# The United States' Strategic Situational Awareness Capabilities

*A Country Primer*

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## Introduction

The United States has extensive and mature strategic situational awareness capabilities across all domains (air, land, maritime, space, and cyber) that help to characterize the operating environment, detect and respond to attacks, and discern actual attacks from false alarms across the spectrum of conflict, both conventional and nuclear. The U.S. military always has relied on these capabilities at the strategic level, but over the last thirty to forty years these capabilities have become increasingly important at the tactical and operational level as technological advances have enabled more granular tracking and detection of enemy forces and communications and coordination between different sensors and shooters that have combined to form a reconnaissance-strike complex to devastating effect. This combination of situational awareness capabilities across all three levels of war and all domains has provided the United States unrivaled strategic situational awareness and has become a lynchpin of U.S. military doctrine and planning. However, potential adversaries like China and Russia have focused on enhancing their own strategic situational awareness capabilities and on developing ways to disrupt, degrade, and destroy U.S. strategic situational awareness.

## Historical Developments

The origin of the United States' current situational awareness capabilities largely traces back to the Cold War and the arms race between the Soviet Union and the United States. Over the course of the Cold War, the United States' strategic situational awareness capacities evolved as the Soviet challenge changed. Initially, U.S. efforts focused on monitoring and evaluating the Soviets' nuclear development program. As the Soviets achieved nuclear parity and U.S. doctrine switched from Eisenhower's massive retaliation to Kennedy's flexible response, early-warning alerts and surveillance and reconnaissance of Soviet nuclear forces became U.S. priorities.[1] During the mid-1970s, U.S. strategic situational awareness capabilities evolved again as shifts in the conventional military balance[2] and U.S.-Soviet nuclear parity necessitated that the United States develop ways to "use U.S. technological advantages to offset the quantitative advantage of Soviet forces."[3] Under the leadership of Secretary of Defense Harold Brown and Under Secretary of Defense for Research and

[1] David Alan Rosenberg, "U.S. Nuclear War Planning, 1945–1960" in *Strategic Nuclear Targeting,* ed. Desmond Ball and Jeffery Richelson (Ithaca, New York: 1986), 65.

[2] The effectiveness of the Arab armies' usage of precision-guided munitions and surface-to-air missile systems to destroy Israeli tanks and aircrafts during the 1973 Yom Kippur War forced military planners to re-think fundamental assumptions such as tanks only being capable of killing tanks, and the viability of air-delivered tactical nuclear weapons.

[3] William J. Perry, "Desert Storm and Deterrence", *Foreign Affairs* 70, no. 4 (Fall, 1991), 68

Engineering Bill Perry, the United States focused on developing three main capabilities: command, control, communications, and intelligence; defense suppression (stealth); and precision guidance. Combined in a system-of-systems approach, these three capabilities formed a reconnaissance-strike complex in which tactical intelligence from several sensors flowed into an integrated command and control (C&C) system that pushed the collective data to "shooters" equipped with precision-guided munitions (PGMs) to enable an unprecedented degree of precision.

At the end of the Cold War, the success of the Second Offset's reconnaissance-strike complex in the 1991 Gulf War drove an insatiable demand for increasingly expansive command, control, communications, intelligence, surveillance and reconnaissance (C4ISR) capabilities integrated into an increasingly networked architecture of high-tech sensors and shooters. The demand for C4ISR capabilities and capacities only increased during the wars in Iraq and Afghanistan as the permissive threat environment and technological advances, such as unmanned aerial systems (UAS), created new intelligence, surveillance and reconnaissance (ISR) paradigms and demands. However, in more recent years the Department of Defense (DoD) has turned its attention toward the challenges that Russia and Chinese advances in anti-access/area denial (A2/AD) capabilities pose for the United States strategic situational awareness.

# Air Domain

The United States has extensive aerial situational awareness capabilities at the strategic and operational levels.

## *Strategic: Intelligence, Surveillance, and Reconnaissance*

The United States operates several manned and unmanned ISR aircraft that perform a range of strategic intelligence functions ranging from collecting signals intelligence (SIGINT), to monitoring potential ballistic missile launches to collecting radar and imagery intelligence from the newest advanced sensors. These aircraft generally fall into three categories: large, manned reconnaissance aircraft; manned ultra-high-altitude reconnaissance aircraft; and high-altitude long endurance (HALE) UAS.

The United States Air Force (USAF) operates a family of large, manned reconnaissance aircraft (RC-135) that collect and disseminate critical intelligence that helps military planners characterize the operational environment and detect ballistic missile launches. The family of RC-135s are roughly similar in size and shape to Boeing's 707 commercial airliner and are equipped with specialized radars, antennas, data links, and other electronic suites that collect and disseminate vital measurement and signature intelligence (MASINT), electronic intelligence (ELINT), and signals intelligence.4 The RC-135 family provides military planners two primary advantages over other strategic situational awareness platforms. First, whereas the United States operates space-based systems that collect similar intelligence, these platforms are limited by orbital constraints compared to the RC-135 aircraft, which can be more rapidly deployed and employed dynamically in response to emerging crises. Second, in addition to the pilot and navigator, RC-135 aircraft are operated by a flight crew comprising electronic warfare officers, airborne systems engineers, and intelligence/mission area specialists who can analyze and disseminate the data as it is gathered.The Islamic Revolutionary Guard Corps (IRGC) seizure of U.S. Navy sailors in 2016 offers a perfect study of the advantages the RC-135 family of aircraft brings over other systems. An RC-135 V/W had been planning on conducting a mission over Afghanistan, but as the situation

[4] Today, the USAF operates three RC-135 variants: RC-135S Cobra Ball, RC-135U Combat Sent, and the RC-135 V/W Rivet Joint. The RC-135S Cobra Ball collect measurement and signature intelligence to monitor and track ballistic missile flights. The RC-135U Combat Sent collects electronic intelligence data on foreign militaries' land, naval, and airborne radar architectures. The RC-135 V/W Rivet Joint collects and disseminates electronics and signal intelligence in real time.

developed, the plane was deployed to instead monitor the IRGC forces. Furthermore, intelligence analysts aboard the RC-135 were able to evaluate the Iranian's intentions in real time after the IRGC kept shifting the drop-off location because of bad weather.[5]

The United States operates only one manned ultra-high-altitude reconnaissance aircraft platform, the U-2 Dragon Lady. Operating at more than 70,000 feet, the U-2 is a manned, multi-mission aircraft that can be configured to provide radar and hyperspectral imagery, SIGINT, or MASINT. Depending on its configuration, the U-2 can carry either the radar imagery collector Advanced Synthetic Aperture Radar System-2 (ASARS-2), Senior Glass ELINT suite, the long-range hyperspectral Senior Year Electro-Optical Reconnaissance System 2 (SYERS-2), or the optical bar camera that captures wide-angle imagery.[6] Although the U-2 operates at 70,000 feet, it is vulnerable to enemy air defense systems.

In addition to its manned reconnaissance aircraft, the United States operates unmanned HALE aircraft like the RQ-4 Global Hawk and RQ-180. The RQ-4 Global Hawk is an unmanned, multmission HALE platform that can be configured to provide imagery and signals intelligence, as well as collecting moving target indicator (MTI) data. The RQ-4 Global Hawk offers similar high-altitude surveillance capabilities as the U-2 Dragon Lady but is able to loiter and offer persistent surveillance for 34-hour plus. However, just like the U-2 Dragon Lady, the RQ-4 Global Hawk is vulnerable to enemy air defense systems.[7]

Finally, the RQ-180 Sentinel is a classified, low-observable UAS platform designed to be a "global strike enabler" in contested or "denied airspaces." Although its specifications are classified, the RQ-180 is likely capable of active and passive electronic surveillance and electronic attack.[8] Furthermore, the RQ-180 is likely to have the capability to detect nuclear activity given that its predecessor, the RQ-170 Sentinel, is reported to have surveilled Pakistan's, North Korea's, and Iran's nuclear programs.[9] Finally, the RQ-180 is rumored to have 24-hour endurance and a range of 1,200 nautical miles, but it is unknown whether the RQ-180 has an in-flight refueling capability to extend that range.

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[5] Joseph Trevithick, "Award Reveals USAF Rivet Joint Spied on Iranian Forces During 2016 Hostage Crisis," *The War Zone*¸ November 27, 2017, http://www.thedrive.com/the-war-zone/16445/award-reveals-usaf-rivet-joint-spied-on-iranian-forces-during-2016-hostage-crisis.

[6] "U-2S/TU-2S Fact Sheet," *United States Air Force*, September 2015, https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104560/u-2stu-2s/; Tyler Rogoway, "A Spotter's Guide to the U-2 'Dragon Lady' and Its Many Configurations," *Foxtrot Alpha,* March 9, 2014, https://foxtrotalpha.jalopnik.com/a-spotters-guide-to-the-u-2-dragon-lady-and-its-many-1539282603; Joseph Trevithick, "This is How America Keeps Watch Over North Korea from the Sky," *The War Zone*¸ April 14, 2017*,* http://www.thedrive.com/the-war-zone/9315/this-is-how-america-keeps-watch-over-north-korea-from-the-sky.

[7] "RQ-4 Global Hawk Fact Sheet," United States Air Force, October 2014, https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104516/rq-4-global-hawk/.

[8] Amy Butler and Bill Sweetman, "Secret New UAS Shows Stealth, Efficiency Advances," *Aviation Week & Space Technology,* December 6, 2013, http://aviationweek.com/defense/secret-new-uas-shows-stealth-efficiency-advances.

[9] Scott Shane and David E. Sanger, "Drone Crash in Iran Reveals Secret U.S. Surveillance Effort," *New York Times,* December 7, 2011, https://www.nytimes.com/2011/12/08/world/middleeast/drone-crash-in-iran-reveals-secret-us-surveillance-bid.html; Greg Miller, "CIA Flew Stealth Drones into Pakistan to Monitor Bin Laden House," *Washington Post*, May 17, 2011, https://www.washingtonpost.com/world/national-security/cia-flew-stealth-drones-into-pakistan-to-monitor-bin-laden-house/2011/05/13/AF5dW55G_story.html?utm_term=.d3e9c56a2dad; David Axe, "Stealth Drone's Secret Pacific Missions," *War is Boring,* December 7, 2013, https://warisboring.com/stealth-drone-s-secret-pacific-missions/.

## *Operational*

### Theater Battlefield Management

The United States operates several manned airborne early warning and control (AEW&C) capabilities that help detect and track enemy aircraft and ground targets, coordinate theater air campaigns and serve as data relays for ground forces. The USAF's E-8 Sentry Airborne Warning and Control System (AWACS) detects and tracks enemy aircraft up to 200 miles away. Onboard air battle managers coordinate theater air operations. The United States Navy (USN) E-2 Hawkeye fulfills a similar mission set for the carrier strike group. E-8 JSTARS provides ground moving target indicator (GMTI) data to support theater ground operations. Finally, the Battlefield Airborne Communications Node (BACN) payload, equipped on both manned and unmanned platforms, enables beyond line-of-sight data relay and communications between troops on the ground and other airborne platforms.[10]

### Theater ISR

The United States employs several aircraft that perform theater-level ISR that contribute to strategic situational awareness for both the maritime and ground domains. Although they are not primarily ISR platforms, fighters and bombers, including the next-generation stealth aircraft F-22 Raptor, F-35 Joint Strike Fighter, and B-21 Raider, are increasingly important as intelligence collection platforms as they are strike platforms thanks to the addition of advanced sensors and radars on those aircraft.[11]

Over the last twenty years, UAS platforms have performed extensive ground surveillance and reconnaissance, given the permissive nature of the wars in Afghanistan and Iraq and drones' advantages over manned platforms.[12] These UAS platforms are largely medium-altitude long-endurance (MALE) UAS platforms equipped with both sensors and precision-guided munition. The two main MALE UAS platforms currently in operation are the Air Force's MQ-9 Reaper and the Army's MQ-1C Gray Eagle.[13] The MQ-9 Reaper has traditionally been operated as a theater-level asset given that it is controlled by operators out of Creech AFB, Nevada whereas the MQ-1C Gray Eagle can be used more tactically becausee it is locally controlled. Furthermore, the Army has enabled manned-unmanned teaming between the MQ-1C Gray Eagle and AH-64 Apache Attack Helicopter.14 The MQ-9 Reaper and MQ-1C Gray Eagle are complemented by several light or hand-launched UAVs, such as

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[10] "USAF Almanac 2018", *Air Force Magazine,* June 2018, 95, http://www.airforcemag.com/MagazineArchive/Magazine%20Documents/2018/June%202018/Air%20Force%20Magazine%202018%20USAF%20Almanac.pdf.

[11] "F/A-18 Hornet Strike Fighter Fact Sheet," United States Navy, May 2009, https://www.navy.mil/navydata/fact_display.asp?cid=1100&tid=1200&ct=1; "F-35C Lightning II Fact Sheet," United States Navy, May 2018, https://www.navy.mil/navydata/fact_display.asp?cid=1100&tid=1212&ct=1; "Sniper Pod Fact Sheet, " United States Air Force , September 2015, https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104527/sniper-pod/; Department of Defense, "Selected Acquisition Report: F-22 Increment 3.2B Modernization," (Washington, DC: Defense Acquisition Management Information Retrieval, March 2016), https://apps.dtic.mil/dtic/tr/fulltext/u2/1019425.pdf.

[12] The RQ-4 Global Hawk and U-2 Dragon Lady are also occasionally used to conduct theater reconnaissance.

[13] "MQ-9 Reaper Fact Sheet, " United States Air Force , September 2015, https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104470/mq-9-reaper/; "MQ-1C Gray Eagle Unmanned Aircraft System (UAS)," United State Army, https://asc.army.mil/web/portfolio-item/aviation_gray-eagle-uas/.

[14] Mark Pomerleau, "Army's Multidomain Battle Brings Manned-Unmanned Teaming to the Force," *C4ISRNet,* August 31, 2017, https://www.c4isrnet.com/unmanned/uas/2017/08/31/armys-multidomain-battle-brings-manned-unmanned-teaming-to-the-fore/.

the RQ-70 Shadow and RQ-11 Raven, as well as the Army's manned, turboprop aircraft RC-12 Guardrail, which collects SIGINT.15

The United States has several manned and unmanned platforms that perform maritime patrol and reconnaissance missions.The unmanned HALE MQ-4 Triton is the backbone of U.S. maritime reconnaissance and patrol architecture thanks to its 24-hour endurance and MULTI-INT capabilities.The MQ-4 Triton can perform not only broad area maritime surveillance (BAMS), but also detect, identify, and track surface ships and capture high-resolution images and full-motion videos thanks to its multifunction active sensor radar and electro-optical/infrared multi-spectral targeting system.[16] From the persistent wide-area coverage provided by the MQ-4C Triton, platforms like the unmanned MQ-8 Fire Scout and P-8 Poseidon aircraft are capable of more precise ISR. The MQ-8 Fire Scout is a short-range unmanned helicopter capable of operating off both ships and land that is used for real-time ISR target acquisition.[17] The P-8 Poseidon is a manned, multimission maritime patrol and reconnaissance platform that is the world's premier anti-submarine warfare aircraft. The P-8 is equipped with several armaments, it can drop sonar buoys, and it is equipped with several integrated multifunction radar systems that work together to locate, track, and destroy enemy submarines.[18] Although the P-8 doesn't have a Magnetic Anomaly Detector (MAD) sensor like its predecessor, the P-3 Orion, the Navy is working to develop an UAS equipped with a MAD that operates with the P-8.[19]

## Future: Unmanned "Swarms"

The United States has multiple efforts underway to develop "swarming" capabilities in which small UAVs, numbering from just a few to potentially thousands, are networked together and share information to form the swarm's collective brain. This collective brain then autonomously controls and directs the individual UAVs comprising the swarm in pursuit of the swarm's broader mission. If one—or several—drones are destroyed or debilitated, the swarm endures as the collective brain compensates for the missing drones and re-orients itself. This ability to autonomously operate and adapt makes the swarm perfectly suited for a number of C4ISR missions that include, but are not limited to, intelligence, surveillance, target acquisition, and reconnaissance of enemy forces, spoofing and jamming of enemy electronic warfare (EW) capabilities, and potentially down the line kinetic attacks.

U.S. efforts to develop swarming capabilities are progressing along two main thrusts: disposable, air-launched micro-drones, which are roughly the size of a large hand, and small, re-usable airborne launched and recovered UAVs. The effort to develop disposable, air-launched micro-drones, led by the Strategic Capabilities Office, successfully tested a swarm of 103 Perdix micro-drones in October 2016. Packed into flare canisters and ejected from an F/A-18 Super Hornet, the micro-drone swarm successfully "demonstrated advanced swarm

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[15] RC-12X: The U.S. Army's Premier State-of-the-Art Tactical Airborne SIGINT System," Northrop Grumman, http://www.northropgrumman.com/Capabilities/Guardrail/Documents/RC12X_datasht.pdf; "MC-12 Fact Sheet," United States Air Force, September 2017, https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104497/mc-12/.

[16] "MQ-4C Triton Fact Sheet Fact Sheet," United States Navy, February 2017, https://www.navy.mil/navydata/fact_display.asp?cid=4350&tid=500&ct=4.

[17] MQ-8B Fire Scout Unmanned Air Vehicles (Fire Scout) Fact Sheet," United States Navy, February 2017, https://www.navy.mil/navydata/fact_display.asp?cid=4350&tid=300&ct=4.

[18] "P-8 Poseidon Multi-Mission Maritime Aircraft (MMA) Fact Sheet," United States Navy, December 2018, https://www.navy.mil/navydata/fact_display.asp?cid=1100&tid=1300&ct=1.

[19] The High Altitude ASW (HAASW) Unmanned Targeting Air System (UTAS) is the MAD UAS program currently in development. See: John Keller, "BAE Systems to Develop MAD ASW Drone to Help Navy P-8A Find Submarines From High Altitudes," *Military & Aerospace Electronics,* January 14, 2015, https://www.militaryaerospace.com/articles/2015/01/bae-subhunting-drone.html.

behaviors such as collective decisionmaking, adaptive formation flying, and self-healing."[20] The second major thrust, re-usable airborne launched and recovered UAVs, is the Defense Advanced Research Projects Agency (DARPA) Gremlins program. This program seeks to develop small UAVs called Gremlins that can be launched out of military aircraft, operate as a swarm to complete missions, and then be recovered by a C-130 or other transport aircraft. Gremlins would be re-usable again after a 24-hour recovery period and are designed to carry a range of advanced sensors up to 150 pounds. As of January 2019, DARPA's Gremlins program is still in development, but is progressing to a full-scale technology demonstration by the end of the year.[21]

### Electronic Warfare

Although the United States has extensive aerial situational awareness capabilities, it has considerably fewer EW capabilities that can jam or disrupt adversaries' situational awareness, particularly against a near-peer competitor like China or Russia.[22] Current U.S. aerial EW capabilities are limited to the EA-18G Growler, the EC-130H Compass Call, and F-16 CM Block 50 "Wild Weasel."[23] Working together, these three aircraft perform the suppression of enemy air defenses (SEAD) mission by jamming enemy radar and communications and destroying them using high-speed anti-radiation missiles (HARM).The EA-18G Growler primarily detects and jams enemy radars but is also equipped with two AGM-88 HARM missiles; the EC-130H Compass Call primarily jams enemy communications whereas the F-16 CM Wild Weasels primarily serve as the HARM shooters after enemy radar and communications have been destroyed. In the future, the F-35 Lightning II, with its next-generation stealth coating and minimal radar cross section, will replace the F-16 CM Wild Weasels role in SEAD missions.[24]

## Maritime Domain

### Undersea Warfare

The Navy's multimission nuclear-powered attack submarines (SSNs) provide the United States an asymmetric advantage over potential competitors like China and Russia. Unlike China or Russia, which operate a mix of diesel-electric and nuclear-powered submarines, the U.S. submarine force is exclusively nuclear-powered, which provides considerably greater speeds and endurance than their diesel counterparts. Additionally, U.S. SSNs are equipped with several advanced sensors, like the Large Aperture Bow sonar array, that enable SSNs to perform their primary mission, the hunting and destruction of enemy submarines. In addition to their anti-surface warfare capabilities, SSNs perform a variety of roles that include covert ISR to include "national-level purposes," insertion and recovery of SOF forces, covert strikes against land targets, anti-surface warfare, and

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[20] Department of Defense, "Department of Defense Announces Successful Micro-Drone Demonstration," Press Release, January 9, 2017, https://dod.defense.gov/News/News-Releases/News-Release-View/Article/1044811/department-of-defense-announces-successful-micro-drone-demonstration/.

[21] DARPA, "Gremlins on Track for Demonstration Flights in 2019," May 9, 2018, https://www.darpa.mil/news-events/2018-05-09.

[22] Sydney J. Freedberg, "HASC EW Expert Bacon: US 'Not Prepared' For Electronic Warfare Vs. Russia, China," *Breaking Defense,* January 8, 2018, https://breakingdefense.com/2018/01/hasc-ew-expert-bacon-us-not-prepared-for-electronic-warfare-vs-russia-china/.

[23] (name redacted) and (name redacted), *U.S. Electronic Attack Aircraft* (Washington, DC: Congressional Research Service, July 2016), 21, https://www.everycrsreport.com/files/20160726_R44572_2a51cdc4899b20866fcbe04719f30416e7d77bf9.pdf.

[24] Ibid., 86

anti-mine warfare.[25] The United States currently operates three different types of attack submarines, the Virginia class, three Seawolf-class SSNs, and a limited number of aging Los Angeles-class submarines.[26] Of special note for strategic situational awareness is the highly-secretive USS Jimmy Carter (SSN-23). The last of the Seawolf-class submarines, the USS Jimmy Carter's hull is extended 100 feet longer than the other two Seawolf-class submarines to accommodate a Multi-Mission Platform that enables a variety of missions including extensive ISR. It has been reported that the USS Jimmy Carter flew surveillance drones over North Korea in 2010 and has the capability to tap undersea communications cables.[27]

The U.S. Navy operates a limited number of unmanned underwater vehicles (UUV), primarily in a mine countermeasures (MCM) role, but it also has two major UUV developmental efforts underway: Large Diameter UUV (LDUUV) and Extra-Large UUV (XLUUV).[28] Both programs are still in early development and are not expected to shift to production until the mid-2020s.[29] When they first enter the fleet, the LDUUV and XLUUV will be single-mission platforms focused on ISR and MCM but they might eventually take on broader missions.[30]

### Surface Warfare

The United States' advantages in surface warfare situational awareness are not because of any singular platform or radar system but rather because of the carrier strike group's cooperative engagement capability (CEC)/Naval Integrated Fire Control-Counter Air (NIFC-CA) capability to synthetize data from multiple sensors across the entire fleet, to include naval aviation, into a single, real-time, composite track picture of the adversary.[31] The real strength is the CEC/NIFC-CA's ability to direct any "shooter" in the fleet to fire upon the common composite picture, regardless of whether that shooter's radars could see the target or not. The CEC/NIFC-CA extends the radar range of the carrier strike group, reducing the vulnerability of individual ships to enemy EW attacks, and improves overall accuracy and situational awareness across the fleet.

## Space Domain

Since the Soviet Union launched Sputnik 1 into low earth orbit in 1957 and kicked off the Space Race, space has held a critical role in establishing global U.S. strategic situational awareness. The United States' initial space

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[25] Ronald O'Rourke, *Navy Virginia (SSN-774) Class Attack Submarine Procurement: Background and Issues for Congress* (Washington, DC: Congressional Research Service, October 2018), https://fas.org/sgp/crs/weapons/RL32418.pdf.

[26] Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2019 Shipbuilding Plan* (Washington, DC: Congressional Budget Office, October 2018), https://www.cbo.gov/system/files?file=2019-01/54564-FY19Shipbuilding.pdf.

[27] David Axe, "The Navy's Underwater Eavesdropper," *Reuters,* July 19, 2013, http://blogs.reuters.com/great-debate/2013/07/18/the-navys-underwater-eavesdropper/.

[28] Ben Werner, "Navy's Knifefish Unmanned Mine Hunter Passes Sea Acceptance Testing," *USNI News*, June 5, 2018, https://news.usni.org/2018/06/05/navys-knifefish-unmanned-mine-hunter-passes-key-test.

[29] Megan Eckstein, "Boeing, Lockheed Martin Moving Forward with Navy XLUUV Acquisition Program," *USNI News*, October 2017, https://news.usni.org/2017/10/17/28810.

[30] Jon Harper, "Navy to Send More Unmanned Systems to Sea," *National Defense,* March 5, 2018, http://www.nationaldefensemagazine.org/articles/2018/3/5/navy-to-send-more-unmanned-systems-to-sea.

[31] "CEC–Cooperative Engagment Capability Fact Sheet," United States Navy, January 2017, https://www.navy.mil/navydata/fact_display.asp?cid=2100&tid=325&ct=2; Sydney J. Freedberg, "You Spot, I Shoot: Aegis Ships Share Data to Destroy Cruise Missiles," *Breaking Defense,* October 24, 2014, https://breakingdefense.com/2014/10/you-spot-i-shoot-2-navy-aegis-ships-with-sm-6-kill-target-together/; Dave Majumdar, "Navy: F-35C Will Be Eyes and Ears of the Fleet," *USNI News,* December 31, 2013, https://news.usni.org/2013/12/31/f-35c-will-eyes-ears-fleet.

capabilities focused on missions that addressed the nuclear challenges posed by the Soviet Union: intelligence collection on Soviet forces and capabilities, early warning launch alerts, and resilient strategic communications.[32] As technology advanced, satellites took on an increasing number of missions, such as high-resolution optical imaging, radar imaging, ELINT, position, navigation and timing (PNT), and tactical communications, to include data relay functions.

Today, the United States enjoys a considerable advantage in the space domain over strategic competitors like China and Russia, particularly with regards to the maturity of the commercial sector. As of November 2018, the United States, including both the U.S. government and firms operating out of the United States, operate more satellites (830) than Russia (149) and China (280) combined. However, in more recent years America's strategic competitors, particularly China, have made great strides in advancing their military space capabilities. Looking only at military satellites, the United States (167) still operates more satellites than either Russia (93) or China (100), but the difference is not as stark as the total for both commercial and governmental entities. Furthermore, in the absence of a strategic competitor in space at the end of the Cold War, the United States emphasized developing a small number of exquisite systems that are increasingly vulnerable to disruption and attack, potentially placing "too many eggs in too few baskets."[33]

The following sections describe the current and near-term U.S. space capabilities, focusing on the military services' unclassified space capabilities. The United States has extensive classified space capabilities, particularly for the different intelligence collection missions, that fall under the purview of the intelligence ommunity. These classified satellites are largely operated by the National Reconnaissance Office (NRO), which has publicly revealed that it operates at least four different constellations: SIGINT, GEOINT, communication relay, and reconnaissance.[34]

## Remote Sensing and Observation

The United States has substantive remote sensing and observation capabilities in space, particularly for the detection of ballistic missiles.

The Defense Support Program (DSP), Space-Based Infrared System (SBIRS), and Space Tracking and Surveillance System (STSS) work together to detect and track ballistic missiles through all three phases of their trajectory (boost, midcourse, and terminal). DSP, the oldest of the three programs, was developed in the 1960s to track Soviet and Chinese ballistic missiles launches but was re-tooled during the 1991 Gulf War to track Iraqi scud missile launches. SBIRS, the follow-on program to DSP, fulfills a similar mission, but with enhanced capability. SBIRS can simultaneously examine wide territory and specific narrow areas of concern unlike the DSP which was limited to one or the other.[35] In addition to its primary missile detection mission, SBIRS' infrared (IR) cameras are used to help create a "catalog of signatures—electromagnetic and IR—of aircraft, missiles,

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[32] Todd Harrison, Zack Cooper, Kaitlyn Johnson, and Thomas G. Roberts, *Escalation & Deterrence in the Second Space Age* (Washington, DC: Center for Strategic and International Studies, October 2017), 3, https://csis-prod.s3.amazonaws.com/s3fs-public/publication/171109_Harrison_EscalationDeterrenceSecondSpaceAge.pdf.

[33] Todd Harrison, "MUOS-5 Highlights a Critical U.S. Vulnerability in Space, *Space News Magazine,* November 7, 2016, http://www.spacenewsmag.com/commentary/muos-5-highlights-a-critical-u-s-vulnerability-in-space/.

[34] "NRO Systems Overview: Module 2 Orbital Mechanics," National Reconnaissance Office, February 2012, http://www.nro.gov/Portals/65/documents/foia/declass/ForAll/092818/F-2018-00033_C05108587.pdf.

[35] Missile Defense Project, "Space-based Infrared System (SBIRS)," Missile Threat, Center for Strategic and International Studies, published August 11, 2016, last modified June 15, 2018, https://missilethreat.csis.org/defsys/sbirs/.

and other military hardware operating globally."[36] Additionally, the Global Positioning Satellite (GPS) has been upgraded to detect nuclear detonations.

Other U.S. remote sensing and observation capabilities include collecting environmental data for military weather forecasting[37]; maintaining space situational awareness through the tracking, characterizing, and measuring of orbital vehicles and debris in Earth's orbit[38]; tracking and detecting foreign naval assets[39]; and exquisite optical and radar imaging that can see through cloud cover and can penetrate soil.[40] Finally, although information on such systems is cassified, it is likely the NRO developed and operates "stealthy" satellites.[41]

## Data Relay and Communications

The United States operates several military communications satellites (MILSATCOM) that generally fall into three main categories: wideband, protected, and narrowband. As a general rule, wideband systems generally support higher capacities, narrowband support mobile users who require low data rates, and protected systems are harder to defect, defended against jamming, and hardened against nuclear attack.[42] In addition to its own communications satellites, the U.S. military enhances its communications capabilities and capacities by leasing coverage from commercial satellite providers like Iridium.[43]

Current U.S. wideband MILSATCOM capabilities consist primarily of the Defense Satellite Communications System (DSCS), the Global Broadcast Service (GBS), and the Wideband Global SATCOM (WGS) systems. These three complementary systems deliver global, high-capacity communications to troops on the ground, sailors at sea, policymakers, and international partners.[44] The launch of the WGS 8, WGS 9, and WG10 satellites between 2017 and 2019 and the WGS 11 and WGS 12 scheduled for 2020 will add considerable wideband MILSATCOM capacity as these five satellites provide 45 percent more bandwidth than the WGS

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[36] Amy Butler, "An Unprecedented Peek Behind the Sbirs Veil," *Aviation Week & Space Technology*, October 20, 2015, http://aviationweek.com/space/unprecedented-peek-behind-sbirs-veil.

[37] Defense Meteorological Satellite Program (DMSP) supports military weather forecasting. See: "Defense Meteorological Satellite Program Fact Sheet," United States Air Force Space Command, March 2017, https://www.afspc.af.mil/About-Us/Fact-Sheets/Article/249019/defense-meteorological-satellite-program/.

[38] The United States has both space-based and ground-based space situational capabilities. The Air Force's Space Fence provides ground-based space situational awareness while the Space Based Space Surveillance (SBSS) system provides space situational awareness from geosynchronous orbit. See: "Space Based Space Surveillance Fact Sheet," United States Air Force, March 2017, https://www.afspc.af.mil/About-Us/Fact-Sheets/Article/249017/space-based-space-surveillance-sbss/; "USAF Almanac 2018," 118.

[39] National Ocean Surveillance System (NOSS). See: National Aeronautics and Space Administration, "NOSS 4," NASA Space Science Data Coordinated Archive, https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1983-008A.

[40] Jeffrey T. Richelson, "Ups and Downs of Space Radars," *Air Force Magazine,* January 2009, http://www.airforcemag.com/MagazineArchive/Pages/2009/January%202009/0109radars.aspx.

[41] Dana Priest, "New Spy Satellite Debated on Hill," *Washington Post,* December 11, 2004, https://www.washingtonpost.com/archive/politics/2004/12/11/new-spy-satellite-debated-on-hill/8f84c587-d800-4271-abd9-372ac948831c/?utm_term=.7b13e9aed65c.

[42] Kendra L.D. Cook, "Current Wideband MILSATCOM Infrastructure and the Future of Ba0ndwidth Availability," *IEEE Aerospace and Electronic Systems Magazine* 25, no. 12 (2010), 23-28, https://ieeexplore.ieee.org/document/5638785.

[43] Todd Harrison, *The Future of MILSATCOM* (Washington, DC: Center for Strategic and Budgetary Assessments, 2013), https://csbaonline.org/uploads/documents/Future-of-MILSATCOM-web.pdf.

[44] "Wideband Global SATCOM Satellite Fact Sheet," United States Air Force, November 2015, https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104512/wideband-global-satcom-satellite/.

satellites already in orbit.[45] Both the GBS and WGS are thought to be particularly susceptible to Chinese "space-based jammers hosted on small satellites."[46]

The Advanced Extremely High Frequency (AEHF) system and its predecessor, MILSTAR Satellite Communications System (MILSTAR), work together in an integrated architecture to provide protected, jam-resistant MILSATCOM communication capabilities. AEHF and MILSTAR satellites are cross-linked, eliminating the need for ground relay stations and reducing the risks of signals being intercepted on the ground. Although these satellites are protected against jamming, spoofing, and other forms of electronic attack, they are vulnerable to kinetic attacks such as those China and Russia already have demonstrated.[47]

The United States currently operates two narrowband MILSATCOM systems: Ultra-High Frequency Follow-On (UFO) and Mobile User Objective System (MUOS). MUOS has shown great promise but has suffered from a lack of compatible terminals and vulnerability to enemy disruption. Although the satellites have been operational for some time, the troops on the ground lack the terminals to interface with the satellites.[48] Additionally, a 2015 Navy Command Operational Test and Evaluation Force found more than 1,000 cyber vulnerabilities in the MUOS ground terminals, half of which were vulnerabilities that "have the potential to result in loss of confidentiality, availability, or integrity."[49]

Finally, the United States currently operates 33 GPS satellites that provide geolocation, navigation, and timing data to U.S. forces globally. The first GPS satellites were launched in 1978 and have since been constantly upgraded to increase capacity and add new capabilities. The current GPS upgrade effort, GPS Block IIIA, focuses on adding GPS navigation signals, for both civilian and military use, and making the U.S. GPS constellation less vulnerable to enemy disruption through increased encryption and anti-jamming capabilities. Despite these additions, the current U.S. GPS constellation remains vulnerable to Chinese and Russian jamming and spoofing.[50]

## Early Warning Radar

The United States employs several radars that work in conjunction with U.S. space-based assets to provide early warning and track ballistic missile launches. In the event of a foreign ballistic missile attack, the launch would likely first be detected by either the DSP or SBIR in space, which would then cue several different ground-based radar systems.

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[45] Phillip Swarts, "Pentagon Ready to Launch First Upgraded WGS Satellite," *Space News,* November 30, 2016, https://spacenews.com/pentagon-ready-to-launch-first-upgraded-wgs-satellite/; Sandra Erwin, "Boeing to Accelerate Production of WGS Satellites," *Space News,* April 18, 2018, https://spacenews.com/boeing-to-accelerate-production-of-wgs-satellites/.

[46] Todd Harrison, Kaitlyn Johnson, and Thomas G. Roberts, *Space Threat Assessment 2018* (Washington, DC: Center for Strategic and International Studies, April 2018), https://aerospace.csis.org/wp-content/uploads/2018/04/Harrison_SpaceThreatAssessment_FULL_WEB.pdf.

[47] Ibid.

[48] Jon Harper, "Navy Satellites Program Navigating Obstacles," *National Defense,* January 9, 2017, http://www.nationaldefensemagazine.org/articles/2017/1/9/navy-satellites-program-navigating-obstacles.

[49] J. Michael Gilmore, *Mobile User Objective System (MUOS) Multi-Service Operational Test and Evaluation-2 Report* (Washington, DC: Office of the Director of Operational Test and Evaluation, June 2016), https://apps.dtic.mil/dtic/tr/fulltext/u2/1011965.pdf.

[50] Harrison, Johnson, and Roberts, *Space Threats Assessment 2018.*

The longest-range ground-based early warning systems are the three 3,000-mile range Upgraded Early Warning Radar (UEWR) located at Beale AFB, California; Thule AFB, Greenland; and RAF Flyingdales, United Kingdom. The UEWR's primary mission is to track and classify objects as threatening or nonthreatening and then cue other sensors and interceptors.[51] The 2,000-mile range Cobra Dane Radar stationed at Shemya Island in Alaska performs a similar role to UEWR, but with some differences. Cobra Dane is able to more accurately classify targets than UEWR because it operates at a higher (L) frequency than the UEWR (UHF). However, Cobra Dane has a more limited observation angle because it has only a singular radar panel, compared to UEWR's multiple radar panels.[52]

These long-range early warning radar systems then cue other radar systems such as the TPY-2 X-band Radar integrated with the U.S. Army's Terminal High Altitude Area Defense (THAAD)[53] and the Air and Missile Defense Radar (AMDR)/AN/SPY-6 aboard the Flight III Arleigh Burke Guided Missile Destroyers. These radars then generate tracks from which U.S. forces can intercept ballistic missiles. The AMDR AN/SPY-6 aboard the Arleigh Burkes does not have only a defensive capability, as its active, electronically scanned array (AESA) can be used to blind the adversary's radars by emitting high-powered radio waves in a tight beam.[54]

## Nuclear Command and Control

In the event of nuclear attack, the United States has two aircraft, the E-4B and E-6 Mercury, designed to ensure that the National Command Authority (NCA) retains situational awareness and C&C capabilities. The E-4B serves as National Emergency Airborne Command Post for the president, secretary of defense, and the Joint Chiefs of Staff and is hardened against nuclear attacks and the resulting electromagnetic pulses. Furthermore, the E-4B allows for worldwide communication, including with the E-6 Mercury, which fulfills the Take Charge and Move Out (TACAMO) mission to launch U.S. second-strike capabilities.[55] The E-6 receives orders from Looking Glass,and verifies and retransmits the Emergency Action Message (EAM) to the surviving nuclear forces to launch a second strike. The E-6 Mercury is capable of operate a wide range of frequencies to prevent adversaries from jamming the EAM.

## Cyber Domain

One of the most difficult challenges for U.S. military planners is that although the United States has extensive ISR capabilities, they generate more data than human analysts are capable of analyzing. To attempt to solve this problem, the DoD has several artificial intelligence efforts (AI) underway that aim to improve U.S. signal and image processing capabilities by rapidly processing massive caches of raw satellite and imagery data to identify objects of interest. These programs use machine learning algorithms, which are trained using an iterative

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[51] Ian Williams, "Upgraded Early Warning Radar (UEWR)," *Missile Threat*, Center for Strategic and International Studies, published April 14, 2016, last modified June 15, 2018, https://missilethreat.csis.org/defsys/uewr.

[52] Ian Williams, "Cobra Dane," *Missile Threat*, Center for Strategic and International Studies, published April 14, 2016, last modified June 15, 2018, https://missilethreat.csis.org/defsys/cobra-dane/.

[53] Missile Defense Project, "TPY-2 X-band Radar," *Missile Threat*, Center for Strategic and International Studies, published April 25, 2016, last modified June 15, 2018, https://missilethreat.csis.org/defsys/tpy-2/.

[54] Missile Defense Project, "Air and Missile Defense Radar (AMDR) / AN/SPY-6," *Missile Threat*, Center for Strategic and International Studies, published April 14, 2016, last modified June 15, 2018, https://missilethreat.csis.org/defsys/amdr/.

[55] Sebastian Roblin, "The Deadliest Aicraft in the U.S. Military's Arsenal You Have Never Heard Of," *National Interest*, April 23, 2017, https://nationalinterest.org/blog/the-buzz/the-deadliest-aircraft-the-us-militarys-arsenal-you-have-20305.

process, to identify the specific features and patterns correlated with an object of interest. The AI algorithms then search through the satellite and imagery data faster than any human could ever hope to with a high degree of confidence. U.S. researchers were able to train an AI program to locate SAM sites in southeastern China in 42 minutes with a 90 percent accuracy, compared to the 60 hours it took novice imagery analysts.[56]

The United States has several AI efforts in this space underway, including Project Maven and a classified pilot program focused on tracking the North Korean nuclear missile program. Project Maven focuses on using AI and machine learning to help intelligence analysts identify objects of interest from the moving and still imagery generated by the UAS fleet.[57] Although the mission of the pilot program on North Korea is classified, it is believed to focus on leveraging AI to monitor the North Korean nuclear program using satellite imagery to track mobile launchers, which can be difficult for human analysts to locate and track in real time.[58]

## How Are All These Systems Integrated?

The United States' military superiority does not come from any singular weapon system or platform but from its ability to integrate multiple C4ISR capabilities into a systems-of-systems approach that translates strategic situational awareness into kinetic and non-kinetic fires. The Navy's CEC/NFIC-CA capability is perhaps the best example of how several strategic situational awareness systems, sensors, and platforms are integrated into a reconnaissance-strike complex with potentially devastating effect. If the United States wanted to target an adversary's capital ships it could send a stealthy F-35 to penetrate the enemy's air defenses undetected and relay the enemy's location back to the carrier strike group, which then could fire long-range anti-surface missiles at the enemy's capital ship without needing to get close.

Military capabilities do not develop in a vacuum and just as U.S. military planners recognized the value of integrating multiple systems, sensors, and platforms into a reconnaissance-strike complex, so too have American competitors. The Chinese and Russians in particular have developed sophisticated A2/AD capabilities that threaten to disrupt, degrade, or destroy essential U.S. C4ISR enabling capabilities. These advances have forced military planners to re-think fundamental assumptions from the last thirty years about the near-guaranteed availability of C4ISR capabilities. Instead of establishing theater-wide strategic situational awareness superiority (i.e., U.S. operations in the 1991 Gulf War or Afghanistan and Iraq), the United States might be capable only of establishing temporary windows of C4ISR superiority for U.S. forces to operate from. U.S. military forces would work within these temporary windows of superiority to disintegrate enemy A2/AD systems and eventually reestablish theater-wide strategic situational awareness superiority, but this requires fundamental changes in U.S. training, doctrine, and force structures.[59]

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[56] Richard A. Marcum, Curt H. Davis, Grant J. Scott, and Tyler W. Nivin, *Journal of Applied Remote Sensing* 11, no. 4 (2017), https://www.spiedigitallibrary.org/journals/journal-of-applied-remote-sensing/volume-11/issue-04/042614/Rapid-broad-area-search-and-detection-of-Chinese-surface-to/10.1117/1.JRS.11.042614.full?SSO=1; Jeremy Hsu, "AI Can Help Hunt Down Missile Sites in China," *Wired,* November 21, 2017, https://www.wired.com/story/ai-can-help-hunt-down-missile-sites-in-china/.

[57] Cheryl Pellerin, "Project Maven to Deploy Computer Algorithms to War Zone by Years End," DoD News, Defense Media Activity, July 21, 2017, https://dod.defense.gov/News/Article/Article/1254719/project-maven-to-deploy-computer-algorithms-to-war-zone-by-years-end/.

[58] Phil Stewart, "Deep in the Pentagon, a Secret AI Program to Find Hidden Nuclear Missions," *Reuters,* June 5, 2018, https://www.reuters.com/article/us-usa-pentagon-missiles-ai-insight/deep-in-the-pentagon-a-secret-ai-program-to-find-hidden-nuclear-missiles-idUSKCN1J114J.

[59] U.S. Army Training and Doctrine Command, *The U.S. Army in Multi-Domain Operations 2028* (Fort Eustis, VA: December 2018), https://info.publicintelligence.net/USArmy-MultidomainOps2028.pdf.

## Concluding Assessments

The United States has considerable strategic situational awareness capabilities, but it will likely never enjoy the same level of unparalleled dominance that it held at the end of the Cold War. Adversaries like China and Russia recognized the importance of U.S. strategic situational awareness supremacy and have worked to catch up to the United States by developing their own strategic situational awareness capabilities, as well as platforms and systems that disrupt or destroy the United States' capabilities. Although the United States retains an overall advantage, particularly in key areas such as undersea warfare and theater battlefield management, China and Russia are rapidly catching up to current U.S. capabilities and have even surpassed them in some areas, such as electronic warfare and counter-space. The challenge for DoD is to develop more resilient systems and longer-range capabilities that can disrupt, degrade, and destroy the Russian and Chinese situational awareness capabilities.

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