THE THREAT OF HYPERSONIC BALLISTIC INTERCONTINENTAL MISSILES, THE SPACE DOMAIN AND THE USE OF MODELLING & SIMULATION

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THE THREAT AND STRATEGIC EQUILIBRIUM

The concept of the ballistic intercontinental missile is not new in the field of military applications, but the new technologies that have transformed this weapon into hypersonic devices have ensured to some Superpowers very powerful and important offensive tools on the global battlefield. In this historical moment, Russia and China have a partial supremacy over the United States because they already have an operating system in an advanced stage of development. These missile systems represent major threats because Western defences are not yet prepared to deal with them: they can travel at speeds above Mach 5. In fact, a cruise missile that flies at hypersonic speed at low altitude or a HGV[1] warhead capable of flying at lower altitudes, make current strategies ineffective and even challenge the effectiveness of the best current defense systems such as the Patriot, THAAD or the GMD. A cruise missile directed at hypersonic speed against a target is therefore difficult to detect by the flight profile radars and can easily overcome missile and anti-aircraft defenses.

Hypersonic technologies are those in which it is necessary to use new engine design features, structures, aerodynamics, propellants and driving systems with requirements and objectives that are difficult to obtain because they require considerable costs and experimentation on the materials. These evolutions have included new hypersonic technologies as an important sector of EDTs[2], in which all Superpowers are investing billions.

The development of EDTs have important implications for civil society, but hypersonic technologies applied to the military can modify the strategic equilibrium due to their unpredictability, difficulty of interception, maneuverability and high speed, reducing evacuation time, defence and response times.

Past and Future

In the recent past, a classification of ballistic missiles was based on taking into account three main types of missiles: short (up to 1,000 km), medium and long range (up to 5,500 km) and intercontinental (over 10,000 km).

A modern ICBM[3] consists of three stages and a MIRV[4], capable of carrying a number of multiple and independent warheads equipped with an autonomous guidance and aiming system to hit multiple targets simultaneously.

The recent generation of hypersonic missiles are the result of complex and expensive technologies that travel at very high temperatures and very great pressures using SCRAMJET[5] propulsion systems that activate only after exceeding the speed of sound. The technological difficulties, despite the availability of suitable materials, have made it possible so far, to develop only two types: a GLIDER module with ample ability to maneuver and modify the path until it hits the target. The other like a standard cruise missile, but equipped with a SCRAMJET engine, which uses another vector that brings it to the speed of sound to activate it.

1 - HGV – *Hypersonic Glider Vehicle*
2 - EDT – *Emerging Disruptive Technologies*
3 - ICBM – *Intercontinental Ballistic Missile*
4 - MIRV – *Multiple Independently Reentry Vehicle*
5 - SCRAMJET – *Supersonic Combustion Ramjet*

Background: U.S. Air Force Minuteman ICBM

Russian RS-28 Sarmat "Satan 2" ICBM

n recent years, Russia and China have focused their technological esearch on these carriers, taking advantage of traditional allistic missiles (such as the Russian RS-18 model or the SS-22) hat can now carry a GLIDER, which in the descending phase an maneuver like a glider with speeds close to Mach 20. China has also developed a new medium-range missile that can carry GLIDER with reentry speeds between Mach 5 to 10. India and France are also conducting sector's studies.

The United States does not have hypersonic missile models despite the large investments of money for the development of this technology. The focus has rather been on other EDT technologies such as satellite constellations for advanced tracking and discovery, equipped with HBTSS[6], MFOV[7] vision and OPIR[8] sensors or energy weapons (LASER cannons).

Space Domain

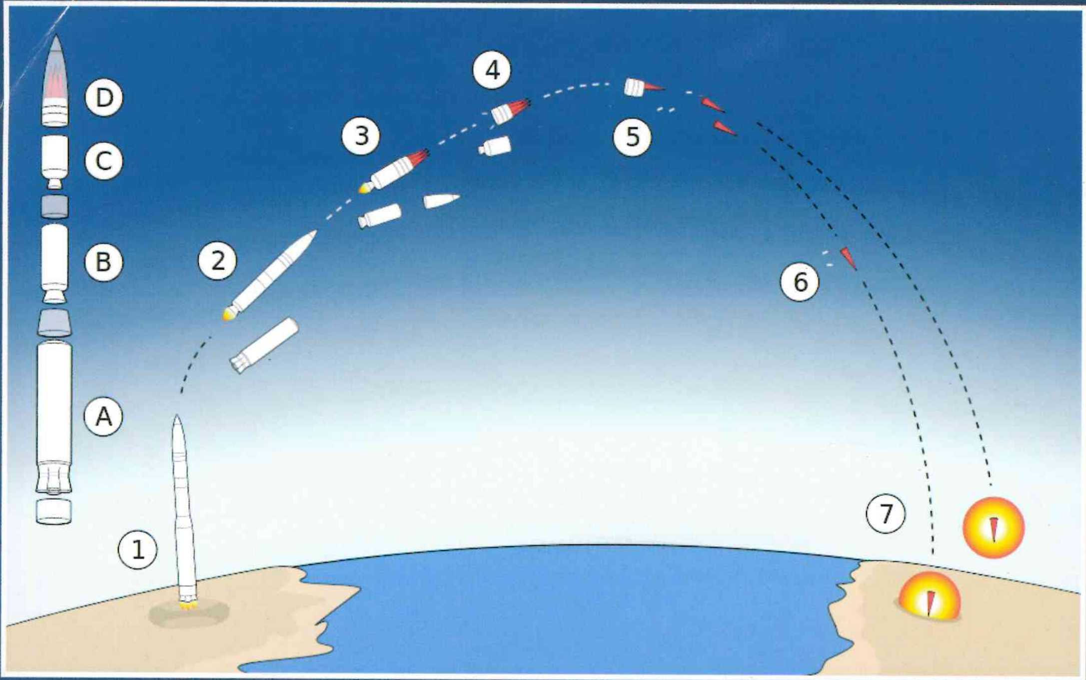
The space domain has forcefully entered into the order of operational dimensions together with the cyber domain to flank the traditional domains. This represents the strategic multidimensionality of the threats that western organizations will have to face in the coming decades.

The rebirth of an intercontinental hypersonic ballistic threat has prompted many nations to establish units to manage their space domain. This trend was born after September 11, 2001, focused to monitor missile threats, airspace, satellites' control, space surveillance, C2 operations for leadership and strategic communications. Today this trend includes the areas of communication, positioning, navigation and GPS data, meteorology and ballistic threat detection capabilities.

These military entities, depending on their size and the national ballistic capabilities, are committed to organizing, training and equipping their "space forces" to counter potential threats, guarantee the freedom of space maneuver and provide to the joint forces on the ground with support derived from space technologies (reconnaissance, communications, aiming, forecasting and in-depth analysis). The ability to recognize space, no longer an inconsistent and benevolent domain, has amplified the value that the space domain brings in a joint context and includes areas without precise boundaries where even opponents

W87 Peacekeeper Warheads

6 - HBTSS – *Hypersonic Ballistic Tracking Space Sensor*
7 - MFOV – *Medium Field Of View*
8 - OPIR – *Overhead Persistent Infrared*



allow the experimentation of new systems and procedures to effectively counter opponents. Technically, a minor strategic capacity a nation can express and the more effective training systems, such as M&S, should be used for its operators, specialists and managers. M&S allows specialists and commanders to be stressed by showing them volatile, uncertain, ambiguous and unpredictable operating environments where there is a real opponent capable of a precise strategy. Three-dimensional scenarios, in addition to taking into account an evident, real and contextualized strategic situation, must allow the staff to be prepared to intervene promptly using techniques, tactics and evaluation processes can operate undisturbed. This need has highlighted the gaps in the training programs for space specialists that have to plan, operate, and manage this domain. The goal is not to train "astronauts" but specialists with extensive digital and IT knowledge, able to maneuver swarms of satellites, manage constellations of orbiting devices, acquire information and manage data, receive alarms and direct communications to carry information and intelligence[9] where it is needed.

This example comes from the U.S. Space Force (USSF) command, which has developed a training plan at the Space Training Readiness Command (STARCOM). This HQ prepares space forces to live and fight in degraded contexts and in deteriorated operational environments to ensure satellite equipment is working and guaranteeing the alarm level for ballistic threats through the application of the most advanced technologies, protected from cyber and kinetic attacks. The focus of this training, carried out through M&S[10], or through accurate models of the systems (satellite, communications, missile, etc.), without approximations, which are used in simulators capable of making them operate in a synthetic multidomain environment where it is possible to test their skills and resilience. Virtual systems can act and react in the same way that the real systems do, training specialists to use resources effectively and apply proper procedures.

Missile Threats and M&S

Beyond the defensive approach adopted by Western nations to counter Russian and Chinese interference in the space domain, the response wants mainly to establish a generation of specialists with a real ability to fight in the space domain and where M&S will play a decisive role.

Modelling & Simulation's purpose in this environment, is not only training but also to support decisions, improve the analysis and to operate routinely in the space domain. The establishment of a "Space Range" is also a characterizing element of this education where satellite control centers are side by side with "Training Space Centers"; in these facilities, operators can manage the model of orbiting assets in training and operational mode.

These simulation centers represent the compromise between the operational needs of the operators and what happens daily in space, bringing the problems of the new domain into a synthetic three-dimensional operating environment. The simulation distributed and federated exercises for the space domain correspond to the classic organization of a CAX[11] where the response cells have different types of missions to complete (engagement of orbital maneuvers, maintenance of space superiority against threats, missile warning, Intelligence, Space domain awareness, space EME, etc.). The exercise direction cells provide the Command and Control functions while the opposing cells simulate the adversary's will to attack the space domain and their skills. M&S is therefore crucial to guide the defensive and offensive response's capacity to manage the space domain and allows studying the moves and countering moves in a critical and current scenario, such as the space environment. The distributed exercises are involved in the virtual space's various systems and units with different operational capacities, connecting all the forces and reflecting on the entire space community.

The Bursting Model

One of the best-known models for modeling ICBMs is the sensitivity analysis of the BURSTING[12]. It is used to evaluate the results of the observation of repeated launches of ICBMs to obtain the optimal results to achieve a target set at 8,000 km, varying the launch variables, the missile configuration and some parameters/variables, also taking into account turbulence and arbitrary values. The model can be used in a simulator in order to perform

9 - IMINT, MASINT, GEOINT, SIGINT
10 - M&S – Modelling & Simulation
11 - CAX - Computer Assisted eXercise

12 - BURSTING – Ballistic Rocket Simulation Testing Interactive Numerical Grinder

e number of launches necessary to study the trajectories. The llistic carrier must meet specific requirements. The main one to bring the MIRV ballistic load to a certain exo-atmospheric titude to make it re-enter the earth's atmosphere and hit rgets simultaneously at a great distance with an acceptable ror (the more negligible the error is the greater power of the llistic load). The design of the carrier must therefore respond parameters that must take into account the features of the issile and its composition in stages, the electronics necessary for e guidance systems, its transportability, management and the ilitary requirements for use. The main physical characteristics a ballistic missile is summarized by its type and quantity of ages, mass and quantity of fuel transported, the release times the stages, expressible power (thrust), while the launch ariables are the weight of the MIRV launch angle, air turbulence nd atmospheric conditions.

he ANOVA[13] statistic study technique was born in experimental esearch to evaluate the effect of certain factors, independent ariables of a continuous or categorical type or on the dependent ariable of a continuous type. The objective of the model is to ompare averages of two or more samples while taking into ccount several variables in order to accurately determine the chievement of the goal.

Conclusions

Hitting a hypersonic aircraft does not seem easy now due to the time it takes for the defense systems to process a response as well as their actual effectiveness. The detection and tracking, as well as determining the firing solution, still takes time which, given the hyper-speed, would not be sufficient to avoid contact. The countermeasures for traditional ballistic warheads were based on prediction and on the calculation of the trajectory with statistic mathematical models such as ANOVA. The presence of multiple warheads and hypersonic speed partially cancels this predictive ability as the new GLIDER systems glide at very high speed approaching targets with flat and low trajectories.

The EKV[14] kinetic systems have only a 50% probability of hit, but they are still too expensive to be developed. The answer, at the moment, seems to come from a detailed and effective study of the adversary's abilities and an efficient contrast through effective detection systems with high technological capacity, to discourage the adversaries from using hypersonic systems. M&S can play a crucial role in this active defense strategy. The representation of models and the use of suitable simulators, can allow the training of personnel to counter these threats and to better support the chain of command in the implementation of procedures and active tactics of contrast, discovery, tracking of threats and defense of the national operational space. LC

U.S. Advanced Hyper Sonic Weapon (AHW) concept

13 - ANOVA – *Analysis Of Variance*
14 - *Exoatmospheric Kill Vehicle*