# The Mechanics of Spaceborne Warfare

## Exploring Anti-Satellite Operations

(Part of the Nightshade Advanced Polymorphic Defense and Warfare Doctrine)

By
Adib Enayati, Ph.D.
Cyber/Electronic Operations and Warfare

**The Mechanics of Spaceborne Warfare: Exploring Anti-Satellite Operations**
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This document is devoted to my esteemed friend and mentor, **J. Barry Foster**. His guidance, support, and leadership have empowered me to overcome my limitations and realize my potential.

## The Importance of Satellite Communications

Satellite communications are the backbone of any modern military network. Satellite networks can cover almost every corner of the earth, provide reliable communications, guidance and navigation, surveillance along with sensory systems in support of the MASINT (Measurements and Signature Intelligence) and strategic systems as well as enabling the high command to be able to track and manage the battlefield developments with the spaceborne sensors with high accuracy and in Realtime. Satellites are an indispensable component of the modern warfare. The reliability of the satellites in supporting our military equipment, armament and components are highly regarded as a key factor in their development in the past five decades.

## Understanding the Role of the Satellites

The importance of satellite networks is not just understood in the military, the vast majority of our daily lives is heavily dependent on the satellites. The United States adversaries have made significant progress in designing and employing spaceborne communications and navigation in order to support the components of their armed forces.

"Mil-Net" which is Short for Military Network, refers to a backbone which military components, weapon systems and infrastructure communicate and operate. The United States adversaries such as Russia, China and Even Iran have been expanding their space-based capabilities and they have a clear roadmap towards space warfare. Satellites provide global reliable and secure communications, guidance and C6ISR capabilities for the modern militaries around the world. You cannot find any advanced nation without them incorporating some sort of satellite technology for their military infrastructure given the fact that Satellites provide an exceptional layer of redundancy for the existing C6ISR networks. While earth based C6ISR components can be targeted with ease across a theater, the assets in space seems to be far from the reach of an adversary which is why they are an indispensable component to any modern military. The new world's threat axis of Russia, China, North Korea and Iran have all understood the importance of it, especially the dynamics of its use for the United States. Such adversarial behavior requires a special attention to the final frontier and the deployed and in-development capabilities of the United States adversaries.

Adversaries have understood the importance of the space and spaceborne capabilities which is why they have been developing their own navigation and guidance instead of relying on the existing technologies, Russia has developed the GLONASS (Глобальная навигационная спутниковая система) with currently 24 operational satellites in orbit providing guidance and navigation for its military and arsenal, China has developed its BeiDou with 35 satellites in orbit and Iran is working on an active space program and planning to employ its own guidance and navigation satellite network (Currently trying to incorporate GLONASS and Partially BeiDou). While the United States adversaries may be far behind the advancements of the United States, they are actively trying to expand their spaceborne capabilities with a hardened terrestrial network. It has been their dependency on the terrestrial networks that has enabled them to harden their terrestrial capabilities. An active focus towards the spaceborne and terrestrial theater will enable the United States to enhance its capabilities in order to guarantee its absolute superiority. Establishing a full symmetrical anti-satellite capability in space and on earth will enable the United States to take a big step towards the dominance of the Electromagnetic spectrum. Adversaries are actively trying to maintain the symmetry in their capacities visa-a-vis the United States', countries such as Russia and China are pushing towards the advancement of their spaceborne capacities in order to be able to dominate the future theaters. While guidance and navigation make up a small part of the space-borne capacities, it is also important to note that the modern-satellite networks are a core part of the C6ISR.

Spaceborne sensors permit the real-time identification of the threats as well as monitoring any adversarial developments. Utilizing the spaceborne systems will enable the high command to understand the order of battle as it develops.

## Understanding EMS and the Modern Electronic Combat

Electromagnetic spectrum consists of the full range of the electromagnetic radiation. Its components stretch from radio waves to visible light and far beyond the X-ray and Gamma radiation. It enables everything around us to function as they are. From your basic analog radio to cellphones, radar and missile guidance and navigation. Consider it the most valuable resources that the humanity has ever owned. However, unlike some strategic resources, the EMS is available to everyone, understanding it and developing the tools for its dominance permits the Unites states to establish its dominance and maintain its superiority in the electromagnetic realm. While this always has been the goal for me; The inhibitors such as lack of general understanding of the modern electronic warfare and its importance in any modern theater have been a challenge. The classical electronic warfare has always been around since the very development of the first radar, electronic warfare as it is understood has always been overlooked as just a force multiplier; its offensive potential has been suppressed by that approach while the United States adversaries intended to use its full potential. The modern electronic combat as I have studied and I would define has

a special emphasis of the understanding of the spectrum and utilizing every aspect of it. Everything from radar and radio to lasers and above are all a subject of the modern electronic warfare with a unique offensive approach. Modern electronic warfare is implemented in design of every equipment, component and even the mission planning for a modern theater. Consider it a sharp blade that cuts both ways. Every offensive technique that we develop is followed by the development of a series of defensive capabilities. This equation must be balanced in order for it to enable the United States full dominance over the spectrum. The modern electronic warfare is no longer just about interference and disruption; it is about elimination via kinetic and non-kinetic means.

**Understanding the Spaceborne Warfare**

Since before the release of the "Electromagnetic Spectrum Superiority Strategy" by the pentagon in 2020; I have been publicly expressing the significance and importance of dominating the electromagnetic spectrum in establishing absolute superiority of the United States and how it can affect the future battle theaters. Much of my nightshade advanced polymorphic defensive and warfare doctrine emphasizing on the importance of the enhancement of the offensive electromagnetic capabilities across five domains of the modern warfare. Spaceborne combat in its essence should be able to secure the United States' C6ISR (Command, Control, Communications, Computers, Cyber and Intelligence Surveillance and reconnaissance) dominance while being able to disrupt or eliminate its adversarial capabilities to maintain the C6ISR. While the core purpose of the spaceborne warfare remains clear, the execution of such a task is indeed a challenge. Establishing dominance in the space requires adaptability and development of a whole series and concepts of battle with the modern electronic warfare in its core. This particular document will expand on the principles of the spaceborne warfare as I have developed as a part of the nightshade. Space is a component of modern warfare and much like its five other domains, it must be dominated to ensure a full battle supremacy of the United States in any modern theater. Satellites, as the most important components of the modern network centric theaters are a key enabler of the modern adversarial capabilities and therefore this document will focus on anti-satellite combat as described in the nightshade advanced polymorphic defense and warfare doctrine.

Unlike combat operations on earth, space is far more unforgiving and there are a lot of components that must be taken into equation for conducting a successful mission. The three-dimensional property of the space should be utilized to develop combat systems yet that would only be a part of the challenge as it has to be placed into what we call an orbit, an orbit is like an invisible circular or elliptical path in which the satellite will rotate at a constant speed relative to its general orbit in order to achieve a stable orbit, every orbit has its own property and the difficulty to successfully inject a satellite into a stable orbit are relevant to the function of the satellite. Taking this into consideration targeting a satellite is a difficult task and requires a lot of precision. The general concern with regards to the kinetic destruction of a satellite is the fact that the debris created by a kinetic action would scatter particles of different sizes into orbit which can cause massive damage to other satellites into and outside that particular orbit, while most of the debris will burn off into the earth's atmosphere, the same cannot be said about the orbit. We will expand on the kinetic approach later on but the most favorable approach is a non-kinetic approach. Albeit understanding every satellite's properties operating in the orbit is the key to a successful operational planning. After all, the goal is to eliminate the enemy's capabilities while securing your own.

Warfare is not just about offense and defense; it is about developing and maintaining the factors which are contributing to the readiness and effectiveness of the offensive and defensive capabilities in the interest of creating an asymmetric theater in your favor and much of those are dependent on one another. I would like to once again emphasize on the importance of the force protection as we are focusing on the offensive capabilities in the final frontier. Securing the backbone of the C6ISR capabilities should be of utmost importance as an offensive approach is planned. The core belief of adversaries such as Iran, Russia and China are to counter any developments made by the United States to be able to maintain battle symmetry. While further; advancing their terrestrial capabilities, it is also notable to mention that among these adversaries, the Russian and the Chinese capabilities are of concern. However, the existence of the private sector in the United States has enabled it for rapid progress which demand protection of such advancements against adversarial campaigns especially espionage.

**The Importance of Surveilling the Space and the Adversarial Space Capabilities**

Monitoring the space, satellite launches and the space-related adversarial capabilities are paramount to the United States national security and important part of the United States' national defense strategy. The final frontier presents dangers as well as limitless opportunities. It must be understood that the United States adversaries are also aiming to dominate the space. Albeit the space surveillance capacities and capabilities of the United States must be enhanced to ensure it has all the tools needed to monitor the threats of the final frontier. Surveilling the space and its developments is paramount in planning and execution of anti-satellite operations especially since the United States' adversaries have taken an offensive approach towards the final frontier.

The United States adversaries should not be permitted to weaponize and establish any form of superiority in space. While it is the general sentiment that the space should not be weaponized, there are a lot of legitimate military targets orbiting the earth, even if the entire world decides to maintain the status quo it is in the best interest of the United States to develop none-kinetic advanced anti-satellite capabilities and position them into the space. (As Argued in Nightshade) Establishing and maintaining superiority in the space is indeed directly affecting the conventional capabilities of the United States armed forces and therefore, the only rational thing to do is to enhance and maintain superiority in space in order to maintain superiority across all domains of the modern warfare.

While the satellites and space-based sensors provide real-time and on-demand accurate sensory information for the United States, it is also important to understand that the adversaries have been trying to achieve the same and have developed their technologies and spaceborne capabilities vis-à-vis the United States while aiming to gain asymmetric capabilities in the final frontier.

**Understanding the Orbital dynamics and their Use**

Satellite developments and launches are still very much limited to the budget and functionality of the satellites, which is why the concept of satellite constellations have gained popularity, the idea to launch multiple satellites in one launch has enabled the concept of satellite constellations, a network of small satellites performing functions. While this has had a more commercial approach the concept of satellite constellations have been used for various purposes, take navigation and guidance satellites for example, to maximize coverage and accuracy specially for guidance (for example GPS, GLONASS or BeiDou) all have satellite constellations and therefore are redundant not to mention the concept jamming is the most basic concept in classical electronic warfare and as these constellations developed for the military purposes they have been hardened against such attacks, however, understanding their defensive capabilities will give you the ability to develop an offensive strategy against them to disrupt their redundancy.

Military communication networks require extreme redundancy, reliability and security. You must have a good understanding of the concepts which are used in hardening and securing a military SATCOM network. While so, understanding of earth-atmospheric properties as well as the factors that can affect radio communications from the temperature, different layers of earth's atmosphere (Exp. Ionosphere) weather conditions and space weather conditions are important. Note that these factors are affecting your operational planning. That aside, understanding your own and the adversarial strategic protocols in case of a large-scale communications blackout with their high commands (Exp. WRA on loss of all communications) are equally important as such miscalculation could result in unwanted strategic weapon release. The concept of the MAD and its components of the nuclear triad are a serious and important challenge of spaceborne warfare concept as any large-scale disruption can affect the friendly and adversarial protocols. This indeed signifying the importance of having a multilayered high precision offensive capability rather than a hail marry.

The low earth orbit is the easiest orbit that an artificial object can achieve. It is occupied by a lot of commercial satellites owned by different companies from all around the world *(some in the contract of the adversarial forces as the importance of redundancy is well known)*. These satellites are broadcast relays, communications and even scientific sensory systems to study weather, earth and the ocean as well as imagery. While space has its general use for mankind, it is also occupied by military satellites which are used for imagery, guidance and communications. The low orbital period intervals are enabling the rapid imagery capabilities in order to get rapid updated imagery from the earth. The low earth orbit is a small circular or elliptical orbit around the earth, you can define it in terms of altitude relative to earth's surface, which can be between 100–1000 Miles/ASL, objects in this orbit are orbiting the earth, objects in LEO can make a full orbit around the earth approximately every 90 minutes to two hours given their average speed which can be 4.8 miles per second. Satellites in this orbit can cover the entire earth's surface with enough satellites to form a constellation. Any kinetic damage to any satellite in this orbit can cause catastrophic damage to a lot of other satellites orbiting the earth.

As an example; The suborbital LEO is used by the ICBM vectors to inject their reentry vehicles in order to deliver a nuclear payload towards the earth's surface as well which is why the current anti-ballistic missile shields are capable to monitor and target that orbit as needed. The guidance systems are redundant and onboard the interceptors as well as the earth as guiding the missile from the earth is a challenging task and no disruptions can be tolerated for such a sensitive task. The current arsenal of the RIM-161 can be used as a unique "hit to kill" kinetic anti-satellite weapon system as well.

MEO or the Medium Earth Orbit is above the LEO and below the HEO (High Earth Orbit), the orbital period for this orbit is less than 24 hours. The altitude for this orbit is between 1243 Miles and 22,236 Miles Above sea level (ASL). Satellites in this orbit require special shielding due to the harsh electromagnetic conditions due to the presence of two large zones of charged particles as a result of the Van Allen radiation belt. This orbit is particularly interesting because in the semi-synchronous orbit the satellites can have an orbital period of every 12 hours

(12,600 Mi/ASL) and they can pass in the same spot on the equator.

It is also notable to mention that the Molniya (Молния) orbit is housing the Russian Molniya (lightning) military communications and remote sensing satellites. It is also important to note that the satellites in this orbit are used for broadcasting, relaying, early warning and military communications.

This specific orbit is highly elliptical. The Soviet/Russian remote sensing satellites УС-К Управляемый Спутник Континентальный (or in English Continental Controllable Satellite (US-K) constellation, is a part of the OKO (EYE) system which is responsible for observing the United States missiles and rocket launches are stationed in this orbit. These satellites are a part of the Russian missile defense network. Russia remained committed to the program even after the dissolution of the USSR.

The geostationary equatorial orbit (GEO) is a circular orbit synchronized to the earth's equator. The orbit has the altitude of 22,236 miles above the earth's equator. An object in this orbit has an orbital period equivalent to the earth's rotational period and orbiting the earth with the average velocity of 1.9 Miles Per second. This property makes them ideal for communications and navigation satellites. Several classes of military satellites occupy this orbit such as Space-based infrared systems which are monitoring for early missile launch detection and very high frequency satellites that can provide reliable and secure communications for military components and also the Wideband Global Satellite communications. Achieving this orbit requires advanced technology so is targeting the satellites in this particular orbit. Which is why disrupting their communications seem to be done easier on the ground at the endpoints. As you can understand, different orbits have different properties and uses in both military and the civilian infrastructures. This highlights some of the challenges of targeting satellites in different orbits.

Another important factor for us on earth is the presence of the ionosphere. This layer is actually positioned between earth's atmosphere and the vacuum. The ionosphere is also the ionized part of the earth's atmosphere which spans from 30 miles to 60 Miles above the sea level (ASL). The ionosphere has a property called the orbital drag, since this layer has a lot of free electrons, it can change rapidly and unpredictably by the sun's activity (Space Weather). The ionosphere shifts with the earth's day and night cycle. While the ionosphere behavior is highly unpredictable, you can get a sense of its behavior with the correct tools and prediction. This layer has unique properties and special effects on different parts of the radio spectrum, the low frequency transmissions, due to the presence of large concentration of the free electrons in this layer, when HF or VHF hit this layer, they tend to bend (this is how the OTH radar utilizes this property to see past the horizon.); this property also enables the long rage communications. Satellites have a higher frequency transmission so that they can penetrate the ionosphere and communicate with their ground stations. Natural Change of the density in this layer affects radio and navigation. Earth's surface weather conditions such as hurricanes can affect the ionosphere as well. It is a very fluid layer.

Another important factor affecting the satellite communications is the space weather. (Much like the storms on earth), the space has its own categories of storms based on the severity of the sun's activity and conditions, Space weather monitors the changing of the magnetic fields, radiation and their effects on earth and satellite communications. Taking the space weather conditions into account and monitoring it is important because it can affect civilian and military infrastructures the same and affect normal operations on the surface of the earth so having a good understanding of its changes and predicting its behavior are equally important.

Tracking orbital objects is a complex task, ground-based sensors alongside terrestrial radars combined with space-based sensor systems are needed for this, something that the United States has been doing very well which is why advancing and maintaining this capability is paramount to the success of the concept across the spectrum.

**Anti-Satellite Operations**

Anti-satellite operations are not a new concept. In fact, it is a well-studied concept yet lacks developed components. The concept refers to the disruption or destruction of the enemy's satellite capabilities, this can range from disrupting satellite navigation and guidance to theater or long-range communications. Much like any battle planning, the principles of war should prevail. Understanding and categorizing the adversarial capabilities alongside an active ISR are they key enablers of this approach. Categorizing the adversarial inventory alongside the ISR will permit you to map the Electronic Order of Battle as the backbone of the adversarial capabilities with an eye towards your own to ensure that your offensive capabilities will not disrupt or damage your own. ASAT (Anti Satellite) Operations as described in nightshade has two major components Endo-atmospheric Anti-Satellite Combat (EA-ASAT) and Exo-atmospheric Anti-Satellite Combat (EXA-ASAT). While the endo-atmospheric Anti-Satellite Combat (EA-ASAT) capabilities are somewhat already in place, the EXA-ASAT capabilities have been neglected and are much are the dream of the United States adversaries, which is why the United States must pioneer offensive and defensive capabilities. However, doing so will most certainly start a whole new concept of spaceborne arm's race but the United States must ensure a continuous development of

its components and tactics to be able to maintain absolute superiority and dominance.

The Anti-Satellite operations in nightshade introducing a high precision multilayered and in-depth approach to the concept. It emphasizes the importance of having a high precision multilayered offensive capability which enables you to conduct the anti-satellite operations as the needs arise without crossing the adversarial threshold. It has kinetic and non-kinetic components which are both equally important. As I have said the principles of war prevail, the anti-satellite operations components should have enough capabilities to be able to bring the adversarial mil net to its culmination point.

Satellites add a unique ability to the adversarial ISR, Guidance, Long-range communication and Navigation. While the guidance systems are built to be redundant, the Space-based guidance is still an important part of their designs incorporated in their capabilities to navigate on the battlefield or to guide their ordinance to their targets. As I have established earlier, the modern electronic warfare is no longer concerned or focused on signal disruptions and interference. Preserving, Protecting and enhancing the friendly capabilities while disrupting and eliminating the adversary is always the objective.

**Core Concepts of the Anti-Satellite Warfare**

The space itself is considered an active theater. There are two main approaches, Kinetic and Non-kinetic. However, each has their own merits and considerations as well as their consequences. I further did categorize the kinetic and non-kinetic options into two distinct subcategories of terrestrial and Spaceborne. There are properties to the concept of any anti-satellite operations and we will introduce them first before expanding on the Kinetic and Non-kinetic options. These properties include Precision, Guarantee, Continuity, Consistency, Interoperability, Integration, Independence, Protection and the M2 factor.

- **Precision:** Any kinetic and non-kinetic action has its own consequences. Precision implies the importance of targeting what we want while inflicting minimum unwanted damage to others. Precision is highly regarded in the modern electronic warfare because as we aim to target the adversarial capabilities, while safeguarding our own. So, precision while can be resource exhaustive, must be implemented unless the theater requires otherwise.
- **Guarantee:** The operation should guarantee to achieve the laid-out objectives. Regardless of what we do or the theater, the principles of war apply. We have to manage our EOF (economy of force) while ensuring mission success as prescribed by the mission objectives.
- **Continuity:** The ability to target the adversarial capabilities must be continuous and the components of the mission must be able to operate with continuity. None-Kinetic options are extremely important as they have the potential for operational continuity yet they are dependent and limited by the energy factor. We must ensure the operational continuity in our designs and engagements. Managing the resources are extremely important in maintaining a steady combat capability.
- **Consistency:** The Components must be able to achieve results with consistency. This emphasizes the important of understanding the adversarial defensive capabilities in a continuous manner in order to be able to maintain the offensive capabilities.
- **Interoperability:** The abilities, hardware, weapon systems and human resources should be employable and operable by all branches of the armed forces. This will enhance the combat capacities across the armed forces spectrum and ensures mission success especially if regulated None-Kinetic options are authorized for wider use by all the components.
- **Integration:** The existing concepts, strategies, abilities, hardware and weapon systems must be integrated into all branches of the armed forces to maximize their combat readiness and protection.
- **M2 factor:** This refers to the Mass and Mixture, the weapon systems and the concepts used should have the power and the effective mixture to be combat effective against the adversarial capabilities at all times. The redundancy in the offensive capabilities is extremely important.
- **Protection:** Regardless of what we do to achieve our combat objectives, one of our primary goals is force protection. Our operations, concepts and planning should consider the survival and continuity of the friendly capabilities at all times.
- **Independent Balanced Access:** As I have written about the concept of a resilient and redundant COC several times in the past, we should understand that the adversaries are aiming to achieve the same objectives as ours. While they might achieve some levels of success, all regional commands must have the ability to utilize the Anti-satellite warfare independently while being able to protect the friendly capabilities. This will enhance the survivability and combat effectiveness should the necessity arise. However, strong protocols should be in place and as we have already established, ensuring that the friendly and adversarial “strategic” protocols are not disrupted should be a fundamental principle.

Terrestrial kinetic options refer to the methods used to target the satellites from the earth via kinetic means (take RIM161 as an example). This can consist of nuclear and non-nuclear payloads targeting an orbit. The damage that this option can cause to other satellites in orbit is large due to the fact that this method and especially the nuclear payload can knock out the satellites in the orbit to force

them off the orbit or cause a mass satellite collision. Options such as this are not favorable due to the fact that the nuclear payload can ionize the atmosphere and disrupt the communications for several hours and damage the satellites with its secondary HEMP effect and therefore inflict unwanted damage to the friendly and the civilian infrastructures and assets in space. We, however, must understand that the United States adversaries who have been expanding the redundancies of their C6ISR do not concern themselves with the consequences of such an action as they have been aiming to create terrestrial redundant platforms. This option is not something that one would consider at the early stages of a conflict but it is always on the table. High Precision Non-Nuclear payloads seem to be much more favorable for this type of attack but the nuclear threat is always present. I should emphasize that the kinetic option always aims to destroy its target and the debris generated by this can always cause secondary damage. Nightshade introduces some kinetic options but they are well out of the scope of this paper.

Terrestrial None-Kinetic Refers to the methods used to target the satellite capabilities on the ground in a localized theater. This option considers the disruption of the adversarial capabilities from the earth utilizing the receiving ends of the terminals or disrupting the satellite signals via established ground stations in a theater. While our positions are fixed on the ground the satellites are rotating the earth (based on their orbit), the adversaries seek constant and uninterrupted coverage for their assets on the ground, this method is utilizing advanced jamming techniques to either disrupt or degrade the satellite signals or the receiving endpoints in order to degrade the adversarial capabilities to maintain C6ISR.

Spaceborne Kinetic refers to the method used to target satellites in space via a prepositioned space platform. I find targeting satellites from a space platform much more reliable and effective by this method has its own challenges and developing such platforms are difficult yet highly achievable. When I was developing the concepts of the nightshade for the spaceborne kinetic options I designed a satellite for both the kinetic and none kinetic options of this concept, I did argue that positioning a weaponized satellite in orbit is the most viable method to take out the adversarial capabilities with minimal friction. Whereas all the launches towards the orbit is monitored by almost every advanced nation on the planet, monitoring the spaceborne launches towards another space-based target is far more difficult and there are no active countermeasures against them. I personally do not favor the kinetic action mainly due to its secondary damage and the harm it can do to the friendly capabilities not to mention it is against the core principles of anti-satellite operations that I have laid out earlier but this is an effective option that must be available this particular option is excellent in the event of an adversarial nuclear launch, a constellation of spaceborne kinetic capable weapon systems can effectively target such a threat from outside of the earth's orbit in combination with the terrestrial kinetic options to maximize the effectiveness. While the focus of this document is on anti-satellite operations, this does not mean its components cannot have other strategic uses.

Spaceborne Non-Kinetic Refers to targeting the satellites via non-kinetic means from prepositioned space-based platform. Active use of the high-powered microwaves to target a satellite, high precision jamming or even the use of high-precision laser systems mounted on spaceborne constellations can be the most effective anti-satellite weapon system. A constellation of satellites orbiting the earth is capable of concentrating several beams of microwave, radio or laser from different orbital angels to a single or multiple targets in order to disrupt or eliminate. It has been a core concept in nightshade's anti-satellite operations. If you recall at the beginning of this document, we have discussed the satellite constellations. Having a large satellite network with the aforementioned capabilities can give the United States the ultimate edge in the dominance of the final frontier.

Hybrid techniques employ both kinetic and none-kinetic approaches to achieve their objectives. I would emphasize that hybrid techniques as are described in the nightshade; are the techniques of the future such as the nightshade's "Goblin" hazardless advanced anti-satellite hybrid weapon system (GHHWS). Several advanced hybrid techniques and technologies have been introduced in the nightshade but expanding on this subject is beyond the scope of this paper and it is not for open publication.

Satellite communications, much like any wireless communications are prone to interception (sniffing), while we can intercept (sniff) the encoded satellite communications decoding them is another major challenge. There are satellites dedicated to the task of intercepting the other satellites communications. While some might consider that with the advancements in digital communications and encryption systems; the interception of the adversarial satellite is not as effective as it used to be, it is in fact quite the opposite. The interception of the adversarial communications remains a key technique in the modern electronic warfare and in the space-borne operations.

**The Importance of a Redundant Orbital, Suborbital and regional Terrestrial Capabilities**

While the conventional orbital capabilities are semi-permanent as we deploy our satellites in a selected orbit with respect to the function and the dynamics and the anti-satellite capabilities of the adversaries, it is also important to understand the importance of redundancy as a major concept in the force protection and its dynamics. The high altitude hardened suborbital vehicles dedicated to the redundancy protocols alongside emergency satellites as well as localized regional terrestrial capabilities will ensure the continuous service in emergency situations even if the adversaries choose to deploy high altitude orbital or suborbital nuclear payloads or as a result of any natural or manmade catastrophic event. Anti-satellite warfare is not just about the expansion of the ASAT capabilities as the force protection is a major part of its dynamics.

**Exploring the Complexities of Space-Based nuclear weapons and Missile Defense Systems**

I wish to discuss the possibilities of placing a nuclear weapon system in space. The idea has been thoroughly explored by the United States' adversaries. Before we get to the subject, I wish to discuss the conventional interception of a nuclear payload. A conventional nuclear weapon system consists of a vector, the reentry vehicle, and the actual nuclear warheads. The vector is responsible for carrying the reentry vehicles to suborbital altitude, and it is essentially a multistage rocket capable of achieving the necessary speed and altitude in order to place its payload, which is the reentry vehicle, into suborbital Low Earth Orbit (LEO) in order for it to release its warheads towards Earth. The trajectory it follows is still the ballistic flight path. The warheads are mounted on the reentry vehicle, and they can be of many varieties, including glide and maneuvering glide vehicles, which are capable of performing maneuvers in order to evade interception or flight path calculation by the defender on the ground.

There are multiple phases to this: the boost phase, in which the nuclear weapon system is launched and in flight to make orbit; the second phase, or mid-course, is when the weapon system has placed its payload into the suborbital LEO for release; and the final phase is called the terminal phase, in which the reentry vehicle has released the warheads towards the terrestrial target. The interception of a conventional nuclear missile is a complex and multilayered approach to ensure its destruction before the weapon system enters the terminal phase.

There are several interception concepts. Once the missile launch is detected, the flight path is calculated by a variety of terrestrial and spaceborne sensors. Of course, the best time to intercept the weapon system is during the boost phase. However, this is hardly the case since the majority of silo-based weapon systems will spend the boost phase far from the range of interception. The next rational phase is while the weapon system is in suborbital LEO. The current RIM-161 interceptors are designed to target the hostile weapon system in this phase via a non-nuclear kinetic payload. In this specific scenario, the interceptor is boosted towards the orbit in order to intercept the hostile weapon system. The terrestrial and spaceborne guidance is key to guiding the kill vehicle so that it can knock the hostile system off the orbit before it can release the warheads towards the terrestrial target.

The final, and of course, the hardest phase is the terminal phase. The reentry vehicle is entering the orbit at MACH 25, making guidance and detection very difficult, regardless of the presence of pyrotechnically designed decoys, and if the warhead has maneuvering capabilities, this indeed makes the interception extremely difficult, if not impossible. This is where the idea of nuclear ABMs came in. The nuclear anti-ballistic missiles, or N-ABMs, use a high yield nuclear payload in order to target the high-altitude suborbital LEO and the hostile nuclear weapon system; an example of this type of anti-ballistic missile is the Russian ABM-4 Gorgon and the American Spartan Missile. Presently, Russia has active nuclear ABM silos across Russia and especially Moscow (Part of the A-135 system). The ones that I have witnessed are fully operational. Regardless, I would like to note that Moscow is the most protected city in the world, guarded with ABM-4 (51T6) Gorgon, ABM-3 (53T6) Gazelle, and other anti-ballistic missile capabilities. It is also notable to mention that efforts to upgrade the network to A-235 is underway.

The downside of the use of N-ABMs is the fact that the actual nuclear detonation will ionize the atmosphere and create a blanket of highly ionized particles, which can, in effect, create a communications blackout across a large geographic area. The secondary issue is the secondary HEMP effect generated by the nuclear detonations.

Russia has been modernizing its nuclear weapons systems arsenal. The current RS-28 Sarmat (Сармат) is capable of maneuvering in polar orbit in an effort to bypass the current missile defense shields of NATO and the United States. The capabilities of the missile and its actual performance and countermeasures have satisfied the Russian VKS and resulted in their green light for the modernization of Russia's nuclear arsenal. The missile frame has been designed to be extremely rigid to be able to withstand the violent vibrations and maneuvers at hypersonic speeds, as I have personally had the opportunity to see the engineering behind its development.

Getting back to the issue, if an adversary were to place a nuclear payload in orbit, it would effectively evade the

current layered interception anti-ballistic missile shield. Based on the blast configurations of the warheads, we can understand the challenges it can present. I would like to once again bring your attention to force protection and the fact that adversaries, such as Russia, are well aware of the importance of their own force protection. We previously have discussed the ramifications of the detonation of a nuclear warhead in an active orbit. The adversaries are well aware of the consequences of a nuclear detonation in an orbit where their own satellites operate as well. However, a low-yield precision strike is still possible. Further on this subject, as we have previously discussed the HEMP effect in the "Arbiter Framework," we can reduce the risk that an adversarial nuclear payload can pose, from ionization of the ionosphere in order to block long-range communications and cause interference with satellite communications and their ground stations, to low altitude airbursts for the HEMP effect in order to knock out civilian and military communications and infrastructure.

Positioning nuclear weapon systems in space is a very risky move that violates the Outer Space Treaty of 1967, as well as posing considerable logistical and safety challenges. However, positioning advanced electromagnetic weapon systems such as multi-stage EPFCG (Explosively Pumped Flux Compression Generator) Powered Weapon systems is a more viable approach to achieving superiority in space. The EPFCG powered weapon systems are capable of creating a high-powered electromagnetic pulse, resembling the HEMP effect. The pulse has enough amplitude to damage power grids, communications, satellites, radar and electronics (Still depends on Design) Nonetheless, such weapon systems are still heavy and cannot be scaled down to smaller sizes, which adds to the complexity of their deployment. The concept of the EPFCG is well thought and researched by the United States and the Russians. The Generator is a key component in developing effective electromagnetic weapon systems.

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