THREE-DIMENSIONAL WARRIORS

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FOREWORD

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 (military logistics community, industrial players, civilian contractors, etc.) along with evolving public-private partnerships among democracies in crafting real military strength. SLDinfo.com is updated every Tuesday; articles, photos and videos are posted on a weekly basis.

Some of the interviews and articles in *Three-Dimensional Warriors* 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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INTRODUCTION: THE F-35B IN THE PERSPECTIVE OF AVIATION HISTORY

Ed Timperlake

Former Commanding Officer, VMFA-321 "Hells Angels"

In the opening days of U.S. combat in World War II, extremely courageous Navy and Marine pilots went up against the Imperial Japanese Navy in inferior aircraft. For the Marines, the Brewster F2-A *Buffalo* was woefully inadequate at the Battle of Midway. An entire Navy torpedo squadron, Torpedo-8, except for a single pilot, was killed in combat.

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

From the Brewster F2-A *Buffalo* to the F-4F and F-4U to the F-6 and, at war's end, the F-8 *Bearcat*, the Navy had a series of prop-driven fighters that mastered the Japanese Zero. The Army Air Corps went from P-39 to P-38 *Lightning*, P-47 *Thunderbolt* to the P-51 *Mustang*, with its wonderful bubble canopy, to carry the fight to the heart of Germany.

Along the way, emphasis was placed on pilot survivability by putting armor plates in the cockpit and installing self-sealing fuel tanks. Since the entire objective was to get first "tally" and then out-maneuver and kill the enemy, the design focus was on an improved blend of speed, range, and maneuverability—in essence, better engines and smarter airframe designs.

While the main effort was producing enough "motors and gun sights," industry and research labs were working on the technology of the air fight.

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

After WWII, the jet engines saw improved airframe system performance by improving speed, range, and maneuverability. But two new dynamics were added—both related to payload.

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

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

Airborne radar and sensors were added to fighters. Those systems helped the payload—guns and early infrared (IR) "fire and forget" missiles became more efficient with the AIM 9 sidewinder series. But then, concurrently, independent performance was put into the payload by improving missiles and linking long-range (BVR) missile shots to radar technology. At first, radar guided missiles needed continuous guidance from the fighter but eventually even radar guided missiles became BVR self-contained "fire and forget."

Unlike WWII research and development, where research on airframes and engines was the mantra, the jet age involved two other major design factors. The first was always a continuous quest for improved radar systems and, second, as technology allowed, improved weapons. Yet again, the art of aeronautical design had to work in partnership with the science of military R&D.

Along the way, survivability concerns shifted from armor, speed, and a good canopy to electronic warfare and the incorporation of stealth characteristics through design, composite materials, and paint chemistry.

Stealth is a survivability factor and multiplies the effectiveness of the fighter. Stealth isn't just *added*, it is *incorporated* into the fighter. Being a multiplying factor means it is sensitive and can drive the entire performance of the airframe and combat system.

At the end of the 20th-century the complexities of fielding the best fighter were a much bigger challenge because of three synergistic but independent factors—basic airframe performance improvements, internal system R&D, and constantly improving weapons.

However, with the computer revolution moving at light speed, a fourth design dynamic is now at work—the man-machine interface.

With the capability of three-dimensional sensing and the ability to distribute information to other warfighters—airborne, on the ground, or at sea—the relationship of the individual pilot to the entire air battle offers a truly revolutionary shift that will continue to evolve.

For example, one of the most important capabilities of the F-35B, not yet exploited, is the distributed information capability. All pilots, regardless of experience, will fly into the air battle with the same knowledge and situational awareness.

Consequently, in the formation, if one pilot gets inside the opponent's OODA loop (observe orient decide act) all are capable of having that same joint knowledge. The revolutionary aspect is that the enemy can "splash" an individual F-35B but they can't kill the knowledge gained by all—a truly unique 21st-century technology brought to an air battle.

Conversely, on the offensive, if one F-35B picks up an enemy's airborne vulnerability, such as an aircraft system, weapon frequency emission, or stealth breakdown—it can be sent to all. Every *Lightning II* is a real time intelligence collection system. The entire engagement is also captured electronically for immediate and direct refinements to tactics and analysis at the Marine Air Weapons Training Squadron during the air battle. Fleet-wide information sharing among services and allies will be a huge factor in winning an air campaign.

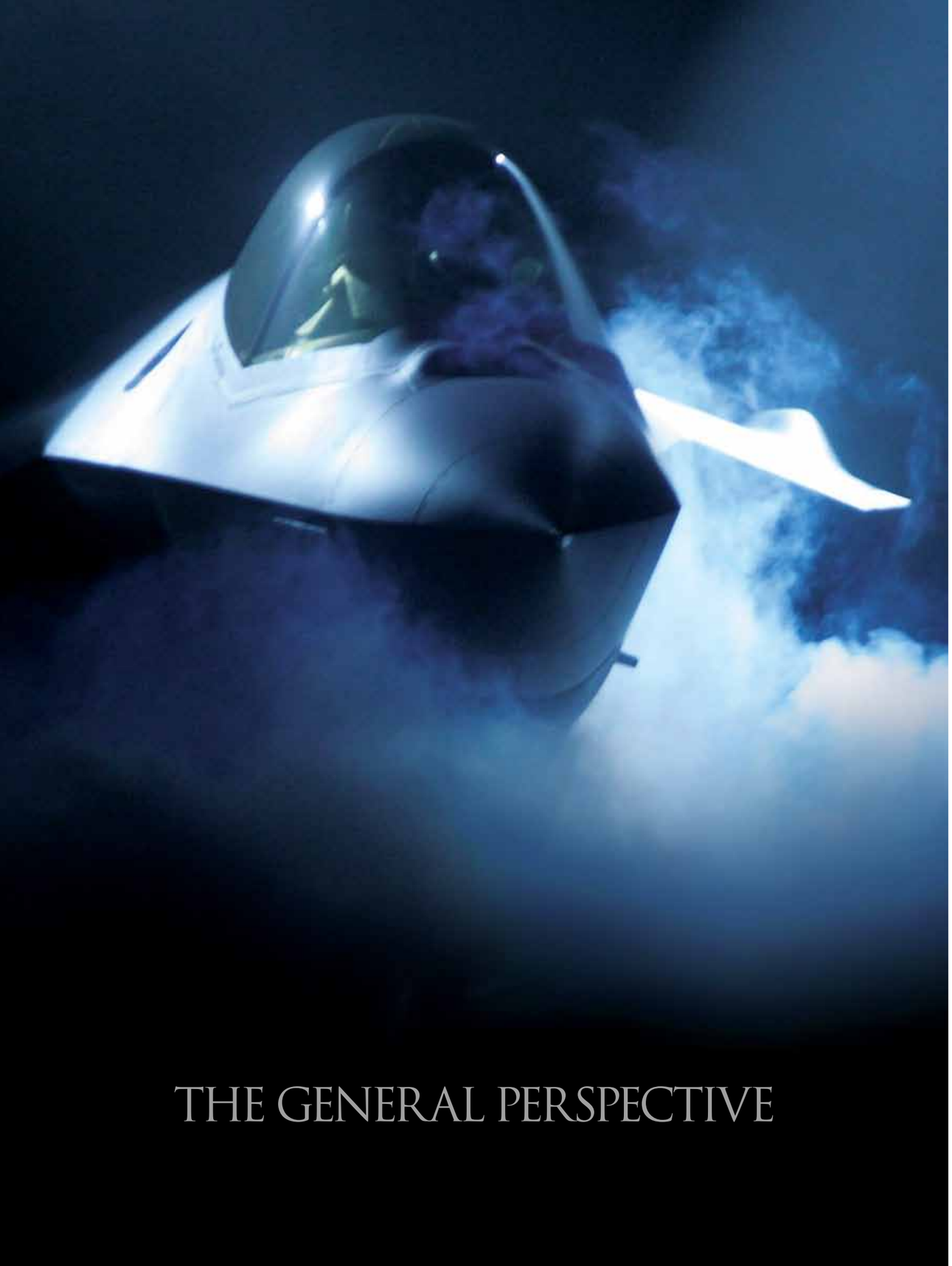
In WWII the *Buffalo* was a "grape" and the design teams worked with wartime efficiency to follow a single path to improve airframe performance. After WWII the technology vectors of improving internal systems and weapons carried were added to the mix. In this new century, the concept of each pilot being a three-dimensional warrior with superior knowledge is being pioneered by the USMC aviation community.

The F-35 is not designed for the early century's concept of the knife fight, and it has the growth potential for internal changes to its systems to always incorporate the best weapons while expanding empowerment of combat pilots to have three-dimensional knowledge and elevate the fight to a new level.

In other words, the F-35 may actually be its own follow-on. Instead of the old paradigm of needing to completely build another fighter to move from the F-2A "Grape" to F-4U "Whistling Death," the Marines can just change and update the F-35B system, sensors, and weapons. The Marines flying the F-35B with a pre-planned product improvement design philosophy to pull and replace or add system capabilities will in the future have total flexibility to add new sensors and the improved AA missiles currently being designed.

Exploiting man-machine, three-dimensional knowledge is truly a brave new world. Consequently, the F-35B is capable of constantly updating the next generation of U.S. fighters, but not by building a new airframe, by staying inside the F-35B basic airframe and adding the next generation of systems and weapons. The American arsenal of democracy is shifting from an industrial production line to a "clean room" and a computer lab as key shapers of our competitive advantage.

It is a bold concept and only history will tell us if this is indeed the best way ahead. In addition, the USMC combat flexibility of basing mode enabled by V/STOL adds a revolutionary capability for the integrated air-ground battle.



THE GENERAL PERSPECTIVE

AN INTERVIEW WITH BRIGADIER GENERAL GEORGE J. TRAUTMAN, III, USMC, DEPUTY COMMANDANT FOR USMC AVIATION ON THE IMPACT OF USMC AVIATION ON THE EVOLVING CAPABILITIES FOR THE U.S. WARFIGHTER

SLD: The Commandant has referred to the F-35 as the centerpiece for the future of the MAGTF. Why is that so?

LGEN Trautman: The Marine Corps is by nature a light force. We don't have the luxury of traveling with a lot of heavily mechanized forces. Because of our naval character, we often go by sea and because of our expeditionary nature we often find ourselves in austere locations early in a campaign. In order to get there early in a campaign, we need to deal with an increasingly inaccessible world.

At the forefront of the ability to operate in this environment is the very low observable capability that the F-35 brings to the fight, as well as the capabilities that STOVL will bring to the fight with regard to close proximity to our expeditionary forces.

The Marine Corps depends on TacAir probably more than some of the other services because of the light nature of our force and the dependency that we have on TacAir to ensure that we can take risk in maneuver. You can only take risk in maneuver if you have adequate intelligence surveillance and reconnaissance, dissemination of information and the firepower that comes with it that will enable you to move about the battlespace without the heavy firepower that, for example, an Army heavy corps would bring to the fight.

So TacAir is essential to our ability to maneuver in the battlespace. F-35 is going to be an incredible contributor because of the sensing and computing power that this machine is going to bring to us. We are going to find ways to better disseminate that information across the entire battlespace and all the way down to our platoon and fire team leaders at the right time and in the right way.

And so in many ways, F-35 will lead us to the next generation of warfighting, if you will, in which information exchange is going to become more and more important, and the F-35 is ideally suited for that kind of operation.

SLD: The F-35 is going to replace several aircraft for the Marine Corps. What contributions does simplification of your fleet bring to the fight?

LGEN Trautman: The tangible benefit of replacing our *Hornets*, our AV-8s, and our EA-6B *Prowlers* with a single type model series is going to be huge. From the perspective of the logistics footprint, from the training perspective, from things like peculiar support equipment, ground support equipment, the training of individual Marines and aviators, we're going to take more than a threefold increase in effectiveness, efficiency and resource savings by transitioning to this single type model series.

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We learned this when we, for example, transitioned our H-1 helicopters to two airplanes, the AH-1 *Zulu* and UH-1 *Yankee*, which have 84 percent commonality. We're already reaping the benefits. We anticipate the same result with the F-35.

It's absolutely essential that a machine that is going to do everything that our STOVL AV-8s, F/A-18 fighter attack airplanes, and EA-6B electronic

warfare airplanes do for us today be a "pilot-friendly" machine. If it's not a pilot-friendly machine, built from the ground up with fused systems, we're not going to be able to perform all of those functions.

We're actually quite optimistic in what we've seen in the simulator and what we've seen through various studies of the systems that are already being built by the contractor that we're going to be able to train to this range of mission sets. We may have to have specialization of some of our aircrew. It remains to be seen as we build our concepts of operation and our tactics, whether we have to evolve into a specialized approach or not. At this juncture, we're actually fairly confident that the enhanced capabilities of the F-35 are going to enable us to avoid building specialized aircrews.

SLD: The USMC has introduced the *Osprey,* which is certainly a transformational product, and the F-35B is coming online. Those two together should give you more integrated capability to certainly provide a leapfrogging capability for your amphib fleets for example.

LGEN Trautman: The range and speed that the *Osprey* brings to the fight is very much transformational, and the ability to connect *Osprey* to F-35 and then to the rest of the joint force is going to open up potentialities that just have not existed in warfighting to date.

I think by the time F-35 comes to the forefront here in the next four to five years and by the time we figure out how to connect the two in the battlespace, we're going to bring to the fight something that is going to be very much a game changer. It's going to be a game changer from the perspective of the kinds of things that commanders can choose to do should they choose to do them.

Combined with the improved intelligence surveillance and reconnaissance capabilities that our nation already has, we're going to be able to exploit our asymmetrical advantage which will be in the combination of the F-35B in the STOVL mode and the V-22 with the range and speed that it contributes to the fight.

SLD: The combined capabilities that you are crafting will be an essential contributor to dealing with hybrid threats. How do you view the multi-mission capability of the F-35 in dealing with hybrid threats?

LGEN Trautman: Some people like to paint the fifth-generation strike fighter, the F-35, as only essential in a state versus state endeavor where a near peer competitor has decided to build a sophisticated integrated air defense system or has decided to spend a lot of money on sophisticated aircraft that can conduct a near peer aerial warfare fight.

I think that's flawed thinking because even in a low end fight, it's possible that you can encounter very sophisticated enemy scenarios with radar guided air defense systems and even double-digit surface-to-air missiles in localized areas that preclude your ability to operate freely. In other words, you can encounter an integrated air defense system on a local level right in the midst of another kind of fight.

So in a single day—much like the Three Block War that General Krulak talked about; much like the hybrid war that we saw the Israelis and Hezbollah involved in—you can find yourself in a COIN fight in one part of the battlespace quickly evolving into a very different threat scenario in another part of the battlespace. This might happen all within the range of maybe 100 miles or 200 miles. You have to be ready and prepared to evolve from one type of threat scenario to another, even at the lower scale, on a daily basis.

Consider, for example, if someone had introduced sophisticated double-digit SAMs into Iraq at some point in the recent past or in the near future; it would change the whole nature of the fight. You have to be prepared to swing across the range of military operations, not just in the broadest strategic sense, but at the tactical level in the context of something like the current fight that we find ourselves in in Afghanistan or previously in Iraq.

EVOLVING MANNED AND UNMANNED CONOPS: AN INTERVIEW WITH LIEUTENANT GENERAL DAVID A. DEPTULA, USAF

[In April 2010, SLD interviewed Lieutenant General David A. Deptula, USAF to discuss the evolving interactions between the new manned aircraft and next-generation unmanned air vehicles.]

General David A. Deptula is Deputy Chief of Staff for Intelligence, Surveillance, and Reconnaissance at Headquarters, U.S. Air Force in Washington, D.C. He is currently responsible to the Secretary and Chief of Staff of the Air Force for policy formulation, planning, evaluation, oversight, and leadership of Air Force intelligence, surveillance, and reconnaissance.

SLD: UAVs and the ISR provided by UAVs have become prominent in public discussions about the future of airpower. What are your thoughts about their future contributions?

LGEN Deptula: Well, it's an interesting question because it takes us down a deeper train of thought where we are focusing beyond remotely piloted aircraft vs. piloted aircraft. It takes us beyond the notion of aircraft as individual systems and moves us into the realm of a future that is dominated not by things but by concepts of how you tie all of these things together and how they can all provide military capability, whether they operate from the ground, on the sea, or in the air.

I like to characterize the point of history we're in today as a transition point between Industrial Age warfare and Information Age warfare.

And that Information Age is being perpetrated by advances in technology that allows us to do many more things on individual aircraft than we've ever been able to do before. This advancement in technology enables different concepts of operation for employing remotely piloted aircraft and joining them together with modern manned aircraft like the F-35 and F-22. These capabilities can help produce concepts of distributed air operations that we simply have not had the advantage of executing in the past.

Modern fifth-generation aircraft like the F-22 and F-35 are not simply fighters. We're trapped by an old historical nomenclature system here. They are in fact flying sensor platforms that have inherent force application capability associated with them. So we need to think about new and innovative ways that they can contribute to a system of individual elements that create a force that can achieve outcomes that are not just sequential in nature.

SLD: So we should begin to think of the correlation between ISR and OPS rather than looking at them as separate entities?

LGEN Deptula: Absolutely. The evolution of technology and information is allowing us to change our culture, a culture that in the past tended to segregate intelligence from operations. That historic segregation of "ops" and "intel" is really dysfunctional and slows our ability to accomplish desired outcomes. Let me give you an example.

In the 21st-century I would tell you that ISR is operations, it's not simply support to operations. A good example is when we took out al-Zarqawi, the Al Qaeda leader in Iraq in 2006. That outcome took about 600 hours of *Predator* time, thousands of hours of analyst time to evaluate that observation activity from those remotely piloted aircraft, and about

six minutes of F-16 time to send al-Zarqawi to the nether regions. So the question is which one was the operation?

The fact of the matter is each one of those activities was required to achieve the desired outcome. As we move into the future—enabled by the variety of different fifth-generation systems that we're going to acquire—we have to think about incorporating all the elements that they can bring to the table, not just the force application pieces. The old approach is sequential thinking as opposed to parallel application of mission capability, which is the fused con-ops approach of 21st-century air operations.

As we move to the future, we need to think about not manned or unmanned aircraft as separate entities but how we can join them together in an integrated fashion to accomplish desired outcomes of a particular joint force commander.

SLD: In a way we shouldn't refer to this as fifth-generation fighters, we should talk about this as integrated sensor strike platforms?

LGEN Deptula: Absolutely. We have to get rid of last-century designators. If you look at either the F-22 or F-35, they conduct a panoply of missions. ISR strike is perhaps a better way to describe them because they perform all of those roles simultaneously.

SLD: The F-35 brings with it significant computational power, several sensors, 360-degree awareness with the distributed aperture system, a different kind of helmet, all of which leads to a different kind of capability. How will that shape the next generation of UAVs?

LGEN Deptula: Because of the powerful nature of the sensor suite resident on the F-35 we're only scratching the surface; we don't know yet. It has a fascinating degree of capability when you look to the future because of the modularity of the avionics packages that were built into it.

At the same time, we have some inkling because you can conceive of a next-generation remotely piloted aircraft that is built to supplement and enhance the capabilities that an integrated ISR on the F-35 can bring to the fight. For example, by acting as out-riggers in the context of providing information beyond the immediate range of the sensors of a particular F-35, the RPA can act as a weapons mule, if you will, by providing additional weapons at a much lower cost, in terms of both the remotely piloted aircraft themselves and in the context of not exposing a human to the threat.

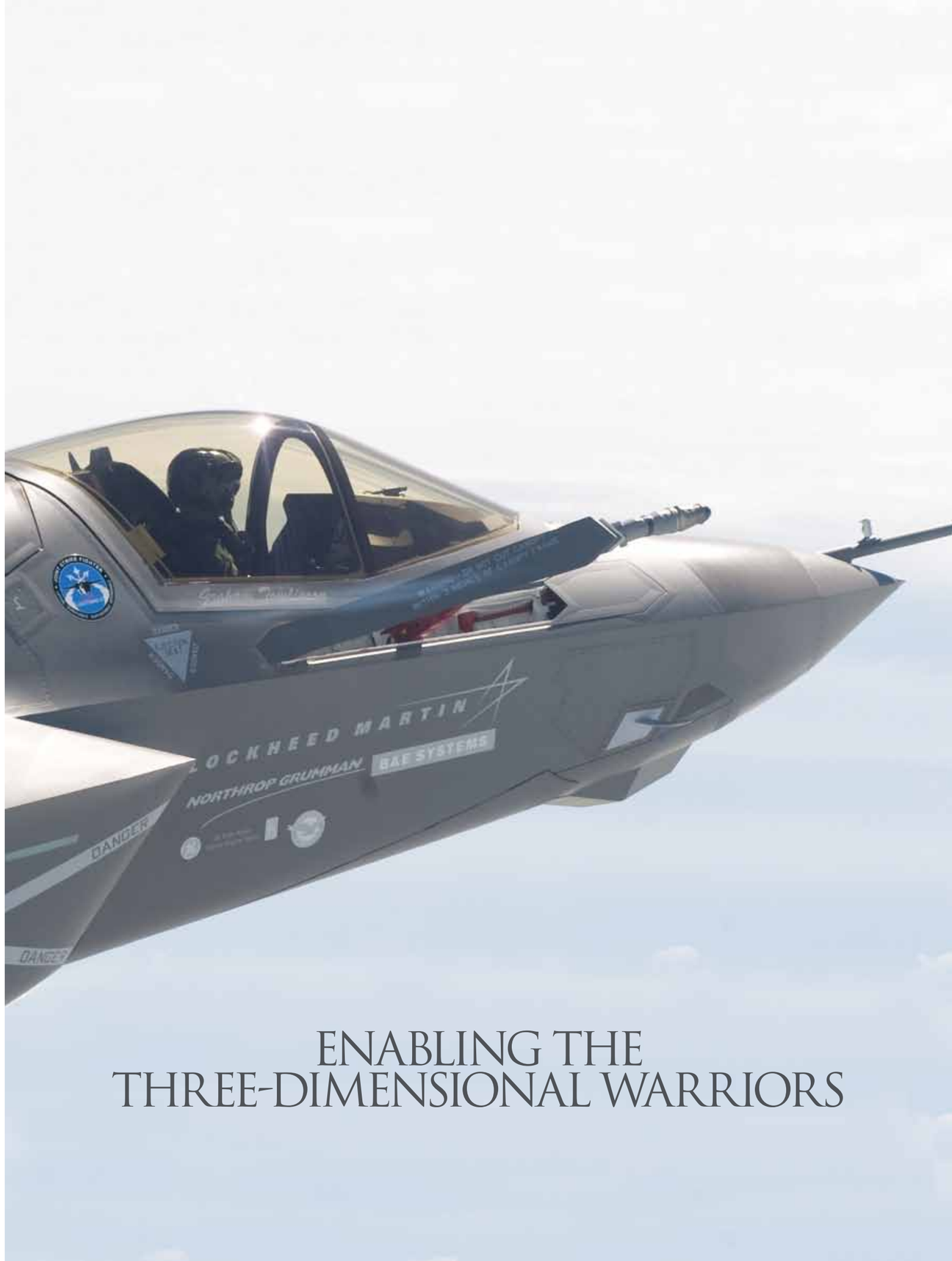
So it can be used in higher threat situations than you would want the F-35 actually to penetrate, and as a part of robust distributed air operation that the F-35 and F-22 in conjunction with remotely piloted aircraft can bring to the fight.

So there's a variety of different ways, but we need to think about using remotely piloted aircraft—not just as separate aircraft to be used in traditional ways, but as elements of a distributed air operation where they can contribute to the entire panoply of missions that an air operation might encompass.

SLD: Can you discuss how the notion of "fractionation" plays off the distributed air operations you just mentioned?

LGEN Deptula: The notion of a fractionated system is separate and distinct from what has been discussed over the past couple of years as network systems. A network traditionally involves different nodes, different systems performing different missions. The notion of a fractionated system is that you have multiple entities operating to provide a particular effect; you can afford to lose some yet not lose the effectiveness of the overall system.

So again, that should lead us toward a concept of operations where we can marry-up remotely piloted aircraft with fifth-generation aircraft in a way to amplify the entire force package in ways we never conceived of in the past. This package is much more survivable than the way we've operated in the past or by using a traditional network approach to the problem.



ENABLING THE THREE-DIMENSIONAL WARRIORS

THE DISTRIBUTED APERTURE SYSTEM AND
360-DEGREE SITUATIONAL AWARENESS

[An interview with Mark Rossi, Northrop Grumman Electronic Systems.]

SLD 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 with DAS is that it's completely unknown to most people. We think of it as revolutionary. If you consider radars, it's evolutionary. Everything since WWII has been equipped with a radar, they just keep getting better. We keep building on it. People are used to what it brings to the fight. They've never had the capability provided by DAS. So we wow them with imagery, we wow them with performance data, and so forth. But I think everybody who listens to our story, especially at a classified level, can imagine what they might do with this thing. But they have no idea what they're getting.

The number one thing that DAS brings to JSF is 360-degree spherical situational awareness. We create this bubble around the airplane where we're just seeing everywhere all the time, we're always on, we never stop. We don't interleave. We do it 100 percent, all the time.

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

Rossi: From a situational awareness point of view, the pilot does absolutely nothing. We are monitoring the world around us all the time and then differentiating things that occur that are important to that pilot—classifying them for him. It's only when we determine there's something important that he'll even know anything's going on.

SLD: DAS provides 360-degree situational awareness for the individual pilot on the F-35, but is there any reason that we couldn't take that fused data and share it?

Rossi: There's no reason we couldn't do it short of limitations of those sharing channels.

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: Absolutely, absolutely, absolutely. All of it's there. What you do with it beyond ownership is all in the realm of possibility.

SLD: So the point—focusing on the individual aircraft now and the pilot managing the aircraft—this allows him to have capabilities to see 360 degrees and understand the threat envelope around him.

Rossi: The pilot gets this situational awareness, and obviously we're providing an IR situational awareness of the world. It's not individual. It's in the IR band and it is completely passive so it's on all the time and it doesn't hurt the LO capability of the aircraft.

Within that situational awareness, another mode that we were asked to develop was a missile targeted at the plane. So we have to know what all those manmade airborne objects are and classify them, and then if we believe that one of those happens to be a missile that's targeted at the plane, we have to actually tell them that.

SLD: So this is a key tool to de-clutter the battlespace so that the pilot can focus on the most important priorities.

Rossi: Absolutely. So the pilot keeps track of the world, but we classify the world into things that the pilot would care about that are manmade. Obviously, this includes missiles and airplanes, both air-to-air and air-to-ground, so if there happens to be something coming from the ground, not only do we need to know that it's something coming from the ground, we need to know that it's coming from the ground and it's targeted at you and we have to tell you where it came from too.

SLD: Why is the DAS so misunderstood or underestimated?

Rossi: I think number one, they don't really understand what it's going to do for them. And number two, the few systems out there that try to do this, never try to this degree. The missile warning systems that exist out there are just fraught with error. The reliability of the DAS ensures a whole new level of trust and confidence for the pilot in operating the aircraft.

The reliability of the DAS ensures a whole new level of trust and confidence for the pilot in operating the aircraft.

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

Rossi: The DAS provides 360-degree NAFLIR (Navigation Forward Looking Infrared) capability. So if you think about it we're out there staring at the world. We have all this information. We can then take and post-process where the pilot is looking on his helmet. We also have an auxiliary channel where he can dial in any particular sector that he wants to keep track of and we can give him near 20/20 IR imagery of the world about him.

So now night landings on carriers are fully enabled. We show this stuff to Navy pilots and they're just awestruck that they can even see the horizon, let alone the boat out there and the wake.

It's going to revolutionize night landings on aircraft carriers.

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 have created so we stick with it. But anywhere the pilot can turn his head—through his legs, through the floor of the airplane—he can look because we're looking everywhere.

SLD: You mentioned fusion. The fact that this data is fused… can you tell me a little bit about what advantage that brings?

Rossi: We take and collect all that information and we, for lack of a better term, we fuse that data and create a global theme within our processor. From that we produce the NAFLIR imagery. We're watching everything and then we're classifying everything by order of importance. So we do all of that, that fusion, ourselves and then the output is per the Lockheed defined interface control drawing as to what messages we send and the streaming video that we also send.

Then that information is fused with other weapon systems on the aircraft and then presented to the pilot. We actually don't determine what gets presented to the pilot, they do. So if we see something and they want to put another weapon system on it to verify it, they might do that. We don't know exactly what they intend to do with all the information we send them. That's a Lockheed fusion job. You don't directly interface with the pilot, other than our imagery on their helmet and the declaration of a plane-targeted missile.

We do a lot of fusion at our level because we have to integrate six sensors into a singular unit that does not lose track of things across sector boundaries and camera boundaries. A lot of systems in the past, even with multiple sensors, were challenged by fusing those into a singular global seam that is impervious to the boundaries relative to tracking things of interest across them. Being able to seam to the point that we don't have a loss of track across the camera or the sector boundaries in inertial space is critical.

SLD: Lockheed is addressing the broader air integration issues, but there's a significant difference between an F-18 or F-16—where you're doing iterative additions to the aircraft—versus what you're doing with the F-35—where you're coming on with an integrated sensor capability—and the DAS—where it can work on a man-machine basis. That is very, very different than just incrementally adding capabilities.

Rossi: That's the whole fifth-generation concept. The F-22 is a fused airplane and so is the F-35, and they can use these other weapon systems to enhance their overall integrative capability. The beauty about DAS is that we're seeing everything all the time in places on a 360-degree basis. Radar's a phenomenal system but it has a cone, right? It's never looking behind you and most of the time it's not looking to the side of you unless you have side arrays.

So we look everywhere and we can let the pilot know that there may be a problem. The pilot may need to turn around and look to see if there is a need for other weapon systems, where in the past you would have nothing in those coverage areas.

And then we have to work in all clutter environments. Think about it, we're looking everywhere. In the daytime, at all times in the daytime, one of our cameras, at least, is looking at the sun. So think of the challenges associated with an IR system that's staring at the sun. We obviously can't bloom on it; we can't bleed over.

Think about those challenges. There are all kinds of things associated with looking everywhere. We're looking at cold sky at the same time as we're looking at a very highly cluttered mountainous range, and we're looking off to the side at backlit clouds all at the exact same time in this 360-degree world. So we can't be tuned to one or the other, we have to be tuned to all of them in order to provide this performance. When you get into the details you realize the challenge associated with doing this because we're looking everywhere all the time in all conditions day and night, and we have to address all those conditions or else we're not a capable system.

SLD: You're providing technologies, tools that really allow the pilot to act very differently, function very differently.

Rossi: Absolutely. We provide a whole lot more situational awareness around the pilot. We project imagery into the helmet to a defined field of view based on where the pilot is looking. All that's mapped, and we predict where the pilot's going to move his head. We have post-processed that region of imagery to provide the near 20/20 quality. We could do it everywhere, but it would just be a processor hog so we post-process the spot where he's looking and the region around where he's looking so to minimize latency as he moves, and then present him that near 20/20 quality visual wherever he moves his head.

And again, he can go pick an area and if he wants to just watch that area all the time, he can just dial that in and he'll stare at that thing. But remember, we're not slewing anything. We're not moving anything. It's all just picking a spot in a virtual global sea. We're doing this in the processor.

SLD: How do you think they'll experience this because it's going to be a very different experience and will drive new battle tactics and operational foci?

The young kids who are going to be flying these airplanes will have grown up playing video games.

Rossi: This will not be foreign to them. We're providing that technology now so that when the next generation of fighters get in that cockpit, it's not going to be unlike what they're used to back home playing they're videogames. If you consider the mentality of the kids that are going to be sitting in those seats, they would be very disappointed if they didn't have that kind of capability. That's just my take on the world. I'm 50 and I didn't grow up that way, but my 13-year-old knows a lot more about it than I do.

The next generation of pilots is going to expect that speed. They're going to expect that image quality to be given to them, and I think that they'll already know how to use it because they will have been trained all their life by playing video games. With this kind of capability, the F-35's mission can be increased.

The missions JSF can do can expand the operational envelope. You don't want to make JSF a drone, but if he's up there anyway and they're everywhere and they're linked, your mind starts to think of the possibilities of what they could do with this kind of 360-degree, fused information.

Also, think about the additional information that we could provide. We're seeing everything so we're seeing ground activity, all of which, right now, we completely suppress. We throw it away because—guess what—it's not an airborne object and right now we don't care about it. But what if with a simple algorithm change you could direct other weapon systems to, say, "Hey, something's moving right there!" Then you point your "soda straws" and, wow, you're not scanning and searching like you do today with your traditional "soda straw" systems.

Even radar is in volume search a lot. DAS is looking everywhere, seeing everything, maybe not with the clarity of a targeting system, but if I see something here, all I have to do is tell my radar or my EOIS to go look, and bingo. There are capabilities limited only by our imaginations!

RESHAPING TACTICAL CAPABILITIES:

THE DISTRIBUTED APERTURE SYSTEM (DAS) AND THE NEW HELMET

[SLD interviewed Lieutenant Colonel "Dino" Michael Dehner, USMC, Headquarters, Marine Corps Aviation about how the new helmet will enhance the warfighting capabilities of the F-35B.]

The new helmet and the interactions between the pilot and the systems on the F-35B provide the hub for new operational capabilities. Lieutenant Colonel Dehner is part of the JSF cell at HQMC. He is currently the USMC test coordinator for F-35 and has flown with prototype test helmets in the F-35 concept of operations simulators.

SLD: Could you describe how the systems on the F-35B shape a new environment within which the helmet functions?

LCOL Dehner: One of the new operational capabilities of the F-35B is its ability to sense the IR energy—the heat coming off of the environment—a full 360 degrees around the aircraft. It's as if you are in the middle of a soccer ball looking out through the facets. There are IR sensors all around. The aircraft also detects more of the electromagnetic spectrum, similar to a Prowler. There is a lot more information available that needs to be understood.

So the next question is, "How does one put information in a way that a human being can understand and act upon it?" The information is displayed to enable the pilot to be a tactical decision-maker. So, instead of being very mechanically-driven, like we are in our current aircraft in which you have to help move the radar around to make it do its thing, with the F-35B the systems on the aircraft do that.

Now, that's only part of the answer. The next piece is the Distributed Aperture Systems (DAS) that is sensing the IR world 360 degrees around. Camera eyes are staring at all times all around. So then we have to ask, "How do we get that information across to a person that, obviously, can only look in one direction at any given time?"

The system's interface, the DAS imagery, gets projected on a patch on the new helmet, which is an improvement from the current helmet. Then you have a window into this other world and can look at information in the IR. When you turn your helmet, you see the world surrounding you through the DAS information that is being transmitted.

SLD: You alluded to the relationship between the classic tactical fighter and a specialized war battle manager, who's on electronic warfare aircraft. Will this change?

LCOL Dehner: Absolutely. The classic tactical fighter was defined by the strike package where there are aircraft that deliver weapons and fighters either clear the way or protect. Then there are electronic attack aircraft to provide another level of support. In contrast, the F-35, by design, will be able to do all three of those things with the same aircraft or the same small family of aircraft. So, you can prioritize different roles; two on the front are the fighters today; the third is going to pick up electronic attack; and the fourth is going to do the strike. But depending on how you're configured, you can flex that in real time.

But with all that increased capability, you still have the same human beings flying aircraft in a similar way that was done 50 years ago. So now there is a need to train those pilots in a different way. You take all the very classic training techniques—teach them how to actually fly the aircraft, teach them how to use the aircraft as a weapon—and then you train them to be an information manager because this aircraft really is an information sponge.

This aircraft is a little information hub in the sky. The job of the pilots is to be effective for their primary mission, but then also to decide how to get information to other people.

This aircraft is a little information hub in the sky. The job of the pilots is to be effective for their primary mission, but then also to decide how to get information to other people—not just other pilots but also to the ground—because they may be in a better spot to be more effective.

SLD: What is the role of the helmet in facilitating what you just described?

LCOL Dehner: The helmet in the F-35 will display fused data, and creates a picture so that, literally, when you look down through what would be the skin of the aircraft, you get the projection of the ground underneath. So, if I am trying to locate a target, the current helmet will give you a little box or a symbol to highlight that target. But as soon as the wing of the aircraft gets in the way then I have to move the airplane. With the new system I can see through the wing.

An immediate benefit is that I wouldn't have to move my aircraft into a place where I might not want to go. For example, when we orbit for an intelligence, surveillance, reconnaissance (ISR) mission there are better paths in the sky for us to stay within. I want to get a really good picture, so I'm going to set up an orbit. But that instantly can change if my wing gets in the way. So then I'm going to have to move the wing out of the way to get a better look, and then get back on profile. That's a lot of the work for the pilot. With the DAS, this problem goes away.

SLD: Can you predict the changes in pilot behavior as a result of this synergy of the DAS and the helmet?

LCOL Dehner: One of the other significant changes will be the way we fly our formations and get more out of the aircraft. With traditional tactics, we're tied relatively close to each other because we're covering each other for anybody shooting from the ground. You're checking me. I'm checking you. So, we tend to fly together. We don't have to, but otherwise it's risky.

In order to get more aircraft over a larger area, we separate. Now you can only do that when you have very fixed-wing tolerant conditions. Then I'm not going to be shot at a lot because I'm either at a higher altitude or the threat is just not there.

With the DAS, the computer is working all the time, looking all around, making sure that no one's taking a shot at me.

With the DAS, the computer is working all the time, looking all around, making sure that no one's taking a shot at me. So that instantly frees up the pilot and the squadron to spread out. We're not taking on risk or adopting a different procedure—which is how we'd mitigate the risk today—because of the DAS system on board.

SLD: By having a closer relationship between the ground and the air element will the confidence level of using weapons in close support go up, resulting in reduced collateral damage?

LCOL Dehner: Technology enhancements in the last 10 years have already improved that quite a bit. This will be the next huge step. More information is getting to the pilots so that's going to make that pilot feel more confident. We've already started sending information down on our legacy aircraft. In the F-35, there will be a lot more information to push down to those ground commanders for shared decision-making.

THE F-35 PILOT

[An interview with Lieutenant Colonel M.G. "Squirt" Kelly, F-35 Flight Operations Lead, VX-23, Patuxent River, Maryland.]

The pilot on the F-35B is really a centerpiece of what we are calling the three-dimensional warrior. The new helmet and the interactions between the pilot and the systems on the new aircraft provide the hub for new operational capabilities.

SLD went to Patuxent River in April 2010 to interview several members of the Patuxent River test team and spoke with test pilot "Squirt" Kelly about his thoughts on the F-35 experience.

SLD: You've been testing the helmet and the plane. What's the synergy between the helmet and the plane?

LCOL Kelly: Well, it is quite a nice synergy, actually. The helmet becomes very natural to the pilot, because it mimics what we have in legacy systems, but it presents it in a way that's clean and easy to understand, and is the building block for the DAS system, for the night camera, and all of the situational awareness that can be provided to the pilot.

SLD: And you don't need night vision goggles?

LCOL Kelly: You don't need night vision goggles; it's all built into the helmet. So, depending on the conditions—the light levels, environmental factors, and cultural lighting—you may choose to use the night camera or your DAS system, depending on what gives you the best situational awareness.

SLD: Do you have better peripheral vision as a result?

LCOL Kelly: Yes. The night vision goggle—the Legacy Night Vision Goggle—is just a sensor. It doesn't provide you with an integrated picture. The F-35 night camera as it's projected in the helmet is really more like using your own vision, rather than looking through a narrow sensor, or soda straw, so to speak.

SLD: Do you foresee a significant adjustment when you start using this in the airplane?

LCOL Kelly: We think there will be a building block approach as we integrate more of the capabilities into the aircraft and the helmet. We saw the same jump in tactics development in the simulator when we first added the helmet capability. We had to take a step back and rethink some of the ways we were performing the mission, because now we had more information, better information, more situational awareness. We could be even more efficient and effective at performing the mission with this helmet.

SLD: Can you give me an example of the difference this makes?

LCOL Kelly: With the F-35, if my wingman finds a target on the ground, he can data-link that information to me and now my helmet will tell me where to look on the ground to find that target and I know we are looking at the exact same target.

SLD: So, in other words, it's shared information?

LCOL Kelly: Yes. It's shared information and the helmet will tell the pilot where to employ sensors and weapons while providing threat information. You get more awareness, throughout your flight, on friendly and enemy positions. So you have shared situational awareness across the board to understand who the "friendlies" are, who the "hostiles" are, what the order of battle is, and what the current situation on the ground is in real time.

You have shared situational awareness across the board to understand who the "friendlies" are, who the "hostiles" are, what the order of battle is, and what the current situation on the ground is in real time.

SLD: Are you also building a consensus between you and your mate on what you think you're seeing?

LCOL Kelly: Absolutely.

SLD: So you have confidence that you're looking at the same thing?

LCOL Kelly: Absolutely. Between you, your wingmen, and the ground. That consensus allows for a safer, more rapid employment of weapons with less potential for collateral damage.

SLD: So situational awareness offers a higher sense of confidence in the decision you're about to make. Is one of the advantages going to be your ability to share this information rapidly with a ground decision-maker?

LCOL Kelly: Yes, based on the information you and your wingmen obtain, you can make timely decisions more effectively as a team, and rapidly pass that information to the ground without relying on other assets.

As you add the F-35, you are going to reshape other capabilities on the battlefield as well, and provide the foundation for managing battlefield assets, UAVs, intelligence, and other tactical information. The F-35 will change the way we think about the role of tactical aviation.

SLD: Is there a cultural challenge to learn how to maximize the impact of the F-35 and to adjust CONOPS?

LCOL Kelly: Yes, but one of the things we made sure of with the F-35 was that it is and will be compatible with legacy systems, like Link 16. Legacy platforms of the United States and various nations are going to be around for quite a number of years. The F-35 will have the ability to interact with those platforms in a large force coalition CAOC environment where there are multiple platforms and multiple services. And then also provide the ability to have a separate communication system that's designed for low observable aircraft, which provides the flexibility to operate differently and more independently.

SLD: I assume that the F-35 will be able to operate more effectively in airspace from the pilot's point of view?

LCOL Kelly: One of the other great things about the F-35 is that it is a first day of the war airplane, but not just a first day of the war airplane. So in those situations where we are supporting Marines on the ground in a rapidly changing environment, the F-35 will be able to safely operate in that environment because of its sensors and the threat information that is presented to the pilot.

In a high-threat, close air support environment, the F-35, through the helmet, will enable the pilot to focus on employing weapons on time, on target, while providing the information to avoid threats where that's possible, or defeat those threats where that's necessary to perform the mission. And the helmet is the key to getting the pilot looking in the right direction. We all know a picture is worth a thousand words, so, hearing something is nice, but being able to see it on the ground in relation to the battlefield really builds the pilot's knowledge and awareness.

SLD: So you are enhancing the probability of looking at the right thing?

LCOL Kelly: Yes, whether it's friendly or hostile, and then having the aircraft, through the helmet, alert the pilot to what action he needs to take in a particular scenario, to either avoid or defeat that threat, and then perform the mission. In a legacy aircraft, depending on what that threat is, you may have to abort your mission. You wouldn't have the real time situational awareness of all the threats, so there could be confusion about whether you can still perform the mission … how safe is it to continue.

I would have to abort missions in a legacy aircraft that I will now be able to continue in an F-35.

SLD: Tactically, the big deal used to be to get your opponent to jettison his ordnance. To react to you, he punches everything off, and you're fighting and you want to kill him if you can't get the silver star, but at least you've stopped your opponent from doing something ugly to your guys. And they're telling you, basically, you're not going to throw anything over the side, you're going to press on with the fight, with enough confidence that you survive a fight and get the mission done.

LCOL Kelly: With this aircraft, I could take off, and after employing weapons on my primary target, my wingmen or someone on the ground can say okay, I've got another threat over here, can you provide me some information. Instantly, you can become a flying ISR platform, and adjust to provide the context for that ground commander. So even after employing your weapons, which was your initial goal, you can continue maximizing your capabilities.

PAX RIVER INTERVIEW:

GUNNERY SERGEANT LARONE THOMAS IN CHARGE OF F-35B MAINTENANCE

[In April 2010, SLD interviewed Gunnery Sergeant Larone Thomas on F-35 maintenance.]

Sergeant Thomas is in charge of maintenance for the F-35Bs that are undergoing tests at Patuxent River. He recently received the Maintenance Officer of the Year Award from the Marine Corps Aviation Association. Thomas has significant experience as an F-18 aviation electrician.

SLD: How is maintaining the F-35 different from traditional aircraft?

Sergeant Thomas: The aircraft is the aircraft. Any good maintainer is going to be ready to walk in and be able to do maintenance on this aircraft. There is going to be a learning curve for some, but it's not going to be much of a learning curve. If the aircraft does half the things that it is projected to do, it is going to be sweet. It's going to be ten times better than any aircraft that we have right off the bat.

The capabilities I've seen on a hover pad—how much thrust and force I have seen—will be a major increase in capability. It's very promising, and as we work on shaping protocols and routines we can help make decisions for the fleet to make it easier to maintain in the field.

SLD: So during the test process you are shaping a protocol process for the maintainers in the fleet?

Sergeant Thomas: Correct. For example, we had some difficulties but they were based on past practices. Unlike other aircraft, you can access many things from panels. This takes getting used to. One day one of the maintainers was having some difficulties, but we found that he was not following a procedure appropriate to the aircraft.

This aircraft is tighter and a lot more reliable. Its chips are pretty hard to damage. The maintainability package is smaller and focused because the F-35 is more maintainable and more solid state.

SLD: Tell us about your approach to shaping the metrics and protocols for maintenance on the F-35B?

Sergeant Thomas: One big change is how we do our maintenance day. On traditional aircraft we have a maintenance checklist and we do a set of tasks each day. Now the day is defined by what the aircraft "tells us" it needs to have repaired. And we are trying to match our work approach to how the aircraft operates.

We're working towards the goal of having an aircraft tell us—"Hey, I'm low on oil." We have to get used to working with this kind of capability. In the long run we will waste less as we won't change things that don't need changing.

SLD: Tell us about your handheld laptops or Personal Maintenance Aids (PMAs).

Sergeant Thomas: These tools allow the maintainer to connect to the aircraft and run up certain systems to verify if the aircraft is in working order and running properly. Right now, the software is not at that state, but that's what we're working towards.

SLD: So the goal is to have the software and the computer to dialogue with the aircraft?

Sergeant Thomas: Correct. The goal is to have my maintenance day determined by what I'm seeing on my screen.

SLD: As opposed to being defined by a checklist?

Sergeant Thomas: We'll have two separate entities. The PMA is able to access CMMS, the Computerized Maintenance Management Tool System. CMMS is where we document our maintenance. We use it to document ordered parts and more, but the other function, the other PMA, will run up systems on aircraft—pull up Joint Technical Data (JTD), things of that nature.

The impact will be shortened maintenance time and the ability to repair the aircraft and generate more sorties in support of the Marine in the field. That is the whole point.

SLD: Unlike the F-18, the F-35 has internal weapons bays. How hard is this to work with?

Sergeant Thomas: I've loaded this aircraft, I've been part of the team here, and I am certified. It's not hard at all. It's not going to be a steep learning curve that will require extra schooling.

SLD: This is the test regime for maintenance, so presumably it will take longer to do maintenance here than when you have necked down the procedures and do it in the fleet?

Sergeant Thomas: Doing pre-flight inspections and post-flight inspections on aircraft is cumbersome here because everything has to be documented. We are shaping a process to make sure that there's not going to be an issue in the fleet. Our inspections are way more involved than what they're going to be once the F-35 is in operation.

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