Making sense of ballistic missile defense pdf

heritage.org A review of US military force November 17, 2020 42 min read USS Shiloh (CG 67) launches a standard missile (SM) 2nd PHILIPPINE SEA (MARCH 19, 2020). The Navy, Mass Communication Specialist 2nd Class Arciaga Missile defense is a critical part of the national security architecture that enables U.S. military efforts and can protect national critical infrastructure, from population and industrial centers to politically and historically important sites. It can bolster U.S. diplomatic and deterrence efforts and provide both time and opportunity to senior policymakers amid crises involving missiles flying on both ballistic and non-ballistic trajectories (e.g. cruise missiles and hypersonic weapons). Growing Missile Threat Missiles remain a weapon of choice for many U.S. adversaries because they have important capabilities such as extraordinarily high speed (which the U.S. has a limited ability to defend) and relative cost efficiency compared to other types of conventional attack weapons.1 The number of states whose missiles will continue to increase, as will the sophistication of these weapons , as modern technology becomes cheaper and more widely available. Despite US diplomatic efforts, North Korea continues its aggressive development of a nuclear ICBM program that will allow it to strike the United States. It has also recently tested ground-based and sea-based ballistic missiles. Iran continues to modernize and spread its regional missile systems. Its recent successful missile launch shows that Iran has the ability to build and fire sophisticated missiles, which implies that it either has or develops the knowledge to move on to the ICBM level of capability.2 According to Dr. Robert Soofer, Assistant Assistant Secretary of Defense for Nuclear and Missile Defense Policy: As adversary missile technology matures and spreads, the threat to the U.S. homeland , allies, partners and our forces in the field are becoming increasingly dynamic and difficult to predict. While traditional fixed and mobile ballistic missile threats continue to grow, opponents are also investing in ground, air and sea launched cruise missiles with different areas. China and Russia are also developing and testing hypersonic missile technology, with Russia recently deploying the world's first operational intercontinental hypersonic glide vehicle (HGV). These missile technologies are incorporated into adversary strategies intended to force and intimidate the United States and its allies by threatening critical targets in our home countries.3 An additional concern is ballistic missile cooperation between state and non-state actors, which further spread sophisticated technologies and compounds to U.S. defense planning.4 The strategic role of missile defense because they are designed to defeat incoming missile attacks , missile defense systems can save lives and protect civilian infrastructure from harm or More importantly, missile defense plays a critical role in strategic deterrence. The ability to deter an enemy from attacking depends on convincing him that his attack will fail, that the cost of carrying out a successful attack is prohibitively high, or that the consequences of an attack will be so painful that they will outweigh the perceived advantage of attacking. A U.S. missile defense system strengthens the deterrence by offering a degree of protection to the American people and the economic base on which their well-being depends, as well as forward-deployed troops and allies, making it harder for an adversary to threaten them with ballistic missiles. Raising the threshold for missile strikes limits missile defenses to a cheap shot against the United States. A missile defense system also gives a decision-maker a significant political advantage: By protecting key elements of American well-being, it reduces an adversary's ability to intimidate the United States into admitting important security, diplomatic or economic interests. Missile defense systems also enable U.S. and allied conventional operations. Opponents want to deny the United States the ability to conduct offensive operations during a regional conflict, which they can try to do by targeting the United States and allies forward deployed personnel or military assets. In addition, they may try to disconnect the United States from the defense of its allies by threatening to strike the U.S. homeland or forces abroad if the United States intervenes in a regional conflict. Missile defense in place makes it easier for the US military to introduce reinforcements that can move more freely through a region and can therefore strengthen the credibility of the US-wide deterred deterrence. Finally, a missile defense system gives policymakers more time to choose the most de-escalating course of action. Without the ability to defend against an attack, Us authorities would be limited to a small set of responses that could range from preventively attacking an adversary to attacking their ballistic missiles on launch pads or even admitting his claims or actions. With a missile defense system, however, policymakers would have more options and more time to assess their implications and arrive at the one that best serves U.S. security interests. In other words, missile defense systems can stabilize deeply. The U.S. missile defense system The U.S. Missile Defense System has three critical components: sensors, interceptors and a command and control infrastructure that provides data from sensors to interceptors. Of these, interceptors get much of the public's attention because of their visible and kinetic nature. Various physical components of a ballistic missile defense system are designed with the flight phase where an interception occurs in mind, although some of them - such as the command and control infrastructure or radars - can support in different different of the flight. Interceptors can shoot down an adversarial rocket in the boost, ascent, midcourse, or terminal phase of its flight. Another way to assess ballistic missile defense systems is of the range of an incoming ballistic missile (short-range, medium-range, medium-range or intercontinental range) that an interceptor is designed to shoot down, since the length of the interceptor's flight time determines how much time is available to conduct an interception and where the various components of a defense system must be placed to improve the likelihood of such an interception. With intercontinental ballistic missiles, the United States has about 30 minutes to detect the missile, track it, provide information to the missile defense system, come up with the most optimal firing solution, fire an interceptor and shoot down an incoming missile, ideally with enough time to fire another interceptor if the first attempt fails.5 The time frame is shorter in terms of medium-range and short-range ballistic missiles. Download Map Download Figure Missile Defense can also be framed by the origin of the interceptor launch. Today, American interceptors are launched from the ground or from the sea. Previously, the United States explored concepts for launching interceptors from the air or from space, but only limited efforts have been made since the US withdrawal from the Anti-Ballistic Missile Treaty in 2002.6 There is renewed interest in boost-phase missile defense concepts within the Trump administration, but the fiscal year (FY) 2021 budget submission for the Missile Defense Agency (MDA), a US Department of Defense accused of developing and deploying a layered missile system defense to defend the U.S. , its deployed forces, allies and friends from missile strikes in all phases of the flight, does not include funding to explore space-based or air-based missile interceptors. The current US missile defense system is the result of investments made by successive US administrations. President Ronald Reagan envisioned the program as having a layered ballistic missile defense system, including ballistic missile interceptors in space, that would make nuclear weapons impotent and obsolete. 8 These teams would include boost, ascent, midcourse, and terminal interceptors, including directed energy interceptors, so the U.S. would have more than one opportunity to shoot down an incoming missile. The United States stopped far from that goal, even though the Strategic Defense Initiative program resulted in enormous technological advances and benefits.9 Instead of a comprehensive layered system, the United States has no boost-phase ballistic missile defense systems and is unable to handle the advanced ballistic missile threats from China or Russia. The volatility and inconsistency of priority and funding for ballistic missile defense by successive administrations and Congress – administrations and controlled, controlled by both major political parties – has led to the current system, which is numerically and technologically limited and cannot handle more sophisticated or more numerous long-range ballistic missile attacks. Historically, U.S. policy has been one of protecting the homeland only from a limited ballistic missile attack.10 The National Defense Authorization Act (NDAA) for fiscal year 2017 dropped the word limited that had been a fixture of policy since the National Missile Defense Act of 1999, although it continued to focus on ballistic missiles. The NDAA in 2020 made it a matter of policy to rely on nuclear deterrence to defend against near-peer intercontinental threats and focus on improving missile defenses against rogue states. 11 In the future, as technological trends progress and modern technology become cheaper and more widely available, North Korean or Iranian ballistic missiles can compete, in sophistication if not numbers, those of Russia or China. Therefore, the United States must be aware of how such threats are evolving and change its missile defense position accordingly. In January 2019, the Trump administration published its congressional mandate Missile Defense Review (MDR), a policy statement that would guide the administration's missile defense programs. Mdr addresses the dangerous threat environment that has developed since the last MDR in 2010, and advocates a comprehensive approach to all missile threats that integrate offensive capabilities, active defense and passive defense. It also acknowledges that the United States is no longer vulnerable only to ballistic missiles and recognizes the need to defend against cruise and hypersonic missiles as well.12 For FY 2021, the Trump administration asked for $20.3 billion for missile defeat and defense (MDD), including $9.2 billion for MDA (a $1.2 billion drop from the FY 2020-adopted budget); $7.9 billion in rocket defense capabilities outside the MDA, such as the Space Development Agency (SDA) and the services; and $3.2 billion for missile defeat or left-of-launch activities. 13 Interceptors Interceptors form an important part of the U.S. missile defense system. Various types of interceptors that respond to various missile threats have been underscored over the years, and these choices are reflected in the composition of today's US missile defenses. Ballistic missile interceptors are designed to intercept ballistic missiles in three different phases of the aircraft. The boost phase is from the launch of a rocket from the platform until the engines stop sticking. The mid-course phase is the longest and thus provides a unique opportunity to capture an incoming threat, and depending on other circumstances such as the path of the incoming threat and the quality of US tracking data, even a second shot on it should fail if the first interception attempt fails. The terminal phase is less than one minute long, which occurs as the missile through the atmosphere towards the target, providing a very limited opportunity to intercept a ballistic missile threat. Boost phase interceptors. The United States currently has no ability to shoot down ballistic missiles in its boost phase. Boost phase interception is the most challenging option technologically due to the very short timeframe in which a rocket increases, the missile's extraordinary acceleration speed during this short time window, and the need to have the interceptor near the launch site.14 However, it is also the most advantageous time to strike. A reinforcing ballistic missile is at its only speed compared to other phases; It is therefore not yet able to maneuver elusively and has not yet deployed decoys that complicate targeting and cut off the problem. Previously, the United States pursued several boost-phase programs, including the Airborne Laser, Network Centric Air Defense Element, Kinetic Energy Interceptor and Air Launched Hit-to-Kill missile. Each of these programs was eventually cancelled due to insurmountable technical challenges, unprocessable operating concepts or prohibitive costs. As mentioned in MDR, the Trump administration is considering an option that would incorporate the F-35 initially as a sensor platform and later potentially as an interceptor platform for boost-phase intercepts. However, the current budget does not include funding for MDA development of a boost phase interceptor program. Cut-off machines in the mid-course phase. The United States deploys two systems that can shoot down incoming ballistic missiles in the midfield phase of the flight. This phase provides more predictability about where the missile is headed than is possible in the boost phase, but it also gives the missile time to deploy decoys and countermeasures designed to complicate interception by confusing sensors and radars. The ground-based Midcourse Defense (GMD) system is the only system that can shoot down a long-range ballistic missile heading for the U.S. homeland. It consists of 40 ground-based interceptors (GBIs) in Alaska and four in California. In 2017, Congress approved a White House reprogramming request to increase the number of GBIs from 44 to 64 to keep up with the advancing ballistic missile threat, but this project is yet to be completed.15 At about $70 million each, GBIs are quite expensive - but they are also much cheaper than the damage that would be caused by a successful ballistic missile attack. In March 2019, the MDA conducted a groundbreaking and successful salvo GMD test against an ICBM target in which a GBI intercepted the target and a second intercepted the largest piece of debris from the exploded target.16 To increase the likelihood of an interception, the United States must fire more interceptors at each incoming ballistic missile. Today, because the stock of ballistic missile defense interceptors is limited, the U.S. can shoot down a handful of ballistic missiles that have relatively unsophisticated countermeasures.17 Aegi's defense system is a sea-based part of the US missile defense system. It is designed to deal with the threat of short-range, medium-range (1,000-3,000 kilometers) and medium-range (3,000-5,500 kilometers) ballistic missiles. It uses different versions of the Standard Missile-3 (SM-3) depending on the threat and other considerations such as ship placement and the quality of tracking data. The U.S. Navy plans to increase the number of BMD-compliant ships from 48 by the end of FY 2021 to 65 by the end of FY 2025.18 The increase reflects an increase in demand for these assets. The Aegis Ashore system in Romania and one being deployed to Poland will relieve some of the stress on the fleet because missile defense-capable cruisers and destroyers are multi-missions and are used for other purposes, such as warship operations and even anti-piracy operations, when released from ballistic missile missions by the land-based systems. These Aegis Ashore facilities will help protect Us allies and forces in Europe from the Iranian ballistic missile threat. Two Aegis Ashore batteries were recently sold to Japan to protect US allies and forces in the Indo-Pacific from the North Korean and Chinese threats, but this project has since been suspended.19 In February 2020, the MDA confirmed that it would conduct an ICBM intercept test with the SM-3 Block IIA missile in the third quarter of 2020. The test would be the first ICBM-class intercept attempt for the SM-3 Block IIA missile. 20 Pentagon hopes to use the SM-3 Block IIAs as a base for the GMD system to defend the homeland, with GBIs taking the first shot at an incoming target and SM-3 interceptors taking another shot if GBIs missed.21 Deploying such a surface would require the Pentagon to develop a concept of operations that includes deploying SM-3 interceptors on Aegis ships or Aegis Ashore sites across the United States. Terminal-phase interceptors. The United States currently deploys three terminal phase missile defense systems: Terminal High Altitude Area Defense (THAAD); Patriot Advanced Capability-3 (PAC-3); and Aegis BMD. A THAAD battery is capable of shooting down short-range and medium-range ballistic missiles inside and just outside the atmosphere.22 It consists of a launcher, interceptors, Army Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2) radar, and fire control.23 The system is portable and rapidly deployable. THAAD batteries have been deployed to countries such as Japan, South Korea, Israel and the United Arab Emirates. The United States deployed a THAAD battery to Romania in support of NATO's ballistic missile defenses in the summer of 2019 and this year signed an agreement to deliver THAAD to Saudi Arabia.24 This year's budget also included funding to prove the technologies to enable the expansion of engagement options and coverage areas for THAAD weapon system. 25 PAC-3 is an air defense and short-range ballistic missile defense system. A battery includes a launcher, interceptors, AN/MPQ-53/65 radar, an engagement control station, and diesel-powered generator units. The system is portable, and the United States currently deploys it in several theaters around the world.26 The system is the most mature of the U.S. missile defense systems. The PAC-3's predecessor system, Patriot, played a critical role in allied insurance during the first Gulf War when it was deployed to Israel. The purpose was to secure Israeli citizens by protecting them from Iraqi missiles, thereby reducing pressure on Israel's government to enter the war against Iraq. Thus, the United States sought to prevent Israel from joining the US coalition against Saddam Hussein's forces in Iraq, which would have violated the Arab coalition. Aegi's defense system also provides terminal capability against short-range and medium-range ballistic missiles, air threats and cruise missiles, among other things.27 Assessment: Interceptor strength is difficult to assess because deploying more interceptors to increase capacity or defend more targets would always be better than just relying on the number deployed. To strengthen regional interception capabilities in the Middle East, for example, after the Iranian ballistic missile attack in January 2020 on al-Asad air base, which did not have missile defense, the Pentagon moved a Patriot battery to al-Asad to provide a short-term solution to the Iranian threat.28 Nevertheless, the deployment of more short-range interceptors to more unprotected sites ad infinitum is obviously not sustainable. The budget for FY 2021 includes funding to acquire additional PAC-3, SM-3, and THAAD interceptors, but DOD can also improve the effectiveness of interceptors more creatively.29 For example, the Pentagon is developing a THAAD remote launch capability, which could allow a commander to deploy THAAD interceptors to expand a defended area.30 In addition, the Army recently increased its THAAD battery requirement from seven (the existing number) to 8.31 This eighth THAAD battery was not included in the FY 2021 budget request; Instead, it emerged as the number two priority on the MDA's Unfunded Priorities List.32 In terms of GBI capacity and ability to defend the homeland, Air Force General Terrence J. O'Shaughnessy, commander, US Northern Command (NORTHCOM), recently stated that he retains confidence in the current ground-based interceptor fleet but that it must improve to stay ahead of new threats.33 After a series of North

Korean provocations in 2017, the Trump administration and Congress agreed on the need to expand interceptor capacity from 44 to 64 to keep up with the North Korean growing threat. Twenty new silos are under construction in Alaska, but they will remain empty because DOD does not have enough interceptors available for Them. Existing GBIs carry Exoatmospheric Kill Vehicles (EKVs) to capture the target of kinetic kill technology, but EKVs are no longer manufactured. MDA intended to produce a redesigned kill vehicle (RKV) program to top the 20 new interceptors, but this program was canceled in 2019. MDA instead initiated the Next Generation Interceptor (NGI) program to develop advanced killing vehicles to fill the 20 new silos and replace the 44 existing GBIs, but fielding of NGOs will not begin until 2028. In addition to a delay in capacity, the GMD system will lose the ability as the existing EKVs face aging and obsolete problems. RKV would have begun replacing EKVs as early as 2021, but with NGI not expected until the end of the decade, the 44 deployed interceptors could be at increased risk. In fact, senior defense officials estimate that the problems of North Korean ICBM advancement and aging EVs will converge around 2025.34 General O'Shaughnessy recently expressed his concerns to the Senate Armed Services Committee: I want to make clear that I am deeply concerned about the resulting delay in adding to our ground-based interceptor capability and capacity. As we progress towards a next-generation interceptor (NGI) capability, USNORTHCOM remains responsible for defending the homeland against missile attacks. It is therefore necessary to rapidly develop and field a lower-tier missile defense capability as a supplement to the NGI to intercept current and new missile threats. Given the nature of the ballistic missile threat, I am a strong advocate for bringing a layered capability on board for the warman well before NGI is fielded.35 Another way to improve interceptor capability is by fielding an interceptor as part of the Army's Indirect Fire Protection Capability (IFPC) Increment 2 to defend against short-range missiles, artillery and mortars , as well as cruise missiles, which the United States lacks sufficient defense capability.36 As a system, the IFPC would fill the gap between short-range tactical air defense and ballistic missile defenses such as PAC-3 and THAAD. In response to a congressional demand to field a temporary cruise missile defense capability to counter the growing cruise missile threat, the Army purchased two Iron Dome batteries manufactured by the Israeli company Rafael. While the Iron Dome has defended Israel from short-range attacks, especially on the Israeli border with the Gaza Strip,37, the army has identified problems with the integration of the Iron Dome as part of a lasting IFPC solution.38 The army is working to find the best option for a long-term IFPC solution, but until it finds that option, it will lack a strong capability in the area of cruise missile defense. Overall, the United States has several skilled interceptors, but there is a lot of room for improvement. The Pentagon has viable plans in place to improve the capability of Aegis and PAC-3 assets and to acquire more systems of each, but it must focus on stabilizing the homeland missile defense system especially in the near future. Sensors The sensor component of the U.S. missile defense system is distributed across land, sea and space domains, giving the US and its allies the earliest possible warning of a launch of enemy missiles in addition to missile tracking and discrimination. The sensors do this by detecting the heat generated by a rocket engine, or booster. They can detect a missile launch, acquire and track a missile in flight, and even classify the type of projectile, its speed and the target that the missile is aimed at. The sensors forward this information to the command and control stations that operate interception systems, such as Aegis (primarily a sea-based system) or THAAD (a land-based system). On land, the major sensor installations are the upgraded morning radars (UEWRs), which are concentrated along the North Atlantic and Pacific corridors that present the most direct flight path for a missile aimed at the United States. These include the phased early warning radars based in California, the UK and Greenland scanning objects up to 3,000 miles away.39 These sensors focus on threats that can be detected starting with the missile's boost or launch phase when exhaust gas emissions create a heat path that is relatively easy for sensors to detect and track. 40 A shorter radar (2,000 miles) is based in Shemya, Alaska. Two other locations, one in Cape Cod, Massachusetts, and the other in Clear, Alaska, are being modernized for use in the layered ballistic missile defense system.41 The other land-based sensors are mobile. These AN/TPY-2 sensors can be forwarded for early threat detection or retained closer to their home country to track missiles in the terminal phase.42 Of the Us's 12 AN/TPY-2 systems, five have been forwarded with U.S. allies.43 In March 2017, in cooperation with the Republic of Korea, the Us deployed a THAAD missile system to the Korean Peninsula; in April it was accompanied by an AN / TPY-2. The THAAD deployment was heavily criticized by China for allegedly destabilizing China's nuclear deterrence credibility because the system would be able to improve the United States. early warning, and therefore interception, of any Chinese nuclear missiles and undermining China's second-strike capability.44 But the THAAD system deployed in South Korea for the purpose of intercepting North Korean missiles is not set up in a way that can track or shoot down Chinese ICBMs aimed at the United States, so why China would be so opposed to it is unclear.45 There are two types of sea-based sensors. The first is the sea-based X-band (SBX) radar mounted on an oil drilling platform and can be moved to different parts of the world as threats evolve.46 SBX is used mainly in the Pacific Ocean. The second radar is the SPY-1 radar system mounted on the 84 U.S. Navy vessels equipped with the Aegis Combat System, which means they can provide data that can be used for ballistic missile missions. Of these 84 ships, 40 Are BMD-compliant vessels carrying missile defense interceptors.47 Finally, U.S. missile defense sensors operate in space. Control of the space BMD system is divided between the MDA, the US Space Force, and the SDA. The oldest system contributing to the missile defense mission is the Defense Support Program (DSP) constellation of satellites, which uses infrared sensors to identify heat from booster and missile plumes. The DSP satellite system has been gradually replaced by the space-based infrared radar system (SBIRS) to improve the delivery of missile defense and battlefield intelligence.48 For example, SBIRS can scan a wide area while tracking a specific target, making it a good scanner for observing tactical or short-range ballistic missiles.49 But congressional funding delays have left SBIRS underfunded and has hindered the system's full development and deployment.50 In 2017, congressional funding delays have left SBIRS underfunded and have hindered the system's full development and distribution. Deployment.50 In 2017, congressional funding delays have left SBIRS underfunded and have hindered the system's full development and distribution.50 In 2017, the Air Force decided to end production of SBIRS early and move on to developing its replacement, the next generation of overhead persistent infrared (next generation OPIR) satellites. The first of these satellites, which are designed to be more survivors against cyber and electronic attacks, is scheduled for delivery in 2025.51 MDA also operates the Space Tracking and Surveillance System-Demonstrators (STSS-D) satellite system. Two STSS-D satellites were launched into orbit in 2009 to track ballistic missiles that go out and enter the Earth's atmosphere in the midphase.52 Although they are still considered an experimental system, STSS-D satellites provide operational monitoring and tracking capabilities and have the advantage of a variable waveband infrared system to maximize their capabilities. Data collected by STSS-D has been used in ballistic missile defense tests. From as far back as President Reagan's Strategic Defense Initiative, successive presidential administrations have called for a layer of sensing satellites into space to track a rocket flight from birth to death. From the ultimate high ground, space-based sensors can detect rocket launches from almost anywhere from boost phase to terminal phase, compared to ground-based radars limited in the tracking area.53 In particular, space-based sensors can help track hypersonic vehicles, flying at lower altitudes than ballistic missiles and can maneuver under their orbits. Since many new threats do not fly on ballistic trajectories, the Trump administration has placed great emphasis on developing this space sensor layer as approved by MDR. In FY 2020 gave a little more than $140.5 million to MDA to develop the Hypersonic and Ballistic Tracking Space Sensor (HBTSS) to meet this need.54 This year, the President asked for $99.6 million for the SDA SDA integrating the MDA HBTSS payload into a future architecture of sensing and tracking satellites scattered in Low Earth Orbit (LEO).55 Assessment: Senior defense leaders have repeatedly stated that the main way to promote sensor capability is to deploy sensor satellites to space to track rockets throughout the flight from the high ground. Today's deployed radars and sensors are both vulnerable to counterattacks and limited in the tracking area. As Admiral Charles Richard, commander of US Strategic Command, has explained: Future space-based sensors may be able to provide birth-to-death detection, tracking and discrimination of hypersonic gliders, cruise missiles and ballistic missile threats globally. These capabilities cannot be fully achieved with the current or future terrestrial radar architecture due to the limitations of the geography and capabilities of future missile threats.56 Similarly, General O'Shaughnessy recently stated that given the new threat, it is urgent to take steps now to develop and field a future space-based sensing layer as soon as the technology does not allow to be exaggerated. 57 But the space sensor team program has been unnecessarily plagued by bureaucratic infighting and inadequate funding requests. In FY 2019 and FY 2020, the administration did not ask for funding for a space sensor team, so Congress provided unilateral funding to the MDA for HBTSS. In FY 2020 and FY 2021, the administration tried to move the program to the SDA, although Congress expressed its desire for HBTSS to remain in the MDA. Furthermore, a decline in research and development funding as requested in FY 2021 will increase the difficulty of demonstrating this space sensor layer quickly, especially due to the technological challenges associated with developing a sensor capable of performing in LEO.58 In addition to space sensors, there is a gap in missile discrimination capability across the Pacific to track North Korean missiles. The MDA's Long Range Discrimination Radar (LRDR), being built in northern Alaska, will improve coverage in the northern Pacific Ocean, but will leave a tracking and discrimination gap across Hawaii and elsewhere in the Pacific. In the FY 2021 budget, MDA abandoned plans to build a Homeland Defense Radar (HDR)-Hawaii and another HDR-Pacific due to budgetary constraints. DOD plans to use deployed AN/TYP-2 radars, SBX radar and radars on Aegis ships, while these homecoming defense radars remain delayed.59 Any deployment of the space sensor layer will also improve this capability, but there is no substitute for a long-term solution that completely closes this Pacific midcourse discrimination gap.60 Any progress in the sensor capacity has been made over the past year. Congress reprogrammed funds for Next-Gen OPIR last year after the requirement for the program moved up the schedule. If implemented by Congress, the budget for FY 2021 should fully fund the program.61 Additionally, the Army awarded a contract for the radars of the Lower-Tier Air and Missile Defense System that will provide 360-degree threat coverage for PAC-3 and other regional missile defense batteries; For comparison, the current Patriot radar can only scan the sky one piece at a time.62 Despite this progress, the achievement of an advanced sensor capacity requires stabilization of the space sensor layer program. Due to their ability to track and characterize missiles throughout the flight, space sensors are essential for the development of an interceptor's ability to promote threats such as hypersonic vehicles. Command and Control The command and control architecture established for the U.S. ballistic missile defense system collects data from U.S. sensors and forwards them to interceptor operators to enable them to destroy incoming missile threats against the US and its allies. The operational hub for missile defense command and control is assigned to the Joint Functional Component Command for Integrated Missile Defense (JFCC IMD), located at Schriever Air Force Base, Colorado. Under the jurisdiction of the U.S. Strategic Command, JFCC IMD brings together the Army, Navy, Marine Corps and Air Force personnel. It is located in Schriever together with MIA's Missile Defense Integration and Operation Center (MDIOC). This concentration of leadership from all the various agencies helps streamline decision-making for those who command and operate the U.S. missile defense system.63 Command and control operates through a variety of data collection and communication relay nodes among military operators, sensors, radars and missile interceptors. To command and control the GMD system to defend the homeland, the first step is the ground-based Midcourse Defense Fire Control (GFC) process, which involves assimilating data on missile movement from america's global network of sensors. Missile tracking data travels through the Defense Satellite Communications System (DSCS), operated from Fort Greely, Alaska, and Vandenberg Air Force Base, California, or ground-based redundant communication lines to the Command Launch Equipment (CLE) software that develops fire response options, telling interceptors where and when to shoot. When the NORTHCOM Commander (who is supported commander during GMD execution) in consultation with the president has determined the most effective response to a missile threat, the CLE fire response option is forwarded to the correct GBIs in the field.64 Once the selected missiles are fired, they maintain contact with an IFICS data terminal (IFICS) to receive updated flight correction guidance to ensure they hit the target.65 Overlaying of command and control operations is command and control , battle management and communication (C2BMC) application. Through the software and network systems, C2BMC feeds information to and synchronises coordination between Layers of the ballistic missile defense system.66 More than 70 C2BMC workstations are deployed worldwide at US military bases.67 C2BMC has undergone several technical upgrades, called spirals, since 2004 to bring more missile defense elements into the network. Last year, the MDA completed an upgrade that will help expand Aegi's missile defense coverage by enabling Aegis Weapon Systems to engage on remote control. In FY 2021, MDA plans to complete a new upgrade to incorporate LRDR into C2BMC. Regional missile defense systems such as THAAD, PAC-3 and Aegis are equipped with their own individual fire control systems to command and control the launch of their interceptors. The C2BMC system can also provide tracking information to individual missile defense batteries from other regional sensors. Aegis BMD systems have built-in command and control controlled by the Aegis Combat System, but they can also provide their sensor data to the GMD system through C2BMC.68 C2BMC connecting sensors and shooters worldwide to a global network, but there is no comparable system for connecting sensors and shooters in a single region. The Army is developing the Integrated Air and Missile Defense (IAMD) Battle Command System (IBCS) to provide this capability. Once fielded, the IBCS would connect all sensors and shooters in a region to a single fire control network, as opposed to having each missile defense battery operate its own collocated sensor and launcher that is made today.69 IBCS would also link defenses against smaller threats, such as ifpc, with ballistic missile defense. Rating: The United States has maintained a global command and control system as it continues to improve and update. In 2018, MDA completed updates to the aging GFC system to improve efficiency.70 Recent spiral upgrades to C2BMC have improved capability, and future spirals planned will continue to increase the integration of ballistic missile defense elements worldwide. As global missile threats go on to include not only ballistic missiles, but also cruise and hypersonic missiles, the United States will need a more advanced command and control capability to deal with this ever-greater range of threats. DOD is currently developing a Joint All Domain C2 (JADC2) system so that it can integrate non-compliant sensors across all domains into a single network to respond more effectively to this complex threat, and missile defense command and control will be strengthened as the services begin to field JADC2 capabilities. IBCS will also provide an important improvement in regional missile defense and must be on track. IBCS was originally scheduled to reach initial operational capability in FY 2019, but has already been delayed until FY 2022 due to technical problems.71 Although the current missile defense command and control architecture can resolve the current threat, progress underway will become increasingly necessary to strengthen the command and for the future. Conclusion When choosing successive post-Cold War Administrations and Congresses, the United States has not put in place a comprehensive set of missile defense systems that would be able to defend the homeland and allies from robust ballistic missile threats. U.S. efforts have focused on a limited architecture that protects the homeland and on deployment and advancing regional missile defense systems. While the United States has several types of capable interceptors, a large sensor network and a command and control system, many elements of the missile defense system need to be improved to defend more effectively against the current threat. At the same time, the development of missile threats, both qualitative and quantitative, exceeds the speed of missile defense research, development and deployment to deal with the future threat. The United States has not invested enough in future ballistic missile defense technologies, has canceled future missile defense programs such as Airborne Laser and Multiple Kill Vehicle, and has never invested in space-based interceptors that would make U.S. defenses more robust and comprehensive. This administration has stressed the importance of U.S. missile defense, but Congress must also recognize its importance and provide adequate funding for programs like GMD and space sensors if we are to reap the strategic benefits it provides. Endnotes US Air Force, National Air and Space Intelligence Center (NASIC) and Defense Intelligence Ballistic Missile Analysis Committee, 2017 Ballistic and Cruise Missile Threat, June 2017, p. 38-39, 20Sheet%20Images/2017%20Ballistic%20and%20Cruise%20Missile%20Threat_Final_small.pdf?ver=2017-07-21-083234-343 (visited June 19, 2020). In a press release from Michael R. 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