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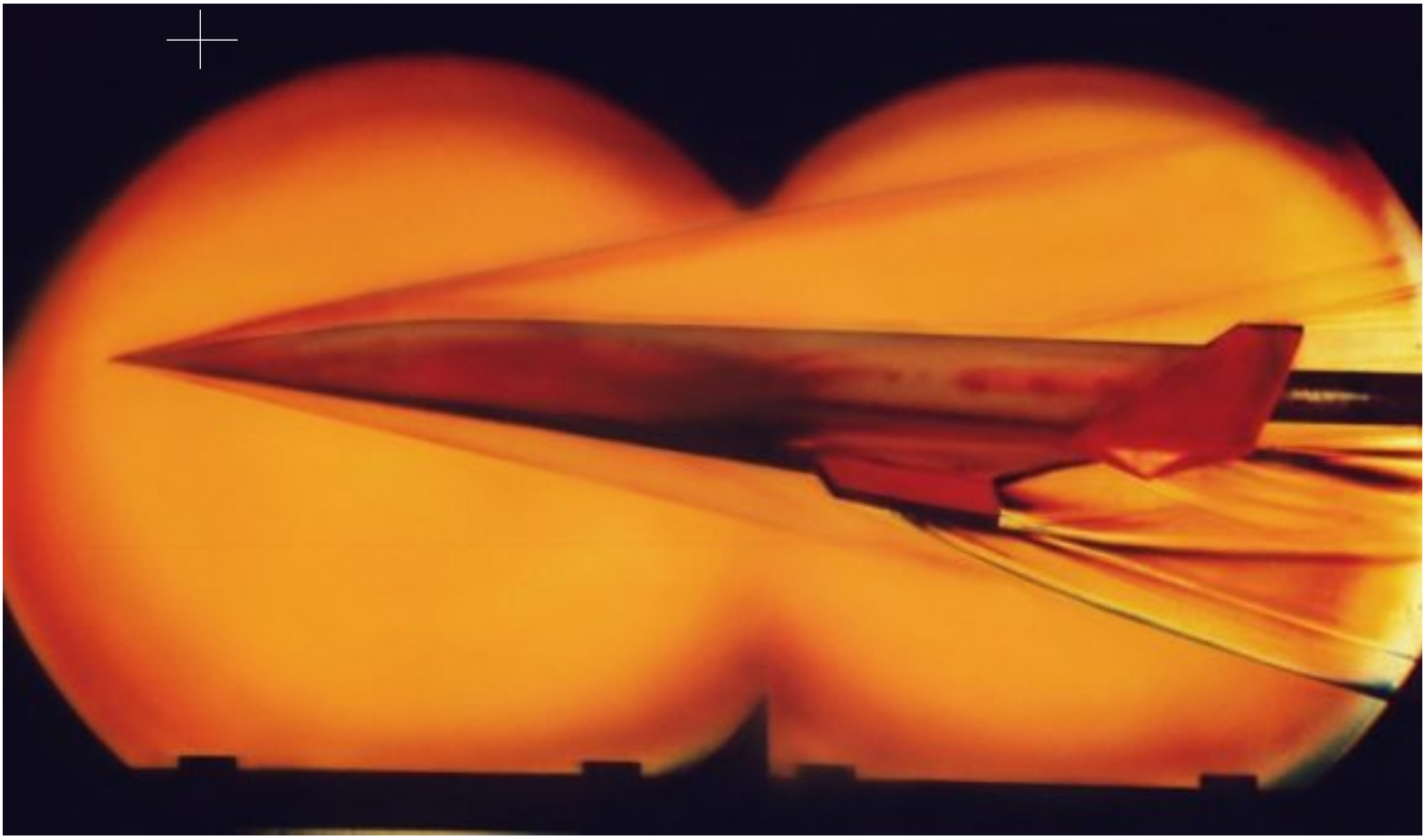
The Coming of Hypersonics



August 20, 2018

The Coming of Hypersonics: How to Deal with the Challenge

Hypersonics has been a key priority for the US until the last Administration pushed the work done to that date into dormancy.

But neither the Russians nor the Chinese went to sleep while the US focused on and resource the land wars instead.

They continued to make progress on this new capability, and with the coming to power of a new Administration, the US is returning to the hypersonics realm.

The new head of Pentagon R and D clearly has highlighted both the threat and the need to focus on hypersonics research and capabilities.

"It is our adversaries, not us, who have chosen to weaponize this type of capability," Griffin said, adding that the U.S. would not be eclipsed by Russia and China.

Griffin's comments came on the heels of Chinese reports announcing the first successful testing of a hypersonic aircraft, a feat the U.S. has yet to accomplish.

When asked about China's sprint to deploy this new breed of weapon, Griffin described Beijing's efforts as "much more thoughtful" compared with Moscow's developments.

"The Chinese have been much more thoughtful in their systems development because they are developing long-range tactical precision-guided systems that will be really influential in a conventional fight," Griffin said. "The Chinese ability to hold our forward deployed assets at risk with very high speed and very hard to intercept precision-guided systems is something to which we have to respond," he added.

https://www.cnbc.com/2018/08/10/space-force-pentagon-blames-russia-china-for-militarizing-space.html

But there is a key question: how best to pursue and deal with the hypersonic threat?

With the President's emphasis on building a new space force through a space corps, naturally, the space element has been heightened as a key element to deal with hypersonics.

And with the appointment of Griffin and loading the Pentagon with space stalwarts, the emphasis could really be narrowly focused on space as the venue and instrument.

Sandra Erwin of *Space News* recently highlighted the space dimension of the hypersonics dynamic as follows:

The Pentagon's panel of four-star generals known as the Joint Oversight Requirements Council will be briefed this fall on potential solutions to a major national security vulnerability: hypersonic weapons that fly into space at supersonic speeds and descend back down to Earth directly on top of targets.

Current sensors could track some portions of the flight but more coverage is needed for the midcourse.

China has been testing hypersonic glide vehicles successfully, and is advancing the technology at an alarming pace, warned Undersecretary of Defense for Research and Engineering Michael Griffin.

The hypersonic threat brings a "new urgency" that the United States has not seen since the Cold War.

A defensive shield would require global coverage and the cost of doing that with ground radars would be prohibitive so this has to be done in space, Griffin said.

"Our response has to be a proliferated space sensor layer, possibly based off commercial space developments."

The U.S. Missile Defense Agency is reviewing proposed concepts for a space-based sensor layer from nine companies: Lockheed Martin, Raytheon, Northrop Grumman, General Atomics, Maxar, Draper Labs, Leidos, Millennium Space and Boeing.

Industry sources said the studies will include options such as constellations in low and medium orbits.

Air Force Gen. Paul Selva, who chairs the Joint Requirements Oversight Council, has asked MDA to come back with an "assessment of the sensor requirements." What will the sensors have to be able to see? How large should the constellation of sensors be? How would sensors in space connect to command and control systems?

"Those are big hard requirements," Selva told SpaceNews last week at a Mitchell Institute breakfast. "We asked for a systems engineering assessment for how they will link all that together." The JROC expects to see a more concrete plan this fall.

During a roundtable with reporters last week, Griffin cautioned that the traditional approach to developing "exquisite" military satellites is not going to work.

The Pentagon already has a network of early warning heat-detecting satellites in geostationary earth orbit that can see missile launches.

The new layer of sensors will be aimed at low-flying hypersonic glide vehicles.

What's needed: "persistent, timely global, low-latency surveillance to track and provide fire control for hypersonic threats."

If the solution is in space, Selva suggested, "Wouldn't it be interesting if a commercial constellation of satellites actually had some capacity? If that's true why would we build our own?"

(SN Military Space, August 14, 2018).

But shaping enhanced sensing in space or an ability perhaps to strike before or during the early launch cycle from space is only part of what is required.

The core problem is how to defend deployed assets through effective endgame strategies leveraging a kill web.

How does is the fleet admiral and the surface warfare officers empowered to kill incoming hypersonic threats?

To know you are going to be killed is not enough; it is to have the means, processes, procedures and information for the weapons officers on what and how to execute the kill function.

Ed Timperlake addresses this challenge in both of his pieces in this special edition focused on hypersonics; first in his S cubed piece and secondly, in his discussion of the kill box challenge.

It is important to put the challenge in perspective.

As one leading researcher on hypersonics put it with regard to U.S. dormancy during the last Administration as well as the evolving Chinese and Russian threats:

The magnitude of the Chinese investment, the number of people they have, the facilities they are building, the ties to their academia, make it all real.

They are flight-testing regularly, and with amazing success.

And hypersonics fits in perfectly with their doctrine.

The Chinese saw Hypersonics as an area that they could develop and surpass the US, and we made it easy for them.

Frankly, an enemy intelligence operative couldn't have disrupted our progress in the field more effectively than we have done to ourselves.

The USAF flew its X-51 successfully in May 2013- what have we done since then?

Instead of continuing and building on that success, we were penny wise-pound foolish; the Air Force gave away most of its money in this area to DARPA, which effectively started over from scratch.

As a result, in the year 2018 we are farther away from flying a scramjet-powered hypersonic craft than we were in 2010.

How insane is that?

The Russians are also a threat, but in their case it is more hype than worry.

And as a senior retired USAF officer put it with regard to the Chinese program on hypersonics:

First, they have a long way to go to operationalize this vehicle.

Second, the US should already have an operational hypersonic military aircraft, but neglect by Congress and past Administrations to ensure our military was funded to capitalize on advanced technologies, and instead shifting those funds in the 90's and 00's to the "peace dividend;" explosive growth in entitlement spending; and strategically misguided Army occupations in Iraq and Afghanistan squandered our military technological advantage.

That misallocation of national resources is still continuing today.

Unfortunately, it will take another catastrophe to wake up America to the need for the advanced capabilities and capacities that are required to achieve military preeminence to deter high-end warfare in the future—and to fight and win if necessary.

A 'Wicked" Problem Deconstructed: Prevailing Against the Hypersonic Threat

08/15/2018

By Edward Timperlake

The Russians and PLA have stolen a beat in R&D on hypersonic weapons research while the United States has been in a "study mode."

Initially, thanks to some very smart American scientists, the U.S. had a commanding lead, especially in the development of Hypersonic Cruise Missiles (HSCM).

Then the full sprint "marathon" of increased developmental testing and further research in fielding 21st Century Hypersonic research was slowed down in the Obama Administration.

Hopefully, now with the Trump Administration funded to engage against peer-to-peer threats, the U.S. 'sleeping giant" can be fully awakened to harness the, scientific, and engineering technological might of the United States in support of an advanced force to deal with peer competitors.

It is past time to harness together an offensive and defensive unity of purpose combat mission in addressing all Hypersonic threats.

This article focuses on empowering those directly threatened by hypersonic end game maneuvering, notably the warriors at sea.

Reaching back to point of origin of launch pads or airfields that create the long-range ballistic missiles or low flying HSCMs threats, especially barraged fired, is essentially a theater Kill Web issue.

A key challenge in dealing with the hypersonic missile threat will be to be able to empower the fleet admiral and his surface commanders to prevail against incoming high speed threats, now being enhanced as hypersonic missiles enter the inventory of the peer competitor.

It is important to keep this perspective in mind when considering both what space systems can provide and what they can not in this mission area.

What space assets provide is a visual monitoring of the incoming treat until it kills you.

To understand the nature of the challenge, one needs to disaggregate the challenge and focus on the key elements of successful defense.

For example, each surface ship CO, from the Carrier to the Cruisers and Destroyers Captains must seamlessly fit together in mutual defense against hypersonic end game maneuvering to save both the fleet and their ship.

This evolving threat is a very hard problem to solve to guarantee ship survival.

This threat is not here yet. And the U.S. and Allies are up to the challenge and must be resourced correctly in R&D efforts against such a threat.

The threat is so far asserted and yet to be proven threat, but in the long term very real and deadly.

Recently, both Russia and the PLA have put the issue of a "hypersonic" attack vehicle in play.

In assessing this threat, first one must put the historic threat of incoming "speed" in context.

The historic Cold War speed of an incoming ICBM is well known and has always been a challenging engineering and laws of physics problem.

In developing many types of defense countermeasures especially satellite warning and ABM missiles, which date back to the early days of the strategic "two scorpions in a bottle" days of U.S. versus the USSR, incoming ICBM speeds, without any endgame maneuvering are well known.

The incoming speed of our ICBM Minuteman III from a California launch to Kwajalein Atoll has been reported ""in excess of 16000 km/h" or in other words, roughly 10, 000 miles per hour.

The Russians announced in 2017 their Kh-47M2 Kinzhal air launched (meaning at a minimum from an aircraft) is a now a maneuvering ballistic missile with a speed of Mach 10, which is slightly over 7,500 MPH.

Putin is now discussing Mach 20 weapons at 15,000 MPH.

In 1960 the USAF had Mach 3, SRAM missile, for our B-52 leg of the US " Triad"

Concurrent with Putin's bragging, the PLA is also touting their Hypersonic Glide Missiles and superfast airframes, the Xingkong-2, otherwise known as Starry Sky-2

"The flight vehicle was launched at a target range in Northwest China with a multi-stage rocket before being released in the air, making "large-angle turning maneuvers," and achieving a top speed of Mach 6, or 4,563 mph, the academy said."

The U.S. response so far has been to build on the foundation kill chain solutions pioneered in the Reagan Administration within today's 21st Century technology information revolution:

Space-based defenses could be used to counter the high-speed missiles.

"The utility of space for hypersonic defense is in the indications of warning, the launch detection, the surveillance, acquisition, tracking—the whole arena of persistent global timely awareness," Griffin said.

https://nationalinterest.org/blog/the-buzz/by-2020-china-could-have-working-hypersonic-missiles-sink-us-24053

But such an approach is limited in creating an effective outcome from the warfighting perspective.

It is certainly correct to focus on the heavens as a combat battlefield, and the announcement of a Space Command is doing that.

But a significant "weather eye" must be kept on subspace technological combat solutions.

Otherwise, a huge and potentially deadly "hole" or seam will created significant vulnerabilities in both our tactical and strategic war-fighting countermeasures.

The threat of HSCM maneuvering warheads will force R&D for sub space mitigation maneuvering endgame "Kill Webs" solutions to become a key focus of attention and is clearly crucial for the maritime forces.

Since no platform fights alone as the UnderSecretary for R&E says about "launch detection, the surveillance, acquisition, tracking," from space then that very useful Intel must be subsumed into a larger context of the actual utility Payload Utility function of Kill Webs in the defense of the air-maritime force.

A focus on sup-space "Pu" or a payload utility function of target acquisition and target engagement inside U.S. and Allied Kill Webs, with new Space Command included in a well funded partnership must always be a concurrent high priority research and developmental and engineering vector.

It must never be overlooked that the Air Force, Navy and Army ADA are the essential joint technology partners in keeping that sub-space research alive with equal resources, all committed in synergy and not in budget competition with the new Space Command.

Consequently, I now more than ever stand 100% behind my research on what I call the "S cubed revolution" which has tremendous promisedirectly to address the enemy's war fighting claims of "extreme endgame maneuvering"

"Against even a Mach 10 threat the F-35 data linked information dominance sensor can off load at the speed of light the incoming track of swarming inbound HSCM threats to other F-35s standing CAP right over the Fleet."

Put bluntly, it is crucial not to reduce the focus upon dealing with the HSCM threat to a mission for the space force; it is a mission for the kill web inclusive of space-based components and elements.

Anticipating the Chinese Challenge: The Perspective of Dr. Mark Lewis

The special report we published in 2011, which highlighted the thinking of Dr. Mark Lewis with regard to the need to keep funding steadily the research and testing in the hypersonics field, was informed by his clear understanding of the nature of the Chinese challenge.

In this 2010 interview we did with him at his office at the University of Maryland, he provided a very clear and comprehensive overview on the Chinese challenge.

The original article follows:

The Evolution of Chinese Science and Technology Capabilities
An Interview with Mark Lewis

10/29 /2010

In September 2010, Second Line of Defense sat down with Mark Lewis, President, American Institute of Aeronautics and Astronautics and Willis Young Professor and Chair, Department of Aerospace Engineering.

Dr. Lewis is the former Chief Scientist of the Air Force under Secretaries James Roche and Michael Wynne.

He is a distinguished expert among other things on hypersonics.

SLD: As the Chinese tend to make large investments, not only internally, but also as they're reaching out around the world in a few key areas of technology, what do you perceive to be the goals for these investments in certain areas of science and technology?

Professor Lewis: If we look at those technologies that the Chinese are investing in, not surpringly in some cases they're the same technologies that we're investing in.

And so, I think an obvious question is why are they doing this; what are their goals, what are their interests?

Before we address specific technical areas, I'll tell you a very interesting story, which just happened yesterday. I got a paper to review for one of our technical journals: the author was extremely familiar with the American literature in the field – the Chinese actually read our literature very carefully – though we're not able to read their technical literature in the way that they're able to read our open literature.

In this particular case, it was obvious that this researcher had read our literature, because he had actually committed wholesale plagiarism out of sections of papers that were written by American researchers in his paper.

As I'm staring at this, I'm thinking that there are several aspects to this that are intriguing:

- First, the author is clearly someone who's trying to make an entrée into the international research community and trying to do so with credentials that are being derived from another source.

- Second, it shows a familiarity with the work that we are doing in the U.S..

There are clearly several interpretations you can derive.

One is, they recognize the value of what we do, and they recognize the quality of research content.

Two, it shows a level of monitoring of the sorts of things that we're doing.

Three, I think it shows a desire to at least match some of our activities, and to interact, maybe participate, maybe compete, maybe also collaborate in certain areas.

I'll give you another anecdote. About 10 months ago, we had a major international conference in my own primary field, hypersonics. It was sponsored by an American organization, the American Institute of Aeronautics and Astronautics.

I'm actually the president of that organization this year.

The meeting was hosted by the German Aerospace Center, the DLR, in Bremen, Germany, and so it had a significant international draw.

About 30-percent of the papers submitted at that conference came from Mainland China.

Now you step back and you say what is the range of applications of hypersonics? It's everything from reentry from space, and we know they have a robust space program, to high-speed weapons, to maybe eventually space launch vehicles. So the Chinese work could play into a full range of products, both military and civilian

But it suggests a level of investment; as one of my colleagues at the conference said, a few years ago when we would see Chinese submissions at these sort of venues, the papers were frankly less sophisticated than papers coming from Europe and the United States.

SLD: More entry level?

Professor Lewis: More entry level. Now they're extremely sophisticated; they're asking the right questions.

They obviously understand the work that other people are doing, which to me shows that not only are they investing the time and the effort into becoming familiar with the literature, but also they're obviously doing their own work along the way.

They're asking questions that show that they're investing heavily in their own research activities.

SLD: In the 50's, the Japanese started replicating simple technologies from Europe and the United States, then they migrated to develop some innovations of their own.

In a certain sense, part of the problem of anticipating Chinese development could well be that we're expecting the same kind of migration, but it seems that some of the investments that you're describing are game changing or breakthrough technologies that do not suggest simply migration.What is your sense about this?

Professor Lewis: I remember all the discussions about Japan and their increasing technological capability. Every once in a while, you'd hear the sort of sneer, a dismissive "Well, but they're just imitative, they're not innovative."

Even then, I'd point out that when we train our students, we start them out in high school, and even as undergraduates, by shoveling knowledge into them.

Most of our undergraduates, learn their material by memorizing things, they learn how to do things often by rote.

They're not creating new knowledge.

SLD: They're iterative.

Professor Lewis: They're iterative indeed, but when they become graduate students, the great leap to becoming a graduate student is that we expect them to be innovative.

We expect them to do research, formulate their own problems, and to develop their own approaches.

I think countries follow an analogous process.

I think that a country such as Japan or China, or frankly, any country that's trying to build up a capability in a technology area will actually start out by first learning what others have done.

When I start a graduate student on a research problem, I say go to the library, read the papers, and see what other people have done. And then they start formulating their ideas, they understand the advances, they understand the shortcomings, and then they begin to build on that to do their own innovation.

I think that's what we're seeing across the board with the Chinese. Hypersonics is one of those areas where a few years ago we saw that they were just getting up to speed in the area. They were just, obviously, reading the papers in the open literature. And now we're seeing them presenting and developing new ideas. Exploring the field, presenting papers on basic research, building facilities. So that's one aspect.

There's another element that I think we have to remember, and that is that quantity has a quality in and of itself. Again, I'll often hear people say dismissively, "well yes, the Chinese are producing many more engineers, but they are not up to the standards that we have," (although in many cases, they are). And to that I'll answer "well, if we're producing a thousand experts in our field, and they're producing 10,000 experts in the field, and if 10-percent of their people are as good as the people we're producing, they're still doing pretty well.

If you generate a certain volume of expertise in a field; if you invest a certain amount in the field, not only in dollars, but also across the board in the workforce, you're bound to see benefits.

We've seen the ability to leapfrog in technology. My friends in directed energy tell me that they have seen advances in the open literature in what the Chinese are doing that really surprised them, that they were moving at a pace that was much faster than anyone had previously expected.

I think a lot of that is just putting in a lot of resources.

We've done that in the past in our country, in the Manhattan project: when you think about the investment in the Manhattan project, we were able to realize incredible technological accomplishments with massive investments.

Other example: the B-29 Bomber. It's one of my favorites from aeronautics. We basically sunk a lot of money and a lot of resources and a lot of manpower and produced an aircraft that, at the end of World War II, was literally a generation beyond the aircraft that have preceded it.

So when you make those sorts of investments, and especially when you're in a country where labor isn't that expensive, you can have these incredible accomplishments.

And I think it behooves us to step back and say well, why are they making these investments?

What are their goals, what are they after?

I think that's a question all of us with an interest in this subject should ponder.

SLD: It's pretty clear that aerospace, generally, has been identified as an important growth area for them, commercially and militarily, but we should remain a bit humble in assuming we understand what the Chinese science and technology growth model might be, don't you think?

Professor Lewis: Correct. For quite some time, we've had a very high number of Chinese students in the United States educational system.

The joke is that there are some science and engineering departments in the United States where the dominant language is Mandarin Chinese.

And that's been the case for many years.

What we're seeing in recent years, including on a campus such as ours, is a rather profound change. Whereas 10 years ago, when we had Chinese students arrive, their goal was generally to stay in the United States.

They wanted to get an education here and they wanted to become Americans, and they wanted to work in American technology.

And so the question they'd ask is how do they become citizens?

How do they become part of the American experience?

Now more and more, we are seeing students whose goal is to learn, and then go back to their homeland and bring the lessons that they've learned here back to their home country. In many cases, they see more opportunities; they see tremendous economic opportunities there.

They also see, I think, social opportunities to advance faster in their home country than they see here.

To a certain extent, I think we've hurt ourselves when we have created barriers for some of these folks to remain here, though in some cases we have done so for very good reasons.

But as a byproduct, we are essentially helping to create our own competition.

Clearly there are crosscutting choices or trends.

On the one hand, you don't want to close your doors entirely; the free flow of information, the exchange of ideas is one of the things that drives the scientific community.

When you clamp down strongly, then you hurt yourself; you limit your own ideas, you wind up getting stuck in your own sandbox.

So bringing in fresh ideas, having an international exchange is a normal part of academic life.

There are really smart people all over the world. And so you don't want to stop that sort of free flow of information when it's appropriate.

When I was on the Air Staff I'd always point to the example of the United States Air Force having very robust international research programs. The Air Force has a research office in Tokyo, a research office in London, and just opened up a research office in Santiago, Chile.

They fund researchers around the world, and there are many good reasons for doing so.

There are smart people all over the globe that you want to tap into them. There's also the argument that when we bring people in from overseas that they learn about us; they learn about our systems, they absorb our values, they learn why this is such a great country. And I think they carry that message back.

But of course, there's also the flipside, which is that we wind up in some cases, selling the farm. We wind up giving away technologies, giving away knowledge. It's that fine line that I think we're frankly very challenged by, and that in some cases we've seen other potential adversaries, potential competitors exploit and use against us.

SLD: It seems that we're really at a crucial crossroads or threshold: on the Chinese side, if they don't commit to serious protection of intellectual property, it raises fundamental questions about what the strategic purpose of their goal is.

On the other side, if the United States, as well as Europe, do not get more serious about competitive manufacturing capability; about their own projects in aerospace and defense, then we will only have ourselves to blame for losing the competitive race.

Professor Lewis: Right. I would agree.

One of the policy issues I was most concerned about on the in aerospace occurred a few years ago, when the Chinese launched their first astronauts. I was actually expecting kind of a hue and cry from Americans saying wow, look at that.

We've got to get back into a little bit of competition. It's not bad competition, but let's robust our space program. We saw that in Sputnik, right? The Russians launched Sputnik and there was a national panic that we were allowing our science/technology to whither.

But when the Chinese launched their astronauts, it was buried in the back of page 3 or 4 in the *Washington Post*, and you heard very few comments. I've heard people prognosticate that the Chinese will probably be back to the moon before we get back to the moon. And at the rate we're going, that's almost certainly true.

Where's the popular concern?

SLD:One thing about the Chinese space program is that there is an assumption that we've already done it, and therefore we don't have to do it. And it goes back to your proposition of quantity is a quality all of its own.

They're investing; they've got thousands of engineers in the space program. We may make the judgment that well, it's repetitive, and so what do you get out of it?

The problem is that we've gone through a period of global dominance and there are assumptions that we can drift along and still be dominant.

People tend to be confusing an event or a program such as returning to the Moon with a particular historic moment.

And not understanding the question is an investment in an overall capability at a different moment in history.

Does that make sense?

Professor Lewis: I would agree with you completely.

We know that they're investing in space, and openly talking about their aspirations in both civil and military space.

Take one example: materials development is a tremendous driver for aerospace. The Boeing 787 is an example: its great advance is the use of composites instead of metal. Mike Wynne, when he was secretary, understood this very well, and he placed a very strong emphasis on composite materials coming into the air fleet.

We know that the Chinese are investing very heavily in that area as well.

Materials technology development has military applications; it has civilian applications as well. Directed energy is another bellwether field.

We know from their publications in the area, that they're very interested in lasers. Laser technology has applications across the board, everything from telecommunications to defense applications.

I think it's pretty clear that they're investing heavily in cyber, and we know that they're making significant inroads in cyber technology; I think the military applications there are obvious.

In many cases, I'm intrigued because it looks like the Chinese have gone back and looked at where we were talking about making investments in the past, and maybe sometimes we didn't make the investments, but they are.

The other point I'd make is that they're making an investment in long-term education. I'll tell you another interesting story; shortly after I came back to campus full-time from the Pentagon, I found out that we have an exchange office on campus that was actually bringing in a group of Chinese faculty members who are coming to our university.

Their goal was to sit in our classes and learn how we teach, and what material we teach, and then go back to their home institution and teach those same sorts of classes.

The intriguing thing was, they weren't necessarily interested so much in the specifics of our course material, they weren't interested in that. Instead, they were interested in our delivery methods.

How do we actually instruct our students?

What processes do we put our students through?

That bespeaks a long-term investment in education, which cuts across disciplines.

And of course, they've got a very close relationship between their universities and their military infrastructure. And in many cases, their universities serve as designed bureaus for their military, so there's a very close coupling.

SLD: One way to look at this is that there's a strategic vacuum in the West. You have this kind of strategic vacuum or pause or however you want to characterize the situation; it's not moving forward.On the other hand, China is becoming a strategic juggernaut.

So you put this strategic Chinese dynamic with a Western strategic pause, you create a different phase in the global competition. Strategic vacuums interacting with strategic juggernauts have a strategic consequence.

And that's really the point.

Professor Lewis: I would agree with you completely. If I look across the board at aerospace technologies, we have essentially produced only two new rocket engines in the last 30 years. In many cases, we're coasting in technology.

In the aircraft area, how do we build on design experience?

What comes after the F-35?

We're not even really having those conversations yet to think about how we're going to be developing our future systems.

With regard to airliners, we have a lot of advanced ideas on the drawing board, but not a lot of real programs. NASA's got concepts for future air and space systems; the Air Force has a lot of concepts as well.

But even when you look at something as modern as a 787, as you correctly point out, it's building on older technology and our hard-earned knowledge base.

So, I'd almost invoke the classic rabbit and tortoise analogy; if the rabbit makes great leaps, but then stops and rests on its laurels, it's relatively easy for the tortoise to catch up. That's especially true if the tortoise gets himself supercharged, and if after he's caught up, he takes off at rapid speed.

I think that in general we tend to see examples where there's a tendency to invest in a certain level of technology, and then coast.

Railroads are a perfect example.

At the beginning of the 20th century, the United States had a phenomenal railroad system.

Our railroad system was the envy of the world.

But once built, we didn't invest very much in it.

Now you look at Europe, Asia, their rail systems are far superior to ours because they invested later on and they got newer technology.

We stopped making those major investments.

SLD: And a key development is the intersection between the new manufacturing base in China, the Manhattan style investments, and the growth in S and T capabilities. It has a magnet effect on the rest of the world as well. Let me give you a story, which reflects on that intersection. I listened to a presentation from Michelin about how they were inverting their supply chain role to becoming a prime manufacturer of automobiles.

And the strategic partner is China. And the entire concept from the Michelin side is a tire is something that you put on, the car generates everything else. But in fact, if you start thinking about electric propulsion or internal propulsion systems, you can put much of what's in the rest of the car on the tire.

And they've actually got designs for this.

Who's their strategic partner? China. Chinese are investing heavily in this technology area. It's just a natural thing attracted by the marketplace, the investments, and the manufacturing base.

So I think we've also deluded ourselves that in establishing a very significant manufacturing base in China, there are no strategic consequences, because they're kind of like Japan.

They're not Japan.

Professor Lewis: Right, exactly. I remember General Moseley was asked if he really thought the United States Air Force would be facing a Chinese military threat at some point in the future?

And I think he made the very profound observation that the chances that we'll be facing off directly against China are extremely small, but the chance that we'd be facing off against their equipment in the future is actually quite high.

Unfortunately, a lot of the reporters picked up the first part of the quote, and they didn't pick up the second part of the quote.

I had an experience when I was the Chief Scientist of the USAF on a trip to Brazil, which highlights this point. During my visit, the Brazilians took me to their space agency and they walk me into a facility where they're assembling satellites.

They have very ambitious plans for space; they had been trying to build their own launch system, they were looking at microsatellites.

And I always remember that visit, because they walked me into big high bay area, their assembly area for satellites.

They took me up to the fourth floor, I went out onto this sort of balcony area, I'm looking down, standing behind a pane of glass.

And on the floor of the facility are about 30 or 40 Chinese engineers working hand-in-hand with the Brazilians. I asked what's going on here?

The answer was the Brazilians had a wonderful working relationship with the Chinese.

The irony was that all their equipment was American-made; they had American shaker tables, they had American environmental chambers to test their satellites.

But the guys on the floor who were working with them were Chinese.

And oh by the way, I asked what's the language for communication? Oh, English.

The Chinese spoke English, the Brazilians spoke English, so they're all speaking to each other in English.

And I asked the Brazilians, "Well, why aren't you working with us?"

And the answer I got was, "It's too difficult."

That was interesting.

Allied Hypersonics: The Australian Case

08/15/2018

By Robbin Laird

Like the United States, the Australians have built a foundation for progress in hypersonics but that effort needs to be re-energized and expanded.

The US under the leadership of Dr, Mark Lewis partnered with Australia in this research area and that effort certainly needs to be re-energized as well.

During a visit to Australia in 2014, I had a chance to visit with a leading hypersonic scientist and to discuss their program.

2014-05-14 By Robbin Laird

The coming of the USMC for a 6-month rotation in the training areas of Northern Australia is a concrete manifestation of the US-Australian deepening their working relationship in shaping 21st century Pacific Defense capabilities. The Aussies are engaged in significant defense modernization projects, such as the KC-30A Airbus tanker, the Wedgetail Air Battle Managements System and the F-35.

Along with these projects, the Aussies are engaged in significant research in the field of hypersonics and have partnered with the U.S. on some of the basic research, but going forward the US should consider extending the excellent working relationship with Australia in the hypersonics area.

Too often, there tends to be an attitude in Washington of fiscal limits overcoming modernization.

Yet when one looks at the Pacific, key allies are investing in defense modernization and in significant innovations as well.

The opportunity is to shape convergent modernization to the benefit of the allies and the U.S. to deal with the challenges from China and North Korea.

It is not us versus the Chinese; it is the allied engagement shaping deterrence in depth against a China with no strategic allies, other than Russia and North Korea.

Recent Chinese tests on hypersonics have underscored that several countries are working to be able to build operational hypersonics platforms, for a variety of purposes. You wouldn't want to be second to the table with a hypersonic strike missile.

Partnering with a solid ally like Australia can help ensure that does not happen to the United States. But this requires significant commitment to steady investment in the hypersonics research area.

Australia has a small but cutting edge team of hypersonic researchers, with the test ranges to play out the evolving technologies, and with significant global working relationships. Research in this field can clearly yield possible capabilities for space access as well, with an ability to launch rapidly ISR and C2 capabilities for Australia and as part of the effort to overcome the tyranny of distance to deal with longer-range threats and challenges as well.

In fact, hypersonic "air-breathing" engines may be the only solution for dramatic reductions in the cost of launching payloads to orbit.

During a recent visit to Australia, I had a chance to visit several defense installations, including a hypersonics research area. I visited with Dr. Allan Paull and members of the Defence Science and Technology Organization (DSTO) hypersonic team located close to Brisbane, Australia.

Dr. Paull made it clear that the team was small but effective.

We combine the skills of several disciplines but each member of the team takes ownership of the entire effort and provides inputs to each and every aspect of the enterprise.

We are not organized around a model of deep pocket experts who stay within the confines of their specialty; we interact across the enterprise to push the research effort forward.

Dr. Paull emphasized that the hypersonic effort required progress in several technologies at the same time, materials, propulsion, computation, etc.

Visiting the workroom of the DSTO where two hypersonic vehicles are being assembled certainly reinforced the point that several moving parts are being worked toward the next hypersonic test.

The key takeaway from the discussion with Dr. Paull was rather straightforward:

By 2015 we will have finished our current round of tests, and by that time there is little question but that the basic scramjet technology works and can be leveraged moving forward.

A key hypersonics program is the HIFiRE program. Australia has worked with the USAF in building out a full set of HIFiRE test vehicles. The objectives of the program are twofold: To develop the science and technology for hypersonic flight with air breathing propulsion; Complete a horizontal flight of a scramjet-powered vehicle for a duration of 30 seconds.

An interesting aspect of the Aussie effort has been to build an engine which can reach hypersonic speeds but fit into the center of a vehicle, thus allowing for an axisymmetric configuration. The team is working a number of innovations to achieve this result.

Such an engine, if proven, would be a major step forward in making practical use of scramjet technology.

If this capability works effectively and can be replicated from a manufacturing point of view, then the path towards achieving hypersonic missiles seems open. Additionally, HIFiRE is testing high angle of attack flight profiles as well which adds a potential of maneuverability to speed.

Much has been achieved by Australia already, working in concert with its partners in hypersonic research in a period of less than a decade. But the importance of this effort, and the need to be on the cutting edge is clear.

The basic hypersonics research effort is being worked for a baseline space system as well.

This program is called SCRAMSPACE which is the first and largest project funded by the Australian Space Research Program. The program is working on a Mach 8 flight experiment. This experiment entails both ground and air tests, with the ground-tests on the vehicles working at up to Mach 14 and the flight test focused on a free-flying scramjet at Mach 8.

The first free flight test for SCRAMSPACE was conducted in Norway but did not achieve the desired results. The first stage rocket motor malfunctioned, which led to the test not being able to deliver the requisite hypersonic flight data.

The Aussies are building a number of hypersonic vehicles and doing ground tests on these vehicles and preparing for future flight tests as well. Tests for the HIFiRE program are performed on an extraordinary test range, the Woomera Test Range, in South Australia. This is a very large area where the vehicles can be recovered and then fully examined to determine their performance parameters. It is not a well-instrumented range, but with proper funding could be.

The US hypersonics program needs a practical focus, as well as a funding and priority boost.

Partnering with Australia can boost the effort by providing for a best value partner, an effective test range, innovative thinking and capabilities from that partner, and an ability to provide that partner with capabilities which they themselves may either lack or would find prohibitively expensive to provide.

For example, if one wished to do a test replicating what the Chinese just did, it would cost 3-5 times more in the United States than in Australia. By building a solid working relationship and joint development, access to the Australian range would make sense for both sides and a more cost effective and capable result in a timely manner could be achieved.

After my visit I had a chance to discuss my findings with Dr. Mark Lewis, the former chief scientist of the USAF and a leading researcher in Hypersonics.

Dr. Lewis underscored the importance of boosting the partnership going forward for a number of reasons.

This is an important relationship because the Australians bring significant intellectual contributions to the table.

They also have important practical flight experience; we can even argue that they flew the very first flying scramjet under their HyShot program, which was a precursor to HiFIRE.

They have an extraordinary test range as well.

Much like the global F-35 would not exist without allies and partners, the effort to work with core partners on other 21st century capabilities is crucial as well.

There is none so more than a steadily and fully funded Australian-US partnership in hypersonics.

Editor's Note: For a version of this piece which appeared in Space News please see the following:

http://www.spacenews.com/article/opinion/40538us-australian-partnership-could-help-hypersonics-take-off

The Challenge of Dealing with Hypersonic Cruise Missiles

08/14/2018

By Robbin Laird and Ed Timperlake

We first dealt with the challenge of the hypersonic cruise missiles in an article published April 16, 2014.

We have heard much about the anti-access, and area-denial threat which China poses to American and allied forces in the Pacific. We have read much about new missiles such as the DF-21, which it is asserted can destroy maneuvering ships at sea to take off the board US aircraft carriers. We have read of Pacific allies wish to deploy substantial fleets of F-35s, and then critics decide that these "short range" assets can not meet the crucial needs of warfighting in the Pacific.

We have also learned in the press that core competencies like amphibious assault have now become virtually impossible because of the A2 AD capabilities of China.

What is lost in all of this hyperbole is what the United States and its allies are doing to shape a new combat capability appropriate to the 21st century. It may be true that a linear air power force would find it difficult to cope with such threats; a distributed S cubed force will not.

Sensors, combined with stealth combined with speed can provide a new paradigm for shaping the Pacific force necessary for the U.S. in working in the Pacific.

At heart of getting the policy agenda right is to understand that warfare is highly interactive. Buying, building and deploying yesterday's technologies against evolving threats is a sure fire way of being in the wrong side of the outcome.

As Lt. General Walsh, the Deputy Commanding General, Marine Corps Combat Development Command, put it succinctly in a recent presentation:

Some say that the development of modern anti-access, area denial threats make an amphibious assault impossible. That has been said before and it was not true then and it is not true now. The challenge is to leverage the asymmetric advantages we have in functions like ISR, precision first, and seabasing. The challenge is to use the sea as a maneuver space in the context of the modern threat. We don't need to give up on the capability. We need to think our way through the challenge.

This is especially true because persistent presence is a key fundamental of the kind of alliance and partner relationships necessary for 21st century Pacific operations, and the role of ships and maritime engagement is crucial across the spectrum of operations, including protecting the conveyer belt of goods and services passing through Pacific and Arctic waters.

What Walsh was hinting it is what we would call the S cubed evolution or revolution of capabilities.

Sensors, stealth and speed can come together to create a powerful distributed force in the Pacific, which can so complicate Chinese military planning as to enhance deterrence significantly.

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

The F-35 has been built to be a fleet, not a silver bullet. As Lt. General Schmidle, the Deputy Commandant of Aviation commented recently with regard to the flexibility and coverage, which the Bs can bring to a theater of operation like the Pacific:

I think that we're going to find ourselves in a situation where we, the Marine Corps, are going to be able to offer much more to the joint force in terms of capability. And as General Hostage put it to me, Marine Corps assets will be considered an integrated part of the joint force, in a way he has not thought of it before. The Air Force Commander will look at USMC or USN F-35s as part of his F-35 fleet from the perspective of the joint fight.

And General Hostage underscored the air combat cloud role of the fifth generation aircraft operating as a fleet.

The advantage of the F-35 is the nature of the global fleet. Allied and American F-35s, whether USAF, USN, or USMC, can talk with one another and set up the distributed operational system. Such a development can allow for significant innovation in shaping the air combat cloud for distributed operations in support of the Joint Force Commander.

http://defense.aol.com/2013/01/10/why-the-air-force-needs-a-lot-of-f-35s-gen-hostage-on-the-com/

Other sensor capabilities will be provided by evolving robotic capabilities, under the sea, on the sea and in the air. The concept of an operating wolf pack whereby robotic elements outside of the fleet and inside the planes themselves will make a stealth-sensors dynamic as a solid foundation for the weapons revolution.

We are currently putting 3rd and 4th generation weapons on 5th generation aircraft. This makes little sense. With a plane that can see significantly further than the weapons it carries can operate, the capabilities of the plane are being limited by the past, rather than enabling a new strike enterprise future.

We have written elsewhere about the core elements of the weapons revolution enabled by the F-35.

http://sldinfo.com/building-21st-century-weapons-for-21st-century-operations-key-attributes-of-the-new-weapons-enterprise/

But the core capability which we wish to highlight here and link to the third S – speed – is offboarding of weapons. Offloading of weapons will be a fundamental opportunity posed by the 5th generation aircraft. The former Chief of Staff of the Air Force, General Schwartz spoke prior to his departure of F-22s training to guide Tomahawk missiles off of surface ships to their targets.

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

http://sldinfo.com/the-air-sea-battle-concept-and-pacific-operations/

This is simply the hint of things to come.

The F-35 has a 360-degree situational awareness and data delivery capability. This poses the possibility of leveraging the 360-degree space to guide weapons to their targets. Target acquisition onboard does not have to be married to weapons CARRIED on board.

This means as well that classic distinctions between tactical fighters doing close air support, or air superiority missions or air defense missions are clearly blurred. The fleet flies and identifies targets for the various mission sets and can guide weapons to a diversity of target sets. The reach of the fleet is the key to the operation of the fleet, not the range of individual aircraft.

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

Mark Lewis, the former Chief Scientist of the Air Force and now head of IDA's Science and Technology Policy Institute, is one the leading hypersonic experts in the world. Lewis has underscored that a hypersonic cruise missile is the low hanging fruit of the hypersonics revolution.

In considering the impact of a high speed missile with evolutions in warheads carried by such missiles one can see the breakthrough possibilities. We discussed with Lewis the types of warheads, which could be delivered by such, a missile.

The goal would be to marry the missile with warheads, which have the ability to get inside the electronics, the fire controls, the signals, the sensors of your opponent flying at hypersonic speeds. With a forward deployed stealth fleet doing target identification as well being available rapidly to prosecute combat advantage from the results of the strike, American and allied forces would be not only more lethal, but a much more effective deterrent force.

Hypersonic cruise missiles are part of the competitive landscape with the Russians, the Indians and the Chinese all investing in these capabilities. We have allies like Australia and France as core players as well in shaping future capabilities. This is not a race one wants to lose to the Chinese, notably because the roll out of the stealth fleet could make such good use of such a capability.

Clearly investments need to be made in this area or more to the point pooled to shape an effective outcome.

As Lewis underscored:

I would also draw analogies to the early work that eventually led to the development of ICBMs. The initial resistance of the bomber community to ICBMs was significant. General Le May originally referred to them as "firecrackers." But to his credit and that of the rest of the USAF leadership, they marshalled the resources and built the ICBM fleet.

I think hypersonic flight requires a very, very similar change in mindset. The fact that I can flight at such speeds means that I can reach in quickly and that I can reach far. Hypersonic systems would give us the ability to marry surgical precision with rapidity of action. And would also provide a measure of invulnerability in the face of enemy defenses as well.

Rather than thinking of it as a silver bullet but part of an S Cubed force, hypersonic speed could enable the forward deployed F-35 stealth fleet to guide lethality to a broad variety of targets.

http://sldinfo.com/a-leap-ahead-in-the-weapons-revolution-the-coming-of-the-hypersonic-cruise-missile/

Such game changing technology needs to be a high priority for DOD and NASA investments. And certainly it can be, as money is saved from exploiting the inherent advantages of the weaponization of the F-35 fleet. As allies develop new missiles and pay to integrate them on the global fleet, the US has access directly to such missiles and in block 4 of the software upgrade we will see MBDA, Kongsberg and Turkish missiles then available across the fleet.

This frees the US from investing in its own capabilities to mimic allied missiles for the F-35 fleet or the legacy fleet. Investments can be concentrated on a breakthrough technology, like hypersonic cruise missiles, or increasingly faster cruise missiles with new types of warheads.

And associated with shaping new delivery vehicles is the development of new warheads as well. New warheads can be developed for the hypersonic missile which have the ability to get inside the electronics, the fire controls, the signals, the sensors of your opponent and to do it at very high speed.

And one way to understand the potential for change is to revisit the large deck aircraft carrier and its future. Does not a hypersonic missile woven into a fleet of evolving capabilities significantly enhance the viability of the force and its lethality?

Imagine the F-35Bs and Cs provide the forward punch to the sea force and identifying forward targets along with robotic elements deployed in the water, under the water and in the, air and guiding a set of new weapons on the F-18s based on the carriers, including a hypersonic cruise missile.

What is there not to like about a maneuvering ship with a variable geometry strike force onboard?

In short, sensors, combined with stealth combined with speed can provide a new paradigm for shaping the Pacific force necessary for the US in working in the Pacific.

As Lewis put it: "Distance only gives you tyranny if you're clanking along at 30 knots. If I'm flying at mach 2, mach 3, mach 5, mach 6, I don't think distance is such a tyranny any longer. And I think that's what speed and range, by the way, in combination brings to the equation."

Many of these themes will be examined in a forthcoming book (by Robbin Laird, Ed Timperlake and Richard Weitz) Rebuilding American Military Power in the Pacific: A 21st Century Strategy, *to be published by Praeger Publishers later this year.*

The S-Cubed Revolution: Laying the Groundwork for Dealing with Hypersonic Threats

08/14/2018

By Edward Timperlake

In an article published on February 18, 2015, the author highlighted ways the US and its allies could leverage technology already being put into operation to shape new capabilities to deal with future threats.

The original article follows:

"You know that stealth may be over-rated," Admiral Greenert, the Chief of Naval Operations, recently noted during a speech at the Office of Naval Research Naval Future Force Science and Technology Expo, Washington D.C.

"I don't want to necessarily say that it's over but let's face it, if something moves fast through the air and disrupts molecules in the air and puts out heat – I don't care how cool the engine can be – it's going to be detectable."

The CNO is exactly right.

Admiral Jonathan Greenert, a nuclear trained Navy submarine officer, and General Mike Hostage the recently retired Commander of the USAF Air Combat Command and an F-22 pilot are in agreement on the dynamic nature of "stealth."

From General Hostage's last interview before retirement and one which he did with us:

People focus on stealth as the determining factor or delineator of the fifth generation. It isn't; it's fusion.

Fusion is what makes that platform so fundamentally different than anything else.

And that's why if anybody tries to tell you hey, I got a 4.5 airplane, a 4.8 airplane, don't believe them.

All that they're talking about is RCS (Radar Cross Section).

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

And fusion changes how you use the platform.

Just like in Admiral Greenert's initial warfighting community, the U.S. Navy's submarines "silent service," airpower commanders have the same type of relative technology dynamic against a reactive enemy but in a different medium.

Both communities have to be ready to fight in a very dangerous three-dimensional maneuvering environment where active and passive sensing and weapons and countermeasures to those weapons mean the difference between life and death.

In our discussions with Dr. Mark Lewis, former Chief Scientist of the USAF and currently head of the Institute for Defense Analysis Science and Technology Policy Institute, we focused on one of the bigger threats coming sooner rather than later to be facing all warfighters in many nations, the hypersonic cruise missile.

Dr. Lewis is a leading expert on hypersonics.

We interviewed Dr. Lewis in the context of rolling out an F-35 fleet with the rapidly approaching Hyper-Sonic Cruise Missile (HSCM) as a new weapon of war.

HSCMs are part of what one might call an S Cubed formula for thinking about military critical technologies for 21st-century targeted R&D.

S-cubed=sensors-stealth-speed of weapons can provide a new paradigm for shaping a combat force necessary for the US Military to fight and win in 21st century engagements.

Stealth or no stealth the F-35 fits perfectly into the S3 revolution in modern war

No matter which path is taken, the F-35 as a single platform with all three attributes combined or as a non-stealth sensor platform, employing speed of weapons carried organically or trading off with other platforms at the speed of light by giving incoming target vectors to their weapons.

A point implicit in the CNO's discussions is that the order of the words is very important.

Starting with sensors, then stealth and speed (again of weapons) they can be combined in one stealth platform or as appropriate stealth and speed can be traded off against one another using a separate platform.

CNO Admiral Greenert has pointed this out before.

As Admiral Greenert correctly points out, improved radars and sensors continue to chip away at stealth. Military advances in technology are always relative against a reactive enemy and are not absolute. Stealth is simply an airframe survivability design feature. Stealth is everything until it is nothing.

How fast an erosion of stealth design features is a critical question as well as the meaning of detecting stealth within a fluid and rapidly evolving battlespace.

Airframe design characteristics are all blended together in tradeoffs and have been focused on constantly improving, payload (improved by systems/and weapons carried), maneuverability (measured by P Sub s), speed, and range (modified by VSTOL–a basing mobility plus factor).

Stealth was a clean sheet design for F-22 and F-35 and is embedded in the total airframe and it is a very sensitive multiplicative factor; one does not add stealth. Additionally like all modern fighters stealth aircraft are also designed with inherent other survivability factors, such as system redundancy and hardening.

The CNO's observation is very true.

Stealth is simply a survivability term that impacts the entire airframe and will eventually decline as better sensors are developed.

This is also why passive sensing is also a real revolution. Passive sensing can attenuate the problem of generating active "signals in space" which often can give away a platform's position either maneuvering or an absolute fixed location for a counter- attack.

Stealth dynamically over time will become more vulnerable as enemies sensors improve.

How long and against what enemy, and where in world will the ant-stealth sensors and successful weapons be employed is unknown, but it will occur.

The CNO being a Nuke engineer is also exactly right about heat signature. But the US and our allies are also a reactive enemy and a SAM or Cruise missile launch also puts out heat. And so far any enemy still needs a period of active sensing for target acquisition. That requirement is often expressed as "emit you die."

Modern air combat, just like submarine warfare is essentially an evolving contest of "blind man's bluff."

Even if and when stealth survivability deteriorates–ENTER the F-35 fusion cockpit with passive sensing and a significant payload of hard points.

External weapon hard-points on the F-35 are a brilliant design aspect, which is often overlooked in most discussions.

The non-stealth F-35 can sling more ordinance than F/A-18 and F-16.

So even in a non-stealth world, advantage goes to F-35, with its 360 active and passive horizontally linked cockpit decision-making ability.

As the CNO says "payloads over performance."

Employing stand-off weapons with current and better payloads the F-35 still wins any combat comparison because the S-3 formula kicks in as a combat reality.

An F-35 as a non-stealth fleet still has a 360-degree sensor platform with "reach not range" as a fundamental fleet enabler.

It is an information dominance fusion platform that can be favorably compared to the equivalent of being a 21st Century version of USN Destroyers standing very dangerous and heroic radar picket duty protecting the Amphibious invasion force and Carrier Fleet against kamikazes off Okinawa.

As the CNO pointed out "something moves fast through the air and disrupts molecules in the air and puts out heat – I don't care how cool the engine can be – it's going to be detectable."

Only this time against the HSCM and also a lesser-included problem of killing slower cruise missiles if F-35 did not exist it would have to be invented.

In other words, an additional benefit of R&D and con-ops efforts to kill HSCMs makes taking down conventional CMs much easier.

It is now time to accept that a war-changing weapon, HSCM is in the late stages of R&D and it must be accounted for in any battle plan. Unlike distant "hyper-sonic" R&D efforts such a Global Strategic Strike aircraft, a hypersonic cruise missile is a rapidly evolving technology, which sooner than later will be demonstrating the art of the possible up close and personal. Such a revolutionary CM in the US arsenal is a very good thing. In the hands of PLA forces it is a very real "wolf at the door."

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

If it is in the hands of an enemy a hypersonic Cruise Missile is a ship killer.

The Cold War USN CBG protection mantra against Russian Bombers with anti-ship cruise missiles was to try and first kill the archer not the arrows.

Top Gun in the late eighties briefed "Chainsaw" tactics, and the F-14 was very well designed for long-range interception of threats against the Fleet.

"Chainsaw" was a focus on reaching out as far a possible against any threats.

Now if Russian and/or PLAAF successfully air launch HSCMs or their missiles are launched from ground batteries or surface ships or subs (USN fast attack subs are of utmost importance in that battle) they will be engaging in their version of the S-3 formula. Just like the USN and USAF they first need sensors to make it all work. The order of the "S" words in the priority of formula is very important.

If they develop a HSCM to empower their fighting force the F-35 does not have to fight in the stealth mode against HSCMs. Even if HSCMs move at Mach 10 an F-35 sensor platform moves "trons" at the speed of light and this can make all the difference.

It is very evident that all fighting forces need both reach and range. The F-35 today can play both stealth and non-stealth and is a generation better than any other aircraft in the world. One just has to look at Russian and PLAAF attempts to develop a real F-35 capability and their stealth airframe is lacking the sensor systems comparable to F-35. It is a pure marketing assertion that they have fusion parity and DAS.

The F-35 "360 Degree Fusion Cockpit" is good for a decade or more as the never ending action/reaction cycle of our enemies attempt to make their technology and training moves to catch up to US.

US and its Allies are the only airpower thinkers and practitioners that can learn TTPs when F-35, F-22 and legacy aircraft mix it all up at a Red Flag. Russian and PLAAF cannot do that training within a decade. They might claim that they are building fusion cockpits in stealth jets-but currently just by looking at their airframes with no nose sensors or wing sensors, they are simply fusing linear improvements to radar systems. They do not have the complete 360-active/passive reach that the F-35 brings to AA, AG and EW fight.

There is one other significant factor of HSCMs.

A ship has an advantage in that it can maneuver at sea, it also has a distinct disadvantage if a mortal blow is landed it sinks.

Whereas an airfield has a disadvantage in that it is a very well-known fixed point on land but an airfield has a significant advantage in that it can be fortified and also have an operational chance with rapid runway repair and other battle damage repair.

Both the US Navy and US Air Force have the vision and resources to develop the most modern training ranges in the world and a dedicated unified approach to collecting operational intelligence against HSCM airborne "signatures."

During a visit to Nellis AFB Major General Jay Silveria, Commander of the USAF Warfare Center, pointed out that one of the missions of his command is to create a mission file for the F-35 fleet.

"The mission file includes all of the data about every threat, aircraft, surface-to-air missile, blue aircraft, and airliner, whatever that airplane may see during its flights.

That intel mission data will fill the mission data file that will build is what the airplane then goes in and looks to see when it fuses that target.

The mission data file that we're building right now in the 513th at the 53rd wing which are part of the Warfare Center were initially building are for the Marines."

The value is that USAF, USMC, USN and Allis have the possibility of working off that same mission data library.

The very practical application and perhaps battle tipping aspect of a fleet wide mission data file is that if just one F-35 anywhere anytime gets hit on a HSCM, the entire fleet can have the data.

This is unique capability to be able to prevail in modern war.

Concurrently, the Navy at Fallon is also building a significant training complex for practicing current con-ops and looking forward to studying how to defeat future threats.

Rear Admiral Scott Conn is Commander of Naval Strike and Air Warfare Center.

He and his team are spearheading a broad based effort to expand the envelope of training to combine live and virtual training by building a Live, Virtual, Constructive (LVC) training range

Rear Admiral Michael Manazir, Director of Naval Air Warfare identifies the Navy way ahead that will allow tactical innovation and practices for the best way to attack and destroy incoming HSCMs:

The threat baseline that we're looking to fight in the mid-2020s and beyond is so much more advanced that we cannot replicate it using live assets. And those advances are in the aircraft capability, the weapon capability, and in the electronic warfare capability of the threat systems. That drives us to thinking about a different way to train.

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

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

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

Thus a key way ahead for R&D and con-ops to deal with the coming HSCM threat is clear.

The F-35 does not have to be in a stealth mode to sense and engage against HSCM racing at a CBG–it can go out and loiter as a 360-sensor picket platform.

My initial paper "winning Air/Sea Battle" only looked at F-35 as early warning only platform.

Essentially, the F-35s are seen giving a "heads up" to Fleet surface ships about "incoming" missiles threats but in the non-stealth mode the F-35 can carry more ordinance than F/A-18 or F-16.

So instead of just a "heads-up" to the Admiral commanding the CBG to make ready his fleet for close in defensive measures, why can't an F-35 carry anti-HSCM designed ordinance to kill HSCMs in flight. Design a missile that can link to the fusion cockpit for an immediate fire control solution and immediately launch a missile with an appropriate warhead to take down an incoming HSCM.

In an email exchange with Dr. Lewis, he has raised a significant challenge which needs to be addressed in R and D and the shaping of effective con-ops.

" The biggest threat I see is actually a swarm attack of high-speed incoming, that might overwhelm any solution. The Chinese have been rather open about this tactic." It is very fair to say it is truly a wicked problem, but he also adds; "the good news is there are indeed solutions that will stop them."

The one point in favor of the HSCM intercept to a kill shot is the need to just get in front of the missile with something that abruptly and directly disrupts its forward motion. The key to defeating it is to make it beat itself to death– the old joke about you only have to be close in Horseshoes and hand grenades applies.

Again quoting Dr. Mark Lewis from that email exchange:

One method of stopping them simple kinetic will be effective, with the challenge that a high-speed maneuvering missile will be rather hard to catch with dumb ordnance. And with a rapid closing speed, the window for that kill chain is of course small.

There are other very promising options as well.

Stability and control of a hypersonic craft is a key element. The DARPA HTV-2 failed twice due to control losses, something that the Air Force warned DARPA about ahead of time. In the case of HTV-2 flight 1, the loss occurred due to yaw-roll coupling; essentially, the vehicle developed a small asymmetry, began to yaw, and corrective control action caused it to roll out of limit. That was a case of bad design, but also an example of how easy it is to mess with these craft. HTV-2's second flight was lost because an important protection system failed again making it uncontrollable.

I can't help drawing an analogy to the old German V-1's, that could be disabled by flying alongside in a fighter and hitting their wing tips. The resulting roll made them unstable!

The third flight of X-51, where a fin broke off the cruise vehicle during solid rocket boost, and when it separated from the solid motor (at Mach 4.8) it almost immediately lost control. So when you are flying at hypersonic (or even supersonic speeds) and take even minor damage, survival is unlikely. Coincidentally, and as a funny historical quirk, there is a pretty long list of hypersonic programs that have been lost due to fin failures completely unrelated to the hypersonic portion of the flight: X-43 first flight, the Australian HyShot first flight, and now most recently, AHW's second flight.

That last one is especially painful; the booster lost a fin a few inches above the launch pad due to an entangled thermal blanket.

A hypersonic missile must travel between Mach 5 and Mach 10, or 3,840–7,680 miles per hour in order to be considered hypersonic.

By comparison, a current missile AA missile, the AIM-120 (accurate wiki graphic) has the following characteristics:

Thus, there is a speed differential of between 1 and 6 Mach and also the HSCMs are also in flight, the intercept missiles are at a standing start.

The first look at intercepting a HSCM inbound against the fleet is one of the first verbal math problem we all had in Algebra 1-"A train leaves a station going 50 mph… Another train leaves it's station going 80 mph.. etc etc."

The logic of that example is that both HSCM and intercept missile are on the "same track" and a parallel track for a perfect "face-shot."

However, the crossing angle to intercept may be much more significant, say for example an F-35 flying on a heading of 090 and the pilot's cockpit's fusion display picks up a HSCM coming at the Fleet heading 180 and the closes point of approach for the physical passing of the F-35 on station and HSCM for intercept is offset by say 30 miles and at a different altitude.

The F-35 sensor shooter for an example could be 90 degrees off the nose for an intercept vector and also off set by some miles and altitude from the physical closes point of approach, this is a very hard shot. The F-35 at best can try to point and shoot with the missile arming and independently maneuvering but having been initially launched many degrees off the aircraft's initial route of flight.

The challenge is that at some point in space and time the kill missile must get in front of the HSCM. It is not necessary to hit a bullet with a bullet. With the current significant Mach differential shown above a conventional missile cannot run down a

HSCM. With focused R&D perhaps a future hypersonic -interceptor missile is possible-but in this example I am using the current art of the possible and assuming a +6 Mach advantage given to the HSCM and it is already in flight while interceptor missile is on the rail at the start.

Therefore, detection and reaction time for launch and missile light-off the intercept angle for the missile altitude differential make time and distance of flight against HSCM everything. At around 88 miles per minute incoming, depending on altitude it is a very hard problem.

The first issue is simply just getting a missile off an F-35 in the time of calculation for sensing something approaching at a high rate of speed.

Using the CNO's formula heat=sensing, an F-35 can see something moving very fast at a distance. How far away is one key BUT not a showstopper. Because if the F-35 can sense at a whatever distance it is reacting electronically at the speed of light and there is the possibility of doing something about it.

What can be done?

Slaving an immediate launch fire-control solution from the F-35 fusion cockpit sensed HSCM route of flight vector to an interceptor missile loaded on the aircraft hardpoints is one way.

But just as significant the F-35 sensor can off load the kill shot to another F-35 with a better chance.

To have any chance of success the launching F-35 has to have a certain head on aspect – if the HSCM is beyond the wing-line the engagement is lost at first detection. The kill-shot game for that one F-35 in launching a counter-missile is already be over.

But now think of a 21st Century "Chainsaw" as a solution set and a way ahead.

The USN strike commander is currently using F/A-18s to refuel F/A-18s. Since stealth in not an issue against an HSCM swarming missile attack, a mix of F-35s with F/A-18 tanking assets can put as many F-35s on a combat air patrol station as far away from the surface fleet as possible for early detection. That effort can then feed-back for defense in depth combat engagements.

Against even a Mach 10 threat the F-35 data linked information dominance sensor can off load at the speed of light the incoming track of swarming inbound HSCM threats to other F-35s standing CAP right over the Fleet.

Additionally, all USN combat platforms can also light up; AEGIS ships, Growlers, E-2 Hawkeyes and other close in defensive combat weapon systems:

Additionally, the Ford CVN-78 has been specifically designed with an area on the flight deck to configure the air wing aircraft quickly and efficiently with the appropriate ordinance for the appropriate mission. In alternating between offensive strikes, using active or passive stealth with weapons in a weapons bay or non-stealth with a significant weapons load, the combat ordinance on an F-35 can be configured quickly.

As the combat situation dictates the defensive requirements of loading anti-HSCM missiles as stated above can also be done quickly. USN ship design teams working on the CVN-78 figured this all out; switching ordinance and/or reloading. It is no small issue; the Japanese Carriers were sunk at the battle of Midway because they were caught in an arming, de-arming, arming cycle. From that moment forward they were going to lose the war.

The second critical point is that even if the F-35C is not arriving at the Fleet in time to counter a HSCM threat, Marine F-35Bs can be ready next year to pioneer modern "chainsaw" con-ops.

And as can be seen in this news report from India there is many ways to marry platforms with cruise missiles. If a supersonic cruise missile can be added to an Indian Navy platform the HSCM is but a simple step away from world-wide proliferation.

The challenge for the R&D community is to immediately give a lot of thought and research on what type of ordinance, missiles and warheads are best to defeat a HSCM.

Everything in this important field of research is an ongoing work in progress and U.S. and Allied Militaries and their industrial partners must be up to meeting this challenge.

This article only focuses on defense against HSCM.

Marrying an HSCM strike weapon to an F-35 enabled fleet opens up many other possibilities.

F-35 wide area targeting mapping capability against surface ships and shore instillations is beyond excellent.

So marrying up a HSCM into an F-35 strike package is a very strong battle winning technology match.

As a very smart Navy Captain said recently in discussing con-ops-"we have no problem using the word attack we are Naval Officers."

Allied Hypersonics: The UK Case

08/14/2018

By Stew Magnuson with introduction by defense.info

In an article published on April 24, 2018, Stew Magnuson provided a look at the UK development of a hypersonic engine.

The US could clearly leverage what French, UK, and Australian allies are doing in this area, but the US needs to change its quite narrow approach to not invented here and the heavy hand of defense protectionism which undercuts the capabilities of US forces, and puts them at unnecessary risk.

Watching what has happened with tanker and the endless "experiments" on light attack aircraft, when the A-29 is the obvious answer, are simply two examples, but there are many, many more.

Let us not do this yet again in an area vital to US and allied security as clearly hypersonic capabilities clearly are.

A next-generation engine that its British designers say could go faster than Mach 5 will be partially developed in the United States to meet the military's need to reach hypersonic velocities.

The Synergistic Air-Breathing Rocket Engine (SABRE) is being called a hybrid jet and rocket engine that combines the best features of both technologies, its developers said April 19 at the Space Symposium in Colorado Springs, Colorado.

Reaction Engines on April 12 announced further investments in the company from industry heavy-hitters Boeing, Rolls-Royce and BAE Systems along with some seed money from the Defense Advanced Research Projects Agency.

The U.S. government is making development of hypersonic vehicles a top research-and-development priority in light of recent Chinese and Russian advances in the field, although Adam Dissel, president of Reaction Engine's U.S. subsidiary, said the SABRE can do a lot more.

It is being envisioned as part of an aircraft that could start on a runway and accelerate to five times the speed of sound. After reaching Mach 5 it switches to rocket mode. "So you have a single engine that, in theory, can take you from the runway all the way to space," he said. "It combines the best parts of a jet and the best parts of a rocket engine," he added.

The engine could potentially as an air-breathing vehicle reach speeds higher than Mach 5. "It's its own engine class, so there are many variations of the engine that is possible," he said. "We can tune it as a cruiser. We can tune it as an accelerator. We can make it cruise at Mach 4. We can make it cruise at Mach 5 and a half."

Dissel added: "The company's proposition is not an incremental change in technology, not an incremental improvement. It is nothing short of trying to completely reinvent aerospace propulsion."

One of the key pieces of the technology is the pre-cooler, which enables the engine to move at higher speeds without air friction melting its parts, he said. "It's like a big fancy refrigerator on the front. It quenches the incoming air, steals all the heat out of it, so the core engine can use that air without melting — simplistically."

The technology then takes the energy it has stolen out of the air and injects it into the engine to drive the machinery, so it is regenerating what would otherwise be wasted heat, he said. The temperature inside the engine reaches 1,800 degrees Fahrenheit. The pre-cooler is supposed to reduce this by 1,300 degrees in one-twentieth of a second.

To prove that it can do this, the company is setting up a test facility for the pre-cooler east of Denver, Colorado, that can blast it with 1,800-degree air. The facility will be stationary but it will match the temperature and other conditions found in flight and prove the first third of the engine's capability. "It doesn't have to fly Mach 5 to replicate what it would see after the inlet. So basically we are going to give it the conditions that we would actually see in flight," Dissel said.

A separate facility is being built in the United Kingdom to test the engine core by 2020, he noted. That core contains what he calls the technology's DNA — "the thermal cycle that is specific to a SABRE that enables a SABRE to be a SABRE," he said.

The inlet and the rocket combustion chambers in the back have been developed and proven by industry. The pre-cooler and the engine core have not, Dissel said. "We are really trying to prove out the parts that are the most innovative and the most new in the quickest timescale," he added.

BAE invested 20 million British pounds in 2015. Boeing HorizonX Ventures and Rolls-Royce added to this along with a second round of funding from BAE. The three companies' investment this year totals 26.5 million pounds. The U.K. government has kicked in 60 million pounds. DARPA has provided some funding for the pre-cooler tests, although Dissel declined to disclose the amount. In total, the company has raised 100 million pounds since 2015, a press release said.

Chinese Hypersonic Systems

08/14/2018

By Defense.Info

This week saw a proliferation of articles addressing progress by the Chinese with hypersonic systems.

According to Popular Mechanics:

China just tested a hypersonic aircraft that could fire nuclear missiles at up to six times the speed of sound. The aircraft, called Starry Sky-2, can zoom across the sky at speeds of up to 4,563 miles per hour, and can switch directions abruptly mid flight (which means it could potentially bypass current missile defense systems).

The Starry Sky-2 launched in a multistage rocket, then continued to soar at about Mach-5.5 for 400 seconds. The aircraft performed numerous maneuvers at an altitude of about 18 miles before landing. The aircraft is a type of "waverider" vehicle, which allows the aircraft to surf on its on the shockwaves of its own supersonic lift.

https://www.popularmechanics.com/military/aviation/a22708135/chinese-hypersonic-aircraft-can-launch-missiles-at-6x-the-speed-of-sound/

In an article published by the National Interest, entitled "China Claims to Have Tested a "Cutting-Edge Hypersonic Aircraft that Rides Its Own Shock Waves," it was noted that:

China recently tested a new hypersonic vehicle.

"China has successfully developed and tested a cutting-edge hypersonic aircraft that rides its own shock waves," the state-run China Daily reported on August 6th.

The test was conducted by China Academy of Aerospace Aerodynamics, part of the contractor China Aerospace Science and Technology Corp, on August 3rd. It appears to be the first test of the Starry Sky 2, a hypersonic experimental waverider vehicle, or at least the first acknowledged one.

"A waverider is a hypersonic aircraft that has a wedge-shaped fuselage designed to improve its supersonic lift-to-drag ratio by using the shock waves generated by its own flight as a lifting force," the China Daily article explained.

There are two basic types of hypersonic missiles. The first are called hypersonic glide vehicles (HGVs) and are characterized by being launched into the atmosphere from a rocket and gliding to their targets at low altitudes.

These HGVs typically fly at faster speeds than the second type of hypersonic missiles, called hypersonic cruise missiles (HCMs). As their name suggests, HCMs are cruise missiles that fly at hypersonic speeds. During their entire flight, they are powered by rockets or high-speed jet engines like scramjets.

And Bill Gertz, a long time China watcher, had this to say in a story published by the *Washington Free Beacon*:

It was the first time the Chinese government commented publicly on its development of hypersonic missiles that are capable of delivering both nuclear weapons and conventional arms.

In the past, tests of a Chinese hypersonic glider—an unpowered maneuvering high speed missile—were kept secret but frequently disclosed by U.S. officials.

Unlike another Chinese hypersonic missile known as the DF-ZF, the Starry Sky-2 reportedly uses powered flight.

The test was announced by China Academy of Aerospace Aerodynamics, the Chinese government agency in charge of development. The academy said in a statement the missile was launched Aug. 3 on a multi-stage rocked and during flight carried out extreme maneuvers at speeds of Mach 5.5 for more than 400 seconds. Hypersonic speed is considered faster than Mach 5, or five times the speed of sound.

The top speed of the missile was Mach 6, or 4,603 miles per hour.

According to Chinese reports, the experimental missile employs a wedge-shaped fuselage that is boosted to hypersonic speeds by riding the shock waves generated by its own flight to enhance lift.

The hypersonic craft flew at an altitude of 18 miles and conducted what reports said were sharp angle maneuvers. The missile also tested what was described as a "heat-balanced thermal protection system."

The new missile is part of a hypersonic arms race that has been underway for the past several years involving efforts by the United States, China, and Russia to build ultra-high speed weapons in response to increasingly capable missile defenses.

Russian President Vladimir Putin touted Moscow's advanced missile systems in development during a speech in March.

"We've started the development of new types of strategic weapons that do not use ballistic flight paths on the way to the target," Putin said. "This means that the missile defense systems are useless as a counter-means and just senseless."

Russia is building a long-range, guided-flight hypersonic missile called Avanguard.

The current defense authorization act for fiscal 2019, to be signed by President Trump next week, calls for the Pentagon's Missile Defense Agency to accelerate missile defense programs designed to counter hypersonic weapons.

The legislation also requires Secretary of Defense Jim Mattis to submit to Congress a "validated requirement" for ground-, sea- and air-launched conventional prompt global strike hypersonic weapons in three months.

Asked about recent Chinese hypersonic missile tests and whether China has mastered the technology, Strategic Command commander Gen. John Hyten said he is unable to confirm the status of the Chinese program.

"The only way I could confirm it would be to reveal intelligence information, and I can't do that," Hyten told reporters in Omaha Aug. 1.

"But I can tell you that from open source information, the Chinese government and the Chinese military are conducting very aggressive testing of hypersonic glide capabilities," Hyten said.

The U.S. military is "being aggressive as well," he added.

"And what I've said in public before is as far as I can go today," Hyten noted. "In some areas in hypersonics, I would say that the United States is ahead of China and Russia; in other areas, Russia and China are ahead of where we are."

Because both China and Russia are strategic rivals "that means we have to be able to go faster than our adversaries," Hyten said.

Michael Griffin, undersecretary of defense for research and engineering, recently told reporters that developing hypersonics is a high priority for the Pentagon.

"My view is that this is not an advantage that we can concede to people who wish to be our adversaries," said Griffin, a former NASA administrator. "And there is no reason why we should."

Griffin described the threat from hypersonic missiles as not only nuclear delivery systems but for tactical strike weapons as well. "Very quick response, high speed, highly maneuverable, difficult to find and track and kill," he said, Defense News reported.

Space-based defenses could be used to counter the high-speed missiles. "The utility of space for hypersonic defense is in the indications of warning, the launch detection, the surveillance, acquisition, tracking—the whole arena of persistent global timely awareness," Griffin said.

Griffin said despite tests by China and Russia the United States remains a leader in hypersonic arms technology.

On the United States lagging behind both nations' programs, Griffin said: "We didn't see a need for it. But our adversaries get a vote, and they voted. So we're going to see their hand and raise them one, in both offensive and defensive capabilities."

Griffin said he is worried about the pace of U.S. hypersonic development and as a result will be speeding up programs.

"You're going to see our testing pace stepping up, and you're going to see capability delivery from the early '20s right through the decade," he said.

Dr. Mark Lewis Talks About the Coming Hypersonic Cruise Missile Threat

08/15/2018
By Second Line of Defense

Our interview with Dr. Mark Lewis first published on April 2, 2013, highlighted the key dimensions of the hypersonic missile threat which has only recently become more visible in the public debate.

That interview as published follows:

We continued our discussion with Mark Lewis, former Chief Scientist of the USAF and currently head of the Institute for Defense Analysis's Science and Technology Policy Institute.

Dr. Lewis is a leading expert on hypersonics.

Earlier, we discussed hypersonics with Dr. Lewis, but in this interview we focused on one low hanging fruit which could be available sooner rather than later, the hypersonic cruise missile.

In the context of rolling out a F-35 fleet, the hypersonic cruise missile can be a key part of an evolving approach.

In effect, hypersonic cruise missiles are part of what one might call an S3 or S Cubed dynamic for 21st century expeditionary technologies.

Sensors, combined with Stealth combined with Speed can provide a new paradigm for shaping the Pacific force necessary for the US in working in the Pacific.

The development of a hypersonic cruise missile would clearly be a game changer, especially as it would come in the context of rolling out a deployed fleet of F-35s, both allied and American, in the Pacific.

The Chinese DF-21 would rapidly become a distant memory. The discussion in the Western literature of the DF-21 does reveal a serious gap.

There is no real discussion of the interaction of technology on strategy by the United States and its allies.

Or to put another face on the question, the Chinese put on the table that they have developed a technology – in this case the DF-21, which actually has not been tested against maneuvering capabilities like ships – and worldwide there are stories about the impact on the US and its allies.

But there simply is no look at what the US and its allies are building to shape a different strategic environment as well.

SLD: How important is this missing technological consideration in shaping Western strategies?

Mark Lewis: Let me step back with a historical example that I always like to use to illustrate the problem of the missing technological analysis.

When I was in the Pentagon, we would talk a lot about avoiding technological surprise, sometimes a bit too much. There are certainly reasons to be concerned regarding future peer adversaries.

But the surprises that I'm most concerned about are the surprises based on simply underestimating a potential adversary. Meaning that we assume we have absolute superiority, and that others can't make advances that in fact they've already made, or are poised to make.

I'll give you my very favorite story along those lines; it was actually from the early U.S. Navy. The United States decided to build a fleet of ships in the early1790's; they did their analysis, they looked at navies around the world, they looked at Great Britian with its array of everything from small cruisers to ships-of-the-line.

And the Americans shaped their own model of operations by building a fleet of frigates, the first six Frigates in the U.S. Navy.

They figured out that they didn't have the resources to go really large; they wanted something that was fast, flexible, but also powerful. The United States didn't have experience in building such ships. Essentially they built a fleet that was invented from scratch.

They had ideas of what the ships were supposed to look like; they had ideas of how they should operate, but they didn't have preconceived notions of how they should be designed.

The fleet of ships that they built included the USS Constitution, the President, the Constellation, and what's interesting about it is that, by not having those preconceived notions, I think it gave them a significant advantage. They were able to step back and reinvent many aspects of those ships.

The Naval architect who is primarily responsible for designing the Constitution and her sister ships, Joshua Humphreys, wanted to build these ships larger, but he knew that when ships got too large, they tended to sag a little bit and that's because, as Humphreys understood, the contemporary structural designs weren't quite right.

So, he redesigned the structure of his ships to have diagonal braces that would support higher loads. Those American ships could be built bigger, and therefore thad could have more guns than comparable British vessels.

The Americans did research in hydrodynamics, they understood what the hull should look like.

They looked at materials, and assessed the various woods that were available and they realized that there were really strong woods available in the swamps in North Carolina and South Carolina and they harvested those woods to build these Frigates.

Now fast-forward to the War of 1812, to the first major engagement between a British Frigate and one of the American Frigates. The British frigate, HMS Guerriere, was actually newer than the Consitution; when itw engaged the USS Constitution it did so with what the British would discover was faulty intelligence and erroneous assumptions.

The British knew the American ships were big so they figured they were going to be slow, lumbering behemoths. They thought that they were overweight, so they thought they would be terrible handling ships.

They knew the ships had been built in Boston and Philadelphia, so they figured they were built with the woods from the northern part of the country, including firs and pines, which are not structurally sound.

If you imagine the British commander, he saw the Amerian frigate; he probably thought it was going to be easy prey. And so, he began a rippling broadside, and probably the first thing he noticed was that this American ship was sailing faster than it was supposed to be sailing.

And then, the next thing he noticed was that instead of splintering the wood on the sides of the ship, his cannonballs were actually bouncing off and of course, the Constitution got the name Old Ironsides because of that.

And then the Constitution came cruising up alongside the Carrier and unleashed a single broadside. And basically, the battle was over in 15 minutes, and the rest was mostly cleanup operation.

And the irony is that the British probably should've known better, but they were arrogant. The U.S. was essentially a third-world nation, how could the US possibly field this technology when the British were the masters of the oceans. How could we possibly beat them? And yet, the US did.

And every subsequent engagement between the British Navy and the U.S. Navy early in the War of 1812 resulted in an American victory, such that the British Admiralty issued an order to avoid single-ship engagements. I mean, this would be like the U.S. Air Force telling all of its F-22 pilots if you see an Iranian flight air, run away.

That's basically what the British Admiralty did.

It wasn't until the battle of the Chesapeake and the Shannon sometime later in the war that the British restored their national honor.

Technology shapes strategy and strategy drives the need for technologies, but technological surprise is a key fact of competitive life.

I think this the challenge that we have, and especially in this 21st century where information is so readily available. This last fact means that an adversary or a potential adversary or even a competitor has enhanced capabilities for technological surprise, by learning from our examples and mistakes, and perhaps by taking a clean sheet approach to design.

I think hypersonics really does fall into that category.

This is a technology that the United States has been working on really the 1940's. The first time we flew something at a hypersonic speed – beyond five times the speed of sound – was the WAC bumper flights right after World War II.

We basically put a sounding rocket on top of a V2 missile. But those were certainly hypersonic flights. We've understood hypersonic aerodynamics since the 1950s, every spacecraft we've brought back from space has been traveling at hypersonic speeds on reentry.

The papers are out there, the theory is out there, and the computer codes are out there.

Most recently, our interest in this field has been in things that breathe air, meaning that they are powered by engines that operate off of oxygen that's gathered from the atmosphere.

But even there, the concepts have been around for many, many years. The original papers that were written in this field date from the late 1950s; they were done at the old National Advisory Committee on Aerodynamics, the precursor to NASA.

And so, hypersonic flight is not a new idea; we had even planned on doing tests of high-speed hypersonic engines during the days of the X-15 program in the 1960's, but the program was cancelled before powered engines could be flown.

There is this rich body of literature out there from which almost anyone could pick and choose and see what worked and see what didn't work.

I really think we're kidding ourselves if we don't think that other folks understand the impact of some of these technologies on the evolution of warfighting and are looking at the dramatic strategic consequences of deploying hypersonic technologies.

SLD: Let us look at the applications of hypersonic cruise missiles to the Pacific.

Clearly, a significant Chinese hypersonic cruise missile capability deployed in advance of American capabilities would be dramatic in its effects. The United States struggles with the tyranny of distance to deploy its forces in the Pacific and to forward deploy with allies.

Mark Lewis: I'm going to expose my biases here. Distance only has tyranny if you're clanking along at 30 knots. If I'm flying at mach 2, mach 3, mach 5, mach 6, I don't think distance is such a tyranny any longer. And I think that's what speed and range, by the way, in combination brings to the equation.

You're exactly right that as we go into the 21st century we can't forget about the role that technology will play as a force multiplier. But also, the role that technology brings to each of the capabilities that the services bring to the fight.

Again, when I was in the Pentagon, I used to ofer my explanation for the very existence in the Air Force. Why is there a separate Air Force? Well, it's because of the special technology, and the practitioners of that technology, that are unique in the Air Force mission.

Put another way, why was it important that the Air Force not remain the Army Air Corps?

Because the technology was so significant and designed to such a different paradigm that it required a separate service.

I don't think we can separate that technology from 21st century warfare. We hear a lot about boots on the ground, we hear a lot about getting the soldier into the fight. I certainly don't think that will be true in the Pacific theater.

Airpower will be the determining factor. Certainly, I think our adversaries understand that.

They realize that if they can't meet us in numbers, then they can meet us in technology and they can meet us in engineered solutions that specifically address capabilities that we have.

SLD: In effect, hypersonic cruise missiles are part of what one might call an S3 or S Cubed dynamic for 21st century expeditionary technologies.

Sensors, combined with Stealth combined with Speed can provide a new paradigm for shaping the Pacific force necessary for the US in working in the Pacific.

Does that make sense to you?

Mark Lewis: Absolutely. I love the concept of S-Cubed.

It makes a great deal of sense in describing the inherent or emergent paradigm. Certainly, we've enjoyed a tremendous advantage with stealth, we know that the stealth advantage is changing, other people are developing the technology, which is why it behooves us to look even further.

I'd say very simply if I can no longer be invisible, what's the next step?

And the next step is let them see me and not be able to capture me. Couple that with exquisite sensor technology, and I think you absolutely have a winning combination.

SLD: We could look at the hypersonic cruise missile program as the equivalent to the Polaris program directed by Admiral Rayburn. In the late 1950s, Admiral Rayburn directed Polaris program where American political will identified that the technology was essential for American national security.

At the highest political levels, it was decided that we really have to commit resources to bring one of the elements of strategic deterrence into being. Is the hypersonic cruise missile such a case?

Mark Lewis: I think that it is. I would also draw analogies to the early work that eventually led to the development of ICBMs. The initial resistance of the bomber community to ICBMs was significant. General Le May originally referred to them as "firecrackers." But to his credit and that of the rest of the USAF leadership, they marshalled the resources and built the ICBM fleet.

I think hypersonic flight requires a very, very similar change in mindset.

The fact that I can flight at such speeds means that I can reach in quickly and that I can reach far. Hypersonic systems would give us the ability to marry surgical precision with rapidity of action.

And would also provide a measure of invulnerability in the face of enemy defenses as well.

Rather than thinking of it as a silver bullet but part of an S Cubed force, hypersonic speed could enable the forward deployed F-35 stealth fleet to guide lethality to a broad variety of targets.

SLD: And it is not just about the delivery vehicle, but innovation in the types of warheads, which could be delivered by such, a missile is crucial as well. Don't you want to marry the missile with warheads which have the ability to get inside the electronics, the fire controls, the signals, the sensors of your opponent flying at hypersonic speeds to fly the sites, shut down the radars, lights out?

Mark Lewis: **The ability of a hypersonic flyer to reach in quickly and do things, shut things down, shut things off, I think that's a wonderful combination.**

That's a winning combination. Imagine that a potential adversary knows that you can be there really, really quickly and you can get in really, really deep, and you can do it from platforms that they can't reach, well I can't imagine why we wouldn't want that capability!

SLD: When we talk about putting resources up against a priority task, it is important to highlight it is really about concentrating investments. We have been living off of old weapons technologies for a long time, with the F-22 flying largely with yesterday's weapons technologies.

And a clear advantage of the F-35 will be the ability to leverage global investments in the evolution of new weapons technologies.

So if MBDA builds a 21st century AMRAAM, rather than investing in the US alternative, the US could choose to leverage other F-35 partners investments and concentrate on key priority weapons programs, such as hypersonic cruise missiles. How important is prioritization to getting the job done?

Mark Lewis: **I think you hit upon an absolutely key point, which is that we've got connections and ties with allies who are using the same sort of systems, we can leverage their investments, leverage their knowledge, let them build on our knowledge, and produce systems that are of use to all of us.**

It makes perfect sense.

But let me stand back and discuss the question of cost. I often here that hypersonics will be expensive. We don't know what it's going to cost. It'll probably be more expensive to build a hypersonic cruise missile than a subsonic cruise missile.

But how much more?

I don't know.

We won't know for certain until we develop the technology further.

But more importantly, if a high-speed system can do the job of ten or 20 low-speed systems, well, doesn't it make sense to invest in that, perhaps, higher unit cost system, if it's ultimately more effective?

Let us consider the case of the original strike against Bin Laden. You can imagine the bean counters saying boy, if we build a hypersonic weapon, that would cost a whole lot of money.

But what if we'd had that hypersonic weapon back when we launched our cruise missile attack on his compound? we might have gotten there before the man left and then everything that transpired afterwards, including 9/11 would not have occurred.

What would that have been worth?

It's hard for me to put a cost on the ability to react quickly and effectively and deeply and prevent bad things to happen.

The issue really is not the total amount of our investment in science and technology; it is about investing wisely. Hypersonics is a great example. If you actually look at the total amount of money we're investing in it, it's actually a pretty good portfolio. Between all the various projects we've got, X-51 and HTV2 and AHW, it's an alphabet soup of programs.

But honestly, it is too uncoordinated: not well coordinated between the services, certainly not well coordinated between the defense laboratories and DARPA as effectively as it ought to be. NASA had an investment but that's been an on again/off again commitment.

So our success in hypersonics is about more than simply developing technology, it's about getting those investments focused on something that's useful and practical and operational, and I think that's actually a bigger challenge than getting money per se.

SLD: And does not a hypersonic missile woven into a fleet of evolving capabilities significantly enhance the viability of the force and its lethality.

For example, there is much literature on how the aircraft carrier has seen its day. Imagine the F-35Bs and Cs provide the forward punch to the sea force and identifying forward targets along with robotic elements deployed in the water, under the water and in the, air and guiding a set of new weapons on the F-18s based on the carriers, including a hypersonic cruise missile. What is there not to like about a maneuvering ship with a variable geometry strike force onboard?

Mark Lewis: I agree. And I'll give you another example.

After the first flight of X-51, a reporter for Wired Magazine wrote an article about it. Recall that the X-51 was our experimental hypersonic vehicle that was carried aloft under the wing of a B-52.

And at the end of the article, he waxed a bit poetic about how wonderful it was to see a 50-year-old B52 as the carrier aircraft launching the X-51. He pointed out that if this became an operational system, it would reinvigorate and completely change the mission for something like the B52.

I think a very similar analogy applies to your carrier example.

An old asset now becomes a reinvigorated asset that allows us to deploy and launch quickly and reach deeply, and to do it without susceptibility.

But it is really most effective in the context of what you called S Cubed, namely, sensors, stealth and speed. Speed is not a stand-alone silver bullet.

By the way, some people can get hung up about the definition of hypersonics. We usually agree that hypersonic means in the neighborhood of about mach 5, five times the speed of sound.

The reality is if we had a cruise missile that "only" went mach 4.5, that would still be pretty darn good. More importantly, what I'm interested in is the effect that I want to enable: I want to be able to reach in quickly, I want to be able to strike surgically, I want to be able to puncture right through an adversary's air defense system.

Alternatively, I might go through it or go above it or go around it. And that to me is really what we're talking about when we discuss hypersonics.

It's the capability that we're bringing to the fight.