revolution in the early Air Force. The second time such a thing happened, we had *Phantoms* and we had *Sky Hawks*. When we converted to American machines, it was very good; the F-15 brought a breath of fresh air. It changed the way we fought. We got the first aircraft in 1977, four prototypes of F-15s. We bought them from the test aircraft; they were fit to make some changes to become operational. And we got those. This was a revolution in our Air Force.

The whole way of flying changed after the first four aircraft came here. Of course, when they were multiplied and then added the F-16, it became the Air Force as it is today. But the first aircraft that arrived already made the change. And we didn't expect that this would be the change.

And so, when you ask me about the F-35, I know the qualities of the aircraft. I know the value of low radar constriction, the fact that you have the communication network, the missiles and weapons that you can hold inside, and whatever you can reach. And I know the qualities of the aircraft, but I am sure that the minute the aircraft will actually be used, again, I know that there will be another unanticipated dramatic change.

SLD: No one has ever flown a 360-degree aircraft with combat systems which allow it to manage that space. We have written on the web site about the cultural change associated with the new aircraft. We've talked to many test pilots of this aircraft. And the notion of a 360-degree aircraft, with the kind of combat system integration, which the aircraft has, will create pressure for a culture change.

MajGen Bodinger: You can understand it only if you experience it. And it is very difficult to transmit it to somebody who's never flown the aircraft. And I'm sure that this will not be a small leap; again, it will be a dramatic change.

SLD: Similar to your F-15 kind of experience.

MajGen Bodinger: Yes. I was lucky to put in place the first pilots in the country who flew F-15s. And I'm sure that this will be what will happen. And I know that there will be a big development, but you cannot even imagine what it will be. When it will come, we will know. And it will lift the whole Air Force to another level.

SLD: I think at the heart of the issue from my point of view is sortie generation rate. Your ability to turn an aircraft around quickly to go back into combat.

MajGen Bodinger: Now, you're coming back to the defense against surface-to-surface missiles. We have to retain our ability to take off. But let me go back to discuss the robots, which I consider to be satellites in the atmosphere. I think that wherever you can send a robot, instead of a person, you should choose a robot. Where can you do it? When the targets are static targets, the headquarters of something, any installation or asset that you wish to bring down is ideal for a robot.

That is important for war, strategically or tactically. When you know where a target is, this is what you have to do. In all those cases, I think it's a waste to send a person, because you can do the punch, whatever you wish, it will go and will kill the target and come back. And if it doesn't come back, you send another one. So this is a robot. All the other cases that you have need to have a human mind on the battlefield to decide, because you don't want to kill people who are not involved. When the targets have moved to another location, you need a human mind to decide on the spot. Or if you want to shift priorities, and you have the authority to do it, because that shift in targets is necessary to success.

SLD: That's a really crucial capability… re-prioritization in a fluid environment.

MajGen Bodinger: That's when you have to have a person on board. Lead a herd of those machines—the robots—and give them missions on the spot. Especially when adversaries start to become very accurate because of GPS or any other means via their missiles, we will need dominance in the decision making cycle to prevail. We look to the F-35 to be key to that process. And as we develop the combat capability, we may eliminate many robots; you don't even need a UAV, why do you need a platform to carry your weapon? Launch the weapon. Like the *Tomahawk*, but these will be different *Tomahawks*..

FIGHTING AND SUSTAINING AS A TEAM

http://www.sldinfo.com/?p=12899

An Interview with Brigadier General Art Cameron, USAF (Ret.)

During a visit to the Lockheed Martin F-35 facility in September 2010, *Second Line of Defense* talked with Brigadier General Art Cameron, USAF (Ret.) to discuss the approach to F-35 sustainment. With his long experience in U.S. Air Force maintenance, the focus of the discussion was upon comparing that experience with the evolving sustainment approach to the F-35. At the heart of the shift is the potential to build a fleet-wide maintenance approach to the services' and coalition partners' sustainment capabilities.

SLD: What is your background in fighter maintenance and how does that impact on your thinking about the F-35?

BGen Cameron: I spent 33 years in the USAF doing fighter sustainment, turning wrenches on F-106s in Northern Michigan in the late '70s to working the latest fifth-generation fighter, the F-22. While I've worked all Air Force fighters, most of my career was with the F-16. I worked F-16s at the first operational base, Hill AFB, in 1980. I worked F-16 flight tests at Edwards AFB. I deployed with the F-16. And, I led the MRO&U effort on the F-16 at Ogden Air Logistics Center.

The F-16 was and still is a great airplane. However, it was built like most previous weapons systems, with sustainment not being an integral part of the design. Aircraft operational capabilities have become evolutionary and revolutionary over the decades, but reliability and maintainability have not kept pace with the increased operational capabilities. The F-35, in many respects, is the first aircraft that has sustainment as an integral part of the aircraft design.

The original fifth-generation aircraft, the F-22, was light years ahead in terms of sustainment with some of the integrated sustainment systems, the data management systems and the health management systems that are onboard the airplane. The next fifth-generation iteration, the F-35, is another evolutionary and revolutionary step ahead of the F-22.

What we have learned in aircraft development is that the key to operational capability is to ensure aircraft availability. Therefore, the big difference in the F-35 is that it's built as an "air system" which comprises both the aircraft and the sustainment system. Sustainment has been built in from day one in this airplane. We like to say sustainment is as integral to the aircraft as the wing.

SLD: With regard to the F-16 versus the F-35, you're talking 40 years difference. And as you mentioned, the F-35 like other modern programs has been designed with sustainability in mind. What impact will that have on the ability to sustain the F-35?

BGen Cameron: The F-35 was designed with a focus on affordability, availability and interoperability. The services directed us through the operational requirement documents to build sustainment into the aircraft. The nine F-35 participating countries said that the program would be worked under a "common solution" with a shared supply chain, shared training and shared development, with all the countries bearing the cost of the common sustainment solution. Current global economic realities are driving changes to legacy sustainment systems. My gut tells me that a common solution has to be more affordable, and the facts bear this out. Think about it: one common supply chain vice 13 separate supply chains, one common fleet management system that has fleetwide visibility of assets and systemic fleet issues vice 13 separate systems that have no linkage.

There are also significant sustainment interoperability issues that we never had before. Now our allies can share assets when needed during contingencies without the added complexity of crossing multi-service/multi-country sustainment systems. The advantages of a common sustainment system are staggering. However, the F-35's sustainment system is not only revolutionary, it's a significant change to the way the services presently do business and it's a cultural shift. And as we all know, changing a culture is hard!

SLD: Much of the public debate is focusing on cost versus affordability of operations.

BGen Cameron: You have to remember the genesis of why the F-35 was designed. It was designed because the operational costs on legacy airplanes are increasing exponentially to the point where the services are mortgaging off hardware and manpower to keep old iron flying. At the same time, aircraft availability has been steadily decreasing. Dwindling service sustainment budgets force them to take risk in sustainment funding that has the long-term impact of slowly eroding the fleet health. The F-35 was designed to counter this with a highly reliable and maintainable aircraft, scalable availability based on what the service and the country needs and shared support, with the sustainment costs based on the percentage of the total aircraft purchased versus each service or country building a standalone sustainment infrastructure.

SLD: The F-35 is a beneficiary of the F-22 development process. What has been the experience with the F-22 maintenance?

BGen Cameron: While the F-22 and the F-35 are both fifth-generation fighters, you have to remember that the F-22 is 186 aircraft being flown by one service. The F-35 will be well over 3,000 aircraft, with nine participating countries, comprised of 13 unique services, and an untold number of future FMS purchasers. The real beauty of the F-35 program is that you can scan the entire fleet including the international partners and the domestic partners and tell immediately if there are systemic fleetwide issues. The program can share assets to ensure a surge capability to wherever it's needed and can share the robust supply chain that's already established on the F-35 production line. Our experiences with the F-16 highlight another major advantage of the F-35 approach. The F-16 has been a highly successful program. However, configuration management has been a challenge because it has been handled at the individual service level. Therefore, there are roughly 130 configurations of the F-16. The operators, when prosecuting the air battle, have to know the precise configuration of each F-16 in order to know what capabilities it brings to the fight. The sustainment of the F-16 is even more challenging with spares not being interchangeable among F-16 variants. The F-35 is a common configuration so interoperability is the key in both operations and sustainment.

In addition, pilot and maintenance training become that more relevant and affordable. The pilots will fly the same software in the simulators that they'll fly in the aircraft, and the maintainers will train on the same systems they'll actually see in the field. Any operational-level military member can quickly see the advantages.

The F-35 program has learned from the F-22 and listened to the maintainers on the line. The F-22 is a great stealth platform. The designers of the F-22 learned from previous stealth platforms (F-117, B-2) and designed an "easier" platform to maintain. The F-35 has learned from the F-22. Lower MTBF parts are placed behind easy-to-access panels, parts are not double layered, stealth degradation can be easily measured on the line without sophisticated and cumbersome diagnostic equipment, panels can be reconfigured to accommodate accessing parts, and the coatings are durable and can be easily repaired. The F-35 has definitely benefited from the experiences of previous LO platforms.

SLD: Can you discuss the common training facility at Eglin AFB for the joint pilots and trainers for the F-35?

BGen Cameron: This is not only exciting; it's true goodness for the warfighters. This joint training takes place at the Integrated Training Center. It's truly a genesis of design. And, it starts with the Command construct at the 33rd Wing. The Wing Commander is an Air Force Colonel; his deputy is a Marine Colonel. The Maintenance Group Commander is a Marine Colonel, and her deputy is an Air Force Colonel. The Training Center Commander is a Navy Captain. It is a masterpiece of joint design.

When I retired from the U.S. Air Force after 33 years I wanted to go to work on a program that I thought was going to shape the future. The F-35 was designed to fix the aircraft affordability and availability problems. I knew working this program was going to be hard because, in order to get the maximum benefit out of this program, some existing ways of doing sustainment within the services had to change. However, the truly exciting part of the F-35, from a warfighter perspective, is the interoperability piece of the weapons systems with our allies and own U.S. services. We often talk of the affordability and availability mandate, but it's the interoperability piece that's truly revolutionary. Let me give you just one example of why that's needed. When I was supporting the Bosnia war in the 1990s in Northern Italy we had all the U.S. services and many international partners flying out of our air base. On occasion our supply system couldn't respond fast enough to get us the parts we needed to meet the next day's flying schedule. I knew that the other services and our allies potentially had that part, probably right on the same base, but I didn't have visibility of their supply systems. So, my folks would physically visit each unit to check their part availability. Then, when we occasionally found the needed part, there was no formal process to transfer it from our own U.S. services and certainly no process to transfer from our allies to us. So, think about this. We're at war. And we couldn't get a part from the Navy/Marine side of the base to the Air Force side of the base. That's all within our own U.S. services! We also had Italians, Spaniards and other countries flying off the same field. There was no way I could've shared any parts with them. Now fast forward just 15 years and we're flying the F-35; all flying the same airplane; all using a common configuration, a common supply chain, same training, same everything. We don't need to have a process to move parts from the services or our allies; it's one supply chain.

Interoperability is the beauty of the F-35 program. We can go to war as a team and operate as a team. Affordability and availability are obviously imperatives, but interoperability is the key component the F-35 program that will enhance the warfighter's effectiveness and lethality.

SLD: When people use the term interoperability, it is rare when one refers to it as sustainment or logistics interoperability.

BGen Cameron: It's a key tenent of the program. We fight as a team. And if we're going to fight as a team, then we need to figure out how to work together as a team from a sustainment perspective.

CHANGING THE CULTURE

http://www.sldinfo.com/?p=12441

Shifting the Maintenance Paradigm for 21st-Century Ops

In September 2010, *Second Line of Defense* sat down with maintainers at Langley AFB to talk about F-22 experiences and preparation for the F-35. As the maintainers described it, a significant cultural change was underway which would lead to significant manpower savings and enhanced supply chain efficiencies. Senior Master Sgt. Steven Wehrle and Master Sgt. David Freeman of the USAF discussed their evolving experience with fifth-generation aircraft maintenance approaches.

SLD: What are some of the challenges in preparing for the introduction of the F-35 at Langley AFB from a maintenance point of view?

SMSgt Wehrle: My worries are not focused on the brand new one-striper coming out onto the ramp to crew an F-35; he's going to get trained. The Air Force invests a lot of time into its young troops upfront to ensure they are ready to execute the mission. What we are very concerned about is the Senior Airmen that crewed F-16s or F-15s, and who are transitioning to the F-35. What I'm referring to is a mindset change in our sustainment practices. We have to ensure we are effectively preparing our mid-level airmen and our logistics supervision that are transitioning to the F-35.

The acquisition and sustainment of this platform are wholly different than anything that has been done before. This is not just an exclusive Air Force platform and Air Force buy; there will be many processes and procedures executed differently. It is a joint platform where commonality and affordability have driven concessions amongst us all.

SLD: Is the challenge that most experienced maintainers are used to mechanical versus digital systems?

SMSgt Wehrle: The Autonomic Logistics Information System (ALIS) is at the heart of this new air system. It is a challenge at first to get folks to accept this paradigm shift in technology. ALIS is much different in that there are a number of things that are designed to meet the joint or common solution. Because of the common solution, challenges are bound to arise that make us re-evaluate our legacy processes.

SLD: Are you describing a culture change and the need to anticipate the time necessary to adapt to the new approach?

MSgt Freeman: It's a completely different mindset. I started out on U-2s many years ago, which is one of our most primitive planes still in inventory. There are no hydraulic actuators to assist the flight controls. Cables, bell-cranks and pulleys that must be hand rigged are used. So that's the technology level I learned on. Mechanical ability was crucial to performing maintenance. As a Senior Airman I moved to a more high-tech platform, I moved up to the A-10. I went from '50s technology to '70s technology. So, I went little bit up in the evolution chain to the A-10, a great plane that was easy to maintain, and I liked it.

Later in my career I transitioned to the F-22. It was a big jump, going from analog to digital — still turning bolts, still turning wrenches, but the way everything is put together and fused on the ops side drives a whole new requirement for all the electronics pieces and bits that are put together. It's maintained in a completely different way. You don't rig flight controls on an F-22 or an F-35; well, you do, but you do it with a laptop and a keyboard versus a tensiometer. Many legacy organizations within maintenance are going to fade away on the flight-line. There are reasons these organizations and tools are going away. They're just not needed anymore. Many tasks are done so easily now on a computer or via a bit check. Computers are taking over the workload just like they're taking that workload off the pilot.

SLD: Has this cultural shift that you are describing started with the F-22 maintenance experience?

MSgt Freeman: It has. With the new guys coming out to learn F-22 maintenance, this is normal for them. The challenge arises when you try and train the older guys or even the middle-level personnel who are used to using paper manuals to do repairs or used to looking at a fault-isolation blueprint. Those don't even exist in the fifth-gen maintenance. You have to rely on the prognostics and diagnostic systems on the plane to tell you what's wrong.

When we previously did trouble-shooting, we built fault trees and trouble trees. With fifth-gen we rely on the computer diagnostics and the air system's prognostics. The migration for the older guys will be difficult; moving from the analog to digital will be tough. As we move into the future — into the iPad/iPod generation — it's going to be second nature to the young guys who are coming in and learning this stuff. These tools are going to be very valuable to the older maintainers as well, it's just such a leap, and I imagine even in the pilot community there have been challenges with older pilots who are used to older aircraft as well.

SLD: How is the F-22 maintenance regimen different than the F-15?

MSgt Freeman: The F-22 will tell you what the fault is through the ICAWs, integrated caution and warning system. The jet will tell you, hey, I've got an advisory going on with this system, or hey, I've really got an emergency, you've got engine fire, and it puts out the fire before you even have time to hit the buttons and turn it off. On an F-22, the majority of the emergencies or faults that we have are reported by the aircraft. Sometimes they're not even shown to the pilot until we get to maintenance debrief.

In the F-15 that I flew today, I got this light, and that means it's broken so you guys need to take it from here and fix it. In the F-22, I might have that fault, but it does its own analysis. When I'm done with the aircraft, I bring in my digital transfer cartridges; it's basically about the size of your handheld recorder. I plug it into the computer and then the maintenance system downloads all the faults that the jet is reporting… everything. On the F-22, everything is integrated. So I might lose the electrical system or the vehicle control node, and it has fingers in everything.

SLD: Could you describe the difference between maintenance on the F-22 and the F-15?

MSgt Freeman: You're shifting from a reactionary maintenance regime in a legacy plane to a proactive and targeted maintenance regime in the fifth-generation. If you look at an F-15 or F-18, you don't fix anything until it breaks, until the component is broken. There were very few prognostic-type indicators to forecast that something may break in the near future. We built in a redundancy and we built in schedule maintenance regimes where you inspect things every so many hours.

With the technology that's coming along, you leverage the sensors. This is nothing new and fancy; look at our cars. If you look at a car from the '80s, how do you change your oil? You change your oil every 3,000 miles or every three months. Any new vehicle that's out anymore has a sensor. The computer tells you to change your oil. It's the exact same technology that's being applied now that has been applied to the F-22 and the F-35 and even the F-16, to shift from reactionary maintenance regimes to more prognostic maintenance regimes, where you can begin to predict reliably to lean down your logistics chain to support your operations.

SLD: So leaning down your logistics chain is a big gain for your maintenance regime?

MSgt Freeman: You're not over-inspecting is one advantage. You're not overstocking parts that you may not need. You can begin to really focus your logistics effort by analyzing data fifth-gen fighters are designed to utilize.

On the F-35, the data file that comes off the jet is gigantic. It records everything that's happening on the jet and it goes into a file. Over time, we are going to shape how we use the data generated by the plane to get really effective maintenance metrics.

SLD: How will the data advantages of the F-35 be leveraged over time?

MSgt Freeman: The ALIS system that they have built and the autonomic logistics construct for the F-35 are going to be awesome. Previously, we had many barriers in legacy sustainment of the planes, where there are many federated items in the supply chain. But with a single supply chain driven by an integrated aircraft, a lean approach is possible. The guy on the flight-line doesn't care where his parts come from as long as he can get them.

I don't care where the part's coming from, as long as when my plane breaks I can get a part tomorrow and I don't have to pull it off the plane sitting beside it. If it comes from the United States or any partner nation, I don't care. As long as it's a reliable part that lasts, meets my specifications and standards and I can get it tomorrow, I'll take it.

SLD: How will the ALIS system work for you?

MSgt Freeman: It's very simple. While you're doing your job and you're doing your maintenance, you tick a box. That's all you do to order a part. It's all shot out instantly… electronically. That's all within ALIS. When I first saw it I was shocked. I thought, "Do the supply guys know about this? That all I have to do is tick a box and a part is coming my way?" Normally, I have to fill out a form that is a page and a half long just to get a screw.

In ALIS, all you do is tick a box, and it's intuitive enough to pull in your part numbers, all that data that it needs it already knows, it's already in the system. So you tick the box, the requisition goes over to the supply module of ALIS. The system responds, letting me know if I have this part in my local warehouse. If it's in the local warehouse, it sends me back a message saying it's ready for pick-up, come and get it. If it is not locally sourced, it goes out to regional supply and you'll get a message back within a certain time period of where that availability is and when you're going to get it. Then all these mechanized processes, which are automatically done in the background, are checked, and of course there's supply oversight into the process. It's much more mechanized and automated in the background in ALIS versus legacy systems.

SLD: What has been the reaction of other maintainers when they see the new approach?

MSgt Freeman: Lockheed Martin recently hosted a conference at the Center for Innovation in Suffolk. They invited our HQ ACC/A4 counterparts to come over with their weapon system teams to see the flight-line of the future. The F-22, F-15, F-16 and A-10 weapon systems teams came along. They were able to see ALIS and how it was going to work, including the future of maintenance on the F-35.

Every single one of those maintainers' jaws just dropped. They said it was awesome; they said "I want this for my platform! If you can make it work, I want it."

A great example was the A-10 weapons team superintendent who said he could call DLA right now and ask them how many of these widgets are in supply, and then if he were to call back the next day he would get several answers, usually different answers. All of the legacy teams expressed frustration with an ailing defense supply chain that continues to have challenges keeping their planes in the air. Many echoed "Legacy has grown too large and complex, relying on vendors that are no longer even in business to source parts on our aging fleet."

THE IMPACT OF THE F-35B ON USMC OPERATIONAL COSTS

http://www.sldinfo.com/?p=10063

Lieutenant General George J. Trautman, III,
Deputy Commandant for USMC Aviation

Affordability is the balance of cost and capabilities to accomplish assigned missions. For more than a decade the Marine Corps has avoided the cost of new procurement during a time when the service lives of our legacy aircraft were sufficient to meet the missions assigned. However, in the near future, our investment in the capabilities of the F-35B will outweigh the unavoidable legacy aircraft operations and sustainment (O&S) cost increases we will incur with the F/A-18, AV-8B, and EA-6B. The O&S costs of legacy aircraft across DoD have been increasing at an average rate of 7.8 percent per year since 2000.

The operational lifetimes of legacy aircraft are being extended well beyond their original design limits. As a result, we have been continually engaged in a struggle to maintain operational readiness of our legacy aircraft due largely to the increasing age of the aircraft fleet. Early in an aircraft's life cycle, the principal challenge is attributed to the aging proprietary avionics systems upon which the user depends for warfighting relevance; later it is maintenance of the airframe and hardware components that become the O&S cost drivers.

The Marine Corps strategy for the last eleven years has been to forego the procurement of new variants of legacy aircraft and discontinue a process of sustaining old designs that inherit the obsolescence and fatigue life issues of their predecessors. Instead, we opted to transition to a new fifth-generation aircraft that takes advantage of technology improvements which generate substantial savings in ownership cost. The capabilities of the F-35B enable the Marine Corps to replace three legacy aircraft types and retain the capability of executing all our missions. This results in significant and tangible O&S cost savings.

A common platform produces a common support and sustainment base. By necking down to one type of aircraft we eliminate a threefold redundancy in manpower, operating materiel, support services, training, maintenance competencies, technical systems management, tools, and aircraft upgrades.

For example:

- Direct military manpower will be reduced by 30 percent, approximately 340 officers and 2600 enlisted;
- Within the Naval Aviation Enterprise we will reduce the technical management requirements of the systems requiring support by 60 percent;
- Peculiar Support Equipment will be reduced by 60 percent, down from 1,400 to 400 line items;
- Simulators and training support systems will be reduced by 80 percent; five different training systems will neck down to one;
- Electronic Attack WRAs will be reduced by 40 percent and replaced with easier-to-support, state-of-the-art digital electronics;
- The Performance-Based Logistics construct will nearly eliminate macro and micro avionics repair, and intermediate propulsion support functions;
- Airborne Armament Equipment (AAE) will be reduced by more than 80 percent with the incorporation of a multi-use bomb rack.

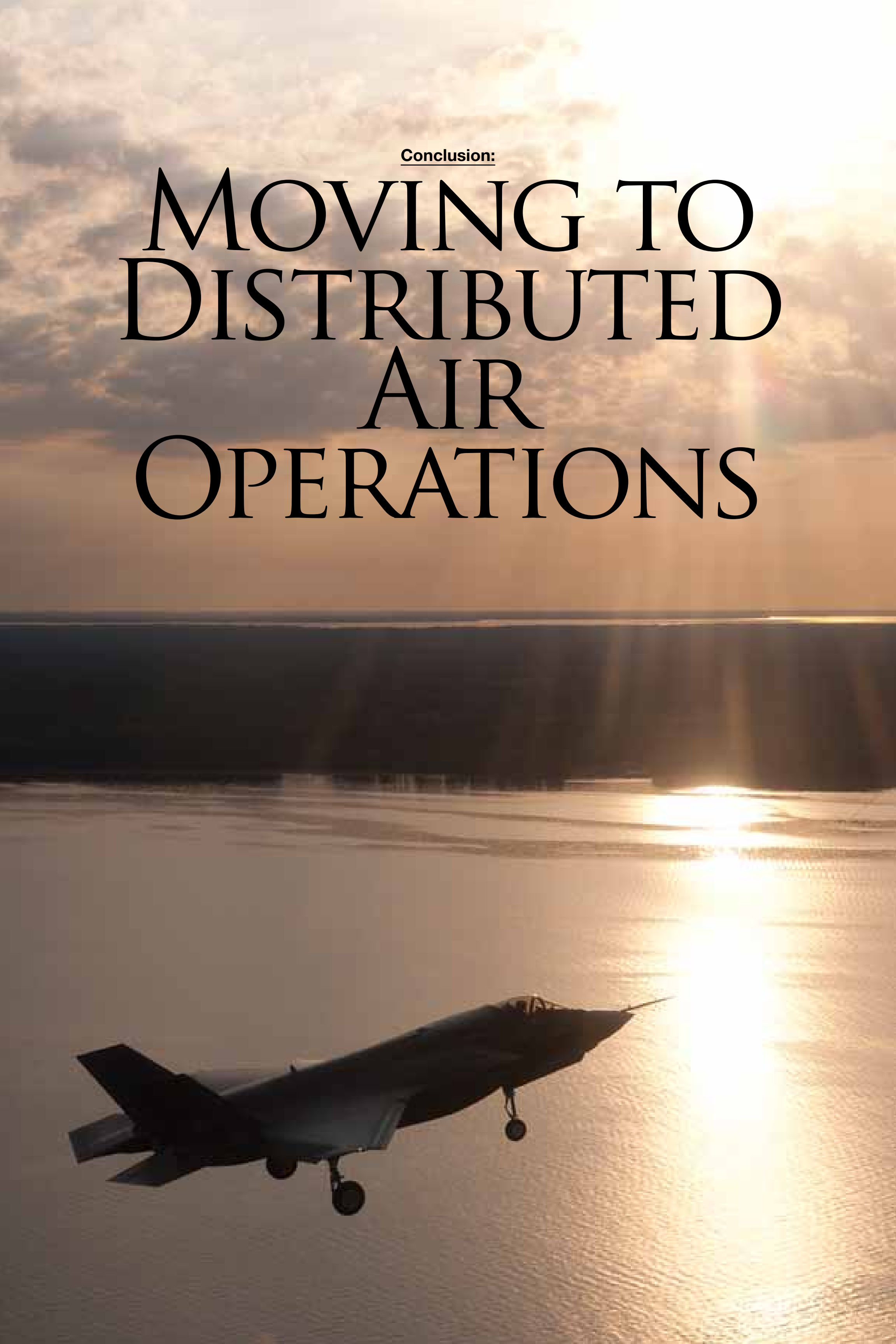
Compared to historical para-metrics we expect our overall O&S costs to decrease by 30 percent.

The key to enabling these reductions is to evolve our supportability concepts, processes, and procedures instead of shackling ourselves to a support infrastructure built for legacy aircraft. We need to be innovative and ensure our sustainment posture keeps pace with technology advancements and global partnering synergies.

Working together with industry, the Marine Corps is intently focused on the future as we seek innovative cost-effective sustainment strategies that match the game-changing operational capabilities resident in the F-35 Lightning II.

Conclusion:

Moving to Distributed Air Operations



LESSONS FROM DUNKIRK

Dr. Robbin Laird and the Honorable Ed Timperlake

http://www.sldinfo.com/?p=13448

A military force is truly blessed if the combat leaders at all levels in the chain of command have the proper weapons and also the wisdom to employ them against a reactive enemy. History of combat often shows that one army's engagement-winning weapons can be offset by their not understanding or exploiting that advantage. It is true that weaker forces through brilliant leadership can vanquish the more technology-capable and stronger army.

Of course, as Napoleon said, he also wanted a general who was lucky, and all combat leaders know how the great unknown of luck can also determine the outcome. And to add to the mix is another great thinker, Damian Runyon, who once quipped, "The race is not always to the swift nor the battle to the strong, but that's the way to bet."

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

But the French and British were defeated; the British Expeditionary Force was evacuated and lived to fight another day on to the eventual V-E Day. So betting on the French and the British was the wrong chip to play on the table of the battlefield. The Germans' Blitzkrieg generals down to the lower ranks were all "making their own luck" by exploiting the French and British approaches with the weapons they had.

The fall of France may have some interesting lessons on CONOPS elsewhere and decision making against a reactive enemy. And those lessons argue for shaping a transition from legacy air CONOPS to new distributed air operations CONOPS, leveraging the F-22 and F-35. The Germans were a quicker and smarter force that defeated the French and the British. Words echoing from history tell us that story and also can now bring interesting lessons learned to the current debate on what is becoming known as "distributed air operations."

The shift from legacy air operations to distributed air operations is a significant operational and cultural shift. Characterizing the shift from fourth- to fifth-generation aircraft really does not capture the nature of the shift. The legacy aircraft operate in a strike formation, which is linear and runs from *Wild Weasels* back to the AWACS. The F-22 and F-35 are part of distributed operational systems in which the decision makers are distributed and a honeycomb structure is created around which ISR, C2, strike and decision making can be distributed.

A new style of collaborative operations is shaped that takes away the ability of an adversary to simply eliminate assets like the AWACs and blind the fleet. Distributed operations is the cultural shift associated with the fifth-generation aircraft, and investments in new weapons, remotely piloted aircraft and the crafting of simultaneous rather than sequential operations. Unfortunately, the debate about fifth-generation aircraft continues as if these are simply aircraft, not nodes driving significant cultural changes in operational capabilities.

In a fascinating book by Hugh Sebag-Montefiore on the courageous men in the British Army who fought the Germans to allow the escape from Dunkirk, some of these lessons were highlighted. [1] The author provided significant insight into how the British and French lost to the Germans in the European forests and battlefields. Comments taken from diaries of the survivors provide significant insight into lessons learned by not engaging in the cultural revolution, which one's new technology provides. The British and French had new equipment which, if properly used and embedded into appropriate concepts of operations, might well have led to a different outcome at the beginning of the war.

The author outlined that the British and the French had some really superior equipment, but simply did not build them in the numbers required.

The first lesson here is that simply to develop advanced equipment is not even half the job. First and foremost, "The campaign showed that politicians must never, even in peacetime, deprive their armed forces of the equipment they need. Complacently assuming that the equipment can be manufactured once war is declared is demonstrably unwise." [2]

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

These difficulties were aggravated a hundred times by the style of French leadership. The soldier who should have had the most influence on the way in which the first counter-attack was mounted was X Corps' Commander General Grandsard, who had direct control over the divisions in the Sedan sector. He was a general of the old school, who had not understood that French strategy must change in line with Guderian's (the German general in charge of the attack) new mobile tactics. [3]

The author, when discussing command style, introduced a key term that is relevant to the shift from sequential to simultaneous air operations.

"The need to refer back to Guderian was, however, limited by the entrepreneurial culture he fostered. German officers were expected to make up their own minds on how to achieve the objectives Guderian set and how to act in a crisis." [4]

A third lesson was the importance of getting inside the enemy's OODA (observe, orient, decide and act loop). The French command structure was too slow to use information and to act on that information in a timely manner. The German commanders were allowed significantly greater freedom of action and could act in minutes, whereas the French operated in terms of hours. "The rapid German response to the threat posed by the counter-attack only serves to underline the slowness of the French… In other words, the Germans began their own counter-attack within 10 minutes of identifying their target, whereas it had taken the French more than 12 hours to launch their troops into the attack." [5]

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

A fourth lesson is the challenge of the enemy exploiting your weaknesses for which he has trained to exploit. The German tanks confronting superior armor in the advanced French tanks were able to exploit weakness in those tanks because of intelligence about the weaknesses and training to exploit those weaknesses. From the diary of a German survivor with regard to meeting the superior French tanks: "The tanks' silhouettes were getting larger, and I was scared. Never before had I seen such huge tanks…. My company commander gave clear instructions over the radio describing which targets to aim at, and the enemy tanks were just 200 meters away before he gave the order to fire. As if they had been hit by lightning, three of the enemy tanks halted, their hatches opened and their crews jump out. But some of the other tanks continued towards us, while some turned…. presenting their broadsides to us. On the… side of the tank there was an oil radiator behind some armor. At this spot, even our (smaller Panzer 2) tanks' 20mm guns could penetrate the armor, and the French tanks went up in flames immediately after they were hit there. It was then that our good training made such a difference." [6]

Chinese study of the classic U.S. air battle and the need to target the AWACS reminds one of the needs to get rid of the AWACS and sequential air battle and the need to move to distributed capabilities in simultaneous operations.

A fifth lesson is to develop logistical systems which allow one to exploit advantages of new technology. The superior French tanks were refueled by trucks and dependent upon truck-provided fuel. The Germans parked a "farm" of fuel containers to which the tanks came for refueling and could thus keep up the speed of the attack. "They (the key French tanks) could not even be expected in their first assembly area at Le Chesne, fifteen miles southwest of Sedan, until 6 am. It would then take around 6 hours to fill them with petrol, another two to move the five miles to their positions to the Mont Dieu forest, and two more hours to refuel them again.

(…) In contrast, the Germans overcame their refueling difficulties by transporting petrol to the front in cans. Once the cans were in the vicinity of the Panzer divisions, all the tanks nearby could be refueled simultaneously on any terrain. The French, on the other hand, had the petrol brought to the front in lorries, which, not being tracked, could not be used over rough ground. Even when the French armor was refueled on a road, the vehicles' petrol tanks had to be filled up consecutively rather than simultaneously which took much longer than the German method." [7]

Keeping the old tanker approach in place while you add the new aircraft undercuts the ability of those aircraft to operate in a distributed approach. By moving the tanker line back significantly, one can refuel almost like the German "fuel farm" and not expect the tankers like the French trucks to come to them.

Even the difference between simultaneous versus sequential attacks was underscored as crucial to the success of the Germans and the negative impact on French morale. As one French officer commented, "Simultaneous attacks would have been very difficult for us. But attacking in waves in this manner means they lose their courage after seeing their burning comrades." [8]

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

Unless one wants outcomes such as the French and British experienced in the forests of Europe against the Germans, it is crucial to accelerate the shift to a new culture and capability built around distributed operations. The old system of sequential air operations built around legacy aircraft, AWACS, and multiple assets needs to be replaced in a timely manner by a well-resourced distributed operations enterprise.

Footnotes:

[1] Hugh Sebag-Montefiore, *Dunkirk*, Harvard University Press, 2008

[2] Hugh Sebag-Montefiore, ibid…, page xiv

[3] Hugh Sebag-Montefiore, ibid…, page 100

[4] Hugh Sebag-Montefiore, ibid…, page 101

[5] Hugh Sebag-Montefiore, ibid…, page 105

[6] Hugh Sebag-Montefiore, ibid…, pages 121-122

[7] Hugh Sebag-Montefiore, ibid…, page 109 and page 120

[8] Hugh Sebag-Montefiore, ibid…, page 107

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