TECHNOLOGICAL EVOLUTION OF SATELLITE DUAL-USE SYSTEM IN THE ARCTIC

PAPER DI RICERCA
MARZO 2022

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strategicgovernance.it

Paper di ricerca – marzo 2022

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ABSTRACT

This paper aspires to provide a research analysis of the dual civilian and military use of satellite technology in the Arctic region. By analysing the Military Polar Orbiting Meteorological Satellite Program between 1962 and 1994, the analysis creates a reference model that can provide valuable keys to understanding the current dual use of satellites, which is covered by military secrecy. To meet this purpose, the paper is structured as follows. While the first part analyses the main theories of space warfare and Arctic geopolitics (considering the human factor as an indispensable element in drafting national strategic doctrines); the second reconstructs the technological evolution of polar-orbiting weather satellites by highlighting their relationship between military use and political purposes of U.S. administrations during the Cold War.

INTRODUCTION

A Mahan or a Douhet theorizing the concept of space strategy has yet to appear. Dolman tried with Astropolitik, taking the concepts of sea power, and applying it to space. The exercise should be meant as something other than disinterested training for intellectual circles. Sometimes, reality simplification – whose knowability suffers from the limited condition of the human being – shall be helpful in formulating theories that make order (cosmos) among the chaos. Far from proposing a strategic theorization of space strategy, this analysis aims to grasp aspects of it, correlate the geographical spatial conception with outer space, and consider the human factor and technology as intrinsic and forming elements of the system.

Horizontally, the space under study coincides with the Arctic Ocean. The choice finds justification in two orders of factors: *in primis*, in the wake of the Russian attacks on Georgia (2008), and Ukraine (2014 and 2022), the area is regaining the strategic significance of the bipolar US-USSR confrontation of the Cold War; *in secundis*, from a geopolitical point of view, allows for an analogy between Mackinder's pivot area, Mahan's chock points, De Severvensky's spherical model, and Dolman's geostrategy. Therefore, along the vertical axis, the analysis considers the atmospheric belt between 200 and 800 km, also known as low orbit (LEO). However, in order not to fall into the trap of geographic determinism, the study emphasizes two other elements that equally shape the behaviour of national states: the anthropological-demographic and the technical.

The protagonist are the American and Russian people; the former defines itself as Arctic by purchasing Alaska in 1867, while the latter, the Russian bear, identifies the Arctic Ocean as its backyard. Finally, the technique. In order to comprehend the dual use (civilian and military) of satellite technology, which is then the focus of this research, shall be considered the National Reconnaissance Office's (NRO) Polar Orbit Satellite Weather Program between 1962 and 1994. The goal is to form a historical reference model to better detect the military use of satellite technology to date covered by military secrecy. To do so, the author cannot help but take a holistic view to capture the complexity of the phenomenon under analysis.

LITERATURE REVIEW
SPACE THEORY AND STRATEGY

Although there is well-stocked literature concerning space technology in warfare and ensuring state security, there needs to be a more strategic theory on space as the fourth dimension of combat in warfare - after land, sea, and air (Botti, 2001). Following the inexorable process of complexification of warfare[1], theory is useful to isolate the strategic, operational and tactical concepts of astropolitics (Dolman, 2002); although, as Col. Ferruccio Botti states in "War and Space Strategy" (2001), " theory as a work of man, it never fully photographs reality, nor can it constitute an immutable obelisk at the centre of strategic reflection [...] it is always an expression of the idols of the time [...] and is affected by human passions and the personal experiences of those who formulate it." In other words, Botti acknowledges, albeit in their relativization of applicability, the usefulness of the doctrines of Mahan[2], Douhet[3] and Jomini[4] in identifying the characters of warfare and spatial strategy. Only with absolute certainty, however, does he affirm that to fully dominate air, sea and land, any power must necessarily dominate space; and that such domination, just as in the case of the other three elements, is not the purpose but the means of strategy (Botti, 2001). "Strategy has a military purpose such that it corresponds to a political purpose to which the military purpose itself is always subordinated." Hence, spatial power becomes that "complex of static and dynamic factors of various orders (geographical, economic, industrial, technological, moral, spiritual, and military) by means of which a state or a group of states acquire the capacity to conquer and maintain, including by military means, a degree of possession and/or control of space corresponding to national interests." (Botti, 2001).

If Botti insists on the conceptual separation of spatial power (the capacity that can be translated into act by military force) and domination (the successful employment of military force), Gray[5] blurs them, being more affected by Mahanian contaminations. Space power then becomes "the ability to use space while denying its effective use to the adversary." (Gray, 1996). According to Gray, technological development would not be the primary contributor to the formation of the specific traits of each armed force, which would be primarily influenced by geography. Nevertheless, just

[1] Fifth Century Cavalry, “Military Revolution” of the XVI and XVII century, “Nation in Arms”, Industrial Age Mass Warfare, “Mechanized Warfare”, Nuclear Warfare, Information Age Warfare.
2 Alfred Thayer Mahan was a naval officer and historian for the United States. His book, The Influence of Sea Power Upon History, 1660–1783 is regarded as one of the most influential American works of the nineteenth century (1890).
3 Giulio Douhet was an Italian Air Marshal who wrote on the air power in modern warfare.
4 Antoine Henri Jomini was a Swiss banker, a soldier, and an historian who served France and Russia as a member of Ney and Napoleon's staffs. Jomini drew his principles from observations of previous military campaigns, such as: Alexander the Great, Julius Caesar, Frederick the Great, and Napoleon.
5 Colin S. Gray (December 29, 1943 – February 27, 2020) was a British-American geopolitics author and professor of International Relations and Strategic Studies at the University of Reading, where he led the Centre for Strategic Studies.

like the elements that precede it, spatial power does not follow its own logic but responds to the general logic of warfare and strategy (Gray, 1996). Still, the older military components are changed as each military revolution is "layered on" and permeates what remains from the previous one (Gray, 1996). Similar to how air power increased the military potency of sea power and how air power and sea power cooperated to allow land power to end conflicts with territorially defined enemies, space power increases the military effectiveness of air power (Gray, 1996). It is important to remember that in the process of warfare transformation, space power is not the only capable of securing and collecting information, although certainly the most effective through technological evolution (The White House, 2022). At the same time, however, since space technology is also capable of logistics and weapon delivery, it should not be understood exclusively in its informational value (Headquarters United States Space Force, 2020).

On closer inspection from their attempts to formulate space power and domination, Botti and Gray do not arrive at drafting a once-and-for-all valid space strategic theory (Spagnulo, 2021). Everett C. Dolman tries a few years later with Astropolitik, which distances itself from the two by starting with theorizing the concept of "astrostrategy." Deriving the concept directly from that of geostrategy, Dolman identifies astrostrategy as the detection of vital terrestrial and extra-terrestrial places whose control can grant military and political dominion of outer space, or at least preventing an enemy from gaining dominance over a strategic place[6] (Dolman, 2002). In a nutshell, since it is concerned with worldview, geostrategic thinking is distinct from tactical, operational, or traditional strategic military thinking. Geostrategies aim to outperform other states on the world stage (Dolman, 1999). If they are unable to achieve supremacy for themselves, they resort to geostrategic planning to limit the

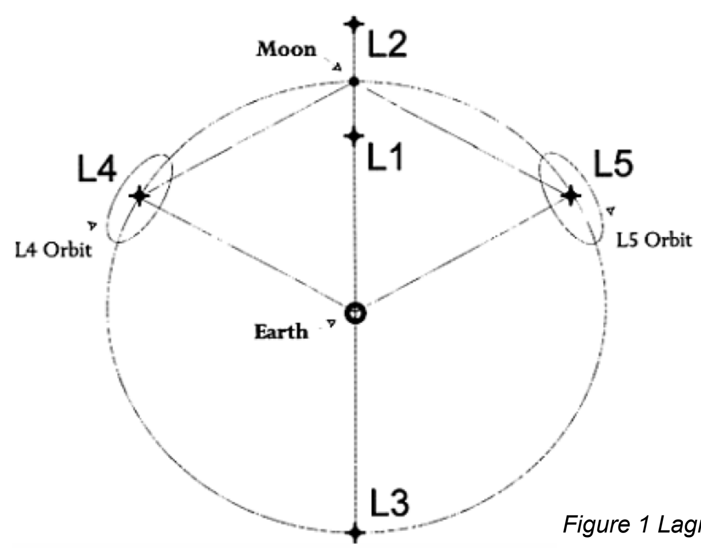

Figure 1 Lagrange libration points; Source: Astropolitik

[6] There are specific orbits and transit routes in space that create natural corridors for commerce due to their fuel efficiency advantages. Like the ocean, space is potentially navigable in any direction; however, due to gravity wells and the prohibitive cost of delivering fuel to orbit, there will be developed specific routes of heaviest traffic over time (Dolman, 2021).

potential dominance of the geographically advantageous state by making the most of their own limited geopositioned resources (Dolman, 2021). Convergently, to identify the strategic points mentioned above, astrographic policy (the spatial equivalent of geographical policy) describes the physical properties of space while also incorporating borders and qualities with political and technological underpinnings (Spagnulo, 2019).

ARCTIC GEOPOLITICS

Technology becomes an influencing variable in the indirect relationship between geography and politics (Marchisio & Montuoro, 2019). Notably, space technological development took off in the aftermath of World War II, both offensively (nuclear) and defensively (control) (Varsori, 2015). Regarding defensive forces, Alexander De Seversky's use of an azimuthal equidistant map[7] was a decisive influential element in increasing American control on the Strategic Nuclear Forces (SYS) of the Soviet Union, which mainly consisted of three basic commands: Strategic Missile Forces (RVSN), Strategic Submarine Forces (VMF/PLARB), and Long-Range Bombers (DA/MAA) (Huitfeldt, Ries, & 0yna, 1992).

In this respect, by the polar perspective, which minimized the distortions caused by conventional Mercator projections, De Seversky demonstrated the strategic value of the Arctic Ocean as an optimal area for delivering nuclear weapons to their key U.S. objectives (Huitfeldt, Ries, & 0yna, 1992). Unlike the United States, which through the Atlantic alliance had missile bases on the European continent, the Soviet Union - except for Cuba - had no military bases adjoining the U.S. from which medium- and intermediate-range missiles could be launched (Weiss, 2001).

Hence, to make up for the above disadvantage, the Russians opted to develop long-range delivery vehicles, which consisted mainly of five basic types of strategic nuclear delivery vehicle (SNDV): Intercontinental range nuclear bombers (LRB), Intercontinental range ballistic missiles (ICBM), the Intercontinental range submarine-launched ballistic missiles (IC SLBM), submarines armed with short-, medium- and intermediate-range ballistic missiles (SR/MR/IR SLBM) and nuclear land-attack cruise missiles (SLCM) (Huitfeldt, Ries, & 0yna, 1992). All the above-mentioned weapon systems have made the Arctic a basing, transit and launch area (Huitfeldt, Ries, & 0yna, 1992). As a result, the Arctic geographic centrality highlighted by De Seversky is compounded by the strategic.[8]

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[7] All points on the map are at the correct distance and azimuth from the centre point. Notably, a polar projection depicts all meridians (lines of longitude) as straight and precisely portrays distances from the pole.

[8] In addition to the advancement in missile technology mentioned, the Eisenhower administration's perceived danger became even more concrete following the first Russian thermonuclear test (1949), the launch of Sputnik (1957), and the shooting down of the U.S. U-2 spy plane (1960).

This was exacerbated by the American perception of the imperviousness of traditional spy systems in the Soviet security system, unable to provide any reassurance about the alleged missile gap with the Russians (Sebesta & Pigliacelli, 2008). Markedly, the inability to know the real military potential of the adversary makes it almost impossible to establish an adequate deterrence policy with plausible and accurate targets. As a result, the American myth of the frontier elaborated up to that point in territorial expansion, thus horizontal, began to be conceived vertically toward space (Moltz 2019): the controllability of its arsenals through satellites became the cornerstone of Mutual Assured Destruction (MAD) (Office of the Director, NRO, 1975). In the specific case that is the subject of this analysis, the Arctic Ocean, satellite monitoring was aimed at controlling new military and nuclear installations in the most remote northern archipelagos of Franz Josef, on the shore of the Kara Sea, Alykel, Tiksi, Chokurdakh, Chesky, Kigelyakh, and Taymylyr (Conley, Bermudez, & Melino, 2020).

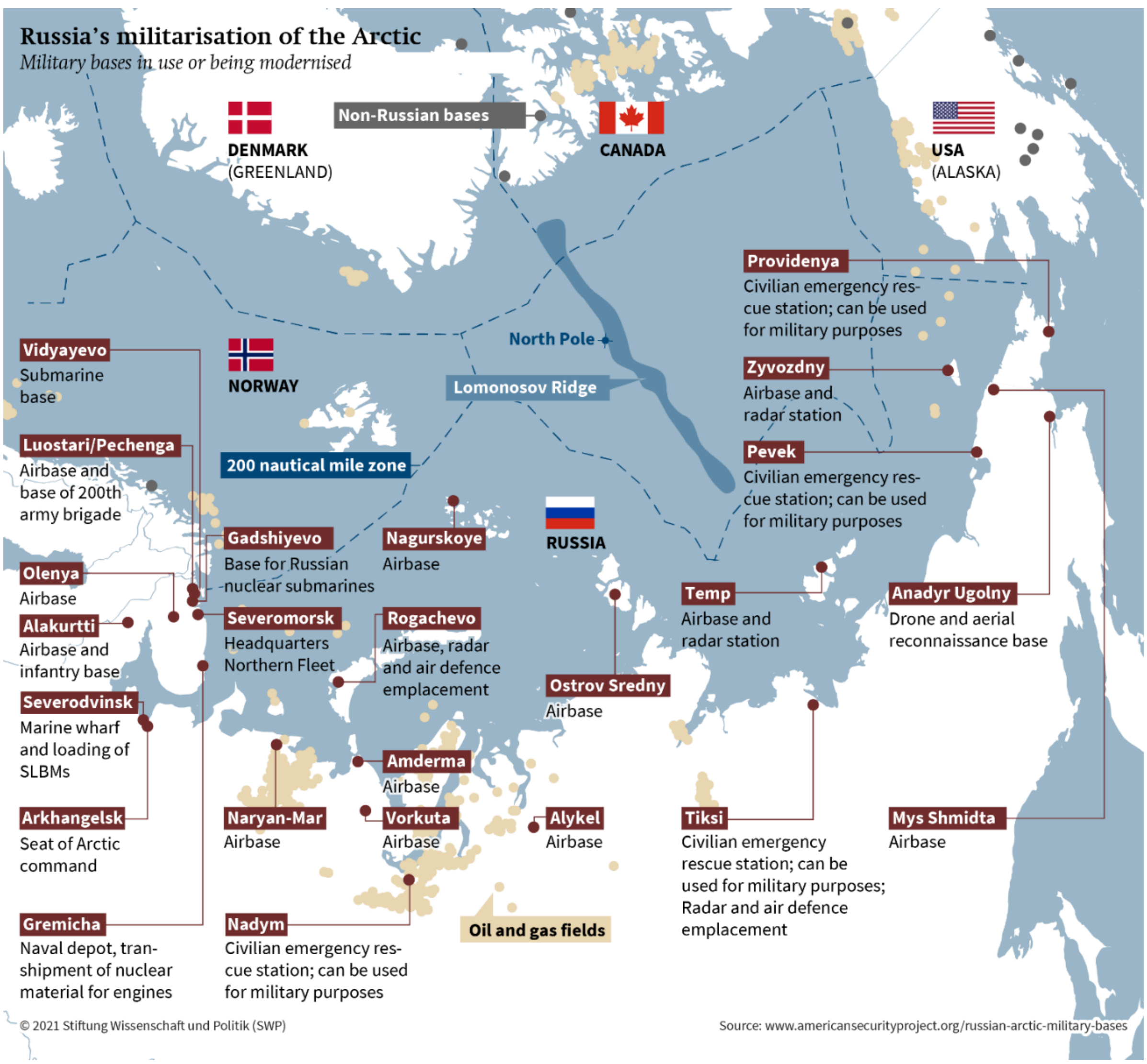

Figure 2 Source: American Security Project

Demographically, Arctic exploitation by Moscow outlines the Arctic nature with which Russians have always identified. Utterly divergent is the American predisposition that has always been perceived as Atlantist. In a nutshell, Americans are interested in the Arctic only because the Russians are interested in it (Fabbri, 2019). The same goes for space: as early as 1860 through Dostoevsky, *cosmism*, later embraced by, among others, the famous Solov'ev, Pavel Florensky, Sergey Bulgakov, Vladimir Vernadsky, Kazimir Malevich, Pavel Filonov, and Valislij Blgakov (Caracciolo, 2021) had already been discovered since the late 19th century by Russian revolutionaries as a faithful mirror of the palingenesis that communism promised to all men of goodwill (Tagliagambe, 2021). Simply put, while the strategic-scientific duality uniquely animated American astronautics (Sexton, 2014), Russian cosmonautics have been inspired by a third element: the cosmist ideology[9]. Concrete with the primacy of Sputnik, cosmism demolishes the liberal democracy-human progress binomial of which the American people have always been the self-proclaimed founders (Tagliagambe, 2021). In geopolitical terms, it is strongly anti-Western and pro-Soviet soul, wholly part of the Soviet (now Russian) strategy that wants people to be staunch supporters of the space race as the mainstay of their civilization (Tagliagambe, 2021).

In the next section, the concept of technological superiority as an element of guarantee of American civilian security is analysed considering the National Reconnaissance Office's (NRO) Polar Program. It is worth anticipating that by technological superiority, the analysis does not elide exclusively to the mere advancement of technology but to the relationship between civilian and military compartments; that is, the diversification of the project implementation and the internal organization within the armed forces themselves (Hall,2001).

ANALYSIS OF THE TOPIC
NATIONAL RECONNAISSANCE OFFICE'S (NRO) POLAR ORBIT SATELLITE WEATHER PROGRAM (1962 – 1994)

"Dual technologies" refers to all technologies with both civilian and military potential. Accordingly, "duality" does not entail that the technology differs from military to civilian usage but rather that it presents an extensive span of applicability (Marchisio & Montuoro, 2019). For this reason, this analysis has a twofold objective: on the one hand, it examines the satellite technological evolution of the National Renaissance Office's Polar Meteorological Program between the 1960s and 1990s, highlighting the contributions of the military apparatus (Defense Meteorological Satellite Program, DMSP) to the civilian (National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA)); on the other hand, it considers the human factor as

[9] Cosmism (Russian Kocmizm - Kosmism) is a philosophical movement that originated in Russia with Nikolai Fedorov's Common Work (1829-1903). It is not only a precise direction of study with a critical role in philosophical reflection but also in scientific research and the field of technological applications.

a marker of distinction between civilian and military technology (ownership, operational management, purposes, mode of access to collect data) (Hall,2001).
In the aftermath of World War II, the satellite assumed an increasingly incisive role in determining the world's strategic balance, so much so that nowadays, it is an essential complement to ground systems in peacetime and wartime (Friedman, 2021). In that context, the satellite weather program was developed to provide data on the cloud cover of the regions flown over and to maximize the surveillance and monitoring information by Corona program (Perry, 1973). Notably, in addition to its noted civilian implications, meteorology enables the acquisition of weather forecasts that are critical to the armed forces (air and navy) for both strategic (reconnaissance satellites) and tactical (local battlefield weather coverage) purposes (Sebesta & Pigliacelli, 2008). Furthermore, the analysis considers only polar-orbiting weather satellites to examine Arctic monitoring modes with 100 percent coverage above the 60th parallel north, excluding the geostationary[10]. Overall, NRO meteorological satellites have a heliosynchronous orbit[11] at a low altitude (LEO) between 800 km and 1000 km with an inclination of 98/99 degrees. This height-slope specific combination has a twofold function: on the one hand, ensuring orbital stability; on the other, allowing the satellite to pass daily at the same hour on a specific point on Earth. Maintaining the same relative orientation towards the sun (one side of the satellite is always in shadow) facilitates heat dissipation of internal equipment and ensures Earth observation under stable solar illumination conditions (Sebesta & Pigliacelli, 2008). In this way, since the terrestrial shadows produced by objects on the Earth's surface are always the same, the construction of new military installations and missile ramps can be easily detected (Sebesta & Pigliacelli, 2008). Eventually, since the satellites' technical characteristics of the NRO Polar Meteorological Program evolved considerably between 1962 and 1994, the analysis shall subsequently consider the technical specifications of satellites and the civilian and military equipment involved in their construction.

For the sake of clarity, the Defense Meteorological Satellite Program (DMSP) shall be divided into two periods: the first, from 1960 to 1970, includes the DMSP 1, 2, 3, 4A, and 4B satellites; the second, from 1970 to 1992, includes DMSP 5A, 5B, 5C, 5D-1, 5D-2, and 5D-3, the latter being the U.S. reference dual-use satellite until 2014. The following technological developments are reported in the first period:
1.Observation, surveillance, and reconnaissance:

10 There are two types of weather satellites: geostationary and polar. Geostationary satellites are located at an altitude of 35,800 km; their time of revolution around the Earth is the same as the Earth's rotation. Therefore, these satellites remain stationary relative to the Earth's surface and are extremely useful for monitoring the evolution of atmospheric phenomena.
11 Heliosynchronous orbit is a particular type of low orbit. It is distinguished from other orbits by the following characteristics: it is a retrograde orbit (the satellite moves from Est to West), quasi-polar, and oriented such that the satellite always passes at the same time at the same point on Earth.

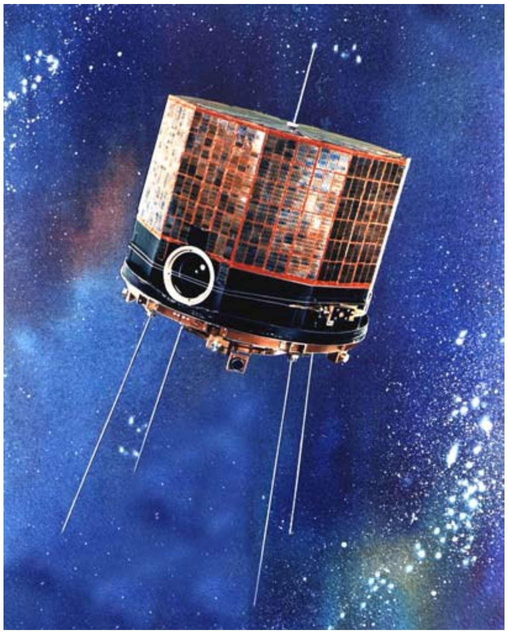

Figure3 DMSP Block 1, Source: Wikipedia

Evolution of observation / surveillance / reconnaissance mode through the transition of optical satellites (vidicon tube camera) to optical and infrared satellites (high-resolution infrared radiometer) from Block 4 in 1965 (Hall, 2001). Initial photos cover an 800-mile surface area, and the image is recorded on tape as an analog signal for later transmission to the ground. The goal of the satellite was to take meteorological images on each pass over the Northern Hemisphere, allowing for the gradual reduction of aerial weather reconnaissance sorties over the pole and Eurasian landmass (Hall, 2001). In addition, the introduction of the infrared radiometer in 1965 allowed for night-time observation. Thus, by capturing near-infrared and thermal infrared of objects, the individuation of underground launch sites of nuclear warheads (warmer than the surrounding terrain) was made possible (Hall, 2001). In a nutshell, infrared sensors enabled the production of raw operational maps of cloud cover, cloud height, and the Earth's heat budget.

2.Satellite control system (SCS) – Spin stabilization:

Spin stabilization is accomplished by maintaining the satellite's axis of rotation (about 12 revolutions per minute) perpendicular to the orbital plane through a ring of direct current (DC loop) along the satellite perimeter (Hall, 2001). The flow of electric current generates a magnetic field that must be aligned with the Earth's magnetic field to maintain the axis perpendicular to the Earth's plane. This system represents a medium of the permanent magnet[12] (passive control system) and magnetic coils[13] (active control system).

3.Telemetry, tracking, and command:

In 1963, the "boresight tower" and the transmitter were replaced with a technique of sun scanning (Hall, 2001). While the formers were used to routinely determine the pointing vector of a tracking/readout antenna and to test the receiving system's sensitivity during operation; the latter, was adopted to determine the pointing vector with a hermetically sealed, low-energy transmitter placed in the centre of the antenna reflector used to test receiving sensitivity (Hall, 2001). In addition, the introduction of transportable terminals ashore and aboard ships increases the timeliness of data

[12] This attitude control mechanism involves the simple principal of a compass. When a magnet is rotated out of alignment with the Earth's magnetic field, it tend to realign with the field if allowed to freely rotate. By attaching the satellite to the magnet, the torque induced by the magnet as it attempts to realign itself is transferred to the satellite, causing its rotation.

[13] Instead of having a magnet oriented to the satellite, direct current is circulated in coils, producing a magnetic field. It is possible to keep the satellite in orbit by controlling the interaction between the satellite's magnetic field and the Earth's magnetic field.

reception and accuracy to the United States Atlantic Command (USLANTCOM / USACOM) centred on the wartime protection of Atlantic Sea lanes from Soviet attack from the North Pole (Hall, 2001).

The sudden technological advancement of the early 1960s was enabled by the adoption of DSAP (Defense Systems Applications Program), later renamed DMSP (Defense Meteorological Satellite Program), which could meet the tactical, operational, and strategic requirements of the Corona reconnaissance program (Hall, 2001). The principal architect was the Undersecretary of the Air Force Joseph V. Charyk, who also headed the National Reconnaissance Office (NRO). He believed that NASA's parallel, dual-use meteorological satellite program met neither the timing nor the secrecy requirements of the NRO's intelligence office[14] (Hall, 2001). Furthermore, the management scheme adopted by the first director, Lieutenant Colonel Thomas O. Haig was structured as follows: first, the technical support of the program was totally entrusted to Air Force personnel without the aid of a civilian engineering contract to expedite work; second, personnel were selected under his aegis; third, the adoption of RCA fixed-price, fixed delivery contracts throughout the program; fourth, telemetry, tracking, and command activities under exclusive military control by transferring the office from Lockheed to Air Force stations in Maine and Washington; lastly, the replacement of NASA's Scout launcher with the SM-75 Thor liquid-propellant intermediate-range ballistic missile (stage I) and the solid-propellant FW-4S (stage II) – used until 1980, when it was supplanted by Atlas (Thor-Burner achieves 86 percent launch success rate)[15] (Hall, 2001).

The management program changed dramatically in the early 1970s due to the higher technological complexity of the space and control segment. The significant change occurred in 1972 with the establishment of a new board composed of representatives that combined civilian and military interests; namely the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), and the Department of Defense. While the choice satisfied the Office of Management and Budget (OMB) and the Department of Commerce requests to cut production costs by avoiding replications in space, it weakened the program management (bureaucratic stratigraphy and slow decision-making) and boosted the risk of violation of the National Aeronautics and Space Act (Hall, 2001). Not coincidentally, the Secretary of State Henry Kissinger abolished the OMB proposal to use DMSP Block 5 for civilian uses, which would have infringed the requirement that military space data traffic had to be separated from civilian and State Department Officials (Hall, 2001). Accordingly, the Undersecretary of the Air Force and director of the NRO, James W. Plummer, opted for a variant of Block 5D. While respecting the National Aeronautics and Space Act, the choice favoured the adoption of a more technologically advanced satellite than TIROS-N of NASA's Nimbus-NOSS program.

[14] NASA's parallel civilian program, Nimbus-NOMSS turns out to be too complex and expensive to meet both the tactical and strategic needs of the NRO.
15 NASA's booster was responsible for increased costs and delayed launches due to a series of failures to put the satellite into orbit, as in the case of launches IV and V on April 26 and September 27, 1963.

The following are the technological evolutions of DMSP Block 5D 1, 2, and 3 with a polar orbit between 1976 and 1987.

1.Satellite control system (SCS) – Three-axis stabilization:
From Block 5D-1, the new lens is about controlling the optical axis of the primary imaging sensor with 0.01-degree precision. The following active and passive control systems have been mounted to achieve three-axis stabilization: reaction wheels, magnetorquer, gyroscope, star-tracker, sun-tracker, earth-tracker, and integrated computers. Reaction wheels – also called momentum wheels – are positioned on three orthogonal axes aboard the satellite: yaw, roll, and pitch axis. They keep the satellite on axis by trading back and forth the angular momentum between the satellite itself and the wheels. Sinning the wheel clockwise produces an equal and opposite thrust on the satellite, which can be reverse by slowing the wheel to rotate the vehicle back. By interacting with Earth's magnetic field, the magnetorquer prevents the accumulation of excessive wheel momentum that accrue in the system due to external forces, such as solar photon pressure or gravitational acceleration. Three gyroscopes (passive control system) are installed to complement the two active control systems just reported (Hall, 2001).

Furthermore, relative and absolute attitude sensors are used to monitor the satellite's attitude throughout its orbit. The first group includes three gyroscopes capable of measuring changes in attitude considering the initial attitude. To overcome error accumulation in attitude determination, the second group - ground, solar, and star trackers – uses external objects to the satellite to monitor the three-axis stabilization. Among the three, star sensors can determine the satellite axion most accurately by comparing the position and apparent magnitude of the observed stars through photodetectors or cameras. Eventually, the embedded computers perform a threefold function: firstly, they make possible automatic on-orbit attitude correction; secondly, they control the launcher in the boost, midcourse, and terminal phase; thirdly, they ensure the proper operation of the Westinghouse electro-optical Operational Linescan System (OLS) (Hall, 2001).

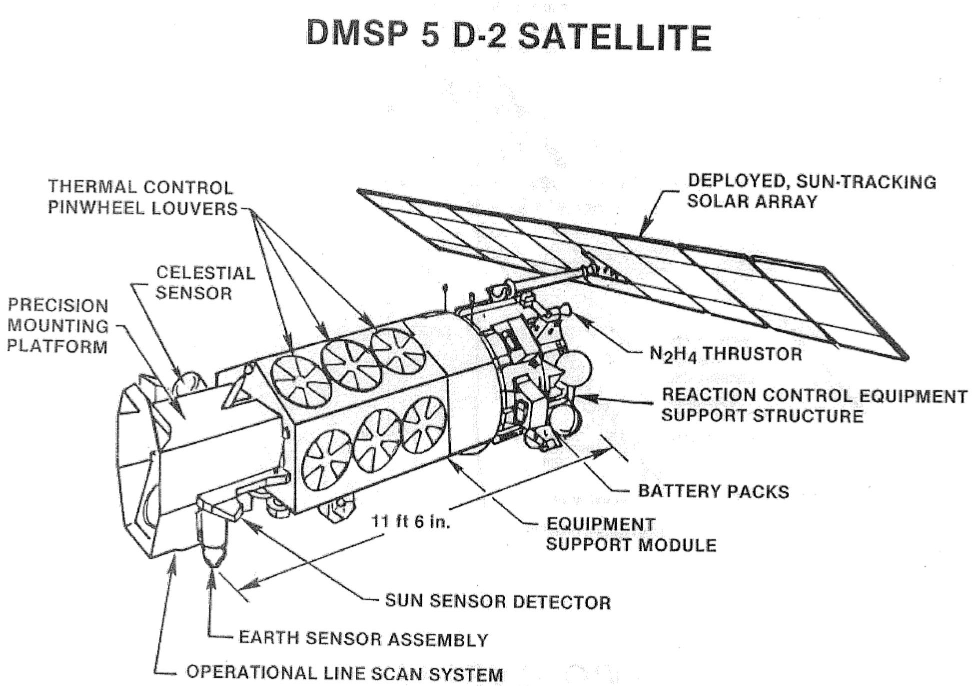

Figure 4 Source: Wikimedia Commons

2.Observation, surveillance, and reconnaissance:
With the new telescope (OLS), the initial swath width of 800 nm is doubled at 1,600 nm and provides a nadir resolution of 0.3 nm at the Earth's surface in the visible and infrared spectra, with an edge resolution of 0.5 nm (Hall, 2001). Technological refinement in optics and infrared granted the acquisition of visual and thermal data related to cloud cover, cloud heights, atmospheric density (nitrogen, oxygen, ozone), photoelectron spectroscopy[16], global atmospheric temperatures of the Earth's surface up to altitudes above 30 km, nuclear detonations in the troposphere[17], electron distribution in the ionosphere[18], ice extent and its conditions, and height and wave pattern of the ocean surface (Hall, 2001).

3.Processing of static models and COMIREX:
The technological advancement of weather satellites ultimately allowed for the development of statistical and predictive models of Earth's cloud cover. According to the declassified records of the NRO Polar Orbit Satellite Weather Program, without the predictions, only 40 percent of the satellite images would have been cloud-free for the entire mission duration (Office of the Director, NRO, 1975). In addition, the Committee on Imaginary Requirements and Exploitation (COMIREX) have

[16] It is the measurement of the energy of electrons emitted from solids, gases, or liquids by the photoelectric effect.
[17] High-altitude nuclear explosions are caused by nuclear weapons testing in the upper atmosphere of the Earth and in outer space.
[18] According to the literature, there are three Chapman layers in the ionosphere, and the temperature is uniform.

been adopted a single standard for requesting satellite meteorological data called WAG Cells. Each WAG cell is a unit of the giant World Aeronautical grid Cells and has an area of 12x18 nautical miles. In such a manner, target identification errors have been reduced (Hall, 2001).

As a result of the gradual increase in satellite program costs, in 1993, the Office of Management and Budget and the Congressional Committees brought to attention the need to reduce space program costs through further convergence of the civilian and military sectors to minimize on-orbit replication and cut mission-involved personnel. Hence, through the presidential directive by William Clinton, the Implementation Plan for a Convergent Polar Orbit Environmental Satellite System was born. Management responsibility was tripartite between NOAA, NASA, and the Department of Defense. In addition, an integrated program office was created to manage the program of dual-use satellites operating in polar orbit (NPOESS). In 1997 the Air Force Space Command site was decommissioned, ending a program that had operated in secret for years for the strategic needs of the NRO's scientific intelligence (Hall, 2001).

CONCLUSION

By analysing the civil and military dual-use of satellites, it turns out that the military contribution was of major importance. Notably, National Reconnaissance Office's Polar Orbit Satellite Weather Program Polar-orbiting satellite program constituted an essential motive of Mutual Assured Destruction (MAD) throughout the Cold War, facilitating the underwriting of the SALT nuclear arms limitation treaties (Office of the Director, NRO, 1975). Notably, monitoring enemy nuclear weapons saved the United States substantial financial costs in the arms race by drastically reducing the number of SR-71 and U-2 air sorties (Hall, 2001). From a strictly technical perspective, the Polar Program is responsible for initiating the air weather revolution through the introduction of the new satellite attitude control systems, satellite monitoring, operational use of infrared imagery, the user requirements-based program (Block 5D), and the increase in satellite lifetime (from 90 days in Block 1 to 5 years in Block 5D-2) (Hall, 2001).

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