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Precision-Guided Munitions: Background and Issues for Congress

Updated June 11, 2021

Congressional Research Service
https://crsreports.congress.gov
R45996

SUMMARY

R45996

June 11, 2021

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Precision-Guided Munitions: Background and Issues for Congress

Over the years, the U.S. military has become reliant on precision-guided munitions (PGMs) to execute military operations. PGMs are used in ground, air, and naval operations. Defined by the Department of Defense (DOD) as "[a] guided weapon intended to destroy a point target and minimize collateral damage," PGMs can include air- and ship-launched missiles, multiple launched rockets, and guided bombs. These munitions typically use radio signals from the global positioning system (GPS), laser guidance, and inertial navigation systems (INS)—using gyroscopes—to improve a weapon's accuracy to reportedly less than 3 meters (approximately 10 feet).

Precision munitions were introduced to military operations during World War II; however, they first demonstrated their utility operationally during the Vietnam War and gained prominence in Operation Desert Storm in 1991. Since the 1990s, due in part to their ability to minimize collateral damage, PGMs have become critical components in U.S. operations, particularly in Afghanistan, Iraq, and Syria. The proliferation of anti-access/area denial (A2/AD) systems is likely to increase the operational utility of PGMs. In particular, peer competitors like China and Russia have developed sophisticated air defenses and anti-ship missiles that increase the risk to U.S. forces entering and operating in these regions. Using advanced guidance systems, PGMs can be launched at long ranges to attack an enemy without risking U.S. forces. As a result, DOD has argued it requires longer range munitions to meet these new threats.

The Air Force, Army, Navy, and Marine Corps all use PGMs. In FY2022, the Department of Defense (DOD) requested approximately $3.5 billion for 16,929 weapons in 15 munitions programs. Previously DOD obligated $1.96 billion for 13,985 weapons in FY2015, $2.98 billion for 35,067 weapons in FY2016, $3.63 billion for 44,446 weapons in FY2017, $5.05 billion for 68,988 weapons in FY2018, $4.3 billion in FY2019 for 60,662 munitions, and $5.3 billion in FY2020 for 55,179 weapons. In FY2021, Congress authorized $3.82 billion for 39,472 weapons.

Current PGM programs can be categorized as air-launched, ground-launched, or naval-launched.

- **Air-Launched:** Paveway Laser Guided Bomb, Joint Direct Attack Munition (JDAM), Small Diameter Bomb, Small Diameter Bomb II, Hellfire Missile, Joint Air-to-Ground Missile, Joint Air-to-Surface Strike Missile (JASSM), Long Range Anti-Ship Missile (LRASM), and Advanced Anti-Radiation Guided Missile.
- **Ground-Launched:** Guided Multiple Launch Rocket System (GMLRS), Army Tactical Missile System (ATACMS), and Precision Strike Missile (PrSM);
- **Naval PGMs:** Tomahawk Cruise Missile, Standard Missile-6 (SM-6), and Naval Strike Missile.

Congress may consider several issues regarding PGMs, including

- planned procurement quantities and stockpile assessments,
- defense industrial base production capacity,
- development timelines,
- supply chain security,
- affordability and cost-effectiveness, and
- emerging factors that may affect PGM programs.

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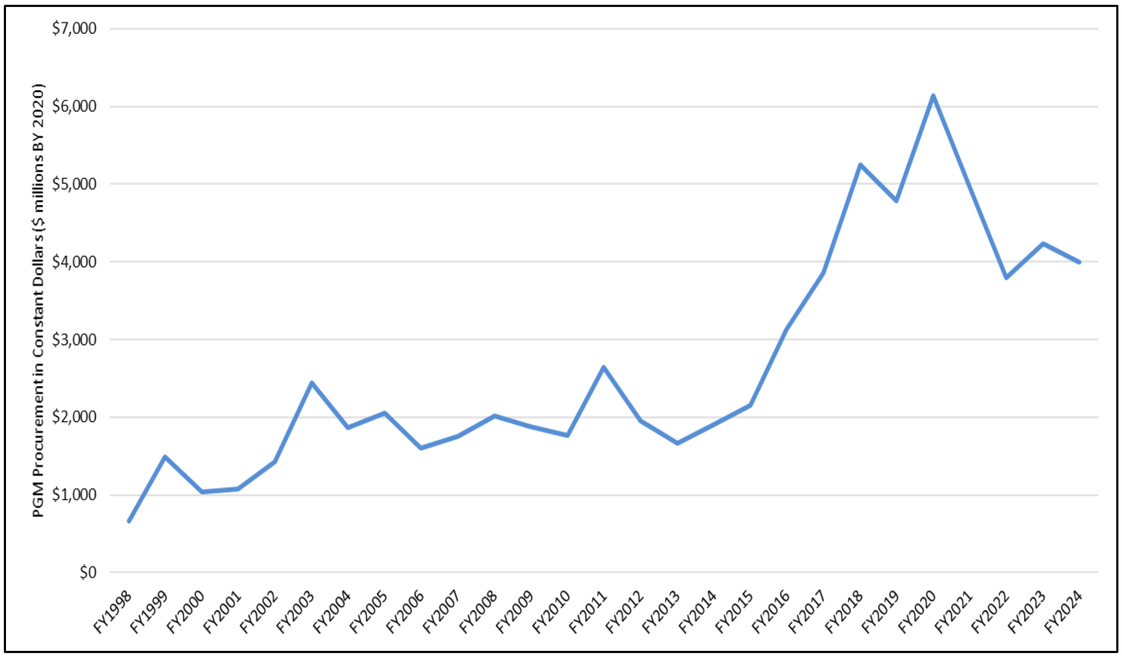
Introduction

This report focuses on selected precision-guided munitions (PGMs) fielded by the Air Force, Army, Navy, and Marine Corps. Over the years, the U.S. military has relied on PGMs to execute ground, air, and naval military operations. PGMs have become ubiquitous in U.S. military operations; funding for these weapons has increased dramatically from FY1998 to the present as depicted in. In FY2021, the Department of Defense (DOD) requested approximately $4.1 billion for more than 41,337 weapons in 15 munitions programs. DOD projects requesting approximately $3.3 billion for 20,456 weapons in FY2022, $3.9 billion for 23,306 weapons in FY2023, $3.9 billion for 18,376 weapons in FY2024, and $3.6 billion for 16,325 weapons in FY2025.[1]

Figure 1. Inflation-Adjusted PGM Procurement

Guided Missiles, Bombs and Rockets from FY1998-FY2025



Source: Department of Defense Budget FY2000-2020 P-1 Procurement budget requests, at https://comptroller.defense.gov/Budget-Materials/, Department of Defense National Defense Budget Estimate for FY2020 pp. 58-59, at https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2020/FY20_Green_Book.pdf, Air Force FY2020 Missile procurement budget justifications; Army FY2020 Missile procurement budget justifications; Navy FY2020 Weapons procurement budget justifications.

Notes: FY1998 through FY2020 totals are actual dollars appropriated. FY2021 is the requested amount. FY2022 through FY2025 are projected amounts.

Congress, through the defense authorization and appropriations bills, has historically exercised its role in the decision to approve, reject, or modify DOD's proposals for PGMs. In addition, these programs pose a number of potential oversight issues for Congress. Congress's decisions on these issues could affect future U.S. military capabilities and funding requirements. Potential issues for Congress include

- planned procurement quantities and stockpile assessments,

[1] Air Force FY2020 Missile Procurement budget justifications; Army FY2020 Missile Procurement budget justifications; Navy FY2020 Weapons Procurement budget justifications.

- defense industrial base production capacity,
- development timelines,
- supply chain security,
- affordability and cost-effectiveness, and
- emerging factors that may affect PGM programs.

Background

DOD defines a PGM as "[a] guided weapon intended to destroy a point target and minimize collateral damage."[2] In addition to these virtues, PGMs also offer other advantages over unguided weapons, namely range and the reduction in numbers of combat sorties required to deliver the desired effects on the battle field. The main disadvantage of these weapons is cost; particularly long range missiles. PGMs include air- and ship-launched missiles, multiple launched rockets, and guided bombs. Current munitions typically use a combination of radio signals from the global positioning system (GPS), laser guidance, and inertial navigation systems (INS)—using gyroscopes—to improve a weapon's accuracy to reportedly less than 3 meters (approximately 10 feet).[3] PGMs have transformed attack operations from the air; instead of using hundreds of bomber sorties to attack a single target, a single sortie from a PGM-carrying platform can attack multiple targets while minimizing collateral damage.

Guided munitions were first developed in the 1940s, when the U.S. Army Air Corps tested radio guidance to glide bombs onto a target.[4] Prior to precision guidance, bomber missions reported an accuracy of 1,200 feet; 16% of munitions dropped by crews landed within 1,000 feet of their intended target.[5] According to defense analyst Barry Watts, guidance systems showed promise in improving weapon accuracy; however, these systems were not fully fielded during the Second World War. This can partly be attributed to technological challenges in developing guidance systems, as well as relatively large unit costs per munition used. Guidance systems during this era used television signals, and required a chase aircraft to provide command and control for the weapon to strike its target.

DOD continued to develop PGMs through the 1950s and 1960s, where they gained prominence during the Vietnam War with the introduction of the laser-guided bomb. Laser-guided bombs became a preferred munition for bombing operations; an Air Force study in 1973 found that the U.S. military used more than 10,500 laser-guided bombs the previous year, with 5,107 weapons achieving a direct hit and another 4,000 achieving a circular error probable of 25 feet.[6] During the

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[2] Department of Defense, *DOD Dictionary of Military and Associated Terms*, July 2019, at https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/dictionary.pdf/.

[3] IHS Janes, "GBU-39/B Small Diameter Bomb (SDB I), GBU-39B/B Laser SDB (LSDB)," June 7, 2019, at https://janes.ihs.com/Janes/Display/jalw9077-jalw.

[4] Barry D. Watts, *Six Decades of Guided Munitions and Battle Networks: Progress and Prospects*, Center for Strategic and Budgetary Assessments, Washington, DC, March 2007, at https://csbaonline.org/uploads/documents/2007.03.01-Six-Decades-Of-Guided-Weapons.pdf.

[5] John T. Correll, "Daylight Precision Bombing," *Air Force Magazine*, October 2008, at http://www.airforcemag.com/MagazineArchive/Pages/2008/October%202008/1008daylight.aspx.

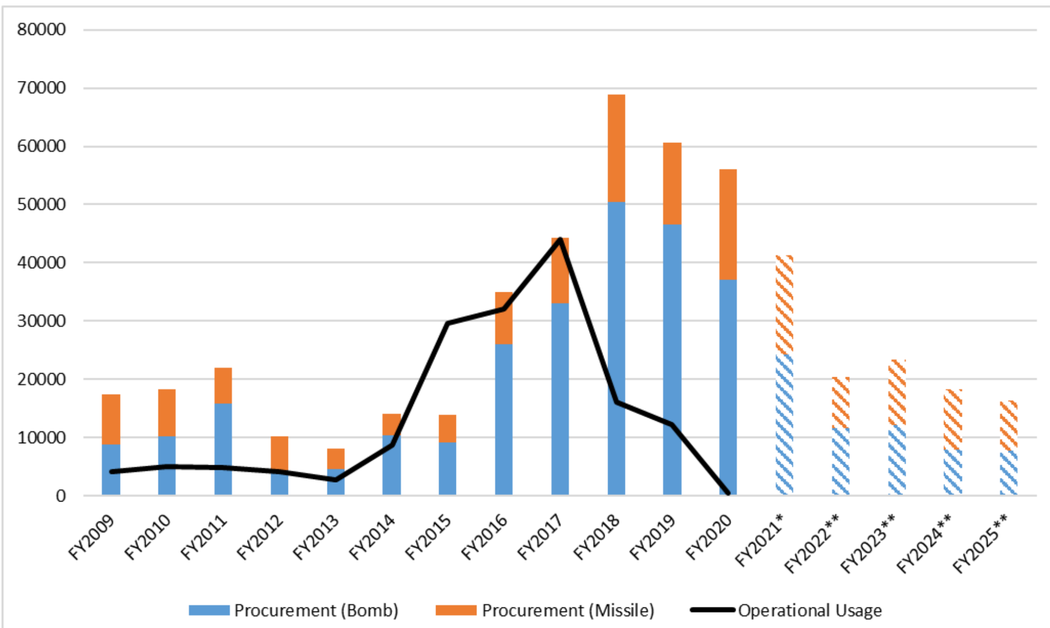
[6] *Circular error probable* is the metric used to identify how accurate a specific munition is. This metric measures the distance 50% of a type of weapon will land from the aim point. Barry D. Watts, *Six Decades of Guided Munitions and Battle Networks: Progress and Prospects,* Center for Strategic and Budgetary Assessments, Washington, DC, March 2007, pp. 9-10, at https://csbaonline.org/uploads/documents/2007.03.01-Six-Decades-Of-Guided-Weapons.pdf.

1970s and 1980s, all of the military services developed guided missiles capable of attacking fixed and moving targets. Laser-guided bombs gained prominence during Operation Desert Storm in 1991. Although PGMs represented only 6% of the total munitions used during the campaign,[7] they struck a number of critical targets, reduced the number of combat sorties required, and limited collateral damage to civilian structures.[8]

Operations over the past decade in Afghanistan, Iraq, and Syria have demonstrated DOD's increasing reliance on PGMs and how important they have become for modern military operations. The Air Force reports that nearly 139,000 weapons have been used in combat operations in the Middle East since 2014.[9] Counter-Islamic State (IS) operations in Iraq and Syria have used numerous weapons: in 2015, coalition air forces used more than 28,000 weapons; in 2016, the campaign used an additional 30,700 weapons; and in 2017 (the height of operations), the campaign used 39,500 weapons (see **Figure 2** for a graphical representation of operational usage compared to DOD procurement). Nearly all of the weapons employed were PGMs, particularly Joint Direct Attack Munitions (JDAMs) and Hellfire Missiles.

Figure 2. PGM Operational Usage and Procurement

Operational Usage in Afghanistan, Iraq, and Syria



Source: Department of Defense Budget FY2000-2021 P-1 Procurement budget requests, at https://comptroller.defense.gov/Budget-Materials/; Air Force FY2021 missile procurement budget justifications;

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7 During Operation Desert Storm, the stockpile of laser guided bombs was limited due to cost. A single Paveway bomb tail kit in 1991 cost approximately $20,000, a reduction from $40,000 in 1998. See Malcolm W. Browne, "Invention That Shaped the Gulf War: the Laser-Guided Bomb," *New York Times*, February 26, 1991, pp. C-1, at https://www.nytimes.com/1991/02/26/science/invention-that-shaped-the-gulf-war-the-laser-guided-bomb.html.

8 Eliot Cohen, Tom Keaney, et al., *Gulf War Air Power Study Volume IV: Weapons, Tactics, and Training and Space Operations*, U.S. Air Force, Washington, DC, 1993, https://media.defense.gov/2010/Sep/27/2001329817/-1/-1/0/AFD-100927-066.pdf.

9 Air Force Central reports the number of U.S. and coalition weapons used in Afghanistan, Iraq, and Syria. Air Force Central, "Airpower Summaries," press release, September 1, 2019, https://www.afcent.af.mil/About/Airpower-Summaries/.

Army FY2021 missile procurement budget justifications; Navy FY2021 weapons procurement budget justifications, and Air Forces Central Air Power Summary.

Notes: Bomb procurement includes JDAM, Small Diameter Bomb, and Small Diameter Bomb II. Missile procurement includes Advanced Anti-Radiation Guided Missile, Army Tactical Missile System, Guided Multiple Launch Rocket System, Hellfire, Joint Air-to-Surface Strike Missile, Long Range Anti-Ship Missile, and Tomahawk. * denotes the Administration's request, ** denotes programmed funding and quantities.

In addition to PGM use in current operations, the proliferation of anti-access/area denial (A2/AD) systems is likely to increase the operational utility of PGMs.[10] Anti-access systems can be defined as capabilities "associated with denying access to major fixed-point targets, especially large forward bases."[11] Area denial systems can be defined as capabilities "that threaten mobile targets over an area of operations, principally maritime forces, to include those beyond the littorals."[12] Peer competitors like China and Russia have developed sophisticated air defenses, such as the S-300PMU (SA-20) and S-400 (SA-21),[13] the HQ-9 surface-to-air missile (China), the DF-21D and DF-26 anti-ship ballistic missiles (China), and the 3M-54 Kaliber anti-ship cruise missile (Russia).[14] **Figure 3** illustrates ranges of potential A2/AD systems. These systems outrange U.S. weapons systems at what experts assess as unacceptable risk—some of these weapons have reported ranges in excess of 1,000 nautical miles.[15] As a result, U.S. ships and aircraft would need to engage targets at long ranges in order to not put themselves in danger. For instance, naval ships could be threatened at ranges of 809 nautical miles from bases that field DF-21D anti-ship ballistic missiles.[16]

[10] Jan van Tol, Mark Gunzinger, Andrew Krepinevich, et al., *AirSea Battle: A Point-of-Departure Operational Concept,* Center for Strategic and Budgetary Assessments, Washington, DC, May 2010, https://csbaonline.org/uploads/documents/2010.05.18-AirSea-Battle.pdf.

[11] Jan Van Tol et al., *AirSea Battle: A Point-of-Departure Operational Concept*, Center for Strategic and Budgetary Assessments, Washington, DC, May 18, 2010, p. 1, https://csbaonline.org/uploads/documents/2010.05.18-AirSea-Battle.pdf.

[12] Jan Van Tol et al., *AirSea Battle: A Point-of-Departure Operational Concept*, Center for Strategic and Budgetary Assessments, Washington, DC, May 18, 2010, p. 1, https://csbaonline.org/uploads/documents/2010.05.18-AirSea-Battle.pdf.

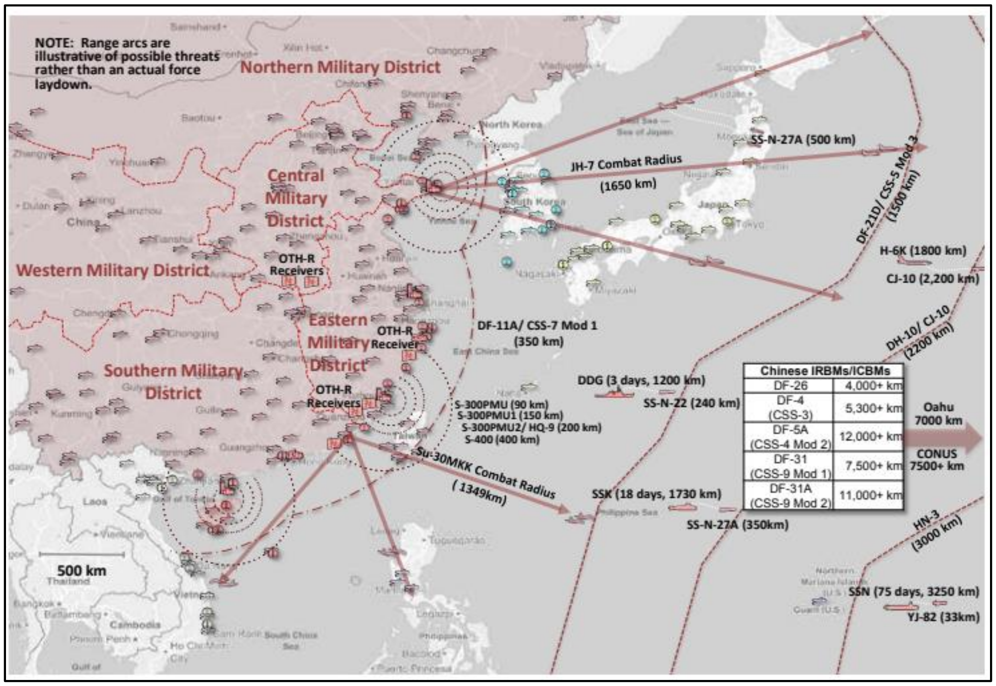
[13] According to IHS Janes, the S-400 has a maximum range of 400 kilometers. IHS Janes "S-400," October 7, 2019, at https://janes.ihs.com/Janes/Display/jlad0593-jaad.

[14] According to IHS Janes, the DF-21D has a range of 1,500 kilometers, and the DF-26 has a range of approximately 4,000 kilometers. See IHS Janes "DF-21," February 21, 2019, at https://janes.ihs.com/Janes/Display/jsws0411-jsws, and IHS Janes "DF-26," February 1, 2019, at https://janes.ihs.com/Janes/Display/jswsa399-jsws.

[15] Jan van Tol, Mark Gunzinger, Andrew Krepinevich, et al., *AirSea Battle: A Point-of-Departure Operational Concept,* Center for Strategic and Budgetary Assessments, Washington, DC, May 2010, https://csbaonline.org/uploads/documents/2010.05.18-AirSea-Battle.pdf.

[16] See IHS Janes "DF-21," February 21, 2019, at https://janes.ihs.com/Janes/Display/jsws0411-jsws.

Figure 3. Potential Chinese Reconnaissance Strike Complex



Source: Bryan Clark, Peter Haynes, and Bryan McGrath, et al., *Restoring American Seapower: A New Fleet Architecture for the United States Navy*, Center for Strategic and Budgetary Assessments, Washington, DC, February 9, 2017, p. 11, https://csbaonline.org/uploads/documents/CSBA6292-Fleet_Architecture_Study_REPRINT_web.pdf.

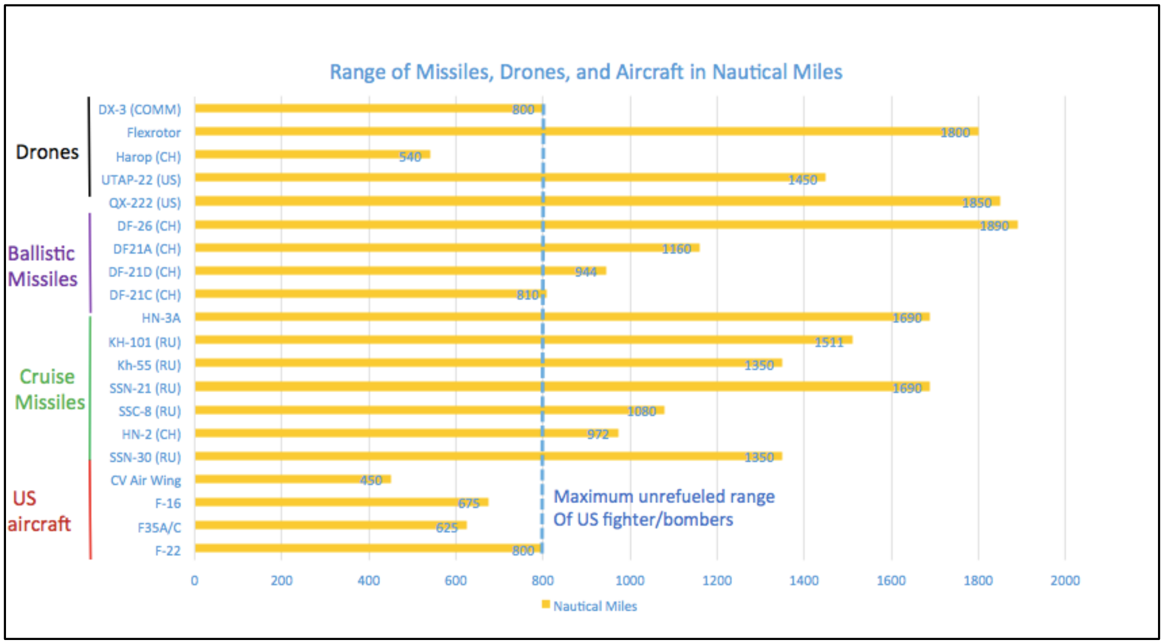
Note: The figure notes state "Data to build this chart derived from OSD, Military and Security Developments Involving the People's Republic of China 2016."

The effectiveness of these missiles is often debated, as is the amount of risk an anti-ship ballistic missile presents to naval forces. Some analysts argue that in a combat situation, aircraft carriers would not enter these weapons' engagement zones because of the threat. Others argue that while there is some risk posed to naval forces, aircraft carriers and major surface combatants would nonetheless be able to operate effectively. Similarly, an S-400 (SA-21) presents risks to aircraft at ranges of up to 215 nautical miles. Many weapons in the U.S. inventory have relatively short ranges.[17] **Figure 4** illustrates the impact that A2/AD systems have on potential military operations. Some analysts argue that U.S. forces would substantially increase their operational risk at ranges in excess of 500 nautical miles (NM).[18]

[17] Guided bombs have a maximum range of 40 nautical miles; longer-range missiles typically have a range around 150-500 nautical miles.

[18] Jan van Tol, Mark Gunzinger, Andrew Krepinevich, et al., *AirSea Battle: A Point-of-Departure Operational Concept*, Center for Strategic and Budgetary Assessments, Washington, DC, May 2010, https://csbaonline.org/uploads/documents/2010.05.18-AirSea-Battle.pdf.

Figure 4. Comparison of Ranges of Military Equipment
U.S. Military Aircraft vs. Adversary Drones and Missiles



Source: https://warontherocks.com/2018/03/america-is-well-within-range-of-a-big-surprise-so-why-cant-it-see/.

Air-Launched Precision-Guided Munitions[19]

Paveway Laser-Guided Bombs

The Paveway is a family of guidance kits that attach to unguided bombs. The assembly includes a guidance seeker on the nose of the bomb, which looks for a laser to mark a target, and a tail kit to guide the bomb onto the target. The Paveway series was originally developed during the Vietnam War to enable tactical aircraft—like the F-4 Phantom and the A-6 Intruder—to deliver precise munitions onto a target.[20] Paveway has received several upgrades, with the development of Paveway III (in the 1990s), which improves low-altitude guidance,[21] and Paveway IV (in the late 1990s), which adds satellite guidance to improve accuracy.[22] The U.S. military predominately uses Paveway II (see **Figure 5** and **Figure 6**) and Paveway III kits; Paveway IV is used exclusively by foreign militaries.

According to IHS Janes, Raytheon has produced more than 350,000 Paveway kits, with Lockheed Martin producing an additional 200,000 kits.[23] Funding for Paveway procurement appears in the

[19] The FY2022 President's budget request included procurement for the U.S. Air Force's Air-launched Rapid Response Weapon (ARRW). According to budget justifications, this is a new procurement program intended to purchase a conventional hypersonic missile that will be launched from a B-52. For more information on this program, see CRS Report R45811, *Hypersonic Weapons: Background and Issues for Congress*, by Kelley M. Sayler.

[20] IHS Janes "GBU-10/12/16/58 Paveway II," October 17, 2018, at https://janes.ihs.com/Janes/Display/jalwa051-jalw.

[21] IHS Janes "GBU-22, GBU-24, GBU-27 Paveway III, and Enhanced Paveway III," September 10, 2019, at https://janes.ihs.com/Janes/Display/jalw3671-jalw.

[22] IHS Janes "Paveway IV (PGB)," February 13, 2019, at https://janes.ihs.com/Janes/Display/jalw9213-jalw.

[23] IHS Janes "GBU-10/12/16/58 Paveway II," October 17, 2018, at https://janes.ihs.com/Janes/Display/jalwa051-jalw.

Air Force's General Purpose Bomb line item; however, the Air Force does not report procurement quantities in its budget justification documentation.[24] DOD has exported Paveway II kits to more than 30 countries, and exported Paveway III kits to at least 9 countries. Paveway IV is used by the United Kingdom, the Philippines, Saudi Arabia, and Qatar.[25]

Figure 5. Paveway II

Source: https://upload.wikimedia.org/wikipedia/commons/2/2d/Paveway_II_p1230135.jpg.

Figure 6. Loading a Paveway II into an F-35B

Source: https://dod.defense.gov/OIR/gallery/igphoto/2001907433/.

Note: In this photo, Marines load a GBU-12 Paveway II laser-guided bomb onto an F-35B Lightning II aircraft on the flight deck of the *USS* Wasp during a certification exercise in the Pacific Ocean, April 18, 2018. Marine Corps photo by Cpl. Stormy Mendez.

[24] U.S. Air Force FY2020 Procurement of Ammunition Line Item 353020 General Purpose Bombs, at https://apps.dtic.mil/procurement/Y2020/AirForce/stamped/U_P40_353020_BSA-13_BA-1_APP-3011F_PB_2020.pdf.

[25] IHS Janes "Paveway IV (PGB)," February 13, 2019, at https://janes.ihs.com/Janes/Display/jalw9213-jalw.

Joint Direct Attack Munition (JDAM)

JDAM modifies unguided bombs—such as the 500-pound Mk-82, the 1,000-pound Mk-83, and the 2,000-pound Mk-84—with GPS guidance. (For a fully assembled JDAM, see **Figure 7**; for a JDAM tail kit, see **Figure 8**.) When a JDAM kit is attached, the weapon is designated as GBU-31/32/38 depending on the weight of the bomb.[26] These weapons have a reported range of 13 nautical miles.[27] The Air Force and Navy began studying how to deliver such weapons in a program known as the Advanced Bomb Family during the 1980s.[28] The first JDAMs were delivered in 1997, and underwent operational testing between 1998 and 1999.[29] JDAM kits are reported to have an accuracy to within 3 meters (approximately 10 feet).[30] The first operational use of a JDAM was during Operation Allied Freedom in Kosovo by a B-2 Spirit bomber. Since their development, JDAMs have been integrated with all U.S. fixed-wing strike platforms.

JDAMs have received several upgrades since their introduction into service. One of the major developments has been developing a laser guidance system in addition to receiving GPS guidance. Adding laser guidance enables JDAMs to strike both moving and fixed targets. In February 2020, Boeing announced its intention to develop a "powered" JDAM to provide a low-cost alternative to cruise missiles.[31] According to Air Force Magazine, this new JDAM would use a 500-pound bomb, and would be the size of a 2,000-pound bomb. Boeing has not stated a unit cost for this new development.

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[26] U.S. Air Force, "Joint Direct Attack Munition GBU-31/32/38 Fact Sheet," press release, June 18, 2003, https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104572/joint-direct-attack-munition-gbu-313238/.

[27] IHS Janes "GBU-31/32/38 Joint Direct Attack Munition (JDAM)," June 18, 2019, at https://janes.ihs.com/Janes/Display/jalw3667-jalw.

[28] IHS Janes "GBU-31/32/38 Joint Direct Attack Munition (JDAM)," June 18, 2019, at https://janes.ihs.com/Janes/Display/jalw3667-jalw.

[29] According to the Air Force, approximately 450 JDAMs were dropped during the operational testing phase. See U.S. Air Force, "Joint Direct Attack Munition GBU-31/32/38 Fact Sheet," press release, June 18, 2003, https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104572/joint-direct-attack-munition-gbu-313238/.

[30] IHS Janes "GBU-31/32/38 Joint Direct Attack Munition (JDAM)," June 18, 2019, at https://janes.ihs.com/Janes/Display/jalw3667-jalw.

[31] Tobias Naegele, "Powered JDAM: Boeing's New Alternative to Cruise Missiles," *Air Force Magazine*, February 28, 2020, https://www.airforcemag.com/power-jdam-boeings-new-alternative-to-cruise-missiles/.

Figure 7. GBU-31/32 Joint Direct Attack Munitions (JDAM)

Source: https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/197589/gbu-3132-joint-direct-attack-munitions-jdam/.

Note: The GBU-31/32 JDAM on display in the Cold War Gallery at the National Museum of the U.S. Air Force (U.S. Air Force photo).

DOD has procured more than 371,000 JDAM kits since 1998.[32] According to IHS Janes, the Air Force originally projected procuring 270,000 JDAM kits. Production peaked at 30,000 kits prior to 2007 before declining until 2015. Increased operational use in Iraq and Syria, in particular, resulted in a reduction in JDAM stockpiles, leading to increased procurement from FY2016 through FY2020. **Table 1** outlines the FY2022 request. In addition to U.S. military use, JDAMs have been exported to 26 countries, including Australia, Bahrain, Denmark, Finland, Israel, Italy, Japan, Kuwait, Pakistan, Saudi Arabia, Singapore, South Korea, Taiwan, Turkey, and the United Arab Emirates.[33]

Table 1. JDAM Requested and Programmed Procurement in the FYDP

	FY2021	FY2022[a]	FY2023[b]	FY2024[b]	FY2025[b]	FY2026[b]	Grand Total
Cost ($millions)	$539.87	$198.24	—	—	—	—	$738.11
Quantity	20,071	4,890	—	—	—	—	24,961

Source: U.S. Air Force FY2022 Procurement of Ammunition Line Item 353620 Joint Direct Attack Munition, and U.S. Navy FY2022 Procurement of Ammunition Line Item 0148 JT Direct Attack Munition (JDAM).

a. Denotes the Administration's request.

b. Denotes programmed funding and quantities.

[32] See Department of Defense Budget FY2000-2020 P-1 Procurement budget requests, at https://comptroller.defense.gov/Budget-Materials/.

[33] IHS Janes "GBU-31/32/38 Joint Direct Attack Munition (JDAM)," June 18, 2019, at https://janes.ihs.com/Janes/Display/jalw3667-jalw.

Figure 8. JDAM Tail Kits

Source: https://www.hill.af.mil/News/Article-Display/Article/909505/munitions-airmen-key-players-during-combat-exercises-at-hill-afb/.

Notes: "Airmen from the 325th Maintenance Squadron, Tyndall Air Force Base, FL., lift a GBU-32 bomb tail section onto the primary bomb body at Hill AFB, UT. The bombs being assembled were later dropped by aircraft participating in exercise Combat Hammer at Hill AFB and the Utah Test and Training Range." (U.S. Air Force photo by Paul Holcomb.)

Small Diameter Bomb (SDB) and Small Diameter Bomb II

The Small Diameter Bomb, designated as GBU-39 (**Figure 9**), is a 250-pound guided bomb. The SDB can use both GPS and laser guidance, enabling it to strike both fixed and moving targets.[34] In 1997, responding to improvements in accuracy due to GPS, the Air Force stated a need to develop a smaller bomb to reduce collateral damage. The SDB reached initial operating capability in 2006.[35] According to the Air Force, the SDB has a range of approximately 40 nautical miles.[36] The SDB was specifically designed around space constraints in both the F-22 Raptor and F-35 Lightning II aircraft to enable these fighter aircraft to carry SDBs internally, while protecting their low observable signature.[37]

34 U.S. Air Force, "GBU-39B Small Diameter Bomb Weapon System Fact Sheet," press release, August 28, 2006, https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104573/gbu-39b-small-diameter-bomb-weapon-system/.

35 U.S. Air Force, "GBU-39B Small Diameter Bomb Weapon System Fact Sheet," press release, August 28, 2006, https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104573/gbu-39b-small-diameter-bomb-weapon-system/.

36 U.S. Air Force, "GBU-39B Small Diameter Bomb Weapon System Fact Sheet," press release, August 28, 2006, https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104573/gbu-39b-small-diameter-bomb-weapon-system/.

37 IHS Janes "GBU-39/B Small Diameter Bomb (SDB I), GBU-39B/B Laser SDB (LSDB), June 7, 2019, at https://janes.ihs.com/Janes/Display/jalw9077-jalw.

Figure 9. Small Diameter Bomb

Source: https://www.jber.jb.mil/News/Articles/Article/592933/operational-f-22s-employ-small-diameter-bombs-during-wsep/.

Notes: During a Combat Hammer exercise, Alaska F-22 Raptors became the first operational F-22 unit to drop GBU-39 small diameter bombs. Combat Hammer—a weapons system evaluation program sponsored by the 86th Fighter Weapons Squadron—provided an opportunity for an operational unit to employ the bombs in a realistic tactical training environment. (U.S. Air Force photo/Tech. Sgt. Dana Rosso.)

The Air Force developed a second small diameter bomb, the GBU-53 laser-guided smaller diameter bomb, or SDB II (see **Figure 10**).[38] The added laser guidance enables the SDB II to strike both fixed and moving targets. SDB II uses Link 16 and ultra-high frequency datalinks, along with infrared guidance, to provide course corrections.[39] Development for the SDB II began in 2005, and the Air Force declared initial operating capability in 2019.[40] The U.S. exports SDB II to Australia and South Korea as of 2019.[41]

[38] The SDB II is a separate procurement line item in both budget justifications and in Congressional authorization and appropriations.

[39] IHS Janes "StormBreaker bomb (GBU-53/B SDB II)," July 8, 2019, at https://janes.ihs.com/Janes/Display/jalwa099-jalw.

[40] IHS Janes "StormBreaker bomb (GBU-53/B SDB II)," July 8, 2019, at https://janes.ihs.com/Janes/Display/jalwa099-jalw.

[41] IHS Janes "StormBreaker bomb (GBU-53/B SDB II)," July 8, 2019, at https://janes.ihs.com/Janes/Display/jalwa099-jalw.

Figure 10. Model of a GBU-53 Small Diameter Bomb II

Source: https://janes.ihs.com/Janes/Display/jalwa099-jalw.

The Air Force and Navy are actively procuring SDBs and SDB IIs as of 2022. From FY2005 through FY2019, the Air Force purchased more than 28,000 SDBs for more than $1.7 billion.[42] (see **Table 2**).[43]

Table 2. Small Diameter Bomb and Small Diameter Bomb II Requested and Programmed Procurement in the FYDP

	FY2021	FY2022[a]	FY2023[b]	FY2024[b]	FY2025[b]	FY2026[b]	**Total**
SDB Cost ($millions)	$95.83	$82.82	—	—	—	—	$178.65
SDB Quantity	2,462	998	—	—	—	—	3,460
SDB II Cost ($millions)	$267.73	$335.53	—	—	—	—	$603.25
SDB II Quantity	991	1,165	—	—	—	—	2,156

Source: U.S. Air Force FY2022 Procurement of Missiles Line Item SDB000 Small Diameter Bomb, U.S. Air Force FY2022 Procurement of Missiles Line Item SDB0032 Small Diameter Bomb II, and U.S. Navy FY2022 Weapons Procurement Line Item 2238 Small Diameter Bomb II (SDB II).

a. Denotes the Administration's request.

b. Denotes programmed funding and quantities.

AGM-114 Hellfire Missile

In the early 1970s, the Army developed a requirement for an anti-tank missile, which resulted in the AGM-114 Hellfire (see **Figure 11**).[44] The first Hellfire was introduced into service in 1982 on

[42] See Department of Defense Budget FY2000-2020 P-1 Procurement budget requests, at https://comptroller.defense.gov/Budget-Materials/.

[43] U.S. Air Force FY2022 Procurement of Missiles Line Item SDB0032 Small Diameter Bomb II, and U.S. Navy FY2022 Weapons Procurement Line Item 2238 Small Diameter Bomb II (SDB II).

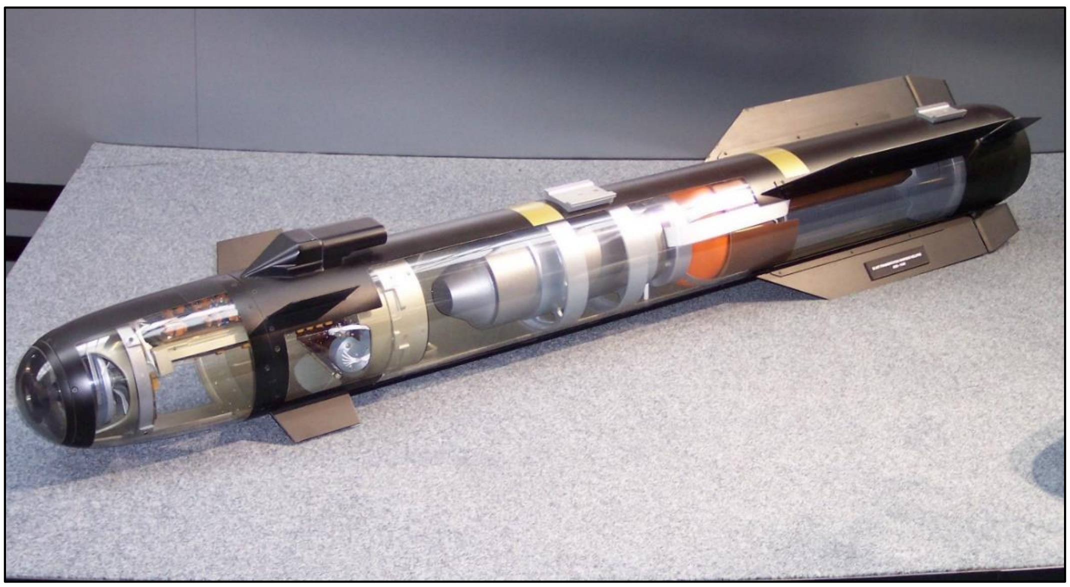
[44] IHS Janes "AGM-114 Hellfire and Longbow Hellfire," June 21, 2019, at https://janes.ihs.com/Janes/Display/

the Army's AH-64 Apache, using laser guidance to target tanks, bunkers, and structures.[45] Hellfire missiles have a maximum effective range of 4.3 nautical miles. By the mid-1980s, the Marine Corps had introduced Hellfire missiles to its attack helicopter fleet. Hellfire missiles have received continual upgrades over the past decades, including integrating infrared sensors, warheads to target small boats, and integration with the Apache's Longbow radar.[46] During the late 1990s and early 2000s, Hellfire missiles were introduced to the MQ-1 Predator, and later to the MQ-9 Reaper, enabling unmanned aerial vehicles to provide a strike capability.[47]

Hellfire missiles have become a preferred munition for operations in the Middle East, particularly with increased utilization of unmanned aircraft like MQ-1s and MQ-9s. Hellfire missiles have been exported to a number of countries, including Australia, Bahrain, Egypt, India, Iraq, South Korea, Kuwait, Qatar, Saudi Arabia, Taiwan, Turkey, United Arab Emirates, and the United Kingdom.[48]

The Army and the Marine Corps identified the need to replace the Hellfire missile. During the mid-2000s, the two services started a new development project called the Joint Air-to-Ground Missile (JAGM), which entered testing in 2012. Both services plan to replace the Hellfire with the JAGM; however, it is unclear when they plan to make the transition.

Figure 11. AGM-114 Hellfire



Source: https://commons.wikimedia.org/wiki/File:Lockheed_Martin_Longbow_Hellfire.jpg.

Note: This image depicts an "exploded" view, depicting the internal components of the missile.

jalw3064-jalw.

[45] IHS Janes "AGM-114 Hellfire and Longbow Hellfire," June 21, 2019, at https://janes.ihs.com/Janes/Display/jalw3064-jalw.

[46] IHS Janes "AGM-114 Hellfire and Longbow Hellfire," June 21, 2019, at https://janes.ihs.com/Janes/Display/jalw3064-jalw.

[47] U.S. Air Force, "MQ-1B Predator Fact Sheet," September 23, 2015, at https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104469/mq-1b-predator/.

[48] IHS Janes "AGM-114 Hellfire and Longbow Hellfire," June 21, 2019, at https://janes.ihs.com/Janes/Display/jalw3064-jalw.

Table 3. AGM-114 Hellfire Missile Requested and Programmed Procurement in the FYDP

	FY2021	FY2022[a]	FY2023[b]	FY2024[b]	FY2025[b]	FY2026[b]	Grand Total
Cost ($millions)	$516.61	$230.04	—	—	—	—	$746.65
Quantity	8,130	1,999	—	—	—	—	10,129

Source: U.S. Army FY2022 Missiles Procurement Line Item 1338C70000 Hellfire Sys Summary; U.S. Air Force FY2022 Missile Procurement Line Item PRDTA2 Predator Hellfire Missile; and U.S. Navy FY2022 Weapons Procurement Line Item 2254 Hellfire.

a. Denotes the Administration's request.

b. Denotes programmed funding and quantities.

AGM-169 Joint Air-to-Ground Missile (JAGM)

The Joint Air-to-Ground Missile is designed to replace the Hellfire, TOW, and Maverick missiles. JAGM uses a new warhead/seeker paired with an existing AGM-114R rocket motor—which is the latest model—to provide improved target acquisition and discrimination (see **Figure 12**).[49] The JAGM has a maximum effective range of 8.6 nautical miles when launched from a helicopter and 15.1 nautical miles when launched from fixed-wing aircraft.

JAGM underwent testing starting in 2010, and the missile entered initial operating capability in 2019, having been successfully integrated on the AH-64E Apache and AH-1Z Super Cobra attack helicopters. JAGM is expected to be integrated on other platforms as well, including the FA-18E/F Super Hornet, MQ-1C Grey Eagle, MH-60M Defensive Air Penetrator, MH-60S Seahawk, F-35 Lightning II, and P-8 Poseidon.[50] In addition, the Air Force has begun procuring JAGMs but has not announced publicly what platforms will employ the missile.

Figure 12. Diagram of an AGM-169 JAGM

Source: https://janes.ihs.com/Janes/Display/jalw9220-jalw.

Note: The JAGM's design integrates a new seeker onto the AGM-114R Hellfire II missile body (Lockheed Martin).

[49] IHS Janes "Joint Air-to-Ground Missile (JAGM)," April 11, 2019, at https://janes.ihs.com/Janes/Display/jalw9220-jalw.

[50] IHS Janes "Joint Air-to-Ground Missile (JAGM)," April 11, 2019, at https://janes.ihs.com/Janes/Display/jalw9220-jalw.

Table 4. AGM-169 JAGM Requested and Programmed Procurement in the FYDP

	FY2021	FY2022[a]	FY2023[b]	FY2024[b]	FY2025[b]	FY2026[b]	Grand Total
Cost ($millions)	$240.20	$201.88	—	—	—	—	$442.07
Quantity	687	550	—	—	—	—	1,237

Source: U.S. Army FY2022 Missiles Procurement Line Item 2605C70302 Joint Air-to-Ground MSLS (JAGM); U.S. Air Force FY2022 Missile Procurement Line Item JAGM00 Joint Air-to-Ground Munition; and U.S. Navy FY2022 Weapons Procurement Line Item 2248 Joint Air Ground Missile (JAGM).

a. Denotes the Administration's request.

b. Denotes programmed funding and quantities.

AGM-158A/B Joint Air-to-Surface Strike Missile (JASSM) and AGM-158C Long-Range Anti-Ship Missile (LRASM)

The Joint Air-to-Surface Strike Missile was conceived in the mid-1990s as a stealthy cruise missile designed to strike targets in heavily defended airspace.[51] The JASSM is a 14-foot-long, 2,250-pound missile that can be carried internally on B-1B Lancer and B-52 Stratofortress aircraft and carried externally on a number of tactical fighters, including the F-16 Falcon, F-15E Strike Eagle, F/A-18 Hornet, F/A-18E/F Super Hornet, and F-35 Lightning II (see **Figure 13**).[52] The AGM-158A JASSM has a stated range of more than 200 nautical miles.[53] Initial operating capability was declared in 2005 (see **Figure 14**). AGM-158As have been exported to Australia, Finland, and Poland.[54]

In 2004, the Air Force decided that it required additional range on the JASSM and developed an extended range version, the AGM-158B JASSM-ER.[55] The JASSM-ER uses the same body as the previous version with an improved infrared seeker, a two-way datalink, and enhanced anti-jam GPS receiver.[56] The range of the JASSM-ER increased from more than 200 nautical miles to 500 nautical miles.[57] This munition reached initial operating capability in 2014 on the B-1B Lancer. It reached full operating capability in 2018 with integration onto the F-15E Strike Eagle, and it is in full-rate production.[58] The Air Force originally planned to procure 2,866 JASSMs and JASSM-ERs, but it has since changed the requirement to 7,200 missiles;[59]as of 2019 the Air Force has

[51] U.S. Air Force, "JASSM - The Air Force's Next Generation Cruise Missile," press release, March 6, 2008, https://www.afmc.af.mil/News/Article-Display/Article/155587/jassm-the-air-forces-next-generation-cruise-missile/.

[52] IHS Janes "AGM-158A JASSM and AGM-158B JASSM-ER," July 23, 2019, at https://janes.ihs.com/Janes/Display/jalw3784-jalw.

[53] U.S. Air Force, "JASSM - The Air Force's Next Generation Cruise Missile," press release, March 6, 2008, https://www.afmc.af.mil/News/Article-Display/Article/155587/jassm-the-air-forces-next-generation-cruise-missile/.

[54] IHS Janes "AGM-158A JASSM and AGM-158B JASSM-ER," July 23, 2019, at https://janes.ihs.com/Janes/Display/jalw3784-jalw.

[55] IHS Janes "AGM-158A JASSM and AGM-158B JASSM-ER," July 23, 2019, at https://janes.ihs.com/Janes/Display/jalw3784-jalw.

[56] IHS Janes "AGM-158A JASSM and AGM-158B JASSM-ER," July 23, 2019, at https://janes.ihs.com/Janes/Display/jalw3784-jalw.

[57] U.S. Air Force, "JASSM - The Air Force's Next Generation Cruise Missile," press release, March 6, 2008, https://www.afmc.af.mil/News/Article-Display/Article/155587/jassm-the-air-forces-next-generation-cruise-missile/.

[58] IHS Janes "AGM-158A JASSM and AGM-158B JASSM-ER," July 23, 2019, at https://janes.ihs.com/Janes/Display/jalw3784-jalw.

[59] Department of Defense, "Comprehensive Selected Acquisition Reports for the Annual 2018 Reporting Requirements

procured more than 4,000 JASSMs. Japan has expressed interest in procuring JASSM-ERs, and Poland was approved to receive 70 missiles in 2016.[60] The Air Force announced plans in September 2019 to increase JASSM production to a maximum rate of 550 missiles per year.[61] The Service intends to grow the total JASSM inventory to approximately 10,000 missiles. In February 2020, the Air Force announced an $818 million contract to produce the latest version of the JASSM-Extreme Range Missile. According to Inside Defense, this new contract will produce 790 JASSM-ER missiles over two production lots.[62] The new production contract includes 40 JASSM missiles to support foreign military sales; however, it is unclear which country will receive these missiles.

The Long Range Anti-Ship Missile (LRASM) was conceived by the Defense Advanced Research Projects Agency (DARPA) as a concept to use a JASSM body to replace the AGM-88 Harpoon.[63] Flight testing for LRASM began in 2012 on board a B-1B, and the missile was tested on an F/A-18E/F Super Hornet. LRASM uses a combination of passive radio-frequency sensors, and electro-optical/infrared seekers for terminal guidance.[64] Japan has expressed interest in procuring the LRASM. In September 2019, the Air Force announced its intent to procure up to 410 LRASM missiles, changing its plan from an original estimate of 110 missiles.[65]

as Updated by the President's Fiscal Year 2020 Budget," press release, August 1, 2019, https://media.defense.gov/2019/Aug/01/2002165676/-1/-1/1/DEPARTMENT-OF-DEFENSE-SELECTED-ACQUISITION-REPORTS-(SARS)-DECEMBER-2018.PDF.

[60] IHS Janes "AGM-158A JASSM and AGM-158B JASSM-ER," July 23, 2019, at https://janes.ihs.com/Janes/Display/jalw3784-jalw.

[61] Sara Sirota, "Air Force reveals plans to grow stockpile of JASSM, LRASM missiles," *Inside Defense*, September 27, 2019, https://insidedefense.com/daily-news/air-force-reveals-plans-grow-stockpile-jassm-lrasm-missiles.

[62] Sara Sirota, "Air Force, Lockheed Martin finalize $818 million JASSM-ER contract," *Inside Defense*, April 1, 2020, https://insidedefense.com/insider/air-force-lockheed-martin-finalize-818-million-jassm-er-contract.

[63] IHS Janes "AGM-158C Long-Range Anti-Ship Missile (LRASM)," July 8, 2019, at https://janes.ihs.com/Janes/Display/jalwa137-jalw.

[64] IHS Janes "AGM-158C Long-Range Anti-Ship Missile (LRASM)," July 8, 2019, at https://janes.ihs.com/Janes/Display/jalwa137-jalw.

[65] Sara Sirota, "Air Force reveals plans to grow stockpile of JASSM, LRASM missiles," *Inside Defense*, September 27, 2019, https://insidedefense.com/daily-news/air-force-reveals-plans-grow-stockpile-jassm-lrasm-missiles.

Figure 13. AGM-158 Attached to an F/A-18D Hornet

Source: https://commons.wikimedia.org/wiki/File:F-18D_Hornet_(HN-466)Tour_de_Sky_2014-08-09_06_JDAM_AGM-154.JPG.

Note: JDAM precision bomb and AGM-154C Joint Standoff Weapon glide bomb under the left wing of Finnish air force F-18D Hornet fighter (HN-466) on ground display at Oulu Airport at Tour de Sky 2014 air show.

Figure 14. JASSM in Flight

Source: https://janes.ihs.com/Janes/Display/jalw3784-jalw.

Note: A JASSM hit its target during 2009 Lot 7 reliability trials (Lockheed Martin).

The JASSM-ER and the LRASM are produced in the same facility.[66] According to budget documents, DOD states that JASSM and LRASM procurement in FY2020 was at maximum production rate; however, since FY2020 it appears that production capacity has increased. The Air Force and Navy are procuring JASSM-ER and LRASM as of 2022.

Table 5. JASSM and LRASM Requested and Programmed Procurement in the FYDP

	FY2021	FY2022[a]	FY2023[b]	FY2024[b]	FY2025[b]	FY2026[b]	**Total**
JASSM Cost ($millions)	$500.01	$747.59	—	—	—	—	$1,247.60
JASSM Quantity	376	550	—	—	—	—	926
LRASM Cost ($millions)	$153.87	$161.21	—	—	—	—	$315.08
LRASM Quantity	48	48	—	—	—	—	96

Source: U.S. Air Force FY2022 Missile Procurement Line Item JASM0 Joint Air-to-Surface Standoff Missile; U.S. Air Force FY2022 Missile Procurement Line Item LRASM0 LRASM0; and U.S. Navy FY2021 Weapons Procurement Line Item 2291 LRASM.

a. Denotes the Administration's request.

b. Denotes programmed funding and quantities.

AGM-88E Advanced Anti-Radiation Guided Missile (AARGM)

The Advanced Anti-Radiation Guided Missile is designed to target enemy integrated air defenses, specifically guidance radars (see **Figure 15**). AARGM was conceived in 2001 to replace the High-Speed Anti-Radiation Missile (HARM). DOD identified several deficiencies in the HARM that limited its operational effectiveness during Operation Iraqi Freedom.[67] Thus, AARGM incorporated a new solid-propellant rocket motor that improved its range over the HARM, along with new guidance and seeker systems—using GPS inertial navigation for guidance and millimeter wave and W-band (higher than 40 GHz) sensors.[68]

AARGM entered operational testing in 2010 and initial operational capability in 2012. AARGM has been integrated on the F/A-18C/D Hornet, F/A-18E/F Super Hornet, E/A-18G Growler, F-16C/D Falcon, and the F-35 Lightning II.

[66] Department of Defense, "FY2020 Program Acquisition Costs by Weapons System," at https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2020/fy2020_Weapons.pdf.

[67] IHS Janes "AGM-88E Advanced Anti-Radiation Guided Missile (AARGM)," July 31, 2019, at https://janes.ihs.com/Janes/Display/jalw3723-jalw.

[68] IHS Janes "AGM-88E Advanced Anti-Radiation Guided Missile (AARGM)," July 31, 2019, at https://janes.ihs.com/Janes/Display/jalw3723-jalw.

Figure 15. Model of an AGM-88E ARRGM

Source: https://commons.wikimedia.org/wiki/File:AGM-88E_AARGM_mockup.jpg.

Table 6 describes the total DOD request for AARGM. AARGM has been exported to a number of countries, including Australia, Italy, Finland, Germany, and Poland.[69]

Table 6. ARRGM Requested and Programmed Procurement in the FYDP

	FY2021	FY2022[a]	FY2023[b]	FY2024[b]	FY2025[b]	FY2026[b]	Grand Total
Cost ($millions)	$123.65	$116.35	—	—	—	—	$240.00
Quantity	16	54	—	—	—	—	70

Source: U.S. Navy FY2022 Weapons Procurement Line Item 2327 HARM Mods.

a. Denotes the Administration's request.

b. Denotes programmed funding and quantities.

Ground-Launched Guided Munitions

Guided Multiple Launch Rocket System (GMLRS)

GMLRS (see **Figure 16**) is a GPS-guided 227-millimeter rocket that was jointly developed by the United States, France, Germany, Italy, and the United Kingdom.[70] Development began in 1999, and the U.S. military began procuring GMLRS in FY2003. GMLRS is capable of being launched

[69] IHS Janes "AGM-88E Advanced Anti-Radiation Guided Missile (AARGM)," July 31, 2019, at https://janes.ihs.com/Janes/Display/jalw3723-jalw.

[70] IHS Janes "227 mm MLRS/GMLRS rockets," April 3, 2019, at https://janes.ihs.com/Janes/Display/jah_1074-jah_.

from the M270 multiple launch rocket system (MLRS) and the M142 High Mobility Artillery Rocket System (HIMARS). GMLRS has a 200-pound unitary warhead and a maximum range of 70 kilometers.[71]

Both the Army and the Marine Corps have procured GMLRS. Since 1998, DOD has spent nearly $5.4 billion to procure more than 42,000 rockets.[72] DOD has requested more than $1.2 billion for approximately 9,900 rockets in FY2020, and it plans to spend an additional $4.3 billion for nearly 29,000 GMLRS between FY2021 and FY2024. In addition, GMLRS is being exported: Bahrain, United Arab Emirates, Poland, and Romania are procuring GMLRS, as are the development partners (France, Germany, Italy, and the United Kingdom).[73] See **Table 7** for an overview of the current DOD request for GMLRS.

Figure 16. GMLRS Launching

Source: https://www.lockheedmartin.com/en-us/products/guided-mlrs-unitary-rocket.html.

Table 7. GMLRS Requested and Programmed Procurement in the FYDP

	FY2021	FY2022[a]	FY2023[b]	FY2024[b]	FY2025[b]	FY2026[b]	Grand Total
Cost ($millions)	$1,064.14	$1,034.22	—	—	—	—	$2,098.36
Quantity	6,524	6,471	—	—	—	—	12,995

Source: U.S. Army FY2022 Missile Procurement Line Item 6005C64400 Guided MLRS Rocket (GMLRS) and U.S. Navy FY2022 Procurement, Marine Corps Line Item 3025 Guided MLRS Rocket (GMLRS).

a. Denotes the Administration's request.

b. Denotes programmed funding and quantities.

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71 IHS Janes "227 mm MLRS/GMLRS rockets," April 3, 2019, at https://janes.ihs.com/Janes/Display/jah_1074-jah_.

72 See Department of Defense Budget FY2000-2020 P-1 Procurement budget requests, at https://comptroller.defense.gov/Budget-Materials/.

73 IHS Janes "227 mm MLRS/GMLRS rockets," April 3, 2019, at https://janes.ihs.com/Janes/Display/jah_1074-jah_.

Army Tactical Missile System (ATACMS)

ATACMS (see **Figure 17**) is a 610-millimeter rocket that can be launched from either the M270 MLRS (two rockets) or the M142 HIMARS (a single rocket). This rocket was originally developed in the 1980s and was later updated to provide GPS guidance.[74] ATAMCS underwent a second upgrade in 1991, which allowed ATACMS warheads to seek and attack armored targets.[75] Other upgrades have improved target discrimination and new penetrating warheads for hardened targets. In 2016, then-Secretary of Defense Ash Carter announced that the Strategic Capabilities Office had developed a new seeker that allowed the ATACMS rocket to target ships.[76] The Army has stated that it intends to retire the ATACMS and replace it with the new Precision Strike Missile.

Figure 17. ATACMS Long-Range Precision Tactical Missile System

Source: https://www.lockheedmartin.com/content/dam/lockheed-martin/mfc/pc/army-tacticle-missile-system-block-ia-unitary-atacms/mfc-atacms-block-1a-unitary-pc.pdf.

Table 8. ATACMS Requested and Programmed Procurement in the FYDP

	FY2021	FY2022[a]	FY2023[b]	FY2024[b]	FY2025[b]	FY2026[b]	Grand Total
Cost ($millions)	—	—	—	—	—	—	—
Quantity	—	—	—	—	—	—	—

Source: U.S. Army FY2022 Missile Procurement Line Item 6472C98510 ARMY TACTICAL MSL SYS (ATACMS) – SYS SUS.

a. Denotes the Administration's request.

b. Denotes programmed funding and quantities.

[74] IHS Janes "610 mm Army Tactical Missile System rockets," June 28, 2019, at https://janes.ihs.com/Janes/Display/jah_1090-jah_.

[75] IHS Janes "610 mm Army Tactical Missile System rockets," June 28, 2019, at https://janes.ihs.com/Janes/Display/jah_1090-jah_.

[76] Sydney J. Freedberg Jr., "Carter, Roper Unveil Army's New Ship-Killer Missile: ATACMS Upgrade," *Breaking Defense,* October 28, 2016, at https://breakingdefense.com/2016/10/army-atacms-missile-will-kill-ships-secdef-carter/.

Precision Strike Missile (PrSM)

The PrSM is a new development program intended to replace ATACMS. PrSM is designed to be launched from the M270 and the M142 HIMARS multiple rocket launcher system. The Army states that PrSM is designed to launch two missiles in a launcher pod compared to ATACMS single missile, has a range in excess of 400 kilometers, and has an anti-jam GPS antenna.[77] PrSM is in development and is planned to enter early operational service in FY2023. The Army has not stated when it intends to begin testing the PrSM. The Army states that although this missile might be sold to foreign militaries in the future, there are no purchase commitments from foreign governments as of 2019. The Army tested the PrSM at White Sands, NM, in its first flight test in December 2019.[78] In its second test in March 2019, the Army successfully tested the PrSMs short-range capabilities.

Figure 18. Notional Design of PrSM

Source: https://www.janes.com/article/83990/us-army-s-precision-strike-missile-moves-ahead-as-us-russia-inf-treaty-falters.

Table 9. PrSM Requested and Programmed Procurement

	FY2021	FY2022[a]	FY2023[b]	FY2024[b]	FY2025[b]	FY2026[b]	Grand Total
Cost ($millions)	$49.94	$166.13	—	—	—	—	$216.07
Quantity	30	110	—	—	—	—	140

Source: U.S. Army FY2022 Missile Procurement Line Item 8540C29600 PRECISION STRIKE MISSILE (PRSM).

a. Denotes the Administration's request.

b. Denotes programmed funding and quantities.

[77] U.S. Army Acquisition Support Center "Precision Strike Missile Fact Sheet," at https://asc.army.mil/web/portfolio-item/ms-prsm/.

[78] Sydney Freedberg Jr., "PRSM: Lockheed Long-Range Missile Passes Short-Range Stress Test," *Breaking Defense*, March 19, 2020, https://breakingdefense.com/2020/03/lockheed-long-range-missile-passes-short-range-stress-test/.

Naval Precision-Guided Munitions

Tomahawk Cruise Missile

The Tomahawk cruise missile was originally developed during the early- to mid-1970s. It was designed to be launched by submarines and from surface combatants. Designed to fly at 570 miles per hour (Mach 0.74, or 74% of the speed of sound) for up to 870 nautical miles,[79] the Tomahawk has received a number of upgrades since it entered service. The Tomahawk Block IV is the current cruise missile in production and comes in two versions—one for surface ships and another for submarines (see **Figure 19**). Upgrades have included improvements to GPS guidance, satellite datalink communications, and propulsion.[80] The first operational use of the Tomahawk was during Operation Desert Storm, where the Navy launched 290 missiles from 12 submarines. Since then, IHS Janes reports that the Navy has used more than 1,600 missiles in Iraq, Bosnia, Serbia, Afghanistan, and Syria.[81] The United Kingdom is the only export customer of the Tomahawk Block IV.

Figure 19. Tomahawk Block IV Cruise Missile

Source: https://www.navy.mil/management/photodb/photos/021110-N-0000X-003.jpg.

Notes: "A Tactical 'Tomahawk' Block IV cruise missile conducts a controlled flight test over the Naval Air Systems Command western test range complex in southern California. During the second such test flight, the missile successfully completed a vertical underwater launch, flew a fully guided 780-mile course, and impacted a designated target structure as planned." (U.S. Navy photo.)

[79] IHS Janes "Tomahawk/RGM/UGM-109A/B/C/D/E," September 2, 2019, at https://janes.ihs.com/Janes/Display/jnws0162-jnw_.

[80] IHS Janes "Tomahawk/RGM/UGM-109A/B/C/D/E," September 2, 2019, at https://janes.ihs.com/Janes/Display/jnws0162-jnw_.

[81] IHS Janes "Tomahawk/RGM/UGM-109A/B/C/D/E," September 2, 2019, at https://janes.ihs.com/Janes/Display/jnws0162-jnw_.

From FY1998 through FY2018, the Navy spent $5.87 billion on 4,984 Tomahawk cruise missiles.[82] (See **Table 10** for the most recent Tomahawk request.)

Table 10. Tomahawk Missile Requested and Programmed Procurement in the FYDP

	FY2021	FY2022[a]	FY2023[b]	FY2024[b]	FY2025[b]	FY2026[b]	Grand Total
Cost ($millions)	$224.69	$124.51	—	—	—	—	$349.20
Quantity	122	60	—	—	—	—	182

Source: U.S. Navy FY2022 Weapons Procurement Line Item 2101 Tomahawk.

a. Denotes the Administration's request.

b. Denotes programmed funding and quantities.

Standard Missile-6 (SM-6)

The Standard Missile-6 was originally designed in 2004 as an anti-aircraft missile, derived from the Navy's SM-2 Block IV (see **Figure 20**).[83] Since its development, the SM-6 has been integrated into the Navy's Naval Integrated Fires-Counter Air (NIF-CA) program to strike enemy surface ships. The missile was designed to receive targeting information from AEGIS radars and has been upgraded to receive target information from the E-2D Advanced Hawkeye. In addition to anti-air and anti-surface missions, the SM-6 is also capable of performing anti-ballistic missile missions.[84] SM-6 entered low-rate initial production in FY2009 and full rate production in FY2013.[85]

The SM-6 is funded under the Navy's procurement line item 2234 Standard Missile.[86] **Table 11** provides an overview of the current DOD request for SM-6 missiles. The FY2022 request concludes a multiyear procurement for SM-6; the Navy intends to submit a legislative proposal to pursue a multiyear procurement for FY2024-FY2026.[87]

Table 11. SM-6 Requested and Programmed Procurement in the FYDP

	FY2021	FY2022[a]	FY2023[b]	FY2024[b]	FY2025[b]	FY2026[b]	Grand Total
Cost ($millions)	$506.25	$605.33	—	—	—	—	**$1,111.58**
Quantity	125	125	—	—	—	—	**250**

Source: U.S. Navy FY2022 Weapons Procurement Line Item 2234 Standard Missile.

a. Denotes the Administration's request.

b. Denotes programmed funding and quantities.

[82] See Department of Defense Budget FY2000-2020 P-1 Procurement budget requests, at https://comptroller.defense.gov/Budget-Materials/.

[83] IHS Janes "Stand Missile-6 (SM-6)/Extended Range Active Missile ERAM)," April 3, 2019, at https://janes.ihs.com/Janes/Display/jnw_0076-jnw_.

[84] Raytheon, "One missile, many missions: SM-6 Missile Gives Surface Forces More Power in More Places," press release, January 9, 2019, https://www.raytheon.com/news/feature/sm-6_anti-surface_warfare.

[85] U.S. Navy FY2014 Weapons Procurement Line Item 2234 Standard Missile, at https://apps.dtic.mil/procurement/Y2014/Navy/stamped/P40_2234_BSA-2_BA-2_APP-1507N_PB_2014.pdf.

[86] U.S. Navy FY2022 Weapons Procurement Line Item 2234 Standard Missile.

[87] U.S. Navy FY2022 Weapons Procurement Line Item 2234 Standard Missile.

Figure 20. SM-6 Launching from a Ship

Source: https://www.raytheon.com/news/feature/sm-6_anti-surface_warfare.

Naval Strike Missile (NSM)

The Naval Strike Missile was originally developed by the Norwegian company Kongsberg as a replacement for the Penguin anti-ship missile (see **Figure 21** and **Figure 22**).[88] This missile is an anti-ship, low-observable cruise missile capable of flying close the surface of the ocean to avoid radar detection. IHS Janes states that "[t]he NSM airframe materials and missile shape are intended to minimise its infrared (IR) and radar signatures and radar cross section."[89] The NSM is designed to fly multiple flight profiles—different altitudes and speeds—with effective ranges of between 100 and 300 nautical miles at a cruise speed of up to 0.9 Mach. The Navy has integrated the NSM on its Littoral Combat Ship, which deployed into the Pacific region in September 2019.[90]

The Navy began procuring the NSM in FY2019. In FY2022, the Navy requested funding for 34 missiles; the Marine Corps as requested additional NSMs in its unfunded priority list.

88 IHS Janes "Naval Strike Missile (NSM)," May, 21, 2019, at https://janes.ihs.com/Janes/Display/jnws0911-jnw_.

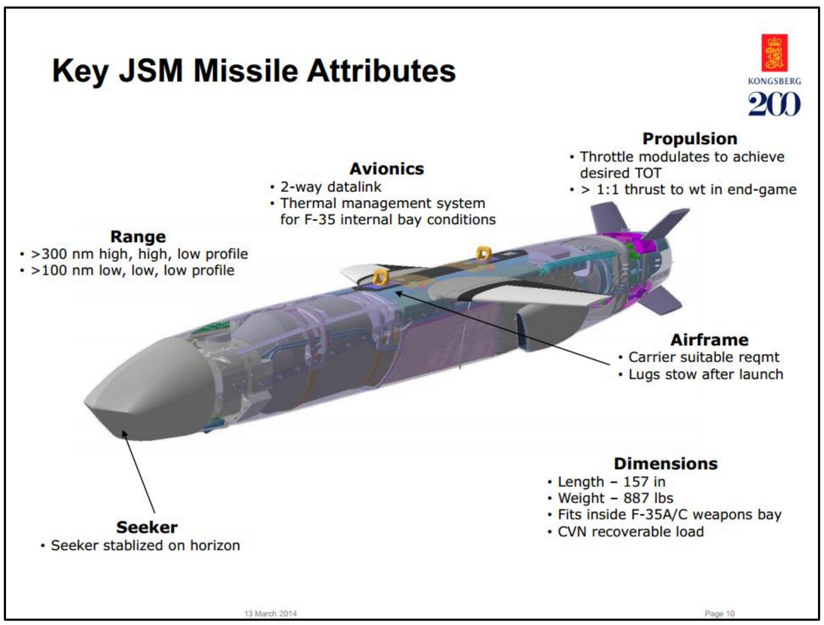
89 IHS Janes "Naval Strike Missile (NSM)," May, 21, 2019, at https://janes.ihs.com/Janes/Display/jnws0911-jnw_.

90 David B. Larter, "US Navy deploys new ship-killer missile to China's backyard," *Defense News,* September 5, 2019, at https://www.defensenews.com/naval/2019/09/06/the-us-navy-just-deployed-its-new-ship-killer-missile-to-chinas-backyard/.

Figure 21. Naval Strike Missile in Flight

Source: https://www.kongsberg.com/news-and-media/news-archive/2019/raytheon-providing-us-marines-with-naval-strike-missile/.

Figure 22. Illustration of Naval Strike Missile with Attributes



Source: https://www.quora.com/Is-it-possible-to-have-a-stealthy-hypersonic-scramjet-or-does-the-geometry-of-the-air-intake-have-a-high-radar-cross-section.

Table 12. Naval Strike Missile Requested and Programmed Procurement in the FYDP

	FY2021	FY2022[a]	FY2023[b]	FY2024[b]	FY2025[b]	FY2026[b]	**Grand Total**
Cost ($millions)	$31.16	$59.33	—	—	—	—	$90.49
Quantity	15	34	—	—	—	—	49

Source: U.S. Navy FY2022 Weapons Procurement Line Item 2292 Naval Strike Missile (NSM).

a. Denotes the Administration's request.

b. Denotes programmed funding and quantities.

Potential Issues for Congress

- **Planned procurement quantities and stockpile assessment.** One potential issue for Congress is whether DOD's desired quantities of standoff munitions are appropriate. Current operations have demonstrated a large demand for all types of PGMs. A potential high-intensity conflict would potentially require large stockpiles of all types of weapons.[91] Several of these types of munitions—particularly JASSM, LRASM, and AARGM—are being procured in relatively small quantities, given their potential use rates in a high-intensity conflict scenario, along with the time it would take for replacement spent munitions once initial inventories are exhausted. A related issue is whether DOD has adequately assessed the sufficiency of existing and planned PGM stockpiles, particularly in light of recent use rates for such weapons. Congress has from time to time required DOD to assess munitions requirements, as well as to report on combatant command munitions requirements. More recently, Congress required DOD to provide an annual report on the munitions inventory, along with an unconstrained assessment of munitions requirements.[92]
- **Defense industrial base production capacity.** Another potential issue for Congress concerns the defense industrial base's capacity for building PGMs, particularly for meeting increased demands for such weapons during an extended-duration, high-intensity conflict. The question is part of a larger issue of whether various parts of the U.S. defense industrial base are adequate, in an era of renewed great power competition, to meet potential wartime mobilization demands.[93]
- **Supply chain security.** Another potential issue for Congress concerns supply chain security, meaning whether U.S. PGMs incorporate components, materials, or software of foreign origin. Supply chain security could affect wartime reliability of these weapons as well as the ability of the U.S. industrial base to build replacement PGMs in a timely manner during an extended-duration, high-intensity conflict.
- **Development timelines.** Congress may be concerned about the development timeline of PGMs compared with development timelines of adversary A2/AD capabilities. China and Russia have developed sophisticated systems over the past 10 years, while DOD has developed relatively few systems. Some analysts argue that these systems can exceed DOD munitions capabilities (such as range

[91] Gary Roughead, Eric Edelman, et al., *Providing for the Common Defense*, National Defense Strategy Commission, The Assessment and Recommendations of the National Defense Strategy Commission, 2018, https://www.usip.org/sites/default/files/2018-11/providing-for-the-common-defense.pdf.

[92] See P.L. 115-232 §1061 and §1067.

[93] For more information, see CRS Report R43838, *Renewed Great Power Competition: Implications for Defense—Issues for Congress*, by Ronald O'Rourke.

and speed).[94] Can and, if so, should DOD develop new systems and at a pace that can match or exceed that of Chinese or Russian weapons systems?

- **Affordability and cost-effectiveness.** Congress may also be concerned about the affordability of DOD's plans for procuring various PGMs in large numbers, and the cost-effectiveness of PGMs relative to other potential means of accomplishing certain DOD missions, particularly in a context of finite DOD resources and competing DOD program priorities. Another aspect of cost-effectiveness concerns the cost of the weapon compared to the cost of a target. For instance, in 2017 a U.S. ally used a $3 million Patriot missile to engage a $300 quadcopter drone.[95]
- **Emerging factors that may affect PGM programs.** Another potential issue for Congress is how DOD's programs for developing and procuring PGMs might be affected by emerging factors such as
  - the U.S. withdrawal from the Intermediate Nuclear Force (INF) treaty;[96]
  - new U.S. military operational concepts for countering Chinese A2/AD forces in the Indo-Pacific region, such as the Army's new Multi-Domain Operations (MDO) operational concept and the Marine Corps' new Expeditionary Advanced Base Operations (EABO) concept, both of which possibly feature the potential use of such weapons from island locations in the Pacific as a way of countering China's A2/AD forces; and
  - emerging technologies such as hypersonics and artificial intelligence (AI).[97]

[94] Gary Roughead, Eric Edelman, et al., *Providing for the Common Defense*, National Defense Strategy Commission, The Assessment and Recommendations of the National Defense Strategy Commission, 2018, https://www.usip.org/sites/default/files/2018-11/providing-for-the-common-defense.pdf.

[95] Chris Baraniuk, "Small drone 'shot with Patriot missile,'" *BBC*, March 15, 2017, at https://www.bbc.com/news/technology-39277940.

[96] For more information on the INF treaty and its implications for U.S. policy, see CRS Report R43832, *Russian Compliance with the Intermediate Range Nuclear Forces (INF) Treaty: Background and Issues for Congress*, by Amy F. Woolf.

[97] For more information on each of these technologies, see CRS Report R45811, *Hypersonic Weapons: Background and Issues for Congress*, by Kelley M. Sayler, and CRS Report R45178, *Artificial Intelligence and National Security*, by Kelley M. Sayler.

Appendix A. Prior Year Procurement by Service

Table A-1. PGM Procurement Cost and Quantities, by Service (FY1998-FY2009)

Service		FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
Army	Nominal Cost ($m)	$330.40	$398.90	$384.70	$377.80	$273.30	$449.20	$189.30	$377.80	$304.70	$201.30	$601.08	$562.33
	Constant Cost ($m FY2021)	$499.09	$594.22	$564.66	$546.27	$388.54	$625.28	$256.99	$499.74	$393.67	$255.00	$749.66	$691.42
	Quantity	1,209	2,096	2,310	2,300	2,224	978	846	1,110	1,082	943	5,004	5,597
Air Force	Nominal Cost ($m)	$48.60	$79.50	$189.20	$203.70	$343.70	$543.70	$540.00	$717.00	$413.40	$609.40	$438.81	$551.44
	Constant Cost ($m FY2021)	$73.41	$118.43	$277.70	$294.53	$488.63	$756.82	$733.10	$948.41	$534.11	$771.98	$547.28	$678.03
	Quantity	1,655	3,778	8,436	8,904	14,468	23,577	20,584	23,633	9,248	11,301	6,588	10,048
Navy	Nominal Cost ($m)	$71.20	$538.60	$148.20	$182.10	$405.40	$798.80	$674.20	$491.10	$547.70	$600.70	$606.56	$447.86
	Constant Cost ($m FY2021)	$107.55	$802.32	$217.53	$263.30	$576.34	$1,111.92	$915.29	$649.60	$707.62	$760.96	$756.49	$550.66
	Quantity	547	1,475	2,153	2,625	14,608	12,750	12,893	7,928	4,830	4,790	2,899	1,752

Source: Department of Defense Budget FY2000-2021 P-1 Procurement budget requests, at https://comptroller.defense.gov/Budget-Materials/, Department of Defense National Defense Budget Estimate for FY2021 pp. 60-61, at https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2021/FY21_Green_Book.pdf, Air Force FY2021 Missile procurement budget justifications; Army FY2021 Missile procurement budget justifications; Navy FY2021 Weapons procurement budget justifications.

Table A-2. PGM Procurement Cost and Quantities, by Service (FY2010-FY2021)

Service		FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021*
Army	Nominal Cost ($m)	$580.41	$486.71	$442.13	$240.23	$382.52	$163.73	$365.12	$968.50	$1,639.33	$1,425.64	$2,102.03	$1,568.00
	Constant Cost ($m FY2021)	$702.68	$579.62	$518.57	$277.86	$436.16	$183.89	$402.96	$1,048.28	$1,739.35	$1,483.19	$2,144.06	$1,568.00
	Quantity	5,393	4,065	4,101	1,741	2,511	1,030	2,249	8,211	12,660	10,423	13,839	10,493
Air Force	Nominal Cost ($m)	$471.19	$748.58	$484.97	$433.86	$587.13	$968.54	$1,792.59	$1,611.86	$2,243.54	$2,155.82	$2,283.85	$1,523.11
	Constant Cost ($m FY2021)	$570.44	$891.49	$568.82	$501.81	$669.47	$1,087.76	$1,978.35	$1,744.63	$2,380.42	$2,242.84	$2,329.51	$1,523.11
	Quantity	11,386	16,955	5,440	5,194	11,226	12,612	32,568	35,701	48,111	40,608	37,542	25,317
Navy	Nominal Cost ($m)	$435.01	$775.85	$410.87	$463.72	$428.87	$423.95	$323.11	$562.42	$676.27	$713.27	$916.29	$992.15
	Constant Cost ($m FY2021)	$526.65	$923.96	$481.90	$536.34	$489.01	$476.13	$356.60	$608.75	$717.52	$742.07	$934.61	$992.15
	Quantity	1,573	1,020	694	1,095	404	243	149	409	8,092	9,631	4,686	5,527

Source: Department of Defense Budget FY2000-2021 P-1 Procurement budget requests, at https://comptroller.defense.gov/Budget-Materials/, Department of Defense National Defense Budget Estimate for FY2021 pp. 60-61, at https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2021/FY21_Green_Book.pdf, Air Force FY2021 Missile procurement budget justifications; Army FY2021 Missile procurement budget justifications; Navy FY2021 Weapons procurement budget justifications.

Appendix B. Prior Year Procurement by Program

Table B-1. PGM Procurement Cost and Quantities, by Program (FY1998-FY2009)

Program		FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
ARRGM	Nominal Cost ($m)	—	—	—	$89.10	$4.90	$3.90	—	—	—	—	—	$41.02
	Constant Cost ($m FY2021)	—	—	—	$128.83	$6.97	$5.43	—	—	—	—	—	$50.44
	Quantity	0	0	0	270	0	0	0	0	0	0	0	0
ATACMS	Nominal Cost ($m)	$89.80	$90.60	$90.80	$95.10	$35.00	$137.50	$57.60	$160.80	$104.10	$76.30	$84.78	—
	Constant Cost ($m FY2021)	$135.65	$134.96	$133.27	$137.51	$49.76	$191.40	$78.20	$212.70	$134.50	$96.66	$105.74	—
	Quantity	109	96	110	100	24	156	60	156	98	18	84	0
GMLRS	Nominal Cost ($m)	—	—	—	—	—	$130.50	$106.80	$111.30	$121.60	$125.00	$263.71	$309.21
	Constant Cost ($m FY2021)	—	—	—	—	—	$181.65	$144.99	$147.22	$157.11	$158.35	$328.90	$380.19
	Quantity	0	0	0	0	0	822	786	954	984	925	2070	2652
Hellfire	Nominal Cost ($m)	$260.40	$308.30	$313.80	$282.70	$238.30	$191.10	$46.10	$202.80	$210.10	$244.50	$387.89	$483.52
	Constant Cost ($m FY2021)	$393.35	$459.26	$460.59	$408.76	$338.78	$266.01	$62.58	$268.25	$271.45	$309.73	$483.78	$594.52
	Quantity	1100	2000	2425	2200	2200	137	172	1020	1423	2958	4611	5584
JAGM	Nominal Cost ($m)	—	—	—	—	—	—	—	—	—	—	—	—
	Constant Cost ($m FY2021)	—	—	—	—	—	—	—	—	—	—	—	—
	Quantity	0	0	0	0	0	0	0	0	0	0	0	0
JASSM	Nominal Cost ($m)	—	—	—	$0.20	$42.70	$53.80	$100.90	$139.20	$98.70	$156.50	$160.04	$139.70
	Constant Cost ($m FY2021)	—	—	—	$0.29	$60.71	$74.89	$136.98	$184.13	$127.52	$198.25	$199.60	$171.77

Program		FY1998	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
	Quantity	0	0	0	0	76	100	240	288	75	163	111	100
JDAM	Nominal Cost ($m)	$64.30	$117.30	$270.40	$272.70	$602.80	$752.30	$689.40	$665.50	$306.10	$280.70	$167.10	$175.09
	Constant Cost ($m FY2021)	$97.13	$174.74	$396.89	$394.30	$856.98	$1,047.19	$935.92	$880.29	$395.48	$355.59	$208.41	$215.28
	Quantity	2202	4523	10300	11229	28945	35620	32666	29756	11605	10585	5724	6242
LRASM	Nominal Cost ($m)	—	—	—	—	—	—	—	—	—	—	—	—
	Constant Cost ($m FY2021)	—	—	—	—	—	—	—	—	—	—	—	—
	Quantity	0	0	0	0	0	0	0	0	0	0	0	0
SDB	Nominal Cost ($m)	—	—	—	—	—	—	—	$29.10	$52.20	$114.70	$94.65	$132.82
	Constant Cost ($m FY2021)	—	—	—	—	—	—	—	$38.49	$67.44	$145.30	$118.05	$163.31
	Quantity	0	0	0	0	0	0	0	199	567	2030	1395	2612
SDB II	Nominal Cost ($m)	—	—	—	—	—	—	—	—	—	—	—	—
	Constant Cost ($m FY2021)	—	—	—	—	—	—	—	—	—	—	—	—
	Quantity	0	0	0	0	0	0	0	0	0	0	0	0
Tomahawk	Nominal Cost ($m)	$26.30	$439.20	—	—	$73.00	$437.10	$352.00	$277.20	$373.00	$353.00	$475.83	$280.27
	Constant Cost ($m FY2021)	$39.73	$654.25	—	—	$103.78	$608.44	$477.87	$366.67	$481.91	$447.18	$593.45	$344.60
	Quantity	0	624	0	0	25	350	322	298	408	355	496	207

Source: Department of Defense Budget FY2000-2021 P-1 Procurement budget requests, at https://comptroller.defense.gov/Budget-Materials/, Department of Defense National Defense Budget Estimate for FY2021 pp. 60-61, at https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2021/FY21_Green_Book.pdf, Air Force FY2021 Missile procurement budget justifications; Army FY2021 Missile procurement budget justifications; Navy FY2021 Weapons procurement budget justifications.

Table B-2. PGM Procurement Cost and Quantities, by Program (FY2010-FY2021)

Program		FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021*
ARRGM	Nominal Cost ($m)	$47.83	$51.91	$76.56	$83.89	$94.06	$106.49	$120.80	$180.05	$183.37	$179.89	$183.74	$147.57
	Constant Cost ($m FY2021)	$57.90	$61.82	$89.80	$97.02	$107.25	$119.60	$133.32	$194.88	$194.55	$187.15	$187.41	$147.57
	Quantity	33	44	72	0	0	0	0	0	0	0	0	24
ATACMS	Nominal Cost ($m)	—	—	—	—	$35.60	—	—	—	—	—	$300.78	—
	Constant Cost ($m FY2021)	—	—	—	—	$40.59	—	—	—	—	—	$306.80	—
	Quantity	0	0	0	0	24	0	0	0		0	232	0
GMLRS	Nominal Cost ($m)	$353.31	$264.55	$333.17	$214.29	$273.03	$127.15	$251.06	$408.84	$1,027.97	$975.51	$1,221.17	$1,128.32
	Constant Cost ($m FY2021)	$427.74	$315.05	$390.77	$247.85	$311.32	$142.80	$277.08	$442.52	$1,090.68	$1,014.88	$1,245.58	$1,128.32
	Quantity	3228	2592	3194	1608	2166	768	1866	3360	6528	7668	8523	7360
Hellfire	Nominal Cost ($m)	$422.45	$439.99	$221.42	$146.08	$166.17	$395.94	$784.04	$681.68	$821.05	$460.97	$726.71	$516.61
	Constant Cost ($m FY2021)	$511.44	$523.99	$259.70	$168.96	$189.47	$444.67	$865.29	$737.83	$871.14	$479.58	$741.23	$516.61
	Quantity	4684	2970	2162	1315	1143	3405	6639	6797	10501	5161	8790	8150
JAGM	Nominal Cost ($m)	—	—	—	—	—	—	$27.74	$83.83	$182.22	$280.57	$285.02	$262.78
	Constant Cost ($m FY2021)	—	—	—	—	—	—	$30.61	$90.74	$193.34	$291.90	$290.72	$262.78
	Quantity	0	0	0	0	0	0	0	469	899	796	854	860
JASSM	Nominal Cost ($m)	$52.52	$168.23	$236.19	$230.19	$271.15	$329.16	$425.58	$431.65	$433.12	$602.83	$483.43	$505.95
	Constant Cost ($m FY2021)	$63.58	$200.35	$277.03	$266.24	$309.18	$369.67	$469.68	$467.20	$459.54	$627.16	$493.09	$505.95
	Quantity	0	171	202	233	187	240	340	360	360	360	390	400

Program		FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021*
JDAM	Nominal Cost ($m)	$192.32	$346.38	$127.25	$144.61	$250.47	$228.44	$533.98	$682.11	$1,149.39	$1,103.57	$1,039.47	$524.87
	Constant Cost ($m FY2021)	$232.83	$412.50	$149.25	$167.26	$285.60	$256.56	$589.31	$738.30	$1,219.51	$1,148.11	$1,060.25	$524.87
	Quantity	7517	13061	4259	4678	10415	8786	22478	28596	42864	39614	28388	20338
LRASM	Nominal Cost ($m)	—	—	—	—	—	—	—	$125.75	$169.46	$174.18	$72.54	$188.65
	Constant Cost ($m FY2021)	—	—	—	—	—	—	—	$136.11	$179.80	$181.21	$73.99	$188.65
	Quantity	0	0	0	0	0	0	0	36	50	52	17	53
SDB	Nominal Cost ($m)	$141.69	$119.22	$20.14	$1.97	—	$51.30	$135.12	$251.36	$384.25	$209.33	$273.29	$95.83
	Constant Cost ($m FY2021)	$171.54	$141.98	$23.62	$2.28	—	$57.61	$149.12	$272.07	$407.69	$217.78	$278.75	$95.83
	Quantity	2694	2785	150	0	0	443	3494	4507	7471	5743	7078	2462
SDB II	Nominal Cost ($m)	—	—	—	—	—	—	—	—	$20.97	$189.63	$291.73	$352.14
	Constant Cost ($m FY2021)	—	—	—	—	—	—	—	—	$22.25	$197.29	$297.56	$352.14
	Quantity	0	0	0	0	0	0	0	0	90	1260	1687	1490
Tomahawk	Nominal Cost ($m)	$276.50	$596.67	$297.61	$293.58	$307.46	$317.46	$202.31	$297.51	$187.35	$98.57	$386.16	$277.69
	Constant Cost ($m FY2021)	$334.74	$710.58	$349.06	$339.56	$350.58	$356.53	$223.28	$322.01	$198.78	$102.55	$393.88	$277.69
	Quantity	196	417	196	196	206	243	149	196	100	0	90	155

Source: Department of Defense Budget FY2000-2021 P-1 Procurement budget requests, at https://comptroller.defense.gov/Budget-Materials/, Department of Defense National Defense Budget Estimate for FY2021 pp. 60-61, at https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2021/FY21_Green_Book.pdf,, Air Force FY2021 Missile procurement budget justifications; Army FY2021 Missile procurement budget justifications; Navy FY2021 Weapons procurement budget justifications.

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