SWEDISH DEFENCE
RESEARCH AGENCY

FOI-R--1264--SE
September 2004
ISSN 1650-1942
**User report**

Lars Höstbeck, Mattias Waldenvik, Mike Winnerstig

# Strategy for space

SWEDISH DEFENCE RESEARCH AGENCY

Defence Analysis
Systems Technology
SE-172 90 Stockholm

FOI-R--1264--SE

September 2004

ISSN 1650-1942

**User report**

Lars Höstbeck, Mattias Waldenvik, Mike Winnerstig

# Strategy for space

Cover illustration: The Swedish ionospheric research satellite Freja, launched on October 6, 1992. The Swedish Space Corporation, SSC, was the prime contractor for the satellite that flew Swedish, German, Canadian and US experiments. Illustration used with permission from Swedish Space Corporation.

# Executive summary

Since their introduction some 40 years ago space systems have become increasingly important as e.g. intelligence systems and for enhancing military effect. From being a strategic asset, the goal for tomorrows space systems is to bring "space support to the warfighter" which implies an even greater dependence than before on space services for military operations.

If Sweden is to be able to use space systems for military effect, and rely on space systems in times of crisis or war, we need a national policy on the military use of space systems and a strategy for securing access to the systems deemed necessary.

Trends in technology as well as politico-military factors will affect the choice of strategy and the choice of strategy will determine the limits for our use of space-based systems, e.g. for intelligence and security critical purposes.

There exist three commonly used systems for describing space activities which together can be used to describe a nation's space program and the purpose of a specific space system. The three typologies are:

**Space activity sectors** – Defines in broad terms *areas of interest* for space activities. The four sectors usually mentioned are *Intelligence*, *Military*, *Civilian* and *Commercial*.

**Space missions** – Describes *what* to do in space. Missions in the military activity sector are *Space Support*, *Force Enhancement*, *Force Application* and *Space Control*.

**Military space doctrines** – Describes a nation's official policy towards the military use of space. A system of doctrines in common use is named Lupton's military space doctrines after Lt Col David E. Lupton, USAF. The four different doctrines are called *Sanctuary*, *Survivability*, *Space control* and *High ground*.

A national policy on space that covers both military and civilian aspects should take into account which space missions, in each sector, the nation should be involved in, and form the policy accordingly. A space policy, in combination with the national security-policy, will point towards the strategy for securing access to space that Sweden should follow.

The Swedish Armed Forces (SwAF) have started a transformation towards what has been called a Network-Based Defence. The transformation is a commitment to a defence structure that enhances military capabilities through a systematic use of modern technology.

This transformation to a network-based methodology coincides in time with a change in the mission for the SwAF. The traditional role of defending Swedish territory and counter an invasion has lost in importance relative to the role of taking part in international peace support operations.

The traditional role for SwAF defending Sweden does not necessarily demand support from military space systems. But the Network-Based Defence and new operation areas have changed the picture. The enhancement of military capabilities such as long-distance high capacity communications or precision positioning are no longer just nice features but necessary to have if a Network-Based Defence capable of international peace support operations is to be a reality. Space systems are one, if not the only, way to create those capabilities. From a Swedish perspective space systems have gone from systems that can enhance military operations to systems that will enable military operations. This means that SwAF will have to get involved in space systems.

If a nation commits to enhance military operations by the use of space-based services, the next step is to create new capabilities by exploring the potential of these space-based services. International examples of such space enabled capabilities are "Blue Force Tracking" and long range UAV-operations with near real-time data download.

Once such capabilities are an integral part of military operations, a heavy dependency on space has been created. This will put the space arena in focus for political and military policy discussions and drive the nations that depend on space towards a doctrine of space control. If such a dependency has been created, one topic for national debate should be what strategy to follow in securing access to space.

A number of possible space strategies to secure access to space can be identified for any given state actor. However, the actual selection, or formulation, of a national space strategy is affected by a number of important factors. These include technical factors, trends in today's space technology and space markets, as well as trends and requirements stemming from the political and military spheres. Five possible space strategies for Sweden as a politico-military actor are briefly presented below:

- In something we could call the Zero Option, things may continue as they stand today: no national space policy and no national co-ordination of space demands and needs.
- A possible development of the zero option could entail a national effort and a national space policy, for both civilian and military purposes, based on the access to commercial space services.
- A third possibility would be a national space policy based on security-policy co-operation with others. The access to space services would then be assured through Swedish participation in international joint ventures.

- A fourth possibility would be a purely national space policy that consists of a national co-ordination system, national military space R&D efforts, and national control of the whole space service chain.
- A fifth possibility would be a purely multinational space policy according to which Sweden would take part in a multinational body.

A major challenge is to achieve integrity in the chain of tasking, or programming the satellites, as to avoid revealing our exact interests and intentions. Space-based reconnaissance and intelligence gathering thus seem to be the really difficult issues in terms of international co-operation.

A strategy of the third kind, based on multilateral security-policy co-ordination, would ensure access to space systems even though Swedish technological or industrial participation would be limited. It would also fit well in line with the technological and political trends of the day. However, this strategy would entail a large amount of trust in the multilateral frameworks. Current trends in Swedish defence policy, especially the interest in the EU security and defence policy (ESDP) – indicate that this is the likely way of the future for the Swedish Armed Forces.

In Europe today there are a number of national space initiatives that are being opened up for international co-operation. Sweden as a technologically and economically well developed country with traditional strong armed forces is an interesting potential partner.

There are actually quite a few options open for Swedish decision-makers on the issue of military space strategy. Some of these options are constrained either by military-security or by technological (or economical) factors.

Given these constraints, and the different factors pushing and pulling Swedish policy in different directions, the most likely option for Sweden would be to adopt a military space strategy together with other EU and NATO states in an international setting, *i.e.* the third kind of strategy as defined above.

As various space projects in Europe show, there are a wide variety of options available within the EU and/or NATO, and thus there are the possibilities to work along the line of the third strategy of international co-operation.

# List of abbreviations

| | |
|---|---|
| ASAT | Anti-Satellite (weapons) |
| DAC | Direct Access Customer (TerraSAR option) |
| DBA | Dominant Battlespace Awareness |
| DS | Decision Superiority |
| EGNOS | European Geostationary Navigation Overlay System |
| EROS | Earth Remote Observation Satellite (Israel) |
| ESDP | European Security and Defence Policy |
| EU | European Union |
| GEO | Geostationary Earth Orbit |
| GLONASS | Global Navigation Satellite System (Russia) |
| GNSS | Global Navigation Satellite System (generic) |
| GPS | Global Positioning System |
| HEO | High Earth Orbit |
| KEASAT | Kinetic Energy ASAT |
| LEO | Low Earth Orbit |
| MEO | Medium Earth Orbit |
| NATO | North Atlantic Treaty Organization |
| NBF | Swedish acronym for Network-Based Defence |
| PE | Precision Engagement |

| | |
|---|---|
| R&D | Research and Development |
| SAR | Synthetic Aperture Radar |
| SBL | Space Based Laser |
| SBSS | Space Based Surveillance System |
| SOP | Satellite Operation Partner (EROS option) |
| SSTL | Surrey Satellite Technology Limited |
| SwAF | Swedish Armed Forces |
| TT&C | Telemetry, Tracking and Control |
| UAV | Unmanned Aerial Vehicle |
| UN | United Nations |
| WAAS | Wide Area Augmentation System |

# Table of contents

# Introduction

Since their introduction some 40 years ago space systems have become increasingly important as, e.g. intelligence systems and for enhancing military effect. From being a strategic asset, the goal for tomorrows space systems are to bring "space support to the warfighter" which implies an even greater dependence than before on space services for military operations.

Traditionally, space services have not been an integral part of Swedish military capabilities. Space services are utilised, but they are not necessarily integrated into the military structure.

The recent focus on network enabled military capabilities, in Sweden labelled Network-based Defence, has led to an increase in the interest for space-based systems. The use of space systems is not in itself a strategic choice to be made, this is already a fact. Satellite navigation and communication is already widely utilized and satellite images are bought on a commercial basis. A key question is how to integrate space systems into the Network-Based Defence in order to enhance military effects and enable new capabilities.

If Sweden is to be able to use space systems for military effect, and rely on space systems in times of crisis or war, we need a national policy on the military use of space systems and a strategy for securing access to the systems deemed necessary.

Trends in technology as well as politico-military factors will affect the choice of strategy and the choice of strategy will determine the limits for our use of space-based systems, e.g. for intelligence and security critical purposes.

The purpose of this report is to describe who the different government actors with an interest in space systems traditionally are, give a brief explanation as to why these actors have interests in space and what this interest consist of. This serves as a background to a discussion on different strategies for securing access to space.

The chapter *Space activities* gives an introduction to "who and why" in space and also an overview of commonly discussed military space doctrines.

*Space in a Network-Based Defence* provides a summary of why space is important for a network-based defence and exemplifies this with examples of the most important space services.

In the chapter *Towards a national space strategy* we discuss five different strategies for securing access to space from technical, commercial, political and military perspectives.

The discussion on strategies are followed by a chapter introducing *International space activities* from three different perspectives: Who owns pay-loads that were launched 2000-2002, what does the industrial base for space look like and what are the forms of co-operation available on space projects.

In *Conclusions* we try to point out the most probable strategy for Sweden to secure access to space services and point to a few facts that support this conclusion.

There are also three appendices for the reader seeking deeper knowledge on some space missions (Appendix A), on satellite orbits (Appendix B) and Space Law (Appendix C).

# Space activities

Space activities started out in the fifties as an area of interest for governments, namely USA and the USSR, and the objectives were strategic.[1] At the top of the list was strategic reconnaissance, followed by strategic warning of missile attacks, and strategic denial of space by the use of nuclear-tipped ASAT-missiles.

Today the picture is very different. Not only have interests in space activities and space technology proliferated to most nations on earth but the number of different actors and their interests have changed from governments interested in intelligence to, among others, commercial enterprises.

If a successful strategy for engagement in space activities is to be formulated on a national level, a stringent foundation for analysis and recommendations must first be defined. There exist three commonly used systems for describing space activities which together can be used to describe a nation's space program and the purpose of a specific space system.[2] The three typologies are:

**Space activity sectors** – Defines in broad terms *areas of interest* for space activities. The four sectors usually mentioned are *Intelligence*, *Military*, *Civilian* and *Commercial*.

**Space missions** – Describes *what* to do in space. Missions in the military activity sector are *Space Support*, *Force Enhancement*, *Force Application* and *Space Control*.

**Military space doctrines** – Describes a nation's official policy towards the military use of space. A system of doctrines in common use is named Lupton's military space doctrines after Lt Col David E. Lupton. The four different doctrines are called *Sanctuary*, *Survivability*, *Space control* and *High ground*.[3]

A national policy on space that covers both military and civilian aspects should take into account which space missions, in each sector, the nation should be involved in, and form the policy accordingly. A space policy, in combination with the national security-policy, will point towards the strategy for securing access to space that Sweden should follow.

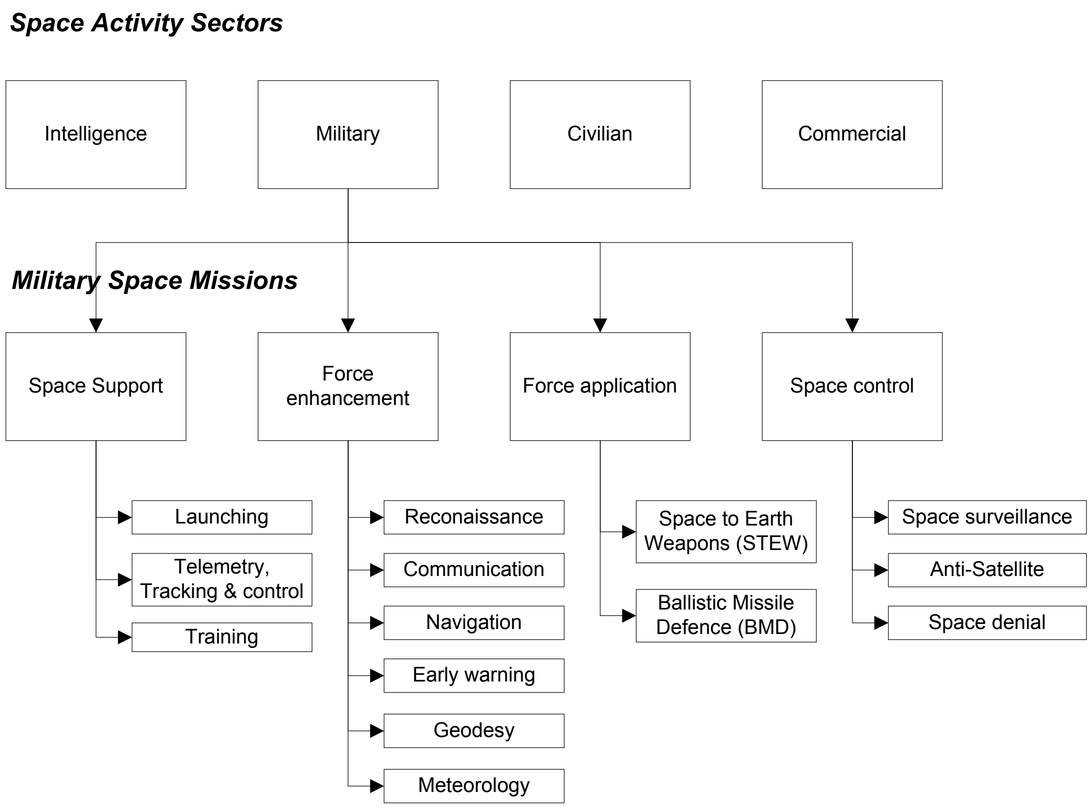


*Figure 1. Space activity sectors and Space missions. These two descriptions of space activities are complementary and even if the missions listed above are taken from the military activity sector, some missions can be conducted in more than one activity sector. The list of different types of missions under each heading is not exhaustive. The characteristics of the missions are not described in this report.*

## Space activity sectors

### The intelligence sector

As mentioned above, space assets were originally tools for the intelligence sector. The first successful Corona mission of august 1960[4] returned images with a resolution of 10-13 meters (30-40 feet). Targeting data had to be decided and programmed into the satellite before launch and the images were subsequently returned to Earth by dropping a film capsule through the atmosphere, where it was snatched in the air by an aircraft. The lead time from decision to returned images could be measured in days at best and only relatively large structures could be resolved. This was sufficient to decide strategic intelligence matters, e.g. that there existed no "Missile-gap" to the advantage of the USSR. The performance of the system was insufficient for imaging data of tactical value.

Today's systems have far better performance. Images are relayed to the ground by radio and targeting of the satellite can be programmed in near real-time and is only limited by the satellite's orbit. The resolutions of the systems are probably half a meter or better. However good the resolution, there is still the need for interpretation and analysis. This implies that there will always be a lead time from when a picture is taken until the intelligence content from that picture is distributed through the system. Here there is a divide between the strategic and the tactical requirements where strategic intelligence needs detailed data but not necessarily fast. From a strategic point of view the time for the delivery of an image may be small compared to the time it takes to do the analysis, even if the image takes days from order to delivery. With the exception of strategic early warning of missile attack all aspect of strategic intelligence gathering from space, not only imaging, will put high resolution of the data before fast delivery. This means that systems that are optimised for strategic intelligence gathering will be unsuitable on a tactical level, and vice versa.

The use of space systems for strategic intelligence used to be a prerogative for the superpowers and their closest associates. This use has, through the availability of high resolution commercial images, proliferated to many countries and the list of states that have the ability to use information derived from space assets is increasing every year.

### The military sector

The military activity sector is in many aspects a new actor in space. The main objective is force enhancement in various forms, often labelled "space support to the warfighter". The force enhancing space services do, of course, include imaging, but also space services for positioning, communications and mapping. The challenges are very different from the challenges in strategic intelligence gathering. The services are often time-critical, *i.e.* the value added by a space service depends on the arrival of the information on time and in a form that can be acted upon immediately. In many cases this means automatic data interpretation, data-fusion and dissemination.

Even if commercial services can be used to some degree in Force Enhancement, e.g. meteorology or geodesy, the concept of time-criticality presents severe limitations. For some missions a national capacity is a prerequisite for a viable and robust military capability. Since the usefulness of space services has become evident from military operations like the Gulf war (1991), Afghanistan (2001) and Iraq (2003) more and more countries have started to get involved in space activities and to gather know-how on space. This can be seen as an indication of a wide-spread interest in space-based force enhancement contrasted to the more passive posture of buying commercial images for strategic intelligence purposes.

The missions of force application and space control are endemic to the military activity sector. If there is wide-spread acceptance of force enhancement, the same can not be said for force application and space control. These two missions are logical next steps as more and more nations get involved in force enhancement from space. The probability of an adversary drawing on space assets increases with every nation that deploys space systems and space-system services. In a conflict, the ability to degrade the capability of an adversary by attacking his space systems, either the space segment or the ground segment, could be an effective way to coerce the adversary to a settlement. This means that we will probably see operational systems dedicated to space control in the near future. An example is the US Space Based Space Surveillance system (SBSS) that is expected to be developed in the next few years.[5] The SBSS is a defensive system designed for surveillance but further down the line there are weapon systems such as the Space Based Laser (SBL) or kinetic energy weapons.

Once weapons are considered for deployment in space, the issue of "weaponization of space" becomes critical. There is wide-spread opposition against the concept of weapons in space. It should be pointed out that most foreseeable scenarios of force application in space could be managed by ground based systems. Deployment of weapons in space is not necessary for a nation to use force in space. An example of a ground based system for use against targets in space is the direct ascent kinetic energy anti-satellite missiles, or KEASATs.[6]

### The civilian sector

The civilian space sector is all the governmental owners and users of space services that are not military. In the same sense that the intelligence sector and the military sector use space in different ways, and therefore have different requirements, the civilian sector uses space differently, and thus has yet another set of requirements.

No comprehensive list of civilian space mission is presented in this report. As a first approximation, the civilian space missions can be compared to military force enhancement space systems, "bringing space services to the citizen". The common interest between the civilian sector and the military sector is the basis for the concept of dual-use. In many cases dual-use can be a reality, but not in all cases. Since the objectives are different, the requirement from civilian and military users will be different. There is no way to guarantee that those different requirements can be fulfilled by one common system.

### The commercial sector

The commercial sector consists of both users and suppliers of space services. In some cases the space service used is military but the application is commercial or civilian. One such example is GPS-navigation for private use. Another is the use of early warning satellites for scientific data acquisition.

More common is probably the other way around: Intelligence and military users using civilian assets. A large percentage of the military satellite communication in the Iraq war was transmitted through commercial satellites and the use of commercial images for intelligence purposes may be wide-spread.

## Space doctrines

Military space doctrines concern the question of how to think about space assets for intelligence or military purposes. A chosen doctrine can be seen as a guideline as to what is acceptable to do in and from space and thus serves as a part of a national space policy. Every national actor with an active military space program has some sort of space doctrine, whether or not it is explicitly formulated. It is beyond the scope of this report to try to define criteria for the different doctrines in such a way that they can be used to analyze a nation's space program. As a basis for a discussion of a national policy for Sweden, Lupton's four doctrines are outlined below.

### The sanctuary doctrine

The sanctuary doctrine emphasizes peaceful use of space. Military utilization of space, e.g. verification of treaties and strategic early warning, are accepted but space should be kept free from weapons. The sanctuary doctrine can be seen as a part of a larger policy of strategic arms control and verification, and since such a policy would require a certain amount of reciprocity between the main actors, the vulnerability of space systems is not an issue. Under the sanctuary doctrine, space systems are strategic assets, not tactical.

### The survivability doctrine

Space support to the warfighter is the main difference between the survivability doctrine and the sanctuary doctrine. This means that military operations will be more heavily dependent on space assets, and are thus more vulnerable if denied the space services. To counter this, space systems should be hardened against various threats. Other ways to handle threats to space systems are to have a redundancy in the services and have spare satellites, either in orbit or on the ground ready for a quick launch. The survivability doctrine also questions whether or not a heavy dependence on space is acceptable due to the development of ASAT-systems.

### The space control doctrine

Space as an environment for military operations can be regarded in the same way as sea or air. The main objectives of space control is to secure ones own access to space and deny an adversary the same access. Space control is analogous to sea control and thus requires systems for space situation awareness and weapon systems to deny access to space. These weapons could attack the space segment of an adversary's space system, the ground segment, or the communications link.

### The high ground doctrine

The final and fourth of Lupton's doctrines is the high ground doctrine. It is a way of looking at space as "the ultimate high ground" for military operations with weapons based in space to influence the outcome of terrestrial conflicts. This could be weapons for ballistic missile defence that would have an impact on any conflict on Earth where ballistic missiles are used, or it can be weapons in space that are used directly against terrestrial targets.

---

[1] The early stages of the exploitation of space have been described from different perspectives in various books. A political perspective can be found in McDougall, Walter A., …*The heavens and the earth*, John Hopkins University Press, 1985. The story from a reconnaissance perspective is told in Taubman, Philip, *Secret Empire: Eisenhower, the CIA and the hidden story of America's space espionage*, Simon & Schuster, 2003.

[2] The three systems are described in more detail in Peter L. Hays et al., *Spacepower for a new millennium*, McGraw Hill, 2000.

[3] Lupton, David E., *On space warfare*, USAF, 1998.

[4] The story of the CORONA project can be found in Day, Dwayne A. et al.,*Eye in the sky – The story of the Corona Spy satellites*, Smithsonian Institution Press, 1998.

[5] Canan, James W., *Controlling the space arena*, Aerospace America, January 2004.

[6] A discussion on weaponization of space can be found in Engnér E., Höstbeck L., Winnerstig M., *Militarisering av rymden* (*Militarization of space*, abstract in English, text in Swedish), FOI-R—1217—SE, April 2004.

# Space in a Network-Based Defence

The Swedish Armed Forces (SwAF) has started a transformation towards what has been called a Network-Based Defence (Swedish acronym NBF)[1]. The transformation is a commitment to an information technology intensive defence structure that enhances military capabilities through a systematic use of modern technology. NBF is a method for development and action that is focused not upon platforms such as ships or airplanes but on functions such as sensors, weapons and decision-making. In NBF the functions are supposed to "belong" to different platforms in different locations, and still be able to work together as a unit, through the network, when solving a given task.

This transformation from platform to network coincides in time with a change in the mission for SwAF. During the cold war SwAF's sole mission was to defend Swedish territory and counter an invasion. Since the end of the cold war the threat of an invasion has dramatically decreased. Peace support operations in co-operation with other nations are the most probable mission for SwAF in the near future. These peace support operations could take place almost anywhere in the world and could cover the whole spectrum from e.g. mine-clearance in a friendly environment to peace enforcement through the use of lethal force in a hostile environment. The new method, NBF, the new, or rather undefined, locations and the broad spectrum of tasks result in new requirements for SwAF.

Space systems have traditionally not been an issue in Swedish defence planning. Since before World War II Sweden has followed a policy of non-alignment, and as a consequence developed many, if not most, critical defence materiel systems nationally. In many cases the capabilities of these systems have been comparable to the best on the international market, and in many cases systems have been exported. Examples are the *Sjöormen* class submarines, Combat Vehicle 90 and JAS 39 *Gripen* multirole fighter aircraft.

National military space systems have never been on the agenda. These have been, and still are, very expensive. To develop national military satellite systems has never been seriously considered. As a consequence space systems have been a non-issue in Swedish defence planning. This does not mean that Sweden has not used any space-based services for defence purposes. Commercial images have been used for mapping and weather forecasts use satellite imagery, though there are no dedicated Swedish military meteorological satellites.

The traditional role for SwAF defending Sweden does not necessarily demand support from military space systems. Communication and reconnaissance are two examples:

Communications can be handled by a ground based infrastructure, designed in peacetime to be used in times of war. Satellite communications may or may not create additional value to an armed force designed to defend Swedish territory.

An optical reconnaissance satellite will have global coverage but will cover the area adjacent to Swedish territory only a few times a week. Add the fact that Sweden, far north, has rather few hours of daylight during wintertime and clouds will often cover the areas of interest. Airborne reconnaissance will probably meet the demands from the traditional SwAF for a lower price and with better effect than a satellite.

The NBF and the new operation areas have changed the picture. The enhancement of military capabilities such as long-distance high capacity communications or precision positioning are no longer just nice features but necessary to have if a network-based defence capable of international peace support operations is to be a reality. Space systems are one, if not the only, way to create those capabilities. From a Swedish perspective space systems have gone from systems that can enhance military operations to systems that will enable military operations. This means that SwAF will have to use space systems.

## The Revolution in Military Affairs

The concept of a network-based defence in Sweden has grown out of the international debate on a revolution in military affairs (RMA), due to the rapid development of information technology (IT). Some key features of the original RMA, as it was presented by FOI's FoRMA project in 2000[2], are Dominant Battle Space Awareness (DBA), Decision Superiority (DS) and Precision Engagement (PE).

DBA could be described as having a better knowledge of the battle space than the opponent. One way to prepare for this is to build systems that can gather various kinds of data from the battle space, turn that data into intelligence and present it to the decision-maker in a timely fashion. The implementation of DBA will, among other things, formulate requirements for sensors, data-handling (analysis, fusion and dissemination) and communications. Sensors should in this context be thought of not only as traditional sensors such as radars or sonars, but as any kind of device that can gather data and communicate it to its master. This could be radars and sonars, but it could also be computer software trolling the internet or satellites imaging areas not accessible otherwise.

Decision superiority in its simplest form is to make a better and faster decision than the opponent and then have it executed. To achieve this, communication is one thing among many that is necessary. High capacity communication will enable intelligence to reach the decision-maker in time, and allow the orders to reach all parties concerned in time.

Precision engagement is the ability to strike with exactly the right type of force at the correct time and in the right place. The idea is to use no more force than necessary, to minimize collateral damage and to avoid putting our own forces at risk. This will require knowledge of the target as well as flexible engagement systems, not necessarily weapons, and a precise knowledge of where to strike in time and space.

*Table 1. Examples of use of space-based systems in a network-based defence.*

| | **DBA** | **DS** | **PE** |
|---|---|---|---|
| Imaging | Area-coverage showing activity and creating a recognized picture of activities. | High-resolution images showing details of targets. | Post-strike damage assessment. |
| Communication | Sending sensor data to analysis. | Sending intelligence to decision maker and decisions to executing forces. | |
| Positioning | Positioning of own troops. Time stamp on data available in the information grid. | Global time reference with nanosecond precision. | Guided munitions. |

All of the three mentioned features, DBA, DS and PE, can be enhanced by space-based systems. In a few instances space-based systems will be an enabler since some capabilities will not be achievable without space systems. Table 1 gives a few examples of how satellite imaging, satellite communication and satellite positioning will support and enable a Network-Based Defence.

### Satellite imaging

In addition to the traditional intelligence role of satellite images, a new tactical role can be envisioned in a network-based defence. Regularly updated satellite images of an area can serve as a means to build a picture of the normal level of activity within an area. Correlation between satellite data and data from other sensors will increase the quality of the picture.

Satellite sensors and airborne sensors can also serve as complements to each other for tactical information such as post-strike damage assessment. To achieve this, two criteria must be met. First there must be a command and control system that can handle targeting requests for satellite imagery and return the resulting images to the end user in a sufficiently short timeframe. "The net" must be able to use satellites.

Second the coverage of the satellites must be good enough for the investment in a command and control system that can handle satellites to be meaningful. The use of commercial imaging satellites, most of which use sun synchronous orbits, will not be sufficient to meet the requirements for tactical use in a network-based defence since these satellites only revisit a certain location once a day and at the same, well known time. However, for peace-time intelligence purposes commercial imaging satellites can handle some missions. The trend towards higher resolution available from commercial system will only increase their usefulness for intelligence gathering.

### Satellite communication

The creation of a true recognized picture of activities is one of the key features in the Network-Based Defence. This picture should not be thought of as a map showing positions of units at a specific time. Although this is one view of the picture, there are others such as the history of events or the probable future and intentions. To be able to achieve this picture a large number of different sensors are needed and the ability to collect data from the sensors and subsequently distribute knowledge derived from the sensor data through the net is essential. A large amount of data will travel through the net at any given time and compared to the systems used today, the capacity will probably have to be increased by orders of magnitude.

Satellite communication is one feasible way to meet this demand for increased bandwidth in a Network-Based Defence. One of the reasons to prefer satellite communication to other high bit-rate technologies is the fact that satellite communication has the same high capacity regardless of distance and that it is immediately accessible upon entering an area, without prior construction of a communications infrastructure on the ground in the area of operations.

### Satellite positioning

The key to precision in time and space is to have an accurate positioning system. To be able to use that positioning system both for territorial defence at home and missions abroad, the system must be at least regional, and for all practical purposes global. The only feasible system that provides global positioning in time and space are satellite-based navigation systems, GNSS. Within a few years there will be three main services available; The US GPS system, the Russian GLONASS and the European Galileo.

There will also be various augmentation systems available such as the European EGNOS (European Geostationary Navigation Overlay System) and the US WAAS (Wide Area Augmentation System), collectively known as satellite DGPS (Differential GPS), to increase the accuracy of the position, thus allowing GNSS to be used for safety critical application, e.g. air traffic control, but also for military purposes.

In a network-based defence, the use of GNSS can be seen as a security critical use of a signal that Sweden as a nation cannot control. This dependency without control created by the use of GNSS will probably be deemed acceptable due to the value created by having access to precision positioning. As a way to decrease the dependency, critical systems for military use should be able to use any GNSS available.

### Space as an enabler for new capabilities

If a nation decides to enhance military operations by the use of space-based services, the next step is to create new capabilities by exploring the potential of these space-based services. The use of space enables capabilities that are not possible to achieve in other ways. International examples of such capabilities are:

- Blue force tracking – By the use of GNSS and satellite communication a system can be built that tracks ones own units. A GNSS receiver pin-points the location of a military unit or a vehicle. A radio transmits the position to a control unit. The control unit will broadcast the position, or updates of it, to those units that either ask for this specific information or that need to now it, as decided by the control unit. Such a system of blue force tracking should be able to decrease "friendly fire" incidents and raise the effect of military units' situational awareness[3].

- Long-distance UAV operations – Autonomous vehicles such as UAVs can be used on long distance reconnaissance missions with a possibility to control and relay data back in near-real time if it can be accurately positioned and uses a broadband communications link to transmit data. This can be achieved by the use of GNSS and satellite communication.

Once such capabilities are an integral part of military operations, a heavy dependency on space has been created. This will put the space arena in focus for political and military policy discussions and drive the nations that depend on space towards a doctrine of space control. If such a dependency has been created, one topic for national debate should be what strategy to follow in securing access to space.

---

[1] There exists a large body of international literature on what in USA is called Network Centric Warfare (NCW) and in the UK Network Enhanced Capabilities (NEC). It is beyond the scope of this report to try to recapitulate these concepts in detail. The interested reader is encouraged to look at e.g. Alberts, Garstka, Stein, *Network Centric Warfare: Developing and Leveraging information Superiority*, CCRP 1999, or Adams, *The next world war*, Hutchinson, London, 1998.

[2] FoRMA is the name used for the Swedish Defence Research Agency, FOI's project to support the SwAF in its transition towards a Network-Based Defence.

[3] A description of such systems used in Iraq 2003 can be found in Robinson, Bruce T., *Who goes there*, IEEE Spectrum, October 2003.

# Towards a national space strategy

One can *a priori* identify a number of possible space strategies for any given state actor. However, the actual selection, or formulation, of a national space strategy is affected by a number of important factors. These include technical factors, trends in today's space technology and space markets, as well as trends and requirements stemming from the political and military spheres. In addition to this come the specific requirements and demands that a particular country's history or political arrangements might cause.

In this chapter, we will initially present five possible national space strategies for Swedish purposes. Thereafter, we will analyse the major factors affecting space strategy in general, and eventually focus on what those factors mean for the eventual formulation of a Swedish space strategy, from technical, commercial, political and military perspectives.

## Possible national space strategies for Sweden

*A priori*, one might consider five possible space strategies for Sweden as a politico-military actor. They are briefly presented below.

### *1. The zero option: Today's situation*

In something we could call the Zero Option, things may continue as they stand today. This actually means no strategy, *i.e.*, no national space policy and no national co-ordination of space demands and needs. The purchasing of space services among domestic military and civilian actors continues in an independent way. This approach is not optimal in terms of coherence and effectiveness, but might continue as long as relevant decision-makers do not act on the issues. It has the effect that every actor can buy the service best suited for his purposes but it denies Sweden the control needed in order to secure the use of space services for politically sensitive applications, as e.g. image intelligence with control of satellite programming.

*2. A national strategy based on commercial assets*

A possible development of the zero option could entail a national effort based on commercial capabilities. Here, national co-ordination and a national space policy, for both civilian and military purposes, would be based on the access to commercial space services. This policy could be regarded as highly rational from an economist's perspective, but entails almost total trust in the accessibility of commercial services even in times of war and crisis. From a security-policy perspective, this strategy can thus *a priori* seem to be risky. The purely political restriction of the United States on delivery of high-resolution images at the earliest 24 hours after capture puts a limit on the usefulness of some commercial systems even in peacetime. The experience from the conflict in Afghanistan 2001 is that in times of crisis the restrictions are even more severe.

*3. A national strategy based on multilateral co-operation*

A third possibility would be a national space policy based on security-policy co-operation with other countries and international actors. The access to space services would then be assured through Swedish participation in international joint ventures, both civilian and military, in the space field. This could e.g. be done within both the EU and the NATO frameworks.

Such a strategy of co-operation could embrace anything from a small Swedish ownership in a commercial system (cf. the Fr-Be-Sw SPOT-satellites) to a joint undertaking to develop and operate a bilateral military satellite system with another nation.

*4. A national strategy based on purely domestic efforts and non-alignment*

A fourth possibility would be a purely national space policy that reflects the traditional non-aligned Swedish defence posture. This would consist of a national co-ordination system, national military space R&D efforts, and national control of the whole space service chain – from the launching of satellites to satellite data processing. Here, one gains independence but most likely at a very high cost.

*5. A multinational strategy based on inter- and supranational co-operation*

A fifth possibility would be a purely multinational space policy according to which Sweden would take part in a multinational body, with the capabilities and competences to structure the space policies of all participating countries. This could be an international or supranational body on which Sweden and all other partners would draw in the field of military space services.

## Factors affecting the formation of space strategies

As was noted above, however, the likelihood of the realization of the strategies formulated in the section above depends a lot on a number of factors exogenous to the strategies. We will in the following discuss these factors to be able to return later to the strategies themselves.

### The use of space for military-political purposes

The first factor one must consider when discussing the topic of a strategy for space access concerns the use of space assets for military-political purposes. In this context, there are basically three major uses of space: navigation, communications, and remote sensing. Remote sensing in itself can be subdivided according to which sensors are used. Imaging sensors are the most commonly used for intelligence and military purposes. Images can be optical or radar and be used for either strategic or tactical purposes.

*Navigation*

In the field of space-based navigation, few major problems appear from a politico-military point of view. Space navigation builds on passive ground segments for the end users, ground segments which are used without any revelation of the intentions or goals of the users. According to some European actors, however, the U.S. GPS system is in some ways challenged by the not yet operational European Galileo system for security-policy reasons. In the hypothetical and highly unlikely situation where the U.S. for political reasons decides to shut down the GPS system, the Galileo system would continue to supply positioning services both for European users, thus enabling Europe to continue to rely on space navigation, and to an adversary to the US. This aspect of the Galileo system is not shared by most European countries, though, which instead see the Galileo system as a civilian system fully compatible with GPS - thus contributing to the overall redundancy of the satellite navigation system of the world.

*Communications*

In terms of space communications systems, there exist both military systems for purely military purposes and commercial space-based communications systems which are available to any customer, including the military sector. There are of course differences between military and commercial systems, but there are also similarities. It can be argued that some military space-based communication services are purely military and have no commercial value, but the bulk of the communication will use services that have a dual-use potential. Despite the fact that communication, in contrast to navigation, demands that the end user has an active ground segment, the amount of intelligence that can be gathered by an adversary by the fact that we use satellite communication (disregarding the value of the contents of the transmissions) is much less than the potential intelligence in the knowledge of programming of imaging satellites.

Hence, the issue of satellite communications per se does not profoundly affect a nation's space strategy choices, since communications services will be available regardless of the political ramifications, but the exact communication service used can have implications for space strategy. The more specialized communications services that are used, the more impact they will have on a strategy to secure access to space services.

#### *Remote sensing*

The issue of space-based reconnaissance and intelligence is the difficult matter for any state's considerations on space strategy. In contrast to the other two areas, although reconnaissance in terms of e.g. space imagery might be commercially available to some degree, the use of space imagery for intelligence purposes requires a large intelligence infrastructure, experienced image interpreters etc.

The major challenge is to achieve integrity in the chain of tasking, or programming the satellites, in order to avoid revealing our exact interests and intentions, and the whole issue is politically sensitive. Military space-based reconnaissance and intelligence gathering thus seem to be the really difficult issue in terms of international co-operation.

### Technological trends

Today's technological trends constitute in themselves a number of factors clearly affecting the formation of space strategy, for any country in general but perhaps for small countries in particular. They can be summarized as follows.

#### *Miniaturization*

One of the most obvious trends in today's space technology is miniaturization through micro technology. This trend leads to smaller and lighter satellites, often produced by private companies to a decreasing price. The UK firm Surrey Satellite Technology Limited (SSTL) is a well-known example of this. A Swedish example is Ångström Space Technology Centre .

Given the proliferation of micro technology, new technological solutions in the space field become more available and cheaper than before, not least due to the decreased weight of modern satellites. This allows multiple satellite launches, which also make the process of putting a space system in place much more affordable.

#### *Launch Capacity More Available*

Formerly, satellite launches were normally expensive and state/government controlled. Today, civilian actors have begun making commercial launch services available, which makes satellite launches possible for smaller actors which do not have a launch capacity of their own. Examples here include the launch sites in French Guyana and Plesetsk, Russia.

#### *The increase of commercial services*

Increasingly, commercial services are available in most sectors of the space field, including space imagery. However, not all countries can profit from the current commercial space systems since their geographical locations might be a problem. Commercial systems are also optimised from a commercial viewpoint, which means that all intelligence or military missions cannot be carried out by commercial systems due to orbital and geographical limitations.

All these trends contribute in some sense to the possibility of a space strategy that is based on commercial assets rather than national ones. It is quite possible to build up a national space system which draws on readily available commercial services.

### Technological limitations and their political effects

#### *Launch capacity*

The access to launch sites is eventually a political issue, since launch sites, even commercial ones, are always located on the territory of a specific state-actor and thus subject to political regulations. However, given the multiplicity of launch sites in today's world, this is not necessarily a problem that affects seriously the choice of a space strategy.

*Programming*

Although commercial services can be readily available, they still depend on a number of political and technological limitations and conditions which might make their use less acceptable, or even unacceptable for a state-actor that chooses a satellite system for intelligence purposes. Although a lot of agreements relating to secrecy etc. can be made when contracting a commercial company, it is still very difficult to completely cover all that might be sensitive from a political point of view. For example, one might "rent" commercial satellite-imaging services and get all pictures transferred directly, without anybody from the commercial company "peeking" into what is being photographed. However, the company that runs the satellites must program the latter according to the customer's desires, and programming obviously tells a lot about the areas of interest for the customer. This information, one could argue, might later on be a liability for the customer if it is leaked to the wrong actor.

Thus, although the commercial services that are easily available today are an obvious temptation for a state that lacks very deep pockets, the security drawbacks that might appear in commercial solutions can be substantial enough so as to trigger a development toward more "controlled" solutions, i.e. state-owned or at least state-controlled systems.

## Future directions in the formation of a Swedish space strategy

Some likely directions in the formation of an eventual Swedish military space strategy can be identified.

In the first place, the "zero option" of doing nothing more than today's business as usual might always be tempting since it is the cheapest one in the short term. However, the technological developments and the military needs they create are factors that likely will push Swedish military-political thinking away from this strategy; it will be perceived as increasingly suboptimal.

A strategy based on commercial assets could be designed as a coherent and effective one, both operationally and economically. As was noted above, the increased availability of commercial space services, including launch capacity and smaller satellites, makes such a strategy perfectly possible. However, other factors – such as the likely demand for military secrecy and accessibility, especially in the area of space imagery and reconnaissance, are likely to discourage the formation of a space strategy completely based on commercial assets. This would be acceptable only if Swedish decision-makers in the political and military spheres would "trust" the commercial agents so much that the issue of national control over such important items as satellite programming etc. would not be regarded as an important one.

A third kind of strategy, based on multilateral security-policy co-ordination, would ensure access to space systems even though Swedish technological or industrial participation would be limited. It would also fit well in line with the technological and political trends of the day; a lot of the same kind is increasingly taking place in the NATO and EU contexts. However, this strategy would entail a large amount of trust in the multilateral frameworks. Current trends in Swedish defence policy, especially the interest in the EU security and defence policy (ESDP), indicate that this is the most likely way of the future for the Swedish armed forces.

The fact that the ESDP in itself is increasingly integrated with NATO – after all, most countries in the EU belong to NATO as well – does not diminish this impression. Another factor likely to push the Swedish strategy in this direction is the economic one; a spreading out of the costs over several states should make space systems more affordable. It is of course fully possible that traditional Swedish security-policy concerns, such as "neutrality" and "non-alignment", could hamper such a development, but it seems increasingly unlikely.

What does seem truly unlikely is the fourth, independence-oriented strategy, based on purely domestic efforts such as the build-up of complete Swedish space systems, from launch sites to rockets, satellites and data processing structures. This might seem to be an un-natural conclusion as most nations that today are involved in military space seem to have chosen this option. Although this strategy of course in principle is very much in line with traditional Swedish security-policy thinking – see "neutrality" and "non-alignment" – the costs associated with this policy will be tremendous and deterring.

It could be argued, however, that such a strategy of domestic efforts, complemented with commercial services or based on cheaply available commercial sub-systems, still would be feasible. Such a mixed strategy would have all the drawbacks of the commercial strategy and still require an extensive national investment in a space infra-structure. Since this goes completely against the idea of a national, independent space strategy and still requires large domestic investments in space, it could be argued that it is a less than likely strategy in the Swedish case regardless of its foundations.

Finally, a Swedish space strategy based on inter- and supra-national co-operation goes very well with the technological trends of the day. What clearly disqualify such a strategy as a realistic one for Sweden is its political ramifications. Sweden has a tradition of non-alignment, and there seems to be no imminent change of this. Thus, it does not seem to be even remotely likely that Sweden would in the end adopt a strategy embracing the idea of supra-national decision-making in such a field as military space issues.

# International space activities

Internationally, space-based services for military or intelligence purposes is an active field of research and development. There are also a large number of state actors or commercial actors involved in space activities. Sweden is not an exception in this field. Even though Sweden's military space research is very small, on the verge of non-existing, Sweden is a space nation with active scientific research and a space industry that supplies both the civilian and the international military market.

In this chapter we give an overview of international space activities from three different perspectives. The first is the perspective of national space endeavors, described by who launched payloads into space during 2000-2002.[1]

The second perspective is that of the industrial base and what countries have a viable space industry, and in which fields. The hypothesis is that a nation that has military space ambitions also will support a national space industry as a way of securing the national integrity of their future space systems. Therefore a nation that has a budding space industry or takes active part in technology trials and demonstrators can be expected to start incorporating space services into its military structure.

The third perspective is that of current military space projects open for Sweden to be a partner in. The projects described are a selection of projects in Europe and Israel that illustrates not the technical performance but the different political and organizational possibilities open to a country like Sweden.

## Launches and payloads 2000-2002

As mentioned earlier, a number of ”new” nations has emerged as actors on the space arena. Launch chronologies from the years 2000-2002 reveals that of the 30 nations that had payloads launched into space, about one third can be regarded as new actors in space. A classification of these can be made as to what degree of “know-how” a nation has. Four groups can be identified:

1. Nations with the competences necessary to launch their own satellites.
2. Nations with the competences necessary to build satellites or satellite subsystems.
3. Nations with the competences necessary to use space based services and where space based services are parts of the infrastructure.
4. Nations without competences necessary to qualify for group three or higher but actively pursuing the building of “know-how”.

Group one consists of the traditional space nations such as USA, Russia, China, India, Israel and Japan. A nation that is on the verge of qualifying for group one is Brazil.

In group two, many western European countries can be found together with e.g. Australia and Canada. Sweden is a fairly typical nation in this group with an active space program and a developed space industry, but lacking the capability to unilaterally develop and operate more complex systems and a national launching capacity. This is, however, more of a political and economic decision than a technical fact. Given Sweden’s history in developing military hardware such as submarines, missiles and fighter aircraft, a domestic military satellite system would not be beyond the nation’s technical reach.

Pakistan is an example of a non-traditional space-nation that belongs to this group and who is actively pursuing a "complete" national space program with domestic launching capabilities.

The third group consists of nations that are bases for commercial satellite operators or nations that have chosen not to develop indigenous industry and instead rely on services available on the commercial market, or through agreements with other nations. Both satellites and satellite launches are bought from other countries and no technology is developed nationally.

The fourth group is in many aspects the most interesting group. Here we can find nations such as Algeria, Argentina, Egypt, Malaysia, Morocco and Saudi-Arabia. These countries have not achieved the level of know-how nationally to build and operate their own systems but are actively trying to raise their level of knowledge.

The reason for developing countries with a demand for investment in national infrastructure to invest in space is a topic for discussion. All nations mentioned in the fourth group above are either situated in volatile areas or have embarked upon military adventures in the near past. The usefulness of space systems in military operations is probably one driving motivation for these countries in their quest for access to space.

## Industrial base

An overview of the global commercial space industry is another way to get an indication as to which nations might be pursuing military space capabilities. Space industry and commercial space assets may be broken down in any number of ways. Here we have chosen the breakdown structure used in Jane's Space Directory 2003-2004 as a convenient way to measure various nations commitment to space in commercial terms.

Countries with only one entry were struck from the table. The fact that China, Russia and Ukraine were among those struck does serve to emphasize how blunt this overview as a guide to space technology. However, at least Russia and China have an almost comprehensive industrial base, though the products are not available commercially. The table also serves the purpose of indicating what countries could be suitable as partners for a future Swedish commitment to military space.

The numbers in the table below correspond to the following sectors:

1. Communication satellites, components and services
2. Earth observation facilities and equipment
3. Earth observation satellites, components and services
4. General
5. Launchers, propulsion systems and launch site services
6. Microgravity facilities, equipment and services
7. Navigation, search and rescue facilities and equipment
8. Satellite actuation systems and thermal control devices
9. Satellite busses
10. Satellite communication facilities and equipment
11. Satellite guidance, navigation and control components
12. Satellite information storage components
13. Satellite and propulsion support hardware

*Table 2. The industrial base for space, using the break-down structure of Jane's Space Directory. Countries with only one entry where taken off the list.*

| **Country** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | ● | ● | | ● | | | | | | | | | |
| Austria | | ● | | ● | | | | | | | | | |
| Belgium | ● | ● | | | | | | | | ● | | | |
| Canada | | ● | | | ● | | ● | ● | | | | | |
| France | | ● | | | ● | ● | ● | ● | | | ● | ● | |
| Germany | | ● | | ● | ● | ● | ● | ● | | | ● | ● | |
| India | ● | ● | | | ● | | | | | | ● | | |
| Indonesia | ● | ● | | | | | | | | | | | |
| Israel | ● | | | ● | ● | | | | | | ● | | |
| Italy | ● | ● | | ● | ● | ● | | ● | | | ● | | |
| Japan | ● | ● | | ● | ● | ● | ● | ● | | | ● | | |
| Netherlands | | | | ● | ● | ● | | ● | | | | | |
| Norway | ● | ● | | ● | | ● | ● | | | | | | |
| South Africa | | | | ● | | | | | | ● | | | |
| Spain | | ● | | ● | | | | | | ● | | | |
| Sweden | ● | | | ● | ● | ● | | | | | ● | | |
| Switzerland | ● | | | ● | | | | ● | | | | | |
| Thailand | ● | | | ● | | | | | | | | | |
| UK | | ● | | ● | ● | | ● | ● | ● | ● | ● | | ● |
| USA | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |

Despite the quite large number of countries appearing in the table above there are but a few countries that have a complete indigenous commercial space capacity, including launch vehicles and launch facilities.

## Projects in Europe and Israel

A logical conclusion from the fact that military space capability demands a degree of national control of space systems involved and the broad industrial base for space is that there will be a large number of national satellite projects going on at any given time. Since space systems are expensive there is always an interest to share the cost of development with others. Basically this can be done in two ways, nationally by developing a dual-use system, which probably means some degree of compromise in performance, or internationally, which probably means less control of the system.

In Europe today there are a number of national space initiatives that are being opened up for international co-operation. In this context, Israel with a strong space industry and a geographical location close to Europe can be regarded as a part of the European military space environment. Sweden, as a technologically and economically well developed country with traditional strong armed forces, is an interesting potential partner. A few examples of space projects that could be of interest to Sweden are presented below.

### Optical imaging

#### *Pleiades*

Pleiades is a French built optical imaging satellite with a resolution of about 70 cm. It is the French contribution to the French-Italian co-operation ORFEO where Italy participates with the SAR-system COSMO-SkyMed. Pleiades is also a multinational endeavour with Belgium (4%), Spain (3%), Sweden (3%) and Austria (1%). The Swedish part is administered by the Swedish National Space Board. How to utilize the Swedish share in Pleiades is probably still to be decided.

#### *TopSat*

TopSat is the name of a satellite built on microtechnology by British QinetiQ in co-operation with among others Surrey Satellite. It will, when launched, have a rather low resolution, about 2-5 meters. The concept of this satellite is to have an inexpensive satellite with a rather short lifetime, but with the ability to download images in more or less real-time to a military unit in the field. Needless to say, this is not a satellite suited for intelligence but optimized for the military activity sector. The usefulness of the system is dependent upon operational concepts and command and control systems that handle satellite images. The interesting part of the TopSat program is the vision of a constellation of TopSats where a number of actors buy their own satellite and thus get access to the whole constellation.

#### *EROS*

EROS-A is a commercial Israeli optical imaging satellite with a resolution of about one metre. It is a derivative of the military Israeli satellites in the Ofeq-series. Of interest here is the special "Satellite Operating Partner" (SOP) program which provides a customer/partner exclusive right to one or more satellites over a defined geographical area, corresponding to the footprint of the satellite when in contact with the customer's ground station. Such a partnership guarantees the customer full and exclusive access to the satellite's camera in the area, i.e. access to programming the satellite and 100% of the images in that area. A contract for a SOP-program would run for 6-8 years and the cost would depend on the size of the footprint.

### SAR-imaging

#### *SAR-Lupe*

SAR-Lupe is a German project built upon Synthetic Aperture Radar (SAR) satellites. The projected system consists of five identical satellites in three different orbital planes. The resolution of the system is of the order of one metre. This is not a commercial but a German national system, owned by the

German Ministry of Defence. If Sweden would seek co-operation with Germany on SAR-Lupe there will probably be a number of possible ways to do this, from supplying an additional satellite to the constellation, to obtain an agreement on buying scenes on a monthly or yearly basis. The amount of control exercised over the satellite's programming will probably be a matter of negotiations.

*COSMO-Skymed*

The Italian contribution to the French-Italian co-operative venture ORFEO is the SAR-system COSMO-SkyMed. It has a resolution of about 1 metre and the constellation consists of four satellites placed in one orbital plane, shifted 90 degrees from each other. Just as with SAR-Lupe, COSMO-SkyMed is a government-backed system, open to co-operation to third parties. Since COSMO-SkyMed and Pleiades use a common ground segment, an agreement with this co-operative venture will probably give easier access to both optical and SAR images than separate agreement with two different suppliers. On the other hand, the large number of nations already involved will probably make the possible partnerships offered less flexible than an agreement with one single government.

*TerraSAR-X*

TerraSAR-X is a commercial SAR-imaging satellite developed by EADS/Astrium. The resolution is to be comparable to SAR-Lupe or COSMO-SkyMed, about one metre. The TerraSAR-X is just one satellite but a follow-on project called TanDEM-X calls for two TerraSAR-X satellites orbiting in a precise and controlled formation. TerraSAR-X offers two customer options. The first called Standard is just a simple "buy a satellite image". The second is called Direct Access Customer (DAC) and offers some customer control of the process as the customer is allowed to downlink the image to his own ground station and do the processing himself. The option does not allow for control over the programming.

A similar description of current satellite communications projects and available forms of co-operation can be made. Since imaging services probably are the most politically sensitive (see p.35), these examples of various forms of partnerships concerning imaging services provides a view of a number of possible ways to handle the problem. As the more or less comparable performance of the different systems (excluding TopSat) shows, a final decision upon who to choose for partner will not necessarily be based on technical performance, but made from the form of co-operation offered.

---

[1] A more comprehensive study of launches 2000-2002 can be found in Engnér E., Höstbeck L., Winnerstig M., *Militarisering av rymden* (*Militarization of space*, abstract in English, text in Swedish), FOI-R—1217—SE, April 2004.

# Conclusions

A strategy to secure access to space must, as this report indicates, take into account a large number of factors. The four traditional activity sectors have different requirements and their needs will probably be satisfied in different ways. A strategy will probably treat intelligence requirements separately from military requirements and communications requirements in other ways than imaging requirements.

Commitments to space-based military and intelligence services can be thought of as three discreet steps. Each of these steps implies a policy decision upon taking the step, and each step will be associated with a different strategy to secure access to space services.

The first step is enhancement of military effect. This is where Sweden is today, using some space-based service to enhance military effect, e.g. GNSS and satellite communications. There are a large number of nations striving to take this first step, as witnessed by the number of "new" countries launching payloads into space.

The next step is that of enabling new capabilities. Nations that take this step will be able to create new military capabilities, but paying the price of creating a dependence on space that goes far beyond the dependence created when "only" using space-based services for enhancement. USA has already taken this step and a number of nations have started the climb. The Swedish commitment to a Network-Based Defence, deployable overseas, will probably put Sweden firmly in the club of nations using space to enable new capabilities.

The third step is that of force application from space. There are signs to the effect that USA, Russia and China might be preparing to take that step.

The three steps are loosely associated with Lupton's doctrines, where the first step corresponds to the Sanctuary doctrine, the second step to the Survivability doctrine and the Space Control Doctrine and the third step corresponds to the High Ground doctrine.

From a national policy perspective it is important to consider the change in policy, and associated need for a change of national strategy, implied with taking each step. This is not only true for national commitment in space but also important when forming a national policy as to other nations use of space. Such a national space policy will be a guideline when Sweden takes a position regarding other space initiatives, and must therefore be consistent with our own use of space.

Thus, after this discussion we might tentatively draw some conclusions. The first one would be that there are actually quite a few options open for Swedish decision-makers on the issue of military space strategy. Some of these options are constrained either by military-security or by technological (or economical) factors.

The second one must be that given these constraints, and the different factors pushing and pulling Swedish policy in different directions, the most likely option for Sweden would be to adopt a military space strategy together with other EU and NATO states in an international setting, *i.e.* the third kind of strategy as defined above. This could *a priori* be said to challenge traditional Swedish security-policy concepts, such as non-alignment. While this is true, Sweden is in most other military aspects currently performing precisely such a strategy: the fundamental transformation of the Swedish

Armed Forces, from a territorial defence posture to a force structure almost exclusively oriented towards participation in UN, NATO or EU led international operations is the most obvious sign of this. With the current reorientation, Swedish traditional non-alignment has lost much of its former connotations and there is no obvious reason to frame future Swedish space strategy in a different way than all other defence strategic issues on the Swedish agenda today.

As the description of various space projects in Europe shows, there is a wide variety of options available within the EU and/or NATO, and thus there are the possibilities to work along the line of the third strategy of international co-operation.

A logical strategy in a foreseeable future would probably be to form a partnership with one or more nations currently developing space systems to gain knowledge of operating space systems and using space services on a regular basis. With this knowledge a next step would be to find a partner with whom we can define a new system from scratch, starting with our own requirements and increasing our amount of control over the system. As the list of the industrial base shows, there are a lot of potential partners and since satellites have global coverage, there are no reasons not to search for a future partner globally.

# Appendix A - The usefulness of space-based systems

## Space missions

There are a number of satellite systems in use for military purposes, civilian purposes or both. These are described as different Space missions. Here we give a short introduction to satellites for navigation, communication and imaging, arguably the most important systems in this context.

### Navigation

The most well known satellite constellation for navigation is the US GPS constellation consisting of about 24 satellites, some of which are in-orbit spares, in circular orbits at 20000 km inclined at 60°. The satellites are distributed into six orbital planes for global coverage. The Russian counterpart to GPS is GLONASS, which provides similar performance. The European Union is planning a similar system named Galileo. Navigation aided by one of these systems is technically very attractive but in a conflict situation there is a real risk of jamming from either an opponent in the conflict, the system owner or both. From a European perspective the lack of control over GPS is one driving force behind the Galileo system.

### Communication

A number of different types of communication satellites, commercial and military, are in use world wide. Among those are satellites in Low Earth Orbits (LEO), Geostationary Earth Orbits (GEO) and Molniya orbits. An example of LEO systems is the Iridium constellation providing a global mobile phone service. Another is the Russian Strela satellites in circular orbits at 1400 km in two orbital planes inclined at 82° which enables low power transmitters to store a message on a satellite. The satellites will then dump the message when flying over a designated ground station.

There are a large number of tradeoffs to be made in choosing one communication system over another, cost being just one of them. An important concept here is the footprint, the area covered by a given transponder. The footprint may very well be the result of a trade off between the area covered and the increased cost in ground stations with large antennas. The concept of foot-prints and ground coverage gets ever more complicated with other orbits than GEO where the foot-print is moving around along the satellites ground track. Similar to the case for navigation systems, the communication channel is held at risk in case of a conflict when the satellite user is not the satellite owner controlling the use of the transponders.

### Imaging

Satellite images are nowadays available on a commercial basis. For any nation wanting to use imaging satellites there are a number of parameters that contribute to the usefulness of a system. The desired set of parameters depends on the primary task intended for a given satellite system. Tasks may range from strategic mapping through surveillance intelligence to tactical information, situation awareness and damage assessment. Depending on the satellite and its orbit there is a revisit period which determines the time between consecutive overflights of a specific object. The resolution of the imaging system determines the type of objects that can reliably be identified in the image. A high resolution imaging satellite is essentially looking down towards Earth through a soda straw and the lack of exact knowledge of a site of interest and a long revisit period may render the system useless from some practical points of view.

Obviously, the image needs to be transmitted to the ground in some way. Some systems use film capsules which are dropped at appropriate times, but today most systems download their images by radio. Whichever download system utilised the satellite needs to be over the horizon relative to a ground station in order to receive new tasking instructions, unless a system of relay satellites is employed. If an imaging system is to be used for some kind of situation awareness it is, of course, incompatible with long revisit periods and long periods between passages over ground stations. Furthermore, depending on the inclination of the orbital plane the global coverage may be limited. In analyzing an imaging system one needs to consider all aspects of the process, including tasking, acquisition, and post processing.

## Space support

Under the heading of Space support we find all activities needed to sustain operations in orbit. That includes training of the personnel, launching of satellites and controlling the satellites and their subsystems once in orbit.

### Launching

A number of different factors contribute to a launch capacity. The availability of a suitable launch vehicle is of course a necessary requirement. The suitability of a given launch vehicle depends on the size and mass of the payload, the desired orbit and the geographical location of the launch site. The geographical location of the launch site is important for several reasons. For a given type of orbit one location may be more suitable than another. Changing inclination is an expensive operation in terms of fuel consumption; it is therefore highly desirable to launch into GEO from latitudes near the equator. It is also desirable to launch in an easterly direction in order to get a helping hand from the Earth's rotation. Launch sites such as Cape Canaveral at 28°N and Kourou at 5°N are therefore suitable for launching satellites into GEO orbits, with the first part of the ascent taking place over the Atlantic Ocean.

Baikonur on the other hand is not only further from the equator, at 45°N, but also forced to launch due west since the first stage would otherwise fall onto Chinese territory. Launching satellites from Baikonur into GEO is therefore more expensive and requires a larger launch vehicle for a given payload compared with some other launch sites, e.g. Kourou. Launch sites far from the equator are only suitable for launches into LEO or elliptical orbits with higher inclinations.

### Telemetry, tracking and control (TT&C)

Telemetry, tracking and control (TT&C) refers to various activities such as turning on or off different satellite sub-systems, monitoring and responding to on board state of health data and so on. TT&C activities can only take place when the satellite is above the horizon relative to the ground segment.

The need to have the satellite over the horizon of the ground station would render it impossible for a country like Sweden to maintain, on its own, a GEO satellite above the Pacific Ocean without some kind of local TT&C station. For LEO satellites in polar orbits the relatively high latitude of northern Sweden is suitable for a TT&C station since relatively many passes of the satellite would be above the horizon. This is the reason for placing a remote controlled European Space Operations Centre near Kiruna.

Due to perturbations from the Sun, the Moon or a degradation of the orbit due to atmospheric drag a satellite will drift out of its desired orbit. The satellite may therefore use small on board thrusters or motors to adjust itself. The amount of fuel carried on board the satellite is then one of the factors limiting the service life of a satellite. The amount of orbit maintenance is highly dependent on the orbit, including the orbit altitude and inclination.

# Appendix B – Introduction to satellite orbits

The possibilities and limitations of a given space system are constrained by the laws of physics. In order to be able to asses the usefulness of a given space system we provide a short introduction to some basic concepts concerning satellite orbits and the launch of satellites.

## Satellite orbits

The motion of a satellite in an orbit around the Earth is governed by Kepler's laws. We will quote Kepler's laws and then provide a brief discussion emphasizing the points important for understanding space systems.

Kepler's first law states that a satellite moves in a plane with the orbit being an ellipse with the centre of the Earth at one focus. The second law is the law of conservation of angular momentum, which translates into the fact that an imaginary line from the centre of the Earth to the satellite sweeps equal areas in equal times. According to Kepler's third law, the square of the orbital period, i.e. the time it takes for a satellite to make one full revolution around the orbit, is proportional to the cube of the length of the major axis of the elliptical orbit.

The plane in which the satellite is moving is either the equatorial plane or a plane at an angle to the equatorial plane. The angle between the equatorial plane and the orbital plane is called the *inclination*. A geostationary satellite is moving in an orbit in the equatorial plane and thus has inclination zero while a satellite passing over the North Pole and the South Pole is in an orbit with inclination 90°.

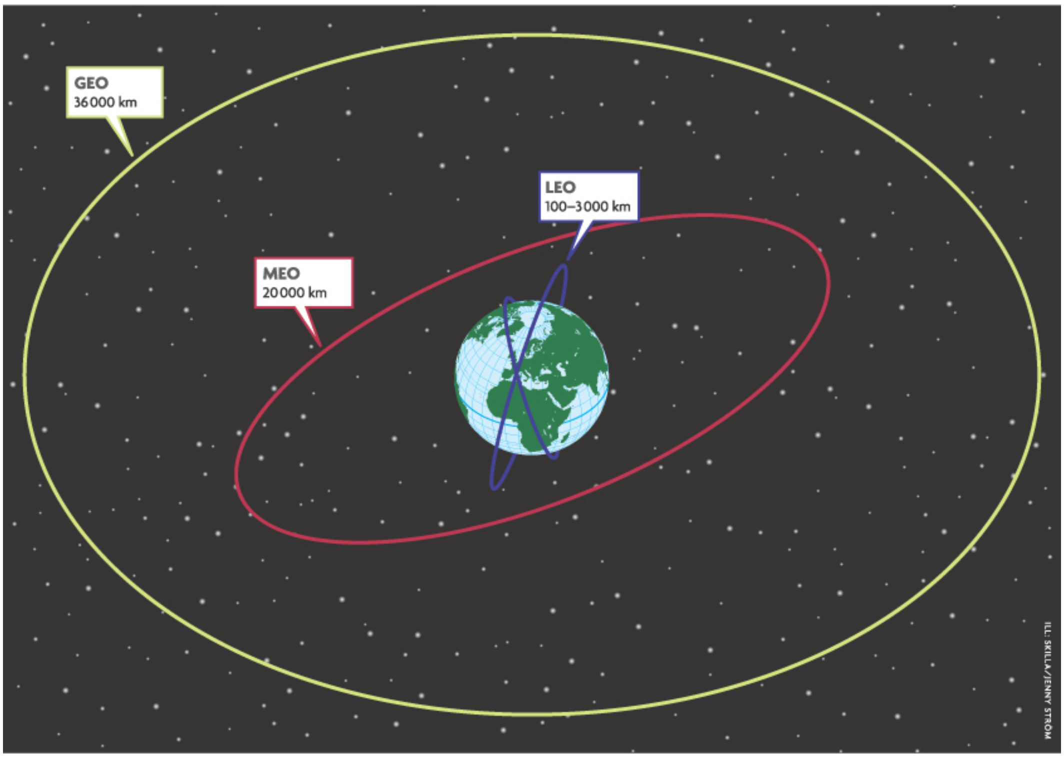


*Figure 2. The relation between different kinds of satellite orbits.*

The orbital plane is fixed relative to the stars. Since the Earth is rotating, the satellite will usually appear above a different longitude on two consecutive laps. Perturbations from, first and foremost, the Moon and the Sun will cause the orbital plane to rotate around the axis of the Earth. This effect is dependent on, among other things, the inclination.

For a circular orbit the satellite is moving with constant speed through the entire revolution with the period increasing with increasing height. An elliptical orbit can be characterized by the closest distance to the Earth, called the *perigee*, and the farthest distance called the *apogee*. Kepler's second law states that the satellite is moving slower when it is at *apogee* than when it is at *perigee*. A minimalist set of numbers that characterize an orbit is the distances at *perigee* and *apogee* together with the inclination. An example is Cosmos-2397 which was launched on 24 April 2003 from Baikonur into 35897 km x 35897 km x 2.3° or a Molniya-3 launched from Plesetsk into 40646 km x 653 km x 62.9°. These are examples of a geostationary orbit (GEO) and a Molniya orbit respectively.

## LEO – Low Earth Orbit

A Low Earth Orbit (LEO) is a nearly circular orbit at an altitude between 250 km and 1000 km. At lower altitudes the atmospheric drag is large and at altitudes above 1000 km the particle radiation levels from the innermost Van Allen belt may damage electronic components. LEO satellites in polar orbits, orbits with inclinations close to 90°, are visible to the naked eye on cloudless nights. The swift motion relative to an earthbound observer will give rise to Doppler shifted signals and may require a steer able tracking antenna at the ground station. Note that a ground station at high latitudes is favoured for satellites in polar orbits.

## GEO – Geostationary Earth Orbit

The period for a satellite in a circular orbit will increase with increasing altitude above the Earth. At an orbital altitude of about 36000 km the period will be equal to the time it takes for the Earth to make one revolution around its axis. If the circular orbit is in the equatorial plane the satellite will appear at the same spot above Earth and will appear motionless from Earth. This is of great practical importance since a fixed antenna can be used to receive and transmit signals to a GEO satellite. This is why the TV broadcasting satellites all are in GEO. Since the GEO is above the equator, the satellite dishes need to face more or less south at our latitudes, and the further north the dish is located, the larger the dish needs to be to compensate for a longer distance from the transmitting satellite, and thus a longer travel through the earth atmosphere, and at a lower angle.

## Molniya orbit

As mentioned above the reception of a signal from a geostationary satellite will be increasingly more difficult for high latitudes. To provide, among other things, satellite services to Siberia, Russia uses satellite constellations in a so called Molniya orbit. The Molniya orbit has an inclination of 62° with apogee at about 40000 km and perigee between 500 and 1000 km. According to Kepler's second law the satellite will move much slower at apogee and will thus spend most of its 12 hour period moving slowly high above Siberia. Theoretically, with a constellation of two satellites in the same orbit, separated by six hours, the system can provide a 24-7 service. In practise three satellites are used. The inclination is chosen to minimize the perturbation effects on the orbital plane which gives the satellites a longer service life since less fuel for orbit corrections needs to be carried onboard the satellite.

## MEO – Medium Earth Orbit

Medium Earth Orbits have altitudes somewhere between LEO and GEO orbits, avoiding both the inner and outer Van Allen belts. Important examples are NAVSTAR/GPS satellites at an altitude of about 20200 km. The proposed European satellite system for navigation, Galileo, is planned for similar orbits. These orbits have the advantage of being semi-synchronous; they make a revolution in 12 hours.

## HEO - High Earth Orbit

High Earth orbits denote satellite orbits at altitudes higher than the 36 000 km characterizing a GEO. Only a few satellite systems have utilised HEO. Among them are the American VELA satellites, at 118 000 km, used to detect nuclear detonations in the atmosphere.

## Polar orbits

Polar orbits are orbits with an inclination close to 90°, passing near both the north and the south pole of the Earth. A polar satellite in LEO will, as the Earth rotates under it, pass over different areas of the Earth on each lap. If the period is 90 minutes the satellite will make 16 laps with each turn of the Earth. If the foot print of the satellite is larger than about 23° longitude the satellite may well cover the entire surface of the Earth every day.

## Sun-synchronous orbits

The ground track for a satellite in sun-synchronous orbit, an orbit with usually around 98° inclination, will pass a given point on the Earth's surface at the same time every day. This may be particularly useful for imaging purposes since changes in how an object on the ground catches the light will reflect a real change. Figure 3 shows the ground-track of ESA satellite Envisat for five consecutive orbits. The satellite orbit has an inclination of 98.6° at about 780 km above the earth surface.

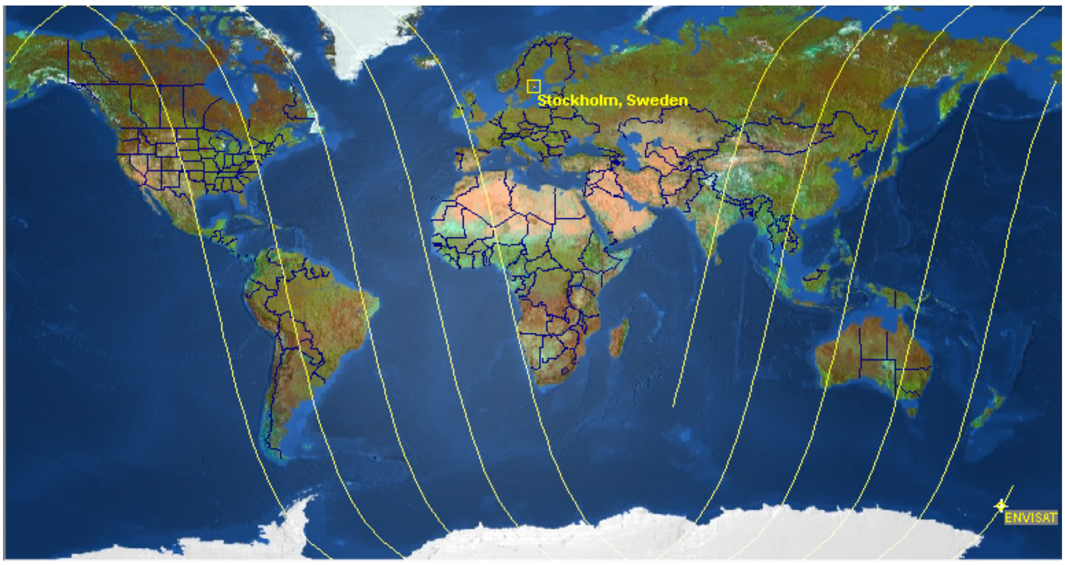


*Figure 3. Ground track of the ESA satellite Envisat.*

# Appendix C – Space law and international treaties

From the end of World War II, when artificial satellites first were seriously considered, until the launch of Sputnik 1 in October 1957, a question of the legality regarding satellites were discussed both in the USA and USSR. The problem is usually labelled "Freedom of space" and can described as whether or not it would be in compliance with international law to "fly" over another nation's territory with a satellite when it's not acceptable for aircraft.

As the Soviet Union launched Sputnik 1, Freedom of Space was to all practical purposes established by a Soviet initiative and from a US point of view there were no reasons to believe that an American satellite should be challenged by the Soviets. From this time and onwards it has been commonly accepted that satellites in orbit do not violate national borders when passing over a nation's territory. The question of where in legal terms the borderline between airspace and outer space should be drawn has still to be resolved. Towards the end of the 1950s the discussions between USA and the Soviet Union can be characterized as a series of propositions and counter-propositions with the aim of creating a framework of regulations of the use of outer space for military purposes. These proposed regulations were the basis for forming an "ad hoc committee" in 1958 and a permanent committee in 1959 under the United Nations that came to handle international space law issues. The committee is named United Nations Committee on the Peaceful Uses of Outer Space, COPUOS.

Today there exist UN resolutions and international conventions on space, negotiated by COPUOS. Some nations, Sweden among them, also have national space legislation.

## Treaties and conventions

The international legislation regarding outer space exists in the form of five conventions: Outer Space Treaty (1967), Rescue Agreement (1968), Liability Convention (1972), Registration Convention (1975) and Moon Agreement (1979). Of these conventions, the Outer Space Treaty can be regarded as a common framework and the following four conventions as elaborations upon various aspects of the first.

Sweden has ratified the four first conventions, but not the Moon Agreement. Official Swedish translations are accessible in the series "Sweden's international Agreements". The Moon Agreement refers to activities on the Moon and on other celestial bodies. Sweden as a nation is not in a position to start exploration of celestial bodies and therefore Sweden has not deemed it necessary to sign the Moon Agreement. By having ratified the Outer Space Treaty Sweden adheres to the basic principles of the Moon Agreement. The same holds true for most states that have signed the Outer Space Treaty.

### Outer Space Treaty

The Outer Pace Treaty states that outer space, including the Moon and other celestial bodies are free to explore by all nations and that scientific research can be freely conducted in space. As of January 1$^{st}$, 2003, 98 states have ratified the treaty and an additional 27 have signed it.

Agreeing nations are compelled not to place nuclear weapons or other weapons of mass destruction in orbit around the earth or install such weapons on celestial bodies. Furthermore, it is not allowed to establish military bases or test weapons on the Moon or other celestial bodies. The distinction between what is allowed in orbit and what is allowed on celestial bodies is clear. Outer Space Treaty does not prohibit weapons in space.

Non-government activities in space shall be carried out in accordance with the treaty and state parties are responsible for all national activities, regardless if they are conducted by government or non-government organisations.

The Outer Space Treaty is more than 35 years old. A lot has changed since the agreement was drawn. The cold war is over and the commercial uses of space have become ever more important. From this it follows that the area of space law probably demands more attention and maybe also modernisation. The framework, however, the Outer Space Treaty, is an international tool with a lot of flexibility.

### Rescue Agreement

The agreement calls for all signing parties to give help to any personnel of a spacecraft in case of accidents or distress. States are compelled to notify both the launching authority and the Secretary-General of the United Nations if a case of emergency is discovered or if personnel of a spacecraft by accident have landed in the "wrong" place. The personnel shall promptly be returned to representatives of the launching authority. Not only personnel but also objects returned from space are covered by the agreement.

### Liability convention

This convention regulates liability to pay compensation for damage done by space objects. Damage is understood to mean both loss of life, personal injury or impairment of health and loss of or damage to property. By the convention compensation must be claimed within one year of the occurrence of the damage or the identification of the responsible state. Launching states have an absolute responsibility for damage their space objects have caused on the surface of the earth or on aircraft in flight.

### Registration convention

The registration convention stipulates that each launching state is compelled to keep a registry of objects launched into space, and to notify the Secretary-General of the United Nations upon the creation of such a registry.

Each state that keeps a registry must as soon as practicable furnish the Secretary-General with information concerning each object in the national registry. The information must include:

- Launching state or states
- Designation of the object
- Date and location of launch
- Basic orbital parameters
- The object's general function

### Moon agreement

The use of force or hostile acts is prohibited on the Moon by the agreement. Likewise, the use of force or hostile acts towards the earth, spacecrafts or man-made space objects from the Moon is prohibited. The agreement specifically states that nuclear weapons or other weapons of mass destruction are prohibited on the Moon. The provisions relating to the Moon also applies to other celestial bodies, other than the earth, and any orbit around the Moon.

### Partial Test Ban Treaty

This treaty is not one of the traditional space treaties but is of interest as it prohibits nuclear tests in the atmosphere, under water and in outer space.

## United Nations resolutions

The United Nations general assembly has between 1958 and 2002 adopted 68 resolutions relating to space. The five conventions described above have been adopted as resolutions. Besides these there are four specific UN resolutions on direct-broadcasting TV-satellites, remote sensing, the nuclear power in space and international space co-operation.

A large number of resolutions have been adopted under the titles "International co-operation on the peaceful uses of outer space" and "Prevention of an arms race in outer space". These resolutions should probably be regarded as expressions of concern from the majority in the General assembly. They have not led to any new conventions being drawn and signed.

## National space legislation

The Swedish law 1982:63 on Space activities states that space activities in Sweden can not be undertaken by anyone without permission from the Swedish government. This also applies to Swedish subjects, persons or organisations, conducting their activities in other nations.

The law defines space activities as all activities that takes place in outer space and the launching of space objects and all measures taken to manoeuvre or in other ways influence launched space objects. The law explicitly states that sounding rockets and the reception of transmissions from space are not to be seen as space activities.

Besides stating how space activities are to be regulated the law also states how permissions should be given and that violations of the law can lead to imprisonment up to one year.

In compliance with the Liability convention the law states that Sweden is liable to pay compensation to another nation following damage done by Swedish space activities. If these activities are conducted by a non-government organisation this organisation is liable to compensate the Swedish government.

# Selected bibliography

Below, a selection of books, reports and other sources on military space policy and strategy, network centric warfare and related topics are listed.

## Books

James Adams, *The next world war*, Hutchinson, London, 1998.

David S. Alberts, John J. Garstka, Frederick P. Stein, *Network Centric Warfare:Developing and leveraging Information Superiority*, CCRP, 1999.

David S. Alberts, John J. Garstka, Frederick P. Stein, *Understanding Information Age Warfare*, CCRP, 2001.

Dwayne A. Day, et. al., *Eye in the sky - The story of the Corona spy satellites*, Smithonian Institution Press, 1998.

Norman Friedman, *Seapower and Space*, US Naval Institute, 2000.

George and Meredith Friedman, *The Future of War*, St Martin Griffin, 1996.

Daniel Gonzales, *The Changing Role of the US Military in Space*, RAND, 1999.

Roger Handberg, *Seeking New World Vistas - The Militarization of Space*, Praeger, 2000.

Peter L. Hays, et. al., *Spacepower for a new millennium*, McGraw-Hill, 2000.

Dana J. Johnson, Scott Page, C. Bryan Gabbard, *Space: Emerging options for National Power*, RAND, 1998.

Steven Lambakis, *On the edge of the earth - the future of american space power*, National Institute for Public Policy, 2001.

Walter A. McDougall, *...The Heavens and the earth - A political history of the space age*, The John Hopkins University Press, 1985.

Oliver Montenbruck, Eberhard Gill, *Satellite Orbits - Methods, Models, Applications*, Springer Verlag, 2000.

James E. Oberg, *Space Power Theory*, US Space Command, 1999.

Bob Preston, et. al., *Space Weapons Earth Wars*, MR-1209-AF, RAND, 2002.

Paul B. Stares, *The Militarization of Space: U.S. Policy, 1945-1984*, Cornell Studies in Security Affairs, 1987.

Paul B. Stares, *Space and National Security*, Brookings Institution Press, 1990.

Philip Taubman, *Secret Empire: Eisenhower, the CIA, and the Hidden Story of America's Space Espionage*, Simon & Schuster, 2003.

## Reports

*US Air Force Transformation Flight Plan*, USAF, 2003.

*United States Space Command Long Range Plan*, USSC, 1998.

Charles H. Cynamon, *Protecting Commercial Space Systems - A Critical National Security Issue*, US Air Force, 1999.

Eskil Engner, Lars Höstbeck, Mike Winnerstig, *Militarisering av rymden* (*Miliatrization of space* - Text in Swedish, abstract in English), FOI-R—1217--SE, 2004.

Peter L. Hays, *US Military Space into the twenty-first century, US Air Force*, 2002.

Gustav Lindström, Giovanni Gasparini, *The Galileo satellite system and its security implications*, European Union Istitute for Security Studies, Occasional papers 44, 2003.

Sandra Lindström, et. al., *Space and Defence*, FOI-R--0765--SE, 2003.

David E. Lupton, *On Space Warfare*, US Air Force, 1998.

Donald H. Rumsfeld, *Report of the Commission To Assess United Staes National Security Space Management and Organization*, US House of Representatives, 2001.

Stefano Silvestri, et. al., *Space and security-policy in Europe*, IAI, European Union Institute for Security Studies, Occasional papers 48, 2003.

Barry D. Watts, *The military use of space: A diagnostic Assessment*, Center for strategic and budgetary assessment, 2001.

## Other sources

James W. Canan, *Controlling the space arena*, Aerospace America, January 2004, www.aiaa.org, 22 March, 2004.

Peter L. Hays, *Current and Future military uses of space*, National Defence University, Presentation at Outer Space and Global Security, 26-27 November 2002.

Niclas Hedman, *Swedish Space legislation*, Swedish Ministry of Foreign Affairs, 2004.

William C. Martel, Toshi Yoshihara, *Averting a Sino-US Space Race*, Naval War Collage, 2003.

James Oberg, *China's great leap upward*, 2003, Scientific American, September 2003.

Bruce T. Robinson, *Who Goes There*, IEEE Spectrum, October 2003.

<table>
<tr><td rowspan="5">Issuing organization<br>FOI – Swedish Defence Research Agency<br>Systems Technology<br>Defence Analysis<br>SE-172 90 Stockholm</td><td>Report number, ISRN<br>FOI-R--1264--SE</td><td>Report type<br>User report</td></tr>
<tr><td colspan="2">Research area code<br>7. Vehicles</td></tr>
<tr><td>Month year<br>September 2004</td><td>Project no.<br>E6056</td></tr>
<tr><td colspan="2">Customers code<br>5. Commissioned Research</td></tr>
<tr><td colspan="2">Sub area code<br>71 Unmanned Vehicles</td></tr>
<tr><td rowspan="4">Author/s (editor/s)<br>Lars Höstbeck<br>Mattias Waldenvik<br>Mike Winnerstig</td><td colspan="2">Project manager<br>Lars Höstbeck</td></tr>
<tr><td colspan="2">Approved by<br>Monica Dahlén</td></tr>
<tr><td colspan="2">Sponsoring agency<br>Swedish Armed Forces</td></tr>
<tr><td colspan="2">Scientifically and technically responsible<br>Gunnar Arbman</td></tr>
<tr><td colspan="3">Report title<br>Strategy for space</td></tr>
<tr><td colspan="3">Abstract (not more than 200 words)<br>The use of space-based systems in military operations is increasing. Space-based services has gone from being mainly a tool for the intelligence community to be systems that supplies “space to the warfigther”.<br><br>The Swedish Armed Forces transformation towards a Network-Based Defence will probably lead to an increase in the demand for space-based services. If Sweden is to build military capability upon space-based services, Sweden needs a strategy to secure access to space in times of crisis or war.<br><br>This report gives a brief description of different actors who need access to space-based services and presents five different strategies on how to secure access to space. An overview of international space activities is presented to show what other nations do in the space arena and to illustrate that there are various possibilities to co-operate internationally and on different conditions.</td></tr>
<tr><td colspan="3">Keywords<br>Space, Strategy, Satellites, Securtity policy, Space industry, International co-operation</td></tr>
<tr><td>Further bibliographic information</td><td colspan="2">Language English</td></tr>
<tr><td>ISSN 1650-1942</td><td colspan="2">Pages 71 p.</td></tr>
<tr><td></td><td colspan="2">Price acc. to pricelist</td></tr>
</table>

| | | |
|---|---|---|
| **Utgivare** | **Rapportnummer, ISRN** | **Klassificering** |
| Totalförsvarets Forskningsinstitut - FOI | FOI-R--1264--SE | Användarrapport |
| Systemteknik<br>Försvarsanalys<br>172 90 Stockholm | **Forskningsområde**<br>7. Farkoster | |
| | **Månad, år**<br>September 2004 | **Projektnummer**<br>E6056 |
| | **Verksamhetsgren**<br>5. Uppdragsfinansierad verksamhet | |
| | **Delområde**<br>71 Obemannade farkoster | |
| **Författare/redaktör**<br>Lars Höstbeck<br>Mattias Waldenvik<br>Mike Winnerstig | **Projektledare**<br>Lars Höstbeck | |
| | **Godkänd av**<br>Monica Dahlén | |
| | **Uppdragsgivare/kundbeteckning**<br>Försvarsmakten | |
| | **Tekniskt och/eller vetenskapligt ansvarig**<br>Gunnar Arbman | |

**Rapportens titel (i översättning)**

Strategi för rymdfrågor

**Sammanfattning (högst 200 ord)**

Nyttan av rymdbaserade system för militära operationer ökar. Rymdbaserade tjänster har gått från att huvudsakligen varit något för underrättelsekollektivet till att vara tjänster som nyttjas på alla nivåer, ut till den enskilde soldaten.

Det svenska försvarets transformation till ett nätverksbaserat försvar kommer med stor sannolikhet att innebära ett ökat behov av rymdbaserade tjänster. Om Sverige skall bygga militära förmågor på rymdtjänster krävs en strategi för att säkra tillgång till dessa rymdtjänster vid kris och krig.

Denna rapport redogör kortfattat för olika aktörer som nyttjar rymdtjänster och diskuterar fem strategier för hur Sverige som nation skall kunna säkra tillgången till rymden. En internationell utblick görs för att visa vad som sker i andra nationer och för att illustrera att det finns ett flertal olika former av internationellt samarbete tillgängliga, på olika villkor.

**Nyckelord**

Rymd, strategi, satelliter, säkerhetspolitik, rymdindustri, internationellt samarbete

| | |
|---|---|
| **Övriga bibliografiska uppgifter** | **Språk** Engelska |
| **ISSN** 1650-1942 | **Antal sidor:** 71 s. |
| **Distribution enligt missiv** | **Pris: Enligt prislista** |