Secure World Foundation

Promoting Cooperative Solutions for Space Sustainability

Through a Glass, Darkly

Chinese, American, and Russian Anti-satellite Testing in Space

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ABOUT SECURE WORLD FOUNDATION

Secure World Foundation (SWF) is a private operating foundation dedicated to the secure and sustainable use of space for the benefit of Earth and all its peoples. SWF engages with academics, policy makers, scientists and advocates in the space and international affairs communities to support steps that strengthen global space sustainability. It promotes the development of cooperative and effective use of space for the protection of Earth's environment and human security.

ABOUT THE AUTHOR

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In his current role as Technical Advisor, Mr. Weeden conducts research on space debris, global space situational awareness, space traffic management, protection of space assets, and space governance. He also organizes national and international workshops to increase awareness of and facilitate dialogue on space security and sustainability topics. He is also Vice-Chair of the World Economic Forum's Global Agenda Council on Space Security.

Respected and recognized as an international expert, Mr. Weeden's research and analysis have been featured in *The New York Times*, *National Public Radio*, *USA Today*, *The BBC*, *Fox News*, *China Radio International*, *Reuters*, *The Economist*, The World Economic Forum's Annual Meeting in Davos, academic journals, presentations to the United Nations, and testimony before the U.S. Congress.

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CONTENTS

LIST OF ACRONYMS

AEHF	Advanced Extremely High Frequency
ALBM	Air-Launched Ballistic Missile
ASAT	Anti-satellite
BMD	Ballistic Missile Defense
CASC	Chinese Aerospace Science and Technology Corporation
CASIC	Chinese Aerospace Science and Industry Corporation
CCS	Counter Communications System
COIN	Counterinsurgency
DF-21C	DongFeng-21C
DNI	Director of National Intelligence
EKV	Exoatmospheric Kill Vehicle
FOBS	Fractional Orbital Bombardment System
FY-1C	FengYun-1C
GBI	Ground Based Interceptors
GEO	Geostationary Earth Orbit
GPS	Global Positioning System
GTO	Geosynchronous Transfer Orbit
HASC	House Armed Services Committee
HEO	Highly Elliptical Orbit
ICBM	Intercontinental Ballistic Missile
IRBM	Intermediate Range Ballistic Missile
IS	Istrebitel Sputnikov
KKV	Kinetic Kill Vehicle
KT-1	Kaituozhe 1
LEAP	Lightweight Exo-Atmospheric Projectile
LC-2	Launch Complex 2
LC-3	Launch Complex 3
LEO	Low Earth Orbit
LM-3B	Long March 3B
LM-3BE	Long March 3B Enhanced
LOL	Laser Optical Locator
MEO	Medium Earth Orbit
MV	Miniature Vehicle
NMTV	National Means of Technical Verification
NOTAM	Notice to Airman
NSA	National security Agency
ORS	Operationally Responsive Space
PAA	Phased Adaptive Approach
PMALS	Prototype Miniature Air-Launched Segment
RDT&E	Research Development Testing and Evaluation
SASC	Senate Armed Services Committee
SBIRS	Space-Based Infrared System
SLBM	Submarine-Launched Ballistic Missile
SLV	Space Launch Vehicle

SM-3	Standard Missile 3
SRAM	Short Range Attack Missile
SSN	Space Surveillance Network
SSA	Space Situational Awareness
SSS	Space Surveillance System
TEL	Transporter-Erector-Launcher
THAAD	Terminal High-Altitude Area Defense

INTRODUCTION

> *"For now we see through a glass, darkly; but then face to face: now I know in part; but then shall I know even as also I am known." – 1 Corinthians 13:12, King James Version*

On May 13, 2013, China launched a rocket from the Xichang Satellite Launch Center in Sichuan Province. The Chinese Academy of Sciences stated it was a high-altitude scientific research mission, but unofficial U.S. government sources say it was actually a test of a new ballistic missile related to China's anti-satellite (ASAT) program. This article uses open source information, including commercial satellite imagery purchased from DigitalGlobe, to assess these claims. It also compares what is known about current Chinese ASAT testing in space with American and Russian ASAT testing in space over the last five decades.

While there is no conclusive proof, the available evidence strongly suggests that China's May 2013 launch was the test of the rocket component of a new direct ascent ASAT weapons system derived from a road-mobile ballistic missile. The system appears to be designed to place a kinetic kill vehicle on a trajectory to deep space that could reach medium earth orbit (MEO), highly elliptical orbit (HEO), and geostationary Earth orbit (GEO). If true, this would represent a significant development in China's ASAT capabilities. But it would not be the first instance of an ASAT weapons system designed to attack satellites in deep space as the Russians developed at least the components of such a system in the 1990s. Thus it is more a signal that China is a new entrant into what is an old game, and while there is some knowledge as to what capabilities China may be developing, why they are developing those capabilities is still unclear.

In June 2013, I argued that the Obama administration should release more information publicly about China's ASAT program and testing in space. Following China's purposeful destruction of its FengYun 1C (FY-1C) satellite using a direct ascent ASAT weapon in 2007 and the resulting creation of more than 3,000 pieces of trackable space debris, the public information released by the United States played a major role in mobilizing international outrage about the test. This international criticism, combined with the United States' destruction of its own USA 193 satellite the following year, arguably resulted in a change in Chinese behavior. Subsequent tests of the same SC-19 system in 2010 and 2013, characterized by China as missile defense tests, targeted suborbital targets and did not result in the creation of any long-lived space debris.

Going public about the testing of a potential new Chinese ASAT test could lead to similar political pressure on the Chinese government, particularly if they plan to conduct another destructive test in the future. Remaining silent risks sending the message to China and other countries that developing and testing hit-to-kill ASAT capabilities is considered responsible behavior as long as it does not create long-lived orbital debris. That message would likely encourage the proliferation of ASAT capabilities, increasing the threat to the space assets of all States, and thus contributing to greater political and strategic instability in space and potentially on Earth.

To date, the U.S. government's public response to and information about China's ASAT testing activities has been relatively muted. The U.S. government remained silent about 2005 and 2006 tests of the Chinese ASAT system designated SC-19 by the U.S. government. The existence of those tests was only made public after the 2007 test of the same system. Following the 2010 test of the same system, a U.S. government official stated that they "detected two geographically separated missile launch events with an exo-atmospheric collision also being observed by space-based sensors." Confirmation that this was indeed another test of the same SC-19 ASAT system comes from a classified State Department cable that was leaked by Wikileaks in 2011. In January 2013, China publicly reported another "mid-course missile interception test" that many have concluded is yet another test of the SC-19 system based on the similarities of its description by the Chinese media to the 2010 test, but it has not been publicly declared as such by the U.S. government.

The U.S. government has provided a single official quote regarding the May 2013 launch, stating that "the launch appeared to be on a ballistic trajectory nearly to [GEO]. We tracked several objects during the flight…and no objects associated with this launch remain in space." The 2013 report of the U.S.-China Economic and Security Review Commission to Congress mentions the May launch and the claims about it being an ASAT test, but provides no new evidence to support those claims. Public statements from multiple U.S. officials, including Director of National Intelligence (DNI) James Clapper, mention increasing threats to U.S. national security space assets and China's ASAT program but provide no details. A January 2014 hearing convened by the House Armed Services Committee (HASC) focused on the challenges China's counterspace program poses for U.S. national security and potential strategies for addressing those challenges, but yielded no new facts or information about the May 2013 test or China's actual ASAT capabilities either. A March 2014 hearing convened by the Senate Armed Services Committee (SASC) discussed the Pentagon's strategy to deal with the growing ASAT threat but no specific details.

The purpose of this article is to place more information about the May launch and other Chinese ASAT testing into the public domain and also in the context of other known ASAT testing activities by the United States and Russia. The hope is that this information will spur both more openness from the U.S. and Chinese governments and spark public debate on this issue by reducing the possibility that doing so would reveal intelligence sources and methods. However, it is possible that the U.S. government will still remain silent despite the newly available public information. That would suggest other rationales for the silence, such as not wanting public discussion of the ASAT testing to jeopardize potential bilateral discussions with China on space security issues. It may also be that the United States does not want criticism of Chinese ASAT testing to lead to a norm that testing and developing ballistic hit-to-kill systems is irresponsible, which in turn would undermine the political support for the United States' own Phased Adaptive Approach (PAA) midcourse ballistic missile defense (BMD) system which uses the same technologies. Creating such a norm would also constrain the United States from developing its own hit-to-kill ASAT capabilities again in the future. If that is the position of the United States, it would be very troubling as it would almost certainly lead to a proliferation of more ASAT capabilities that further increase the threats to all space systems, including those of the United States, and undermine political and strategic stability in space.

The first section of this article analyzes the May 2013 launch from Xichang and attempts to determine why it was characterized by the U.S. government as an ASAT test. A critical part of this analysis utilizes commercial satellite imagery and information from Chinese bloggers and the Chinese public. The second section provides a summary of American and Russian ASAT testing in space from the late 1950s to the present. This section provides important context for the Chinese ASAT testing in that it shows the ASAT technologies and techniques developed and tested by all three countries are very similar in nature, and that efforts to develop means of attacking satellites have gone hand-in-hand with the development of satellites themselves. The third and final section examines the parallels between hit-to-kill ASAT testing and midcourse missile defense and the political difficulty in proscribing one but not the other. It also examines the role that the culture of secrecy plays in the public silence over this issue, and how that may cause more harm than good over the long-term. The article concludes with a call for greater transparency and confidence building measures by all countries, and in particular the United States and China, to enhance strategic stability in space and on Earth.

ASSESSMENT OF THE MAY 2013 LAUNCH FROM XICHANG

In an attempt to evaluate what happened, a good place to start is with the rocket that was launched. Both the United States and China agree that something was launched from Xichang on May 13, 2013. Discovering what rocket was used could help evaluate what actually happened. Neither the American nor Chinese official statements mention specifics, although the official press release from the Chinese government described the launch as that of a sounding rocket carrying a Kunpeng-7 scientific payload to conduct high-altitude experiments. Sounding rockets are rockets designed to carry instruments or small scientific payloads on suborbital flights. Typical missions for sounding rockets include scientific research of the upper atmosphere, the ionosphere, or the Van Allen radiation belts. Sounding rockets are typically much smaller than their orbital cousins and reach altitudes in the tens or a few hundreds of kilometers or miles. In this particular case, a representative of the Chinese Academy of Sciences was quoted in a later news story stating that the launch involved the release of a cloud of barium powder at an altitude of 10,000 kilometers to study the magnetosphere.

Mystery Rocket

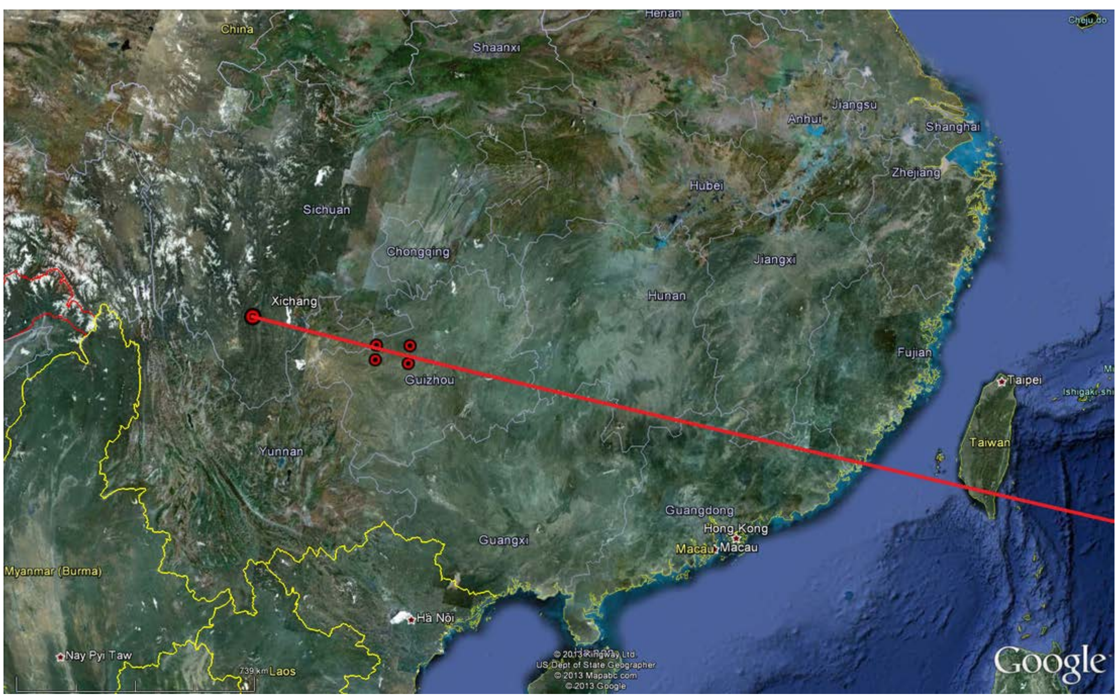

Figure 1. Launch trajectory from the NOTAM (Source Spaceflight101.com) Image © 2013 Google Earth.

To asses these statements, some information can be gleaned from the Notice to Airman (NOTAM) that China released earlier that month and updated just prior to the launch. NOTAMs are typically provided publicly to alert air traffic of rocket launch activity as a safety precaution. In this case, the NOTAM indicated a launch trajectory very similar to that of orbital launches to GEO from Xichang, as shown in Figure 1. However, analyst Patrick Blau concluded that both the time of the launch and the warning area provided in the NOTAMs were unusual for any of the Long March rockets typically used for orbital launches to GEO. The late evening (9 pm local) launch time resulted in some spectacular reports from individuals as far as away as Hong Kong and several photos published online showing a massive rocket plume, much larger than typically associated with a sounding rocket. One of these photos is shown in Figure 2, labeled by the individual who took it as a "failed rocket" because of the unusual size and intensity of the plume.

Figure 2. Image of the May 13 launch from Xichang taken from Hong Kong (Image credit Wah!)

Despite their relatively small size, sounding rockets are still fairly large. The Canadian-designed Black Brant XII, capable of lofting a small payload of a few hundred kilograms (650 pounds) as high as 1500 kilometers (930 miles), stands more than 18 meters (60 feet) tall. Because of their size, sounding rockets, like orbital rockets, are typically launched from fixed locations known as "pads" with dedicated support facilities. These facilities often include an umbilical tower that provides fuel, electricity, and access to a rocket and spacecraft and a service tower with cranes and elevators to assist in the stacking and mating of a rocket and payload. Furthermore, different types of rockets usually have their own dedicated pads because of their unique size or support requirements. The size and intensity of the plume from the May 2013 launch has led some to suggest that perhaps a Long March space launch vehicle (SLV) was used instead of a sounding rocket. Xichang is the main Chinese launch center for space launches carrying satellites to GEO orbits using the Long March 3B (LM-3B). If the May 13 launch did use a LM-3B, it would need to originate from the launch pad at Xichang designed for Long March rockets, designated Launch Complex 2 (LC-2). This pad is located at 28.245547°N latitude and 102.026811°E longitude.

Figure 3. Imagery of LC-2 at Xichang. Images © 2013 Google Earth.

Figure 3 shows a series of satellites images from Google Earth of the LM-3B pad before and after May 13, 2013. The image from January 21, 2013, shows the servicing tower rolled back from the umbilical tower and a LM-3B sitting on the pad next to the umbilical tower. The servicing tower is closed up against the umbilical tower in the photos from April 20 and May 20. Publicly available launch records indicate that the orbital launches from Xichang around this time were that of a Long March 3B Enhanced (LM-3B/E) carrying Chinasat-12 to geosynchronous transfer orbit (GTO) on November 27, 2012, a LM-3B/E carrying Chinasat-11 to GTO on May 1, 2013, and a LM-3B carrying the Chang'e-3 lunar orbiter to Earth-moon transfer orbit on December 1, 2013. Thus, it is likely that the image from January 21 shows the initial stacking and preparations of the LM-3B/E used for Chinasat-11.

If this is the case, it leaves only twelve days between the Chinasat-1 launch on May 1 and the unknown launch on May 13. Stacking and preparing a LM-3B or any SLV for launch in this timeframe is not feasible. Furthermore, it seems highly unlikely that China would use a relatively expensive (and overpowered) SLV like a Long March for what they stated was a simple scientific experiment. Combined with the information provided by the NOTAM discussed earlier, it is highly unlikely that a Long March SLV was used on the May 13 launch or that the launch occurred from that pad. Knowing that something launched from Xichang on May 13 leads to the question of what was launched from where within the Xichang complex. Officially, there are only two launch pads at Xichang. LC-2, as previously described for LM-3B launches, and Launch Complex 3 (LC-3) located just to the northeast of LC-2. LC-3 was previously used for the Long March 3A (LM-3A) and is currently undergoing renovations. Thus it is unsuitable as a candidate launch pad for the May 2013 launch.

Thus, it may be that there are additional launch pads at Xichang that are not officially recognized. One consistent way to identify pads that are used for launching rockets is to look for lightning masts. A tall, metal rocket sitting out in the large flat area is almost certain to attract lightning strikes that can damage internal systems or potentially even destroy the rocket. To combat this, tall metal towers known as lightning masts are placed around launch pads to attract any potential lightning strikes away from the rocket and divert them to ground. These masts are usually spaced around the launch pad to provide equal coverage. Figure 4 shows the three lightning masts around Pad 39B at NASA's Kennedy Space Launch Center in Florida.

Figure 4. Lightning masts at Pad 39B. Image credit Wikimedia Commons (source).

Figure 5 shows a larger image of the entire Xichang launch complex with lightning masts highlighted with red circles. The lightning masts can be clearly identified by their elongated triangular shape which can occasionally take the form of a "V-shape" if the angle of the image shows both the tower and its shadow. Two sets of three large masts can be clearly identified around LC-2 and LC-3, as expected. However, there are also sets of smaller masts located near flat concrete areas located to the northwest and southeast of the main pads. These appear to be additional launch pads, although they lack the traditional towers and other support structures that typical SLV launch pads have.

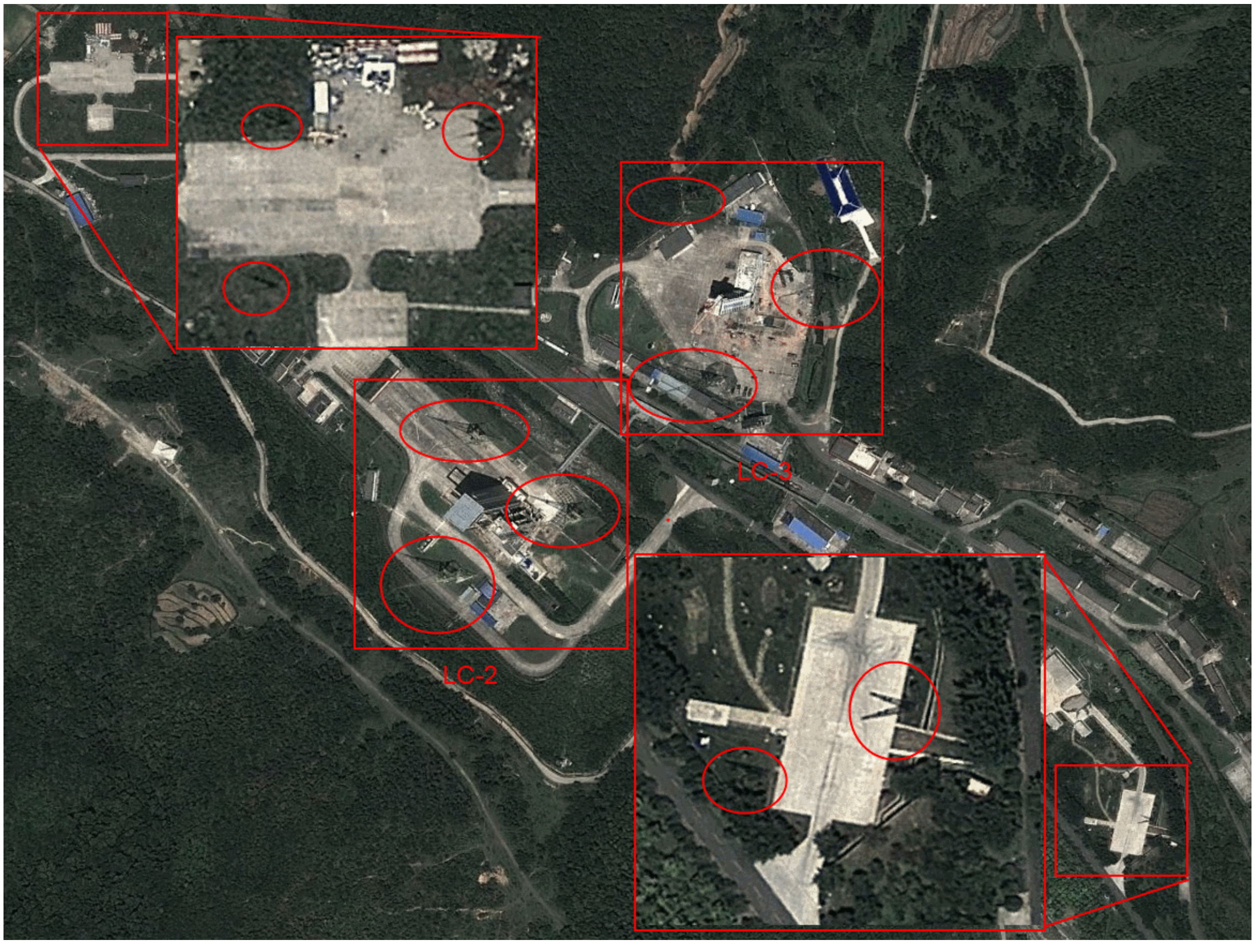

Figure 5. Lightning masts at Xichang (circled in red). Image © 2013 Google Earth.

One clue as to the possible function of these pads comes from the timing of their construction. Figure 6 shows the history of the northwest pad based on historical imagery from Google Earth. As of April 2005, the northwest pad did not exist. The pad, rectangular in shape with its long side aligned roughly easy-west, was created sometime between April 2005 and November 2005 along with three small support buildings to its south and east. As of 2012, a number of cylindrical objects are visible along the north edge of the pad. Also, a large support building has been added its southwest, along with an access road connecting it to the pad. The image from April 2013 shows what looks like a cloud sitting on top of the pad, but in reality is likely to be the result of a firefighting test, with the white material consisting of firefighting foam that is emanating from a small truck at its lower left corner.

Figure 6. Historical imagey of the northwest pad at Xichang. Images © 2005, 2006, 2012, & 2013 Google Earth.

In 2007, Dr. TS Kelso presented a paper at the Advanced Maui Optical and Space Surveillance (AMOS) Conference where he speculated that this northwest pad was built for the testing of a Chinese direct ascent ASAT weapon system, designated SC-19 by U.S. intelligence. The SC-19 is thought to be based on the DongFeng-21C (DF-21C) road-mobile intermediate-range ballistic missile (IRBM). It was first tested on July 5, 2005, and again in 2006 and 2007, all from Xichang. The 2005 and 2006 tests did not have any known targets. The 2007 tested destroyed the Chinese FY-1C weather satellite at an altitude of 860 kilometers (534 miles), creating more than 3,000 pieces of trackable[1] orbital debris that will remain in orbit for decades if not longer. The timeline for the creation of the northwest pad could possibly fit with these testing dates, although additional imagery of the location just prior to the July 2005 test would be necessary to confirm the pad was finished in time.

[1] Trackable orbital debris is defined as debris large enough to be reliably tracked and cataloged by the U.S. military's Space Surveillance Network (SSN). Typically this is debris larger than 10 centimeters (4 inches) in low Earth orbit.

Figure 7. Historical imagery of the southeast pad at Xichang. Images © 2006, 2012 Google Earth.

Figure 7 shows the history of the southeast pad at Xichang, which is similar in nature to the northwest pad in that it has a large concrete area connected by service roads to multiple buildings. The main difference is that it is somewhat thinner in shape and its long side is orientated almost north-south. This southeast pad was built sometime after November 2006 and before April 2013. This alone does not indicate much. However, an additional satellite image purchased from DigitalGlobe and shown in Figure 8 clearly shows a raised transporter-erector-launcher (TEL) located on the southeast pad just weeks prior to the May 2013 launch. A TEL is used as the chassis and launch infrastructure for road-mobile ballistic missiles in place of a fixed launch pad.

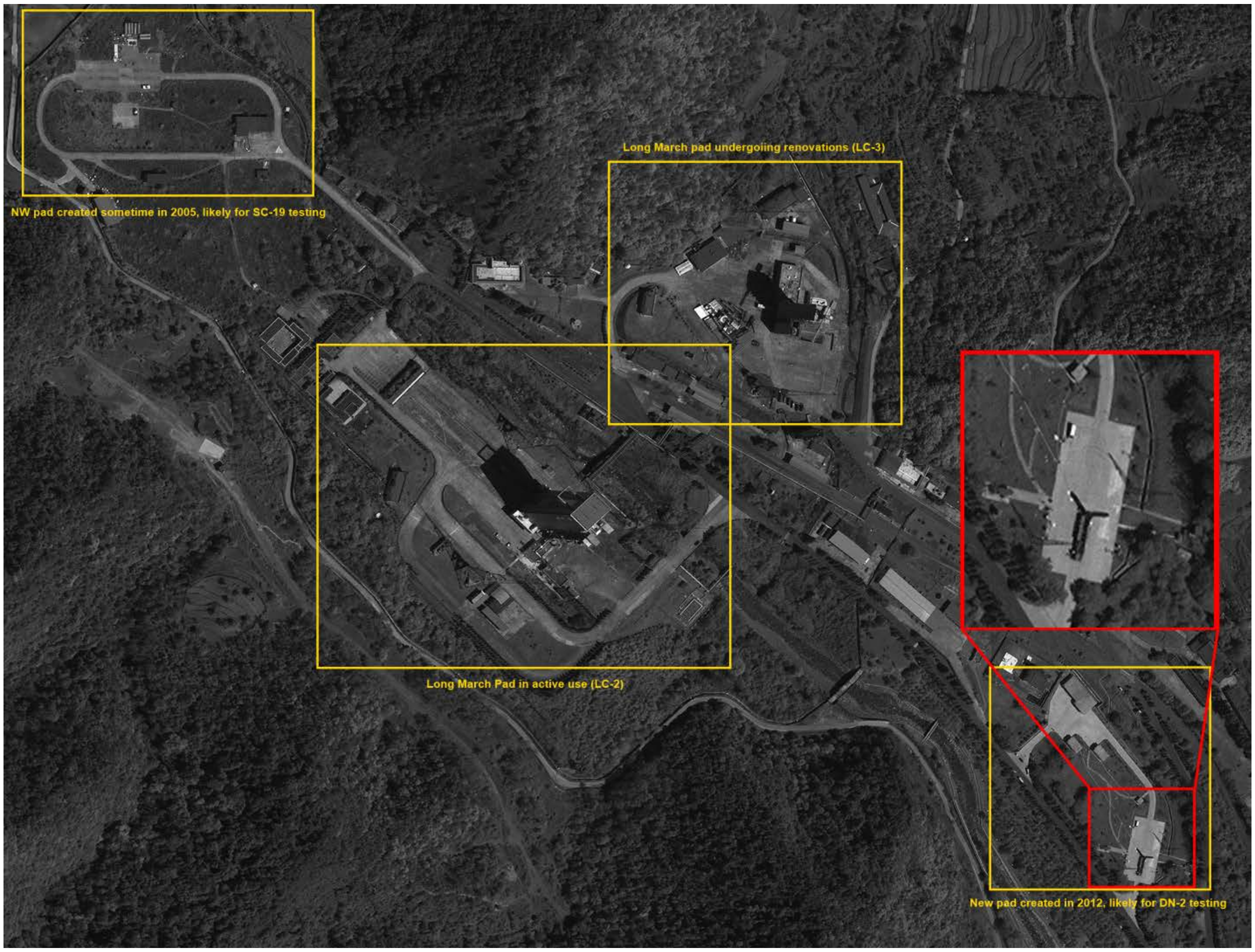

Figure 8. Imagery of Xichang from April 3, 2013, showing a TEL on the southeast pad. Image © 2013 DigitalGlobe. All rights reserved. For media licensing options, please contact info@swfound.org.

The image does not have enough spatial resolution to clearly identify what the missile or TEL is, but measurement of its size and the conical top appears to be similar in size and shape to the DF-21C TEL shown in Figure 9.

Figure 9. DF-21C TEL elevated for launch. (Image credit Air Power Australia)

The absence of a viable sounding rocket or SLV at Xichang and the presence of a TEL on a newly-constructed mobile launch pad gives significant credence to the claims regarding the mobile nature of the Chinese direct ascent ASAT system. It supports, but does not conclusively prove, the theory that China is using a mobile ballistic missile as the basis for its direct-ascent ASAT system. The presence of a second mobile pad at Xichang also suggests that China has begun testing a second, new system that is fundamentally different from the SC-19. The differences orientation between the northwest and southeast pads also suggests either a larger TEL or a different flight trajectory is involved in the testing of the new system.

Altitude and Re-entry

The key difference between the claims made by the U.S. and Chinese governments about the May 13, 2013, launch is in the altitude the test reportedly reached. The Chinese press releases mention that it reached an altitude of 10,000 kilometers (6,200 miles), although it is not clear if that was the apogee of the trajectory. In contrast, official U.S. government comments to the press stated that the launch "appeared to be on a ballistic trajectory nearly to geosynchronous Earth orbit (GEO)." While this leaves open the question as to exactly what is meant by "nearly to GEO," it is clearly a reference to a much higher altitude than 10,000 kilometers. For the purposes of this article, we will assume that "nearly to GEO" means somewhere near 30,000 kilometers (18,600 miles).

Currently, there is no publicly available data source that could be used to confirm how high the launch actually reached. However, it is possible to test whether or not the launch could have reached an apogee of 30,000 kilometers by comparing the re-entry location with the flight time required to land in that location. U.S. officials stated that objects from the launch "re-entered the Earth's atmosphere above the Indian Ocean." Figure 10 shows the area commonly defined as the Indian Ocean. While the potential area is quite large, this piece of data is still useful to help evaluate these claims.

Figure 10. The boundaries of the Indian Ocean. Image credit Wikimedia Commons

If we assume that the launch re-entered somewhere in the Indian Ocean near the Equator, then we can use that information to draw a rough estimate of the rocket's trajectory. An analysis by Dr. David Wright from the Union of Concerned Scientists projects the flight path along the trajectory given by the Chinese government in their NOTAMs to the Equator, a distance of roughly 7,200 km (4,500 miles). In order to have the rocket land in the Indian Ocean, it needed to be in flight long enough for the Earth to rotate underneath it. As shown in Figure 11, a rocket launched from Xichang to the Equator on a non-rotating Earth would land at Point A whereas with a rotating Earth it would land at Point B. The distance between points A and B is roughly 8,500 km (5,300 miles), which means it would take the Earth roughly five hours to rotate that distance.

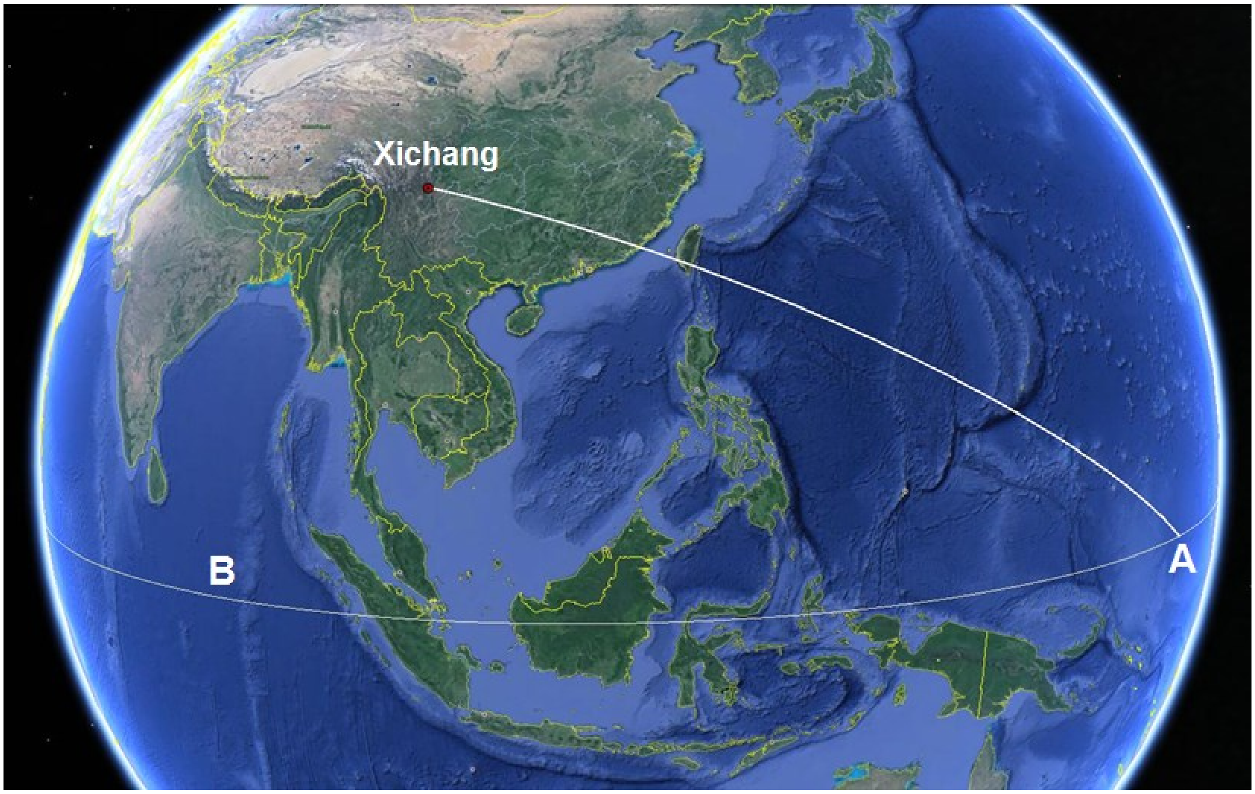

Figure 11. The ground track of a rocket from Xichang for a non-rotating Earth indicated by Point A and a rotating Earth indicated by Point B (source). Image © 2013 Google Earth.

Using a LM-3 SLV as a reference, Dr. Wright calculates that a flight along the trajectory shown in Figure 11 to an apogee of 10,000 km results in a flight time of only 2 hours. However, an apogee of 30,000 km results in a flight time of 6.7 hours. This implies that the rocket must have had an apogee much higher than 10,000 km for it to have been in flight long enough for the Earth to rotate underneath it and the objects from the launch to land in the Indian Ocean. Thus, if one takes the U.S. government at its word regarding the re-entry location over the Indian Ocean and assumes it was referring to something other than the very northern portion, then that re-entry location is much more consistent with an apogee of 30,000 kilometers rather than of 10,000 kilometers.

An important point is that both the U.S. government and Chinese government statements regarding the altitude of the test could be technically accurate. The Chinese statement says that the Kunpeng-7 payload released a barium cloud at 10,000 kilometers (6,200 miles) but does not specifically say that altitude was the apogee of the flight. It is entirely possible for there to have been a scientific payload on this launch which did indeed release an experiment at 10,000 kilometers on its way to a much higher apogee near 30,000 kilometers before re-entering over the Indian Ocean. That would serve two purposes – providing a payload for the rocket test and providing a scientific cover story. If so, this would certainly not be the first time a scientific program has been used as the cover story for a secret military program. During the late 1950s and early 1960s, the United States used the Discoverer scientific program as the cover for its Corona surveillance satellite program.

The other important question is whether or not any of the Chinese mobile ballistic missiles could reach such a high apogee. A typical rule of thumb is that the apogee a ballistic missile can reach is approximately one half of its maximum horizontal range. A DF-21C IRBM has an estimated maximum horizontal range of 2,500 kilometers (1,550 miles), meaning that it could reach an altitude of approximately 1,250 kilometers (775 miles) when fired straight up. Even China's newest and most powerful ballistic missile, the DF-31A Intercontinental Ballistic Missile (ICBM), has an estimated maximum horizontal range of only 12,000 kilometers (7,500 miles) with a 600 kilogram (1,300 pound) payload, meaning that it could theoretically reach an altitude of 6,000 kilometers (3,700 miles) or so. It is theoretically possible for a DF-31A with a very light payload to reach the 10,000 kilometer altitude claimed by China, but not possible for it to reach the apogee near 30,000 kilometers claimed by the United States.

A final set of clues comes from a February 2014 blog posting on SinoDefence.com that examines another Chinese launch from September 25, 2013. That launch took place at the Jiuquan Satellite Launch Center located in northwest China close to the Mongolian border. Chinese media reports at the time noted that the launch placed a small remote sensing satellite into orbit, which was subsequently tracked and cataloged by the U.S. military. The launch vehicle was named Kuaizhou "Quick Vessel" and further media reports revealed that it was a new solid-rocket SLV developed as part of a Chinese Operationally Responsive Space (ORS) program. As with the American ORS program, the goal is to develop a launch vehicle and payloads that could be procured, mated, set-up, and launched much more quickly than the months to years that it normally takes. This would allow for more rapid replenishment or replacement of satellites.

Citing a Chinese researcher and blogger named kktt, the SinoDefence blog post goes on to explain the development of the Kuaizhou SLV. Chinese rocket development is centralized in two State-owned corporations. The Chinese Aerospace Science and Technology Corporation (CASC), and specifically its Academy of Launch Vehicle Technology (CALT), is responsible for the Long March family of SLVs, silo-based DF-4 and DF-4 ICBMs, and the DF-31/DF-31A ICBMs. The Chinese Aerospace Science and Industry Corporation (CASIC) is responsible for nearly all of China's tactical ballistic missiles, including its DF-21 IRBMs.

According to kktt, CASIC sought to leverage the DF-21 and its expertise in solid rockets to develop a new line of solid rocket SLVs. The first attempt was the Kaituozhe 1 (KT-1), a four-stage rocket 13.6 meters (44.6 feet) in length and 1.4 meters (4.6 feet) in diameter that was designed to place a 50 kilogram (110 pound) payload in a 400 kilometer (248 mile) sun-synchronous orbit. Both known tests of the KT-1 failed, and the project was apparently canceled. Kktt says that a larger 1.7 meter (5.6 feet) diameter version called the KT-2 was planned but never developed. However, in 2002, CASIC won a contract to build a 1.4 meter diameter, four-stage rocket (three solid with a liquid upper stage) called the KT-409 that was launched from a WS2500 TEL. This is apparently the system the U.S. military has designated as the SC-19 ASAT weapon; as kktt states it was used to destroy the FY-1C satellite in 2007.

Again citing kktt, the SinoDefence blog post also states that the Kuaizhou SLV is the third solid rocket SLV in this family. It utilizes much of the same technology as the KT-409 but has a larger 1.7 meter diameter that allows it to lift a larger payload. The Kuaizhou also has three solid stages and a liquid upper stage, but apparently the liquid stage is integrated with the payload. This is to allow for a faster mating of the payload and upper stage to the solid rocket stages, in keeping with the Kuaizhou's ORS goal. The Kuaizhou is also reportedly launched via a TEL. Although the official images of the Kuaizhou launch have anything on the ground airbrushed out, Figure 12 shows an image of it on the launch pad at Jiuquan taken by an observer from an access road beyond the fence. It clearly indicates some sort of TEL vehicle, although it is hard to make out exactly what model or version it is. It is plausible that the rocket launched from Xichang on May 13, 2013, was the Kuaizhou, launched on a ballistic trajectory instead of placing a payload into LEO.

Figure 12. Image of the Kuaizhou launch taken from an access road near the launch site. (Source)

To summarize, there is substantial evidence to support the conclusion that China is developing two different ASAT weapons systems derived from road-mobile ballistic missiles. The first system, designated SC-19 by U.S. intelligence and possibly KT-409 by China, was tested five times as summarized in Table 1. The first three tests were likely conducted from the northwest pad at Xichang that was constructed sometime between April and November 2005. According to a classified 2010 State Department cable leaked by Wikileaks, the fourth test was conducted from the Korla Missile Test Complex. The third test in 2007 destroyed the FY-1C satellite while the fourth and fifth tests involved successful interception of ballistic targets launched by other ground-based missiles. The end of testing at Xichang could indicate that the RDT&E portion of development for this system is complete, although there is no direct, publicly available evidence supporting that hypothesis.

Table 1. Summary of tests in space of the SC-19 ASAT weapons system (source).

Date of Test	Target Object	Interceptor Object	Interceptor Type	Amount of Trackable Debris Created	Notes
7/5/2005	None known	SC-19	direct ascent	0	Likely rocket test
2/6/2006	None known	SC-19	direct ascent	0	Likely flyby of an unknown orbital target
1/11/2007	FengYun 1C	SC-19	direct ascent	3,280	Successful intercept and destruction of an orbital target
1/11/2010	CSS-X-11 (ballistic)	SC-19	direct ascent	0	Successful intercept and destruction of a suborbital target
1/27/2013	Unknown (ballistic)	SC-19	direct ascent	0	Successful intercept and destruction of a suborbital target
		Total Amount of Trackable Debris		**3,280**	

The preceding section presents circumstantial evidence to support the conclusion that a second ASAT weapon system was tested for the first time with the May 13, 2013, launch from Xichang. The exact rocket used in the test is unknown, but the most likely candidate is one launched from a TEL located on the new southeast pad at Xichang because there was no obvious SLV pad or rocket available at the time. It very unlikely any of the existing Chinese ballistic missiles could have reached the 10,000 kilometer altitude claimed by the Chinese government, let alone the 30,000 kilometer altitude claimed by the U.S. government. However, the new Kuaizhou solid rocket SLV might be capable of doing so, and the photo from its launch in September 2013 shows that it too is launched from a TEL. On the issue of whether the May launch reached 10,000 km or 30,000 km apogee, if objects from the May launch re-entered the Earth's atmosphere in the Indian Ocean anywhere south of the Indian subcontinent that would be a clear indication that its apogee much higher than 10,000 kilometers.

If the May launch was indeed the test of a new rocket for a new ASAT system designed to attack targets in deep space orbits, it is likely that there will be additional tests in the future as part of comprehensive testing program. Based on the testing program for the SC-19, future tests of the new system would likely involve more rocket flight tests and possibility future intercepts. If the new system utilizes the same kinetic kill vehicle (KKV) as the SC-19, actual intercepts may not be necessary since that KKV has been tested and demonstrated multiple times. However, if there is something different about the deep space engagement and intercept scenario compared to the LEO scenarios previous tested the Chinese government might consider an actual destructive intercept in in or near GEO. That could be an extremely dangerous and damaging event for the space environment, as it could put at risk the hundreds of billions in both government and commercial assets by all nations in GEO. Preventing a destructive ASAT test in or near GEO by any State must be a goal of the entire space community.

Finally, the military utility of such a hit-to-kill direct-ascent ASAT system for attacking satellites in deep space orbits is not entirely clear. Satellite navigation systems in MEO such as the U.S. military's Global Positioning System (GPS) are not very vulnerable to such a system. The more than 30 GPS satellites currently in orbit are distributed across multiple orbital planes and widely spaced apart within each plane. A position fix requires receiving a signal from at least four satellites at once, and the constellation is designed so that many more than that are overhead most of the time. Thus, using a hit-to-kill direct ascent system to attack GPS would require many separate launches and successful intercepts over many hours to degrade GPS in any meaningful fashion.

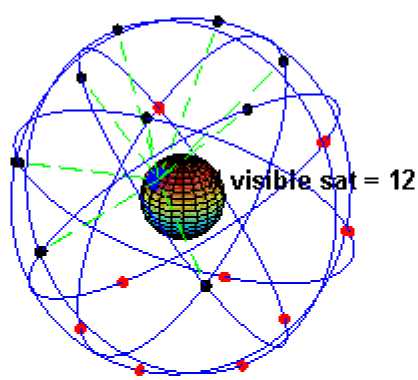

Figure 13. A notional 24-satellite GPS constellation and the number of satellites visible from a ground location at 45 degrees north latitude. Image from Wikimedia Commons (source)

Satellites in HEO, such as the U.S. military's Space-Based Infrared System High (SBIRS) are somewhat more vulnerable to attack by direct ascent hit-to-kill systems but still fairly resilient.

HEO orbits, also known as Molniya orbits after the Russian [military communications satellites] that first made use of them, have an apogee as high as 40,000 kilometers (25,000 miles) and a very low perigee of around 1,000 kilometers (600 miles). Thus they spend most of their 12-hour orbital period “hanging” over a portion of the Earth’s surface before whipping around perigee and coming back overhead. The ever-changing orbital velocity and altitude of satellites in HEO orbits complicates the targeting of a direct-ascent ASAT system, but the relatively few numbers of such satellites means one or two successful intercepts could knock out significant capability.

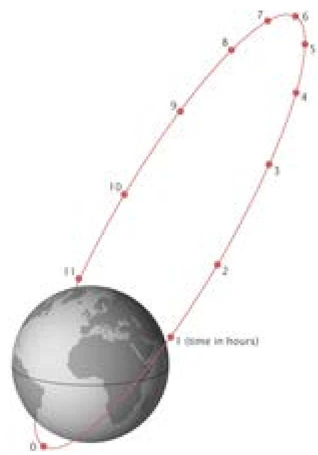

Figure 14. An example Molynia orbit, with the satellite's location in the orbit marked in hours from perigee. Image from Wikimedia Commons (source)

Satellites in GEO such as the U.S. military’s Advanced Extremely High Frequency (AEHF) communications satellites are the most vulnerable to a hit-to-kill direct ascent ASAT weapon system. They appear to hang over a fixed location on the Equator, making them always visible to the same ground location. The flight time of a direct ascent ASAT to GEO is measured in hours and the launch of such systems using conventional rockets is easily detected by U.S. missile warning satellites. Given this lengthy flight time, it is much easier for a target satellite in GEO to detect the attack and possibly maneuver to avoid the intercept than a satellite in LEO that only has minutes to do so. Furthermore, an interceptor on a suborbital trajectory to GEO only has one chance to collide with the target. However, the increasing focus on high efficiency ion engines over chemical engines for maneuvering capability of newer GEO satellites may leave them unable to change position fast enough to avoid an intercept. Combined with the concentration of capabilities in a small number of very large and expensive satellites, such systems are vulnerable to this type of attack.

ASAT WEAPONS TESTING IN SPACE BY OTHER COUNTRIES

In evaluating the potential significance of China's ASAT weapons testing and development, it is important to place it in context by comparing its ASAT weapons development to that of ASAT weapons development programs by other States. ASAT weapons launched into space generally fall into one of two categories: direct-ascent or co-orbital systems. Direct ascent systems use rockets to put an interceptor on a suborbital trajectory that intersects with the target in orbit without the interceptor entering orbit itself. Both of the Chinese ASAT weapon systems described above fall into this category. By contrast, co-orbital systems use an SLV to place the interceptor into orbit, after which it maneuvers to either collide with or pass near the target. China is not known to be testing a co-orbital ASAT system, although some have claimed that recent on-orbit maneuvers and rendezvous by Chinese satellites is a demonstration of just such a system. However, as I discussed in my article about similar 2010 rendezvous activities of the Chinese SJ-12 satellite, there is no publicly available evidence to support the conclusion that these were tests of a militarily-useful ASAT weapon. Instead, all evidence points towards the testing of an on-orbit inspection capability.

It is also important to distinguish between the testing of systems that could have residual ASAT capabilities and testing of weapons systems that are designed to provide specific, operationally useful military capabilities. The former is usually characterized by one-off testing and experiments, while the latter is usually characterized by more extensive testing programs that consist of multiple tests of increasing complexity or difficulty. This following discussion of U.S. and Russian ASAT development and testing will focus on projects that involve launching objects into space as part of the research, development, testing, and evaluation (RDT&E) of operationally useful military capabilities or their precursors. It will also include significant real-world demonstrations of residual ASAT capabilities. It does not include ASAT weapons programs that did not progress to real-world testing, nor programs that involved non-kinetic weapons tests (such as laser dazzlers or radiofrequency jamming).

United States ASAT Testing in Space

The United States was the first country to develop an ASAT weapons system. Although there were several early ideas for various ASAT capabilities and weapon systems, the first to be actually tested in space began in 1958 as part of a U.S. Air Force technology development program for new strategic weapons known as Weapon System 199 (WS-199). It included the development of a nuclear-tipped, air-launched ballistic missile (ALBM) named Bold Orion (WS-199B). The first version of the missile included a single solid rocket stage and was designed to be launched from a B-47 bomber. Eight tests of this version were conducted between May 26, 1958, and June 19, 1959, during which the missiles reached apogees near 100 kilometers (62 miles) during their flights.

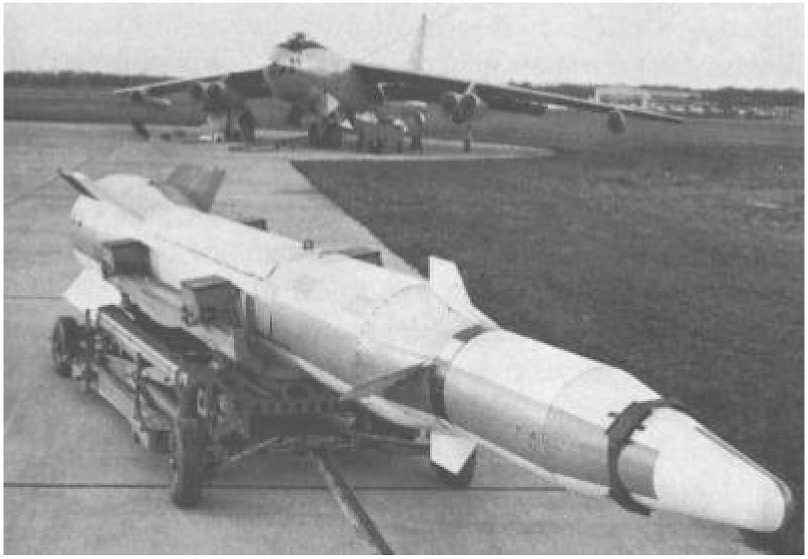

Figure 15. Bold Orion missile and B-47 aircraft. Image credit Wikimedia Foundation

A second, two-stage version with a horizontal range of 1,770 kilometers (1,100 miles) began a series of four tests on December 8, 1958. The last of these tests, conducted on October 13, 1959, was conducted to see if the missile could potentially be used in an ASAT role. The test targeted the American satellite Explorer VI at an altitude of 251 kilometers (156 miles). The interceptor passed within 6.4 kilometers (4 miles) of the target satellite, which qualified as a success due to the blast radius of its nuclear warhead. Although neither Bold Orion nor High Virgo were developed into operational ASAT systems, they did pave the way for future operational systems and provided useful testing data for later U.S. ASAT development efforts.

Table 2. Summary of tests of Bold Orion in ASAT role (source)

Date of Test	Target Object	Interceptor Object	Interceptor Type	Amount of Trackable Debris Created	Notes
10/13/1959	Explorer VI	Bold Orion	direct ascent	0	Successful test, passed within 6.4 kilometers of target
	Total Amount of Trackable Debris			0	

A separate project, designated WS-199C and code-named High Virgo, also examined the feasibility of a nuclear-tipped ALBM for the B-58 bomber. High Virgo was very similar to Bold Orion, using essentially the same one-stage solid rocket. Four High Virgo tests were conducted between September 5, 1958, and September 22, 1959, with the final test examining its potential as an ASAT weapon. However, no telemetry or camera data was recovered from the test and so its outcome is uncertain.

Table 3. Summary of tests of High Virgo in ASAT role (source)

Date of Test	Target Object	Interceptor Object	Interceptor Type	Amount of Trackable Debris Created	Notes
9/22/1959	None	High Virgo	direct ascent	0	Unknown results due to loss of telemetry
	Total Amount of Trackable Debris			0	

During the early 1960s, the U.S. Navy was also researching possible ASAT capabilities. Early efforts focused on matching a Navy Sparrow anti-aircraft missile with a Polaris Submarine-Launched Ballistic Missile (SLBM) but these efforts did not proceed beyond ground experiments. However, in 1962 the Navy began work on Project HiHo which involved a Caleb rocket fired from a Phantom 4D fighter bomber aircraft. Although the primary focus was on developing an air-launched SLV, a secondary objective was to develop ASAT capabilities. Two test launches in space were conducted in 1962, with the second launch reaching an apogee of 1,600 kilometers (1,000 miles). In the end, the Navy decided not to pursue an operational version.

Table 4. Summary of tests of Project HiHo in ASAT role (source)

Date of Test	Target Object	Interceptor Object	Interceptor Type	Amount of Trackable Debris Created	Notes
April 1962	None	Unknown	direct ascent	0	Unknown
July 1962	None	Unknown	direct ascent	0	Unknown
	Total Amount of Trackable Debris			**0**	

The first operational U.S. ASAT weapons system was Program 505, which grew out of the Nike Zeus program. The objective of Nike Zeus was to develop the capability to intercept nuclear warheads using a nuclear-tipped, ground-launched ballistic missile. The first version, Zeus A, had the capability to intercept warheads in the upper atmosphere. The second version, Zeus B, was much larger and more powerful and designed to intercept warheads at altitudes of hundreds of kilometers. Both versions were equipped with a 400 kiloton W50 nuclear warhead.

In 1962, Secretary of Defense Robert McNamara created Project Mudflap out of the Nike Zeus program in order to counter the Soviet Fractional Orbital Bombardment System (FOBS). The goal was to create an ASAT weapon capable of intercepting Soviet FOBS satellites carrying nuclear weapons to drop on the United States. Multiple tests were conducted in 1962, and in 1963 the program moved to Kwajalein Atoll in the Pacific. In May 1963, a modified Zeus B missile successfully intercepted an Agenda D rocket stage in orbit, demonstrating an effective ceiling[2] of about 370 kilometers (200 miles). From this point onward, Program 505 was considered operational and remained so until 1967 when the program was terminated.

Table 5. Summary of testing of Program 505 (source)

Date of Test	Target Object	Interceptor Object	Interceptor Type	Amount of Trackable Debris Created	Notes
12/17/1962	None	Nike Zeus	direct ascent	0	Successful intercept of designated point in space at 100 miles
2/15/1963	None	Nike Zeus	direct ascent	0	Successful intercept of designated point in space at 150 miles
3/21/1963	None	Nike Zeus	direct ascent	0	Unsuccessful attempt to intercept simulated satellite target
4/19/1963	None	Nike Zeus	direct ascent	0	Unsuccessful attempt to intercept simulated satellite target
5/24/ 1963	Agena D	Nike Zeus	direct ascent	0	Successful close intercept
1/4/1964	None	Nike Zeus	direct ascent	0	Successful intercept of a simulated satellite target
April 1965	None	Nike Zeus	direct ascent	0	
June-July 1965	None	Nike Zeus	direct ascent	0	Four test intercepts, of which three were successful
1/13/1966	None	Nike Zeus	direct ascent	0	Successful intercept of a simulated satellite target
Total Amount of Trackable Debris				0	

Program 505 was replaced by Program 437, the second operational American ASAT weapons development program. Program 437 was similar in nature to Program 505 but replaced the Nike

[2] In this article, the term "ceiling" is used to describe the functional upper altitude limit of an ASAT weapon system while the term "apogee" is used to describe the highest point in the trajectory of a particular flight.

Zeus missile with a Thor missile, giving it longer range. McNamara initiated Program 437 in 1962 following a series of high-altitude nuclear tests, including the Starfish Prime test that ended up unintentionally crippling one third of the operational satellites in orbit at the time. Program 437 conducted a total of ten test launches from Johnston Atoll in the Pacific and was declared operational in 1964. Program 437 could target satellites orbiting as high as 1300 kilometers (700 mi) in altitude and utilized a 1.4 megaton W49 nuclear warhead with a detonation range of 8 kilometers (5 miles). Program 437 remained operational on Johnston Atoll until the early 1970s and was formally terminated in 1975.

Table 6. Summary of Program 437 tests (source).

Date of Test	Target Object	Interceptor Object	Interceptor Type	Amount of Trackable Debris Created	Notes
2/14/1964	Transit 2A Rocket Body	Program 437	direct ascent	0	Success (passed within kill radius)
3/1/1964	unknown	Program 437	direct ascent	0	Success (primary missile scrubbed, backup missile passed within kill radius)
4/21/1964	unknown	Program 437	direct ascent	0	Success (passed within kill radius)
5/28/1964	unknown	Program 437	direct ascent	0	Failed (missed intercept point)
11/16/1964	unknown	Program 437	direct ascent	0	Successful Combat Test Launch (passed within kill radius)
4/5/1965	Transit 2A Rocket Body	Program 437	direct ascent	0	Successful Combat Test Launch (passed within kill radius)
3/30/1967	unknown piece of space debris	Program 437	direct ascent	0	Successful Combat Evaluation Launch (passed within kill radius)
5/15/1968	unknown	Program 437	direct ascent	0	Successful Combat Evaluation Launch (passed within kill radius)
11/21/1968	unknown	Program 437	direct ascent	0	Successful Combat Evaluation Launch (passed within kill radius)
3/28/1970	unknown	Program 437	direct ascent	0	Success (passed within

	satellite				kill radius)
	Total Amount of Trackable Debris			0	

In the late 1970s, the United States began development of its third operational ASAT weapon system, initially called the Prototype Miniature Air-Launched Segment (PMALS) and later designated the ASM-135. Like Bold Orion and High Virgo, the ASM-135 was designed as a missile to be fired from an aircraft, specifically an F-15 fighter. The ASM-135 used a modified AGM-69 Short Range Attack Missile (SRAM) two-stage nuclear air-to-surface missile as the launch vehicle with the Miniature Vehicle (MV) as the payload. The MV used an infrared sensor to home in on the target satellite. The ASM-135 was tested five times between 1984 and 1986, with the successful intercept and destruction of the U.S. P78-1 Solwind satellite in 1985. Table 6 summarizes these tests.

Table 7. Summary of tests for the ASM-135 ASAT weapon system (Source).

Date of Test	Target Object	Interceptor Object	Interceptor Type	Amount of Trackable Debris Created	Notes
1/21/1984	None	ASM-135	direct ascent	0	Successful test of the missile without the MV
11/13/1984	Star	ASM-135	direct ascent	0	Failed test of the missile without the MV
9/13/1985	Solwind	ASM-135	direct ascent	285	Successful destruction of the target
8/22/1986	Star	ASM-135	direct ascent	0	Successful tracking of the target star
9/29/1986	Star	ASM-135	direct ascent	0	Successful tracking of the target star
	Total Amount of Trackable Debris			285	

U.S. Air Force plans called for the operational deployment of 112 ASM-135 missiles and 48 modified F-15 fighters with units in Washington and Virginia. However, the program was canceled in 1988 due to a combination of Congressional restrictions on its testing, budget restrictions, and concerns over potentially igniting a space arms race with the Soviets.

Currently, the U.S. military does not have any known dedicated, operational ASAT weapons systems aside from the Counter Communications System (CCS). The CCS is a “temporary and reversible” ASAT weapons system that interferes with an adversary’s ability to utilize a satellite, likely through jamming or other radio frequency interference techniques, without permanently damaging the satellite. However, many consider the U.S. Aegis ballistic missile defense system to have an inherent ASAT capability. This is largely due to the successful use of the Aegis system to destroy the failed USA 193 satellite on February 21, 2008. The stated reason for the operation, known internally in the U.S. government as Burnt Frost, was to prevent the satellite's stock of toxic hydrazine fuel from presenting a danger in the event it survived atmospheric re-entry. Although one study supporting the danger of such a tank was eventually released as the result of a Freedom of Information Act request, its methodology and thoroughness left much to be desired.

Burnt Frost involved launching a Sandard Missile 3 (SM-3) from the guided missile cruiser *USS Lake Erie* with a Lightweight Exo-Atmospheric Projectile (LEAP) interceptor onboard that collided with and destroyed USA 193 at an altitude of 247 kilometers (153 miles). Before and after the interception, the U.S. government made a significant public case for its responsible behavior in conducting the interception. It argued that it had designed the intercept in such a way as to minimize the amount of long-lived orbital debris it created, and made a direct contrast to the 2007 Chinese ASAT test that destroyed the FY-1C weather satellite. Steps taken by the United States to limit debris included disabling the third stage of the SM-3 to limit the intercept velocity, and hitting the target after the interceptor passed through perigee and was on a downward trajectory. After the interception, a U.S. government press release said "nearly all of the debris will burn up on reentry within 24-48 hours and the remaining debris should re-enter within 40 days."

The reality of the debris created by Burnt Frost was quite different. The U.S. military's Space Surveillance Network (SSN) tracked and cataloged 174 pieces of orbital debris from the destruction of USA 193. By March 1, one week after the intercept, only two pieces of debris from the event had re-entered. By the end of March, more than half the pieces had re-entered, but it would not be until October 28, 2009, more than eighteen months later, that the final piece of debris would re-enter the atmosphere. The main reason for this was that a significant proportion of the debris was thrown into much higher orbits than the altitude of USA 193 at the time of intercept. The delta-v from the intercept pushed several pieces into orbits with apogees above 400 kilometers (248 miles), and at least two pieces into orbits with apogees above 700 kilometers (434 miles). This contrasts sharply with the public comments made by the United States on its efforts to minimize the debris from the intercept as the resulting debris field was the same order of magnitude in size as that created by the destruction of Solwind in 1985 by the ASM-135 ASAT weapon system.

Table 8. Summary of the ASAT tests conducted using the Aegis SM-3 BMD system (source).

Date of Test	Target Object	Interceptor Object	Interceptor Type	Amount of Trackable Debris Created	Notes
2/21/2008	USA 193	LEAP	direct ascent	174	Success
		Total Amount of Trackable Debris		174	

At the time the United States argued (and has since continued to argue) that this was not an ASAT test and the SM-3 interceptor is not an ASAT weapons system. It stated that the software for the missile used in the test (and two other backup missiles) was modified to allow the missile to track and intercept a satellite and that after the intercept the software was returned to normal. However, this claim is not verifiable through external means. Thus, because the Aegis system has clearly demonstrated the capability to intercept and destroy a satellite and there is no way to verify whether a particular Aegis ship has SM-3s with modified missiles on it or not, potential adversaries likely assume that any Aegis BMD vessel could be a potential mobile ASAT threat.

The caveat to this conclusion is that the version of the SM-3 missile currently deployed has a limited engagement range. Burnt Frost utilized the Block IA version of the SM-3 with the third stage disabled. The U.S. government has not explicitly stated what the ceiling of the SM-3 Block 1A is, but outside analysts have estimated that an SM-3 utilizing all three rocket stages could have a ceiling of approximately 600 kilometers (373 mi). There are only limited numbers of operational satellites orbiting below 700 kilometers (434 miles), which means the current version of the SM-3 has limited value as an ASAT weapon and can only reach the lower portions of LEO.

However, the Missile Defense Agency is currently developing the Block IIA version in collaboration with Japan which will have significantly greater delta-v and thus a higher ceiling, possibly between 1,450 kilometers (900 miles) and 2,350 kilometers (1460 miles). Those ranges encompass virtually all the operational satellites in LEO, including nearly 100 Chinese and Russian satellites. Block IIA is expected to begin testing in 2015 and be operationally deployed in 2018 aboard ships with Aegis BMD version 5.1 and also the Aegis Ashore sites in Poland and Romania. Figure 14 shows a comparison of the various versions of the SM-3 missile.

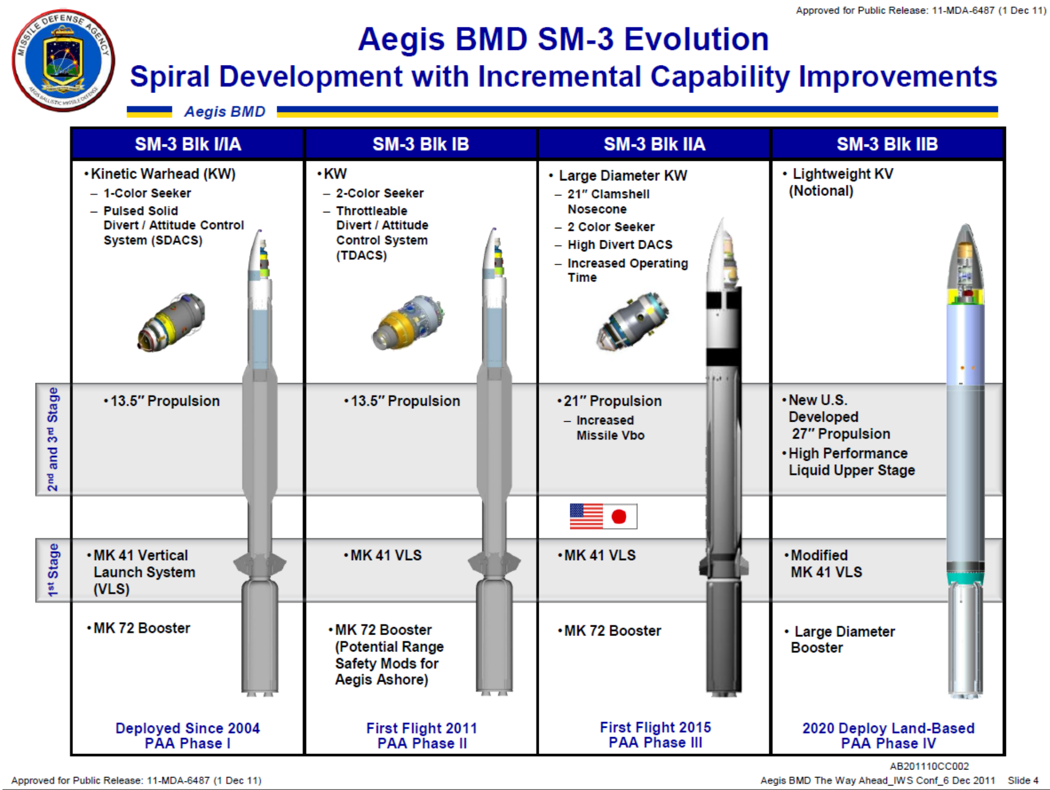

Figure 16. Aegis BMD-SM-3 evolution (Source) Image credit Missile Defense Agency.

Moreover, it is an open question as to whether the same software change that was made to the SM-3 could be applied to any of the 30 Ground Based Interceptors (GBIs) that are currently fielded in missile defense silos in Fort Greely, Alaska, and Vandenberg, California, as part of the U.S. Ground-Based Midcourse Defense (GMD) system. The GBIs are three-stage missiles with Exoatmospheric Kill Vehicles (EKV) as the payload and have an estimated ceiling of 2,000 kilometers. This ceiling is the result of the need to intercept potential nuclear warheads launched on potential ICBMs from North Korea. Although the GBIs have never been tested against an orbital target, they have the reach to do if the United States so desired. And while their fixed locations in Alaska and California make them much less flexible than a mobile system, it could be that potential U.S. adversaries also treat the GMD as a potential ASAT system.

Finally, it is important to point out that not all missile defense systems have latent ASAT capabilities. Missile defense systems are generally broken down into three types based on which phase of ballistic missile flight they target. Boost phase systems target ballistic missile during their boost phase, which generally only lasts for the first few minutes of flight. Terminal phase systems target the warheads from ballistic missiles during or after their atmospheric re-entry which is only the last few minutes of flight. Midcourse missile defense systems target ballistic missiles or their payloads during flight after boost and before re-entry. It is these midcourse missile defense systems that are very similar in capability to ASAT systems as they are designed to target objects moving through space in the same altitude regime as LEO satellites. Most boost phase missile defense systems, such as theoretical concept for drones armed with missiles, and terminal phase systems, such as the U.S. Army's deployed Terminal High-Altitude Area Defense (THAAD) systems, do not have significant ASAT capabilities.

Russian ASAT Testing in Space

In contrast to the United States and China, Russia has largely preferred the co-orbital type of ASAT systems with its own weapons development and testing dating back to the 1960s. The first ASAT weapons system developed by Russia was a co-orbital ASAT weapon system called the Istrebitel Sputnikov (IS) or "satellite destroyer." The IS system consisted of a kill vehicle and a launch vehicle based on the R-36 ICBM (designated the SS-9 Scarp by U.S. intelligence) and later on the Tsyklon-2 SLV (designated SL-11 by the U.S.). After being placed into orbit, the kill vehicle would maneuver to intercept the target satellite and detonate onboard explosives, generating a significant amount of shrapnel that could damage or destroy the target. Development began in the early 1960s and the system was tested in orbit multiple times between 1962 and 1982. Beginning in 1980, the tests involved an upgraded version known as IS-M that could target satellites at altitudes as high as 2,000 km. The target for all of these tests was a special armored satellite with onboard sensors to record hits that could reportedly survive multiple attacks. Table 8 presents a summary of these tests, the target for the test (if there was one), and the amount of orbital debris cataloged by the U.S. military's tracking network of each grouping of interceptors and target.

Table 9. Summary of Soviet tests of the IS co-orbital ASAT weapon system (source).

Date of Test	Target Object	Interceptor Object	Interceptor Type	Amount of Trackable Debris Created	Notes
11/1/1963	None	Polyot 1	co-orbital	0	Engine and maneuvering test
4/12/1964	None	Polyot 2	co-orbital	0	Engine and maneuvering test
10/27/1967	None	Cosmos 185 (IS)	co-orbital	0	First test launch of IS interceptor
10/20/1968	Cosmos 248	Cosmos 249, Cosmos 252 (IS)	co-orbital	251	Attacked twice: Cosmos 249 on Oct 20 and Cosmos 252 on Nov 1
10/23/1970	Cosmos 373	Cosmos 374, Cosmos 375(IS)	co-orbital	145	Attacked twice: Cosmos 374 on Oct 23 and Cosmos 375 on

					Oct 30
2/25/1971	Cosmos 394	Cosmos 397 (IS)	co-orbital	116	
3/18/1971	Cosmos 400	Cosmos 404 (IS)	co-orbital	0	
12/3/1971	Cosmos 459	Cosmos 462 (IS)	co-orbital	27	
2/16/1976	Cosmos 803	Cosmos 804, Cosmos 814 (IS)	co-orbital	0	Attacked twice: Cosmos 803 on Feb 12 and Cosmos 804 on Feb 16
7/9/1976	Cosmos 839	Cosmos 843 (IS)	co-orbital	0	
12/17/1976	Cosmos 880	Cosmos 886 (IS)	co-orbital	67	
5/23/1977	Cosmos 909	Cosmos 910, Cosmos 918 (IS)	co-orbital	0	Attacked twice: Cosmos 910 on May 23 and Cosmos 918 on Jun 17 (both failures)
10/26/1977	Cosmos 959	Cosmos 961 (IS)	co-orbital	0	
12/21/1977	Cosmos 967	Cosmos 970 (IS)	co-orbital	0	Missed target, used as target itself in following test
5/19/1978	Cosmos 970	Cosmos 1009 (IS-M)	co-orbital	5	
4/18/1980	Cosmos 1171	Cosmos 1174 (IS-M)	co-orbital	41	
2/2/1981	Cosmos 1241	Cosmos 1243, Cosmos 1258 (IS-M)	co-orbital	0	Attacked twice: Cosmos 1243 on Feb 2 and Cosmos 1258 on Mar 14 (both failures)
6/18/1982	Cosmos 1375	Cosmos 1379 (IS-M)	co-orbital	3	
	Total Amount of Trackable Debris			842	

A major shortcoming of the IS system was that it could only attack targets in LEO and it needed at least two revolutions around the Earth in order to sync up with the target. This took anywhere from three to five hours and thus allowed significant time for the target to detect the attack and potentially maneuver out of the way. As a result, an upgraded version that could target maneuvering satellites, known as IS-MU, was reportedly developed in the 1980s and was declared operational from 1991 through 1993. There is no publicly available information on any operational tests of the IS-MU system in space, and the program was withdrawn from operational service in 1993.

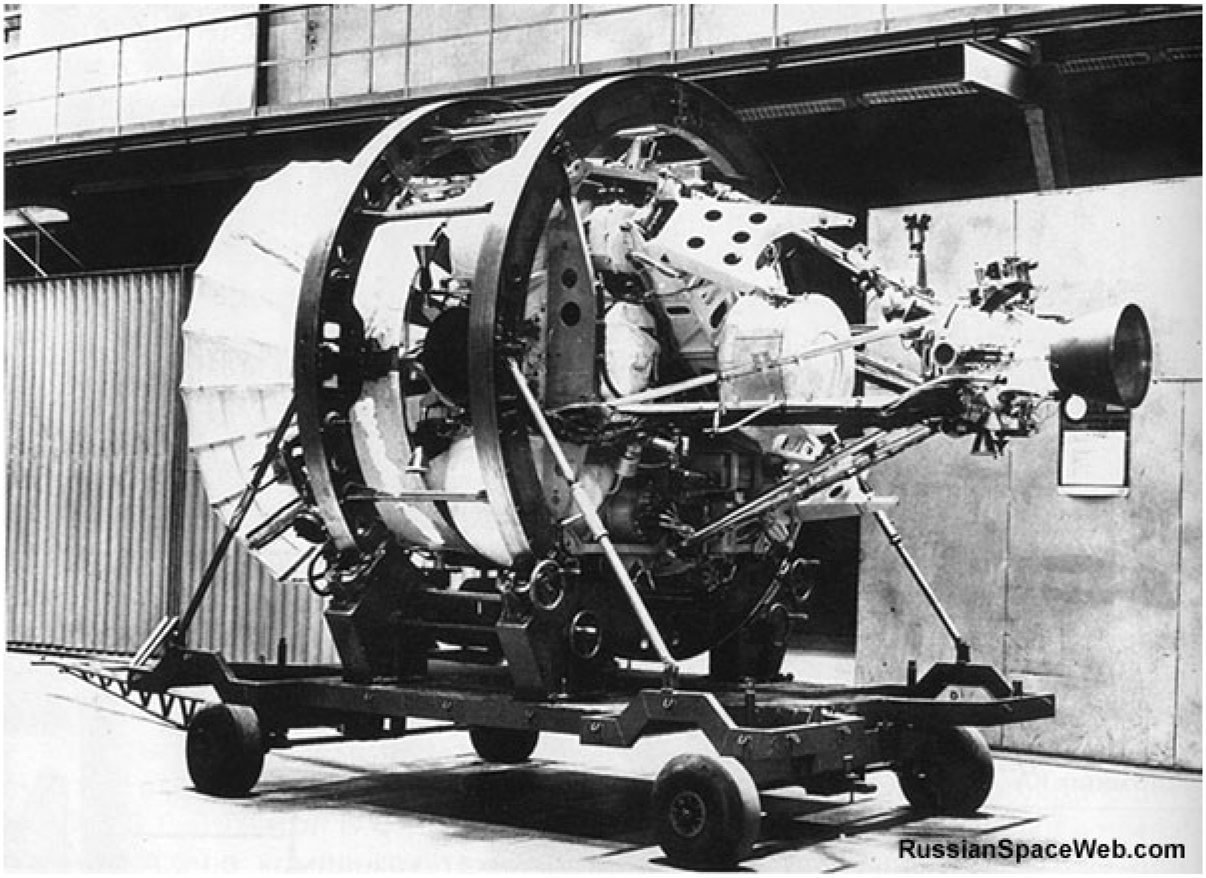

Figure 17. Photo of the Soviet IS killer satellite during ground processing. Image courtesy of the Russianspaceweb.com Credit: TsNII Kometa

During the mid-1980s, the Soviets began development of a second co-orbital ASAT weapons system known as Naryad. This system utilized a rocket based on the UR-100NU (NATO designation SS-19 Stiletto) that was fitted with a powerful upper stage. The upper stage was significantly more powerful and lighter in weight than previous ones and could reportedly reignite up to 75 times. This would allow the upper stage to place one or more kill vehicles into orbits as high as 40,000 kilometers (24,850 miles), allowing them to independently target and home in on multiple target satellites before detonating. The Naryad system was reportedly tested multiple times, but there are scant details on the nature and number of those tests. Publicly available information indicates two suborbital tests from Baikonour Cosmodrome in 1990 and

1991, and the first orbital launch in 1994 of a satellite that was placed into a 1900 by 2145 kilometer (1,180 by 1332 mile) orbit. It is rumored that the satellite, designated Radio-ROSTO by the Russians, was actually based on the Naryad interceptor .There are no known instances of actual test intercepts of the Naryad system or of the creation of orbital debris as a result of these tests.

Figure 18. Scale models of the Briz-K and Briz-KM upper stages. Image credit RussianSpaceWeb.com

After the demise of the Soviet Union, the Naryad system was repurposed into a commercial SLV operating out of the Plesetsk Cosmodrome. The UR-100R became the Rockot SLV and the upper stage was rebranded as the Briz-K and later developed into the Briz-KM. The Rockot has been mostly successful, with 18 successful launches through 2013 placing more than 40 satellites into LEO. The Briz-KM was further modified with the addition of external fuel tanks to become the Briz-M. Since 2000, the Briz-M has been the main upper stage used in Russian space launches of payloads to deep space orbits, including GEO. More than 70 Briz-M upper stages are currently in orbit, and given their ASAT ancestry it is possible that the U.S. military is suspicious of whether or not all of those are benign.

In 1984, in response to the American ASM-135, the Soviets began work on their own air-launched direct ascent ASAT system known as Kontakt. The Kontakt system involved a specially modified MIG-31D fighter mated with a 10-meter-long (33 feet) rocket. The original rocket was designed to have the capability to intercept satellites as high as 600 kilometers (373 miles) in altitude, with later versions envisioned to have an additional stage that could engage targets up to 1500 kilometers (932 miles). The ground infrastructure for the Kontakt program included the 20Zh6 Krona radar and the 0Zh6 LOL "laser optical locator" to help identify and precisely track the satellite targets. The goal of the program was to create a system that could attack and destroy up to 24 satellites in as little as 36 hours.

Most analysts have concluded that the program did not proceed to the testing phase before its cancellation in in 1989. However, a MIG test pilot who worked on the program said in an interview that the missile was launched from a plane several times at a target in space but was detonated before it actually intercepted to prevent the United States from detecting the test. The Krona and LOL tracking systems are still an active part of the Russian Space Surveillance System (SSS).

THE PROLIFERATION OF HIT-TO-KILL SYSTEMS AND THE END OF SPACE AS A SANCTUARY

The preceding discussion of Chinese, American, and Russian ASAT testing and weapons development programs illustrates three main points. First, it is clear that efforts to develop the ability to intercept and destroy satellites have been under development since satellites first became reality. Originally, ASAT development was driven by the need to counter satellites that could be carrying nuclear weapons for de-orbiting over a target without trigging the detection and warning systems that were in place at that time. ASATs were thus seen as the only policy option to prevent such systems being used for coercion. As the Cold War progressed and space systems became an increasingly important part of national technical means of verification (NTMV) for various arms control agreements, interest in ASAT development tailed off. However, the increased use of space capabilities for force enhancement in towards the end of the Cold War rekindled interest in ASATs. More recently, the development and deployment of midcourse missile defense systems have brought with them ancillary ASAT capabilities. The increasing number of States using satellites to provide national security capabilities and concerns over ballistic missile and WMD proliferation will only accelerate this trend.

Second, the technology to destroy a satellite using rockets has been well understood for at least five decades. The requirements are a rocket that can loft the kill vehicle to the altitude of the target satellite or place the interceptor into orbit, the ability to track a satellite and communicate that information to the interceptor, and an interceptor that can track and home on the target. The launch portion can be done by any SLV in use today and most medium-range ballistic missiles, and there has always been a cross-flow between ballistic missile programs and SLV programs in virtually every country that has developed them. It is common for ballistic missiles to become SLVs or parts of SLVs after retirement from their missile role. A hit-to-kill kinetic intercept is much more challenging than using a stand-off device such as a nuclear warhead, but the technology to target and track satellites with the precision to do a physical intercept has existed since at least the 1970s and has only gotten easier with modern electronics, computers, and software.

Third, there is no meaningful difference between midcourse ballistic missile defense and hit-to-kill ASAT capabilities. Because midcourse ballistic missile systems are intended to destroy warheads travelling at speeds and altitudes comparable to those of satellites, all midcourse ballistic missile defense systems have inherent ASAT capabilities. Typically the only difference between the two systems is the software and control algorithms used to detect, track, and home in on a satellite as compared to a warhead. In fact, these systems are likely more effective as ASAT weapons than missile defense systems due to most satellites being easier targets to detect, track, and target than warheads, which are likely accompanied by penetration aids to confuse potential defense.

This duality presents a significant political problem for the United States which is trying to simultaneously promote the development of midcourse missile defense capabilities by itself and its allies while stigmatizing the development of ASAT weapons by its potential adversaries. To this end, the United States has gone to great lengths to try and create artificial difference between the two capabilities. An example of this is the definition of the Chinese SC-19 as a "kinetic energy weapon" and the American SM-3 as a "low-altitude, direct-ascent interceptor" in the "Space System Threats" chapter of the Air University Space Primer, when in reality they are both low-altitude, direct-ascent interceptors that utilize kinetic energy kill vehicles. This duality may also play a significant role in the unwillingness of the United States to go public on China's ASAT weapons development because it would also invite criticism of its own midcourse missile defense development.

Quelle surprise?

Given the well-known history of ASAT weapons testing by both the United States and Russia, one might wonder why the Chinese ASAT program, and in particular the May 2013 launch, caused so much consternation within the U.S. government. There could be several factors at work. First, it may be that the U.S. intelligence community estimated China's capabilities in this area to be at a certain level and that estimate turned out to underrepresent their progress. They may also have forecasted China's development of ASAT capabilities to be progressing at a much slower rate than reality. So as in the case of a publicly traded company failing to meet or exceeding Wall Street's estimates of performance, the U.S. government's reaction to the test may be based in part on a reaction to its previous assessments.

However, given the array of ground, air, sea, space and cyber intelligence capabilities the United States has at its disposal it likely has a very good assessment of where China's capabilities stand now and in particular the capabilities of the ASAT systems that have been tested. What is more difficult to assess is the intent behind those capabilities. Given some of the public statements and writings from senior Chinese military leaders as well as parts of Chinese military doctrine on space, at least some in the U.S. government are concerned that China's ASAT capabilities are for more than just a political bargaining chip or show of force. If the increasing tensions between China and its neighbors in the East China Sea do escalate to a military engagement, there is a concern by some that attacks on U.S. satellites may take place. It is the combination of the theoretical potential for this scenario, the uncertainty and lack of information about China's decision-making process, and the lack of clarity of intent behind China's ASAT testing and weapons development that leads to a significant amount of concern in U.S. national security circles.

Some have claimed that China's ASAT testing and the May 2013 launch in particular represent a fundamentally "new" capability and a new threat to U.S. national security space systems. This is true only in the strictest sense. No other country has tested a direct ascent ASAT weapon system with the potential to reach deep space satellites in MEO, HEO, and GEO. However, the publicly available information does not indicate that developing such a system involved developing new technology. The United States or Soviet Union could have developed it long ago, but lacked the incentives to do because there was nothing of value for either to attack in deep space orbits that was worth risking the sanctuary of their own satellites or nuclear war. Moreover, development of such a Chinese capability would not represent the first time U.S. national security satellites in deep space orbits were at risk. The vulnerabilities of such satellites have been known for decades and in many cases are the result of a deliberate choice by system architects. The Russian Naryad program resulted in a highly maneuverable platform that could theoretically be used to attack those same satellites and potentially posed an even more dangerous threat by being able to persist in orbit until such time as the weapons would be needed. High-level U.S. officials claimed in 1988 that the Soviets were then developing mobile ASAT weapons based on their ballistic missile TELs, similar to what China appears to be doing now. Thus neither the mobile nor deep space threat is entirely new.

Another factor could be the long-standing preference of the U.S. intelligence community to keep quiet about China's activities in space, sometimes even within the U.S. government. The intelligence community, and particularly the space portions of the intelligence community, has evolved a deep culture of secrecy. The origins of this culture trace back to the beginnings of the space-based reconnaissance program during the Eisenhower administration. At the time, the existence of the WS-117L effort to develop the world's first satellite reconnaissance capability was highly classified and even kept from many in the U.S. military. The main impetus for this was not to hide it from the Soviets, but rather to avoid provoking the Soviets by not publicly "rubbing it in their noses" that the United States possessed such a capability. This policy of secrecy was extended by the Kennedy administration and eventually resulted in a classified 1962 Department of Defense directive that mandated the "blackout" of all U.S. military space activities. Although some parts of that blackout policy have been rolled back over time, this culture of secrecy has become deeply ingrained in the space intelligence community even long after the original impetus for it went away. The more recent addition of cyber intelligence capabilities has only reinforced the culture of secrecy across the whole intelligence community.

A significant part of this culture of secrecy is protecting the capabilities the United States has for collecting intelligence by not revealing its "sources and methods." Such revelations could lead to discovery of the means by which the United States determined the information and changes to systems or operational practices that undermine future collection efforts. This was the primary rationale for the complete secrecy surrounding the National Security Agency's (NSA) program for mass collection of telephone metadata and its program for collection of foreign intelligence information from electronic communication service providers. In regard to China, this has led to a policy of the United States not revealing anything it knows about Chinese space activities, unless information about such activities is available from other sources or revealing it is overwhelmingly in the interests of the United States (as was the case of the 2007 Chinese ASAT test).

It is likely that not everyone in the U.S. government is behind this secrecy approach, as it is not a unitary actor and has its multiple factions and interest groups. Those in the State Department or even in the Pentagon who are backing efforts to engage with China and other countries on developing norms of behavior for space activities and those who are tasked with protecting U.S. national security space assets are likely pushing within the interagency process to reveal more about what China is doing. However, space-based satellite reconnaissance has long held a particularly privileged position in U.S. national security circles owing to the importance of such capabilities to U.S. decision makers. Thus, the intelligence community has what almost amounts to veto power over any national security decision that could theoretically jeopardize its interests.

This tendency towards overwhelming secrecy is not new and has contributed to significant negative impacts on U.S. national security in the past. For example, Soviet efforts to build and launch a satellite in the late 1950s were well known to the upper echelons of the Eisenhower administration because of its intelligence collection efforts. At the same time, the efforts of the United States to develop its own rockets and satellites, including the WS-117L surveillance satellite program, were also under way (and by some measures on par with or even ahead of the Soviets). The lack of details in the public domain about either the Soviet or American programs laid the groundwork for the public shock that resulted after Sputnik. This was a shock the Eisenhower administration never recovered from and one that deeply affected the American public. More recently, DNI Clapper has said that the U.S. government should have been more open about some parts the NSA's surveillance programs from the very beginning to create legitimacy and avoid some of the current controversy created by the leaks from former NSA contractor Edward Snowden. One wonders if the overbearing secrecy regarding intelligence about Chinese ASAT testing might end up negatively impacting U.S. policy efforts down the road, including efforts to develop norms of behavior in space.

It is also clear that there are elements within the United States that have an interest in portraying China as a substantial threat to America. This is not a conspiracy per se but rather a direct result of economic and organizational incentives. The intelligence community has a vested interest in protecting its ability to collect intelligence data and also to expand its data collection efforts. There is also an on-going battle within the Pentagon over what the future national security threat landscape looks like and whether the U.S. military should align itself to conduct counterinsurgency (COIN) and counterterrorism operations as in Iraq and Afghanistan or fight regional conventional wars with Iran, North Korea, China or even a resurgent Russia. There are also factions within Congress and the broader punditry universe for whom a more dangerous China aligns with a range of ideological and political worldviews and desired outcomes.

Given the paucity of information about what China is really doing and their intentions, it is impossible to state with certainty what the reality is concerning China's ASAT weapons program. The secrecy surrounding the issue and the rampant opportunities for manipulation and spin only exacerbate the situation. The combination of the secrecy of the intelligence community, the desire by some to have a new "near peer" adversary, the opportunity for a lot of defense contractors to make money re-equipping the Pentagon to fight such an adversary, and grandstanding by members of Congress to use China as a means to their ideological and political ends, and the likely reaction by China to all these U.S. actions results in a very troubling feedback loop that drives the two countries towards confrontation.

The Uncertain, Risky Future

There is the potential that a similar blanket of official government secrecy over the developments in China's ASAT testing program (and perhaps other efforts that the public is not yet aware of) will create its own negative consequences. It is becoming increasingly difficult for any government, including the United States and China, to completely hide all knowledge of these events from the public. As this article has clearly pointed out, there are many photos, videos, papers, presentations, and eyewitness accounts to draw from, even in China. In the United States there are also anonymous sources within the national security community that have repeatedly leaked classified information on Chinese ASAT activities to select members of the media. The danger is that these trickles and leaks can be deliberately manipulated by various parties to serve their own political or ideological interests. This type of agenda control is not uncommon in media reporting and government leaking, but its persuasive effects are enhanced by the lack of other information and facts to weigh it against. Attempting to exert control over an issue area by withholding information gives others the opportunity to seize control by providing their own information.

The U.S. government should release more precise details about where the pieces from the May 13, 2013 launch re-entered. Its capabilities to do so are commonly known and doing so should not reveal sources and methods. Providing such information would add significant weight to the U.S. claim that this launch went much higher than China claimed, and also add credence to the U.S. claims that this launch was a test of a new ASAT capability. This could open doors to political pressure on China, especially if China conducts future tests of the system and is considering an actual intercept. At the same time, the Chinese government could back up its claims that it was merely a scientific test itself by providing more information on the launch. For example, details on what type of sounding rocket was used and what pad it launched from could add credibility to its story. If there was a scientific package onboard that conducted experiments, announcing when and where the data and results will be published would also add credibility. Furthermore, if there are any indications that China or any other country is considering a destructive test in or near GEO, preventing such a test should be the top priority for the entire space community.

A bigger issue than this one event is the significant changes taking place in the space security world. There is increasing evidence that hit-to-kill midcourse missile defense and ASAT systems are proliferating around the world. The United States and its Japanese and European allies plan to deploy 43 Aegis BMD ships, loaded with 486 SM-3 Block 1A/1B missiles, and Aegis Ashore installations in Romania and Poland with 14 Block IIA missiles by 2018. In 2012, the Russian media reported that the Russian military would be restarting work on its airborne laser ASAT system. The Russian media also reported in 2013 that the Duma called for the Russian military to restart the Kontakt air-launched ASAT program. Largely in response to the Chinese ASAT developments discussed above, India has also made several statements about their interest in developing an ASAT capability from their ongoing missile defense program to deter attacks on Indian space assets.

At the same time, a growing number of countries are integrating space into their national military capabilities and relying on space-based information for national security. This increased reliance means there is also an increased chance that any interference with satellites could spark or escalate tensions and conflict in space or on Earth. This is made all the more difficult by the challenge of determining the exact cause of a satellite malfunction: whether it was due to a space weather event, impact by space debris, unintentional interference, or deliberate aggression. All of this suggests a much more dangerous and uncertain security situation in space for all, and particular the United States which is the most dependent on space and has the most satellites in orbit. How the United States and the world deals with that future and what the repercussions will be is an extremely difficult question to answer.

Framing that question in terms of the weaponization of space or an arms race in space is likely not a useful path towards finding an answer to this problem. Those debates typically revolve around the placement of weapons in outer space and thus exclude the ASAT weapons launched from the ground, air, or sea that make up the vast majority of the systems described above. The core issue is not the placement of weapons *in space* but rather the proliferation of ASAT capabilities in general, regardless of whether they are space-based, ground-based, air-based, or sea-based. As more and more countries begin to rely on space capabilities for national security, the development and testing of ASAT capabilities is more likely to undermine political and strategic stability. The actual use of ASAT capabilities against space systems is also increasingly likely to spark or escalate conflict on Earth. All of this could jeopardize the long-term sustainability, safety and security of space for all and humanity's ability to utilize space for its many benefits, both known and unknown.

We do have some idea what the United States' strategy is for dealing with this uncertain and risky future. In testimony before SASC in March 2014, Deputy Assistant Secretary of Defense for Space Policy Doug Loverro outlined the Pentagon's strategy for dealing with these challenges. The strategy includes five main elements: building and reinforcing international norms of responsible behavior in space, improving space situational awareness (SSA), making DoD space systems and architectures more resilient against attacks, deterring aggression against

U.S. space systems, and being able to defeat attacks on those systems. This represents a comprehensive and multi-layered approach but also one that will take a decade or longer to implement, leaving a critical near-term vulnerability. Explaining the rationale behind this strategy and how this near-term vulnerability might be addressed will be the subject of a future article.

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