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Moving U.S. Tracking Sensors to Space[1]

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Introduction

Today, missile defenses offer protection of the U.S. homeland against long-range ballistic missile attack from North Korea, and they provide point and regional defenses for U.S. forces abroad as well as U.S. allies and international partners against ballistic and some hypersonic missile threats. Now the threats posed by ballistic missiles are evolving to include more challenging hypersonic and cruise missiles, which are able to either fly under or maneuver around existing terrestrial missile defense tracking sensors and, thereby, avoid engagement by missile defense interceptors.[2] The United States must continue to push its missile defense tracking sensor 'center of gravity' (that is, the major concentration of the tracking sensor architecture) to space to improve the overall performance of the nation's Missile Defense System against an increasingly diverse missile threat. Ultimately, the United States needs a layered sensor architecture consisting of terrestrial and space sensors to detect and track missiles and discriminate threat objects. Moreover, the sensors should have sufficient sensitivity and accuracy so that very precise targeting data on these evasive threat objects can be provided to interceptors.

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Advantages of Moving to Space

More and more, missile systems are being designed to act in a less predictable manner. Maneuvering payloads and payloads that change velocity challenge the ability of defenders to use the initial boost phase of flight after launch to predict where the payload is heading and the time of impact.[3] Without the ability to track the missile payload throughout the flight (as opposed to tracking boost, losing it in glide or midcourse phase, and trying to pick it up again in terminal phase), the ability of a missile defense system to intercept the payload diminishes significantly and the armed forces will be unable to intercept these highly dangerous missile threats with any meaningful consistency.

Today, the United States deploys a mix of terrestrial-based radars and space-based sensors to execute the missile defense mission. It has terrestrial radars (ground- and sea-based) and overhead sensors to alert political and military leaders and warfighters to an unfolding missile attack.[4] In the 1960s and 1970s, the nation's military and civilian leadership saw the wisdom of putting missile warning capabilities in space, where it might then be possible to watch most of the Earth's surface for a missile launch.[5] That system today relies on early warning Defense Support Program and Space-Based Infrared System, communications, and Global Positioning System satellites, and other space sensor assets.

The nation's current missile tracking and discrimination sensor capabilities, in sharp contrast to the missile warning and detection sensor capabilities, reside almost entirely on Earth, either on the ground or at sea. The great advantage of placing these launch detection sensors in space, of course, was the global persistent coverage that could now be afforded, as they were now in closer proximity to the threat missile, which frequently travels through space). Despite knowing these advantages, it is striking that the United States to this day continues to rely on its Earth-bound sensor network to perform the missile tracking function.

The disadvantages of placing sensors for global tracking on Earth are many. The country must rely on continued host-nation approval for many of its terrestrial missile tracking sensors. The arrays on all U.S. terrestrial tracking radars are fixed – they do not rotate and the platforms are not mobile. In other words, they only face one direction, so it would be possible for a maneuvering threat to approach the target from outside the known bounds of the existing radar fans. The system tracking sensors set up for defense of the U.S. homeland today are oriented to maximize viewing of missile threats launched from two countries, North Korea and Iran. Change the threat country, or move the missile trajectory outside the corridors that may be covered by the fixed radar (by using a submarine or an air platform to launch the missile, for example), and the missile defense mission becomes more challenging. There is also a basic physics problem associated with terrestrial radars. For many of the more advanced threats, terrestrial radars would not be able to acquire the incoming target at sufficient range because of the curvature of the Earth.

Constellations of tracking satellites, by contrast, would be able to provide persistent "birth-to-death" (launch to termination of flight) coverage of threats by augmenting ground-based radar coverage and filling coverage gaps. Space provides a global presence and the best

viewpoint for addressing missile threats, including threats posed by hypersonic glide vehicles, which might begin their flight on a ballistic trajectory before moving into glide and maneuvering phases. Such coverage would improve the overall performance and effectiveness of the Missile Defense System. Another advantage derived from the use of space sensors for missile defense is force protection. The more the sensor "center of gravity" moves to space, the more complicated and challenging it would be for an adversary to attack those assets.

Current Efforts

While the country is now making good progress towards the goal of placing more sensors in space, especially for missile defense, the current state of space sensors is inadequate to meet near- and far-term missile threats. Currently, the U.S. Space Force Space Development Agency (SDA) and Space Systems Command, and the Missile Defense Agency (MDA), are developing prototype and operational satellites to improve the country's ability to acquire, track, and disseminate data required to track, target and cue, and then intercept ballistic and hypersonic missiles.

SDA's mission is to develop elements of a new and responsive space architecture through the deployment of many small satellites in Low Earth Orbit (LEO) as a foundation, utilizing commoditized buses for a more resilient and affordable alternative to the very large, expensive satellites traditionally developed by the Department of Defense. SDA's vision is to field this sensor architecture using two pillars: 1) proliferating the number of satellites in the transport (data distributing and processing satellites) and tracking layers, so that the satellite constellation will have resiliency and persistent coverage of the globe, and 2) an acquisition approach that leverages spiral development, which will enable timely deployment of capabilities.[6] The Space Force is also developing an independent Medium Earth Orbit constellation of satellites to bolster the architectural resiliency of the LEO tracking layer and provide global access for missile warning, tracking, and defense.

MDA initiated the Hypersonic and Ballistic Tracking Space Sensor (HBTSS) in 2018 to detect hypersonic, ballistic, and other advanced threats much sooner than terrestrial radars, providing hypersonic threat-tracking data for hand-off through linked missile defense weapons. The unique contribution of HBTSS when compared to the SDA-developed missile tracking satellites will be its ability to provide very precise data, or what warfighters call "fire control quality data," which is data needed for targeting the threat missile.[7]

It is undeniable that there is a growing warfighter requirement for integrated space sensors to meet the newest missile and space threats. Indeed, the greatest leap in capability that could be achieved in today's Missile Defense System is the addition of a space tracking layer. Such a change in the sensor architecture would buy valuable mission response time globally.

So, what is standing in the way of implementing a vision of a missile defense architecture that puts the sensor center of gravity in space?

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Challenges

Technology has bedeviled implementation in the past, but significant progress has been made over the past decades.[8] Meaningful advances have been made in sensor, spacecraft, and computer processing technologies, in large part because of private sector investments and commercial space ventures. Today, the government must do what it can to capture the remarkable progress made in the private sector. Still, there are significant technical challenges that must be taken on, with perhaps some of the more pressing ones stemming from the growing complexity of the modern battlefield and the need to retrieve information, process that information, decide, and act within a tactically meaningful timeframe.[9]

Another challenge is that of achieving the rapid deployment of advanced space capabilities in order to counter a very dynamic threat. Using the standard Defense Department acquisition processes does not allow missile defense developers to get through that process before the system they are developing is overtaken by events.[10] Special acquisition authorities are critical to the development of advanced satellites for deployment on a rapid timeline to counter the emerging missile threat. The timelines for development today in most programs are lamentable as the Defense Department is not used to buying systems that time out in five years. The traditional ways of doing space acquisition must be reformed in order to add speed to the nation's acquisitions to meet its priorities. While progress is being made, the troubling bottom line remains that the Pentagon is not yet accustomed to refreshing short-lived spacecraft that are part of a proliferated LEO system. [11]

The Pentagon is looking into deepening its partnerships with private companies.[12] Capitalizing on the commercial investments that have been made makes sense. The possible use of commercial services will likely remain restricted to the use of satellite communications. And indeed, there are some defense activities that must remain strictly owned and operated by the government. Regarding the missile tracking and missile defense mission, the Government would understandably want to retain control over the tactical data links that are tied into weapon systems.

The development and deployment of space tracking satellite constellations also are encountering obstacles at the policy level. The United States today recognizes the changed dynamic in the space environment in its security policies and strategies, and its leaders have been promoting greater awareness of the space threat while also reorganizing the Joint Force and command structure to protect U.S. space assets and mature U.S. spacepower. Space is increasingly recognized to be vital to the American way of life. Yet this higher-level assessment of the importance of space at the policy level is not well reflected in the nation's vision or budget.

The emergence of the space warfighting environment should be driving U.S. strategies for space technology and system development. Lack of coherent vision not only impedes development of important military systems that leverage the space environment to maintain the U.S. competitive edge, inconsistent and uncoordinated strategies also negatively affect investments by the government and commercial sector.[13] One of the negative impacts coming

from a lack of vision is that bureaucratic obstacles are hindering the execution of more responsive launch operations, this despite the push by senior space officials to be more open about strategies and capabilities. Overclassification problems continue to hinder space program advocacy and important collaboration with allies.[14] If we want deterrence to be effective, the nation's leaders must be able to talk about existing and planned capabilities as well as the threats posed by adversaries.

The deployment of missile defense tracking sensors in space also will benefit three other missions that belong to the Department of the Air Force and the Space Force – Missile Warning, Space Domain Awareness (or what used to be called Space Situational Awareness – that is, an understanding of which spacecraft are orbiting Earth, operated by which country, and what activities they are engaged in), and counterspace operations (or defense of friendly space assets).[15] Policy makers and those responsible for funding the development, deployment, and operation of the missile defense space tracking capabilities should be aware that these investments will have mission-multiplying effects that benefit other mission areas critical to U.S. space superiority and Joint Force operational agility.

Multi-mission capabilities, to include space surveillance, warning, tracking, intelligence collection, and fire control for missile defense, are the way of the future and the vision of the Commander of the U.S. Space Command, who is looking for ways to get the most out of what the country has today.[16] This idea that the nation can leverage these capabilities to perform many missions is desirable. Because the United States has demonstrated space sensor tracking capabilities over the last couple of decades and is pushing to deploy operational sensors in space over the next several years, the nation's leadership has realized that the data from these satellites can serve other purposes, transforming single-purpose satellites to do more than one job.

Conclusion

America has made great strides in defending against ballistic missile threats posed to the U.S. homeland by lesser powers, such as North Korea, and against theater-range missile threats to U.S. forces deployed abroad and U.S. allies and partners. It is generally recognized that missile defenses can help deter an attack, provide leaders options and additional time to respond to attacks or stabilize a crisis situation, assure U.S. allies and reinforce alliance unity, and provide a measure of protection in the event deterrence fails. Yet, with an increasingly diverse threat set, the effectiveness of the missile system will hinge on the agility, persistence, and precision of its sensors, both on Earth and in space, which need to be largely in space to reach their highest performance capacity.

The country still must move beyond development and initial deployments that will occur over the next few years to fill out the entire architecture that is envisioned. This not only requires continued funding and advocacy for satellite and ground system development, but the country also needs to put new emphasis on the development of responsive launch capabilities. If the missile tracking and discrimination capability is to be fully realized, the

satellites to be deployed will need to be placed on orbit in sufficient numbers and then incrementally and periodically replaced with follow-on satellites.[17]

The Biden Administration must now lean into this vision for missile defense and be the impetus behind the shifting of the missile tracking center of gravity from Earth to space. A clearly articulated vision will put the nation on the best path to coming up with solutions for protecting its space systems from attack and providing reassurance to the commercial sector. Leaders should use the opportunity of a newly published directive to publicize broadly the U.S. vision for space in forthcoming policy and strategy documents. All federal departments and agencies and the Congress need to be educated and enabled to carry out this policy direction. Whatever approach is taken, the adoption of a vision within national security policy will invariably require a whole-of-government approach.

[1] For a fuller discussion of this topic, see Steve Lambakis, *Space Sensors and Missile Defense* (Fairfax, VA: National Institute Press, 2023), available at https://nipp.org/monographs_cpt/space-sensors-and-missile-defense/.

[2] Missile systems being developed and deployed by potential adversaries of the United States -- China, Russia, North Korea, and Iran -- are designed to have global reach, increased velocity and maneuverability, greater accuracy, different basing modes, and improved countermeasures. Defense Intelligence Ballistic Missile Analysis Committee, *2020 Ballistic and Cruise Missile Threat*, available at https://www.mda.mil/global/documents/pdf/DIBMAC%20Slicky%202020.pdf, pp. 2-5.

[3] Twenty-first century missile defenders must prepare to engage an increasingly diverse set of threat missiles. Steven T Dunham and Robert S. Wilson, *The Missile Threat: A Taxonomy for Moving Beyond Ballistic* (Arlington, VA: Aerospace Corporation Center for Space Policy and Strategy, August 2020), pp. 9-19

[4] For a more in-depth description of the Missile Defense System and how it works, see Megan Crouse, "The technological challenges of complex missile defense," *Military & Aerospace Electronics*, August 26, 2022, available at https://www.militaryaerospace.com/sensors/article/14280041/missile-defense-sensors.

[5] Website article, "Missile Early Warning: Peeking Over the Curtain," *Military.com*, available at https://www.military.com/history/missile-early-warning-peeking-over-the-curtain.html.

[6] Author's interview with Dr. Derek Tournear, August 5, 2022. Amanda Miller, "Emerging Emphasis on Missile Tracking Reflected in Space Force's 2023 Budget Request," *Air Force Magazine Online*, April 26, 2022, available at https://www.airforcemag.com/emerging-emphasis-on-missile-tracking-reflected-in-space-forces-2023-budget-request/.

[7] Vice Admiral Jon A. Hill, written testimony *Before the House Armed Services Committee, Strategic Forces Subcommittee*, June 15, 2021; Author conversations with MDA Director, VADM Jon Hill (July 14, 2022); Theresa Hitchens, "MDA Director Sees New Space Investment," *BreakingDefense.com*, June 29, 2021, available at https://breakingdefense.com/2021/06/mda-director-sees-new-space-investment/.

[8] Samantha Beu, "Sensor Tech Key to Effective Missile Defense," *National Defense Magazine*, April 2, 2021, available at https://www.nationaldefensemagazine.org/articles/2021/4/2/sensor-tech-key-to-effective-missile-defense

[9] Megan Crouse, "The technology challenges of complex missile defense," *Military-Aerospace Electronics*, August 26, 2022, available at https://www.militaryaerospace.com/sensors/article/14280041/missile-defense-sensors; Author's interview with Mr. Walt Chai, MDA Director for Space Systems, June 29, 2022.

[10] See, for example, Sandra Erwin, "Space Force procurement chief criticizes over-engineered satellite programs," *SpaceNews Online*, September 20, 2022, available at https://spacenews.com/space-force-procurement-chief-criticizes-over-engineered-satellite-programs/.

[11] Sandra Erwin, "New guidance from Space Force acquisition boss: 'The traditional ways must be reformed," *SpaceNews Online*, November 1, 2022, available at https://spacenews.com/new-guidance-from-space-force-acquisition-boss-the-traditional-ways-must-be-reformed/.

[12] "With so many new capabilities being provided by industry, commercial services are taking off in ways that we never probably imagined just a few years ago," said Brigadier General Timothy Sejba, program executive officer for space domain awareness and combat power at the USSF Space Systems Command. Sandra Erwin, "New Space Force procurement shop subscribes to the space-as-a-service model," *SpaceNews Online*, November 21, 2022, available at https://spacenews.com/fighting-fomo-with-comso/. See also Jon Harper, "Spacecom leader warns of potential 'failure modes' as DOD pursues commercial space capabilities," *DefenseScoop.com*, January 24, 2023, available at https://defensescoop.com/2023/01/24/spacecom-chief-warns-of-potential-failure-modes-as-dod-pursues-commercial-space-capabilities/. See also Theresa Hitchens, "White House advisory group to explore DoD use of commercial space," *BreakingDefense.com*, February 23, 2023, available at https://breakingdefense.com/2023/02/white-house-advisory-group-to-explore-dod-use-of-commercial-space/.

[13] Michael Marrow, "U.S. still lacks 'whole-of-nation' vision for space, report warns," *InsideDefense.com*, August 24, 2022.

[14] Theresa Hitchens, "'Out of control': DoD reviews use of super-secret SAP classification, for space programs and beyond," *BreakingDefense.com*, February 14, 2023, available at https://breakingdefense.com/2023/02/out-of-control-dod-reviews-use-of-super-secret-sap-classification-for-space-programs-and-beyond/; Sandra Erwin, "Pentagon working with Congress on unclassified space strategy," *SpaceNews Online*, February 15, 2023, available at https://spacenews.com/pentagon-working-with-congress-on-unclassified-space-strategy/.

[15] Colin Kahl, Office of the Secretary of Defense for Policy: "We need a missile warning, missile tracking and integrated air and missile defense that accounts for all of those [developments], which is why we're making significant investments — not just in things like updating our interceptors for ballistic missiles or cruise missile defense, but also significant investments in space-based missile warning and tracking," Courtney Albon, "Pentagon leaders discuss China's space ambitions at classified meeting," *DefenseNews Online*, September 8, 2022, available at https://news.yahoo.com/pentagon-leaders-discuss-china-space-154830430.html.

[16] Amanda Miller, "Dickinson: U.S. Space Command Is Studying New Ways to Use Existing Satellites," *Air & Space Forces Magazine*, November 29, 2022, available at https://hypeaviation.com/story/dickinson-us-space-command-is-studying-new-ways-to-use-existing-satellites/83331/.

[17] For a good example of what can happen in the world of compromise, see Courtney Albon, "Lawmakers chart 'middle course' on space-based missile warning funding," *C4ISRNET.com*, January 13, 2023, available at https://news.yahoo.com/lawmakers-chart-middle-course-space-162738016.html.

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