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SPACE IN THE PORTUGUESE DEFENCE SECTOR

O ESPAÇO NO SETOR DA DEFESA EM PORTUGAL

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Abstract

Access to data from space platforms is increasingly taking a lead role in the everyday life of today's society. In Portugal, more precisely in the Defence sector, the importance that this type of data has currently and its future perspective is no different. As such, it is relevant to analyse the current relationship between Space and the Defence sector, in particular, how to get the data and in what activities it is used, and to assess the degree of dependence on that data. The purpose of this research paper is to assess the level of dependence that Portugal presents, in terms of Defence, on data from space capability.

This study is based on a qualitative research strategy, in which the main instruments of observation and data collection were semi-structured interviews and the analysis of technical documents, government reports and other official documents, as well as reference works.

Keywords: Defence, Space, Space Capability, Military Operations

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Resumo

O acesso a dados provenientes de plataformas espaciais assume, cada vez mais, um papel cimeiro no quotidiano da sociedade atual. Em Portugal, mais precisamente no setor da Defesa, a importância que este tipo de dados tem presentemente e que se perspetiva que tenha no futuro, não é diferente. Como tal, é de todo pertinente analisar a atual relação entre o Espaço e o setor da Defesa, nomeadamente, como se obtêm os dados e em que atividades estes são utilizados, assim como avaliar o grau de dependência em relação aos mesmos. O objetivo deste artigo consiste na avaliação do nível de dependência que Portugal apresenta, no âmbito da Defesa, relativamente aos dados provenientes da capacidade espacial.

Este estudo baseou-se numa estratégia de investigação qualitativa, em que os principais instrumentos de observação e recolha de dados foram as entrevistas semiestruturadas e a análise documental de relatórios técnicos e governamentais, assim como de outros documentos oficiais e de obras de referência.

Palavras-chave: *Defesa, Espaço, Capacidade Espacial, Operações Militares*

Introduction

Humanity has always been fascinated by space. At first, simply by watching the sky, mankind tried to understand phenomena and relate them to everyday life. The Ancient Greeks developed the first theories on phenomena of this type. However, it was only when the first astronomical instruments were built that the precision and range of the observations increased significantly.

The first astronomical study recorded in Portugal dates back to the 15th century. However, the first significant advances in the field date to the period of the Discoveries, largely due to their usefulness for maritime navigation (Ferreira, 2002, p.14). Even after the Discoveries, the national interest in astronomy did not fade, and the first telescopes are known to have arrived in Portugal in the early 17th century[1].

The 20th century witnessed another significant advance in the field when man-made objects were launched into space. Since then, and to this day, the development of space technology has been unstoppable, and has had an impact on numerous activities of humanity's everyday life.

Portugal has not been a stranger to this scientific path, nor has the Defence sector, in particular the Armed Forces (AAFF). The participation of representatives from the three Branches in the *Comissão Permanente de Estudos do Espaço Exterior* (CPEEE) [Permanent Commission for Outer Space Studies][2], from 1983 onwards, is proof of this.

[1] Telescopes were introduced in Japan by the Jesuits, in 1613, and it is noteworthy that Galileo used his first telescope for astronomical observation in 1609 (Ferreira, 2002, p.28).

[2] The responsibilities of the CPEEE were to advise, cooperate and monitor national exploration and management activities in outer space, and it was composed of representatives from several areas of civil society (Arquivo de Ciência e Tecnologia, n.d.).

Although the CPEEE was extinct by 1986, Portugal's involvement in this field of science did not fade, and the launch of the first and only Portuguese satellite to date, the PoSAT-1[3], is a noteworthy accomplishment.

The PoSAT-1 was used by both military and civilian organizations. The PoSAT-1 allowed the AAFF to carry out tactical and strategic communications, in particular data transmission, encrypted and unencrypted messages, reception of images and meteorological information (Marado, 2014, pp.36-37). Data from the PoSAT-1[4] is no longer used by the AAFF, which now relies on private contractors and agreements with third countries or institutions.

Now that over a decade has passed since the last data from PoSAT-1 was used, and aware of the increasing need for this type of data (Melo, 2016), it seems relevant to analyse the current relationship between Space and the Portuguese Defence sector, in particular, how to get the data and in what activities it is used, and to assess the degree of dependence on that data. That analysis is the aim of this research paper, which sought to answer the following question: What is the Defence sector's level of dependence on data from space capability?

The methodology employed was based on a qualitative research strategy, in which the main instruments of observation and data collection were semi-structured interviews and the analysis of technical documents, government reports and other official documents, as well as reference works.

Bearing in mind that the object of this research is the Portuguese Defence Sector today, and how data from space capability is used, we should first understand the concepts of Space and Space Capability. Likewise, it is crucial to understand the specific concept of National Defence, and how the sector was defined in the present study, which shall be described in the second part.

The third part will look at the relationship between Space and Defence from a specific perspective, namely how data from space capability is used in military operations.

Next, we will describe the relationship between Space and the Defence sector in Portugal, and whether there is dependence on that data, thus answering the question that guided this research. Finally, we will present the main findings.

1. Space and Space Capability

Although there is no consensus on what space is, and on how to define it, the international community has strived to agree on a definition of the concept of outer space since the 1960s. This research paper will consider the definition of the *Fédération Aéronautique Internationale*, the *von Karman line*, which sets the boundary of outer space 100 km above sea level (FAI, 2012).

[3] The PoSAT-1 was launched into orbit on 27 September, on board the Ariane 4 rocket. The satellite was developed by several public, private, and military entities, and was partly financed by the government. The programme aimed to prepare the Portuguese industrial fabric to gain presence in the space industry and to promote Portugal's technological and scientific development (Marado, 2013, p.236).

[4] The PoSAT-1 ceased operations in 2005, as its reliability could no longer be guaranteed (Marado, 2013, pp.237-40).

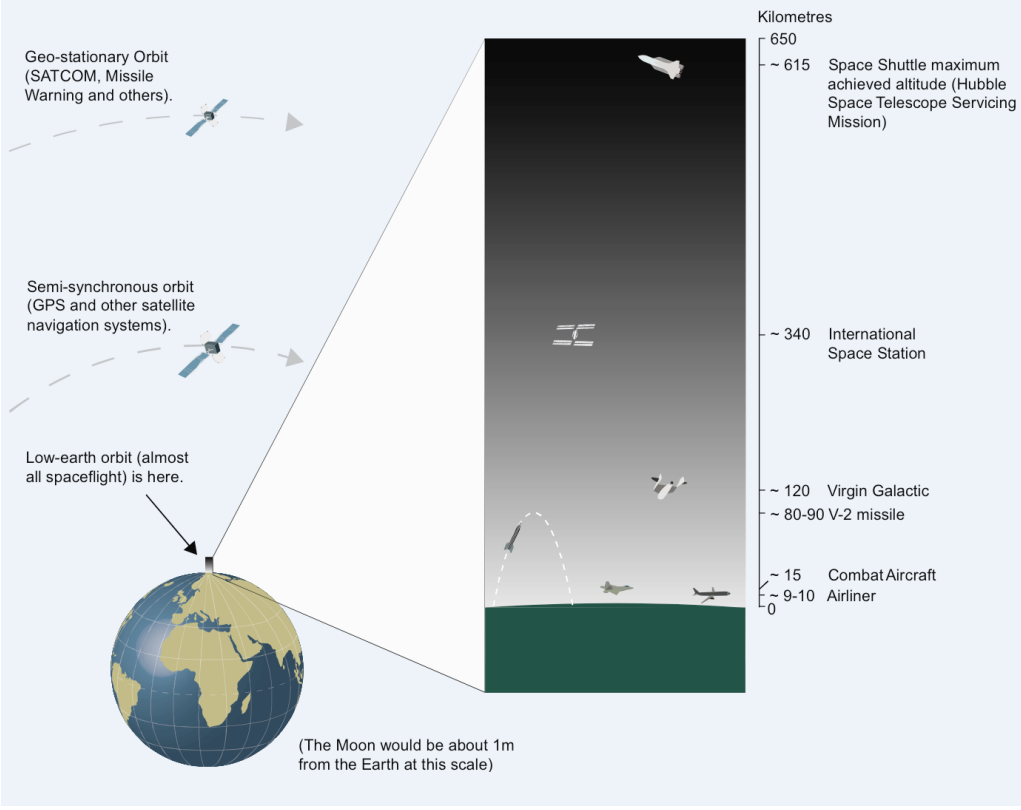

Figure 1 - Location of satellite orbits

Source: (MNE7, 2012, p.2-2)

Satellites can be placed into orbit at different altitudes, according to their purposes and characteristics. As such, low altitude orbits (between 160 and 1600 km) are used for communications, Earth observation and meteorology; medium altitude orbits (between 1600 and 19,300 km) are suitable for navigation and communications support; geostationary orbits (at 35,786 km) are used for communications, warning systems, nuclear detection and meteorology; and highly elliptical orbits (between 1060 and 38,624 km) are generally used for communications, scientific research and surveillance (Air Command and Staff College, 2009, pp.89-93).

Once the definition of space which will be used in this analysis has been defined, it is important to understand what is space capability and how it influences the Defence sector.

According to the *Diretiva Ministerial de Planeamento de Defesa Militar* (DMPDM) [Ministerial Guidance for Military Defence Planning], military capability is '...the set of elements which coordinate in a harmonious and complementary manner, and which contribute to the execution of a set of operational tasks, or to an effect which must be

attained, combining several doctrine, organization, training, equipment, leadership, infrastructure and interoperability components'. (Ministro da Defesa Nacional, 2014).

Analysing the DMPDM raises the question of whether by adopting the concept, including only its intrinsic specifications, space capability can be considered a military capability.

These doubts arise from the fact that space capability is a broad concept, both in terms of resources and in terms of practical application. In order to shed light on the above question, we resorted to the *Conceito Estratégico Militar* [Military Strategic Concept] (Conselho de Chefes de Estado-Maior, 2014). Annex B of the present document specifies a set of military capabilities, among which the terrestrial and maritime *Capacidade de Operações Aéreas de Vigilância, Reconhecimento e Patrulhamento* (VRP) [Surveillance, Reconnaissance and Patrolling (SRP) Aerial Operations Capabilities]. This is an encompassing capability with regard to resources, as it relies on Air Force (AF) platforms C-295M, P-3C/CUP+ and EH-101 (Dias, 2014; FAP, 2015).

Concerning the scope of a military capability in terms of its applications, we analysed the concept of capability in Unmanned Aircraft Systems (UAS) used in the work conducted by Pais (2013). The author used a DOTMLPIII[5]. methodology, based on the doctrine of the North Atlantic Treaty Organization (NATO) (JAPCC, 2010, pp.16-17). The latter is similar to that of the DMPDM, but includes the dimension Network Integration.

Once established that the scope of space capability, both in resources and in its applications, does not mean that the concept of military capability cannot be adopted with the due adjustments, it is relevant to learn how third countries and institutions define space capability.

According to the *NATO Space Handbook*, space capability consists in the space segment, which includes satellites and communication links, and the ground segment, which is responsible for controlling a satellite (OTAN, 2013, p.6). According to this document, space capability is determined by the system and by the technological resources of that system.

[5] DOTMLPIII: Doctrine, Organization, Training, Equipment, Leadership, Personnel, Infrastructure, Interoperability and Network Integration. The abbreviation used in English-language literature is different by one letter (DOTMLPFII), with the term 'Facilities' being used instead of 'Infrastructure'.

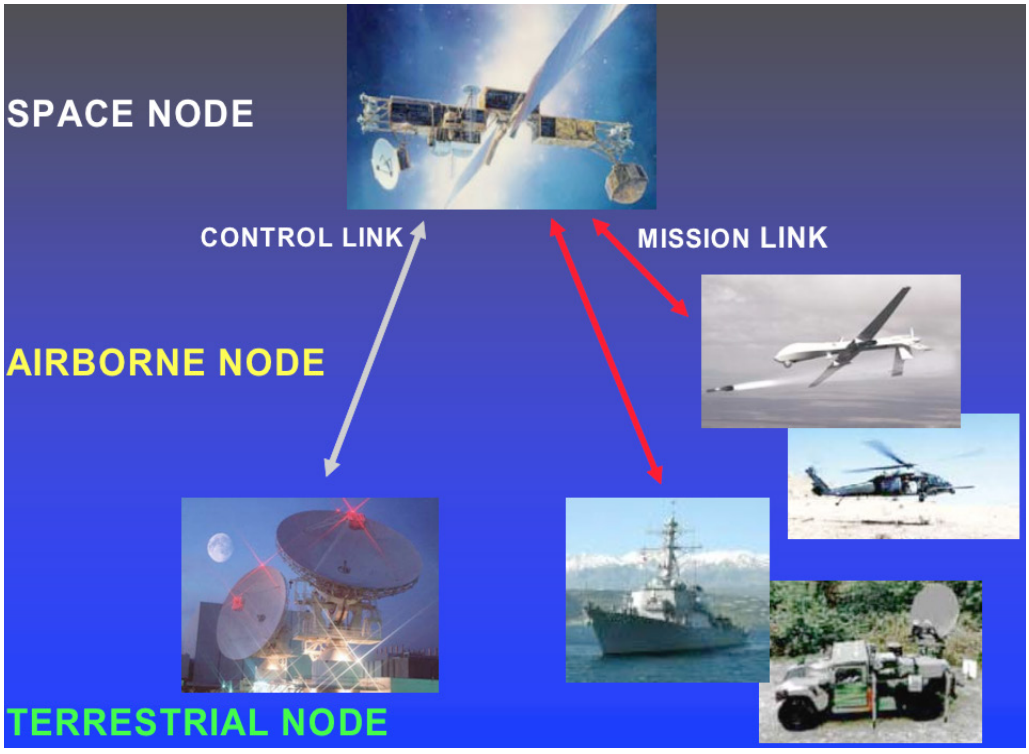

Figure 2 - Space Capability Segments

Source: (USAF, 2006, p.6).

According to the British Ministry of Defence, space capability comprises four areas: Data Networks in Space, which includes satellite communications and Position, Navigation and Timing (PNT) data retrieval; surveillance from space; and surveillance and control of space (MoD UK, 2010, p.3-1). That is, space capability is defined according to its applications.

The above examples are proof that there is more than one approach to space capability. One may emphasise the technical resources it employs, or its practical applications.

Bearing in mind the different approaches to the concept of space capability by other actors, and that the concept of military capability, as presented in the DMPDM, has been used as a starting point for defining other capabilities that encompass a broad range of resources and applications, this same process can therefore be used to define space capability in the present analysis. Thus, space capability is defined as: the set of elements of space technology and their respective suitability and employment, which coordinate in a harmonious and complementary manner, and which contribute to the execution of a set of operational tasks, or to an effect which must be attained, comprising doctrine, organization, training, equipment, leadership, infrastructure, and interoperability components, among others.

The present research considers the following data from space capability: PNT, Earth surface imagery and satellite communications. This categorization will inform our analysis of how data is used in the sector[6].

2. The Defence Sector

Once a definition of Space has been identified, as well as the concept of space capability, it is necessary to understand the concept of National Defence.

Given the external and internal challenges that Portugal is facing, which are characterised by high instability and uncertainty (Governo de Portugal, 2013a, p.6), there is no longer a clear separation between the two planes. Historically, the Defence sector, more specifically the AAFF, has been entrusted with external security, while the Security Forces have been in charge of national security. However, the strict separation between internal and external security is compromised when the threats began to share the same space, acquiring an international and transnational dimension (IDN, 2013, pp.387-92).

The discussion around what is understood by Security and Defence was brought up during the review of the *Conceito Estratégico de Defesa Nacional* (CEDN) [National Defense Strategic Concept], in 2013, where the concept was subjected to review[7]. The CEDN features only the term 'Defence' in its name; however, after the analysis and discussion of the constitutional legitimacy of the boundaries of the concept of Security and Defence, it was found that, not only should it be more encompassing, it should also relate to what is referred to as National Security. This concept encompasses not only military security, but also the safety of national independence and sovereignty; national security, as it relates to the constitutional objectives of national defence; 'social' or 'societal' security, as it guarantees the founding values of the State and its identifying symbols; humanitarian security and fundamental rights, and collective and cooperative security (IDN, 2013, pp.387-92).

For another author who has also reflected on this issue, Garcia Leandro (2009), the Defence is no longer the sole responsible for protecting the national territory, as well as its maritime and air space, and internal security is no longer the exclusive province of National Security. In the author's words: '...therefore, an External Component of National Threat coexists with an Internal Component of Foreign Threat...' (Leandro, 2009, p.152).

Since countries other than Portugal face these national and foreign challenges characterised by high instability and uncertainty, and given their international and transnational nature, it was deemed relevant to ascertain how those countries approach them.

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[6] The categorization adopted in this research results from an analysis of the sector, which included an exploratory interview conducted with the Deputy Head of the Office of Communications Systems of the DIRCSI (Directorate of Communications and Information Systems) of the Armed Forces General Staff (EMGFA) (Vaz, 2015). While space capability is not limited to this categorization, as evidenced by Portugal's application to the Space Surveillance and Tracking European programme, the latter reflects the sector in Portugal today.

[7] The institution responsible for carrying out the above reflection was the National Defence Institute, with the support of several institutions, research groups and academics, military and civilian contributors (IDN, 2013).

The National Security Strategy of the United States of America covers military defence, security within its borders, fighting terrorist threats, building conflict-prevention capabilities, fighting against the dissemination and use of weapons of mass destruction, fighting against climate change, guaranteeing access to common areas (sea, air, space and cyberspace), and guaranteeing security in terms of public health (US President, 2015).

In France, the concept of National Security was presented in the white paper on National Defence and Security. The traditional focus on protecting the territory and its populations against external aggression by third states is being replaced by a holistic approach, which includes the need to respond to direct and indirect risks and threats which may affect the way of life of the French Nation (République Française, 2013, pp.9-12).

Last November, in the United Kingdom, a document, the 'National Security Strategy and Strategic Defence and Security Review 2015', was presented before the Parliament, specifying the National Security strategy for the next five years. The latter emphasises that the objective is to guarantee the safety of the United Kingdom, of its diaspora, and of its foreign interests, to ensure a strong economy, and to consolidate the country's global reach and influence. It is an encompassing concept of National Security, supported by the efforts of the Armed Forces and the Security Forces, as well as those of the Defence and Intelligence Agencies (UK Government, 2015).

In all the cases analysed, the concept of National Security blurs the line between internal and external security, similarly to what was conceptualised in Portugal.

In the discussion which preceded the approval of the CEDN, the document 'Grandes Opções do Conceito Estratégico de Defesa Nacional' [Main Decisions of the National Defence Strategic Concept] was presented to the *Assembleia da República* [Assembly of the Republic], presenting the concept of National Security as follows:

'National Security corresponds to the state of the Nation, which translates into the permanent guarantee that it will survive in Peace and Liberty. National Security must thus guarantee the sovereignty, the independence, the unity, the integrity of the territory, the collective safety of people, goods, and values, the normal functioning of the State's tasks, the freedom of political action of the sovereign organs and the full operability of the democratic institutions'. (Governo de Portugal, 2013b, p.3).

Thus, it can be said that National Defence contributes to National Security through inter-sectorial and multi-instrumental measures. Returning to the discussion promoted by the IDN, the concept of National Defence is presented as follows:

'...the set of measures, both military and political, economic, social and cultural which, once properly integrated, coordinated and developed globally and sectorially, may enhance the Nation's potential and minimise its vulnerabilities, in order to prepare it to face all types of threats that may compromise National Security directly or indirectly'. (IDN, 2013, p.179).

The concept of National Defence used in this research paper is precisely the latter. As implied by the wording, several political, economic, social and cultural entities contribute to

National Defence. However, the present study will only cover: the *Estado-Maior-General das Forças Armadas* [Armed Forces General Staff] (EMGFA) and the three branches of the AAFF. These three institutions are in fact the actors of the national military operations. We shall see next how Space plays a role in those military operations, and what type of relationships are established.

3. Space and Military Operations

The development of space technology has been linked from the onset to military operations. Today, the products and services made possible by space capability[8] are characterised by the global overview, response capability, and persistence they lend military operations (USAF, 2006, p.2).

Military operations depend on space capability to provide support to Command and Control (C2), communications, situational awareness and reconnaissance, surveillance and intelligence. Likewise, access to meteorological conditions that may influence the execution of operations; precise PNT information, which benefits mobility; early warning of missile launches; the ability to locate forces and to acquire shared situational awareness; the existence of precision armament for sensitive targets; and the possibility to shorten the time window between a Commander's instructions and the execution of a mission are proof of how space capability can provide support to military operations, in the context of armed conflict, as well as in rebuilding and stabilization activities (JAPCC, 2009, p.3).

The NATO Allied Joint Doctrine for Air and Space Operations (AJP-3.3) lists the benefits of the use of space technology in military operations: global coverage; intelligence gathering in specific geographic locations which would be hard to access by other means; the flexibility of each individual asset, as they can be reprogrammed remotely and provide multiple services, if needed; synergies, with regards to the results from coordination with land forces. (OTAN, 2009, pp.6-1-6-3).

The research developed by Costa (2015) focused on the relationship between space technology and the military operations developed by the Portuguese AAFF, both present and future. Although the scope of that research focused on the operational use of space technology in joint military operations, rather than on the general activities and operations carried out by the branches and by the EMGFA, it is nevertheless relevant to analyse it. The study's observation that the use of space technology contributes to the operational product of the AAFF and to the implementation of the Missions of the AAFF is noteworthy, as is the identification and evaluation of alternatives to the use of this technology. The branches of the AAFF mainly rely on unmanned aircraft systems as alternatives; however, their applicability to the national strategic space is limited (Costa, 2015, pp.40-46).

[8] By 'Product', we mean the output generated by space capability (example: Earth surface imagery). By 'Service', we mean the support possibilities of space capability for Commanders, General Staffs and forces in military operations (example: the ability to establish communications well beyond the line of sight) (OTAN, 2013, '.6).

4. Space in the Portuguese Defence Sector

The interviews conducted with several experts in the sector allowed us to discover the types of data from space capability that are used, how it reaches the user, in which operations or other military activities it is used, and what is the level of dependence on that data. In essence, to ascertain the role of space in the Portuguese Defence sector.

a. Position, Navigation and Timing Data

The most widely used PNT system today is the Global Positioning System - GPS. The North American system provides a global position, navigation and timing service. The system comprises the space and ground control segments which are developed, maintained and operated by the North American government, as well as the users' segment. The civilian GPS signal is available to any user with a receiver for this type of signal. The military signal, the P(Y) GPS, is only available to the North American armed forces and to their allied countries, as well as to government agencies (US Government, 2015).

The Portuguese AAFF use both GPS signals. The Navy uses the civilian GPS signal for navigation, with the exception of frigates, which use the P(Y) GPS signal (Pinto, 2015). However, the use of PNT data is important not only to the Navy, but to maritime navigation in general. Portugal has differential GPS stations to improve the precision of the GPS signal by comparing the information received with a known location. The signal is then corrected and broadcast to receivers who require this type of service. The stations[9] report to the *Direcção de Faróis* [Lighthouse Directorate], which in turn reports to the *Autoridade Marítima Nacional* [National Maritime Authority].

GPS signal correction is extremely important for this branch of the AAFF, and in particular for the *Instituto Hidrográfico da Marinha* (IH) [Navy Hydrographic Institute], due to the precision it lends to the cartographic process. The IH has a mobile differential station for that purpose (Artilheiro, 2015).

The Army uses the civilian GPS signal for ground navigation and for geo-referencing communications in some tactical equipment. One such equipment is the *Sistema de Informação para o Comando e Controlo do Exército* (SICCE) [Information System for the Army's Command and Control][10].

The use of PNT data is also deemed essential to the cartographic process of the *Instituto Geográfico do Exército* (IGeoE) [Army Geographic Institute]. This process uses data from the Global Navigation Satellite System (GNSS), which combines signals received from the GPS, Glonass, and, in the future, the Galileo systems (IGeoE, 2015).

In 2006, the IGeoE implemented the SERVIR network, composed of a group of permanent reference GNSS observation stations, which provide support to the Institute's cartographic

[9] Position: Cabo Carvoeiro, Sagres, Porto Santo and Horta (Faial).

[10] A system developed by the Army to locate units in the field and visualise their position on a digital chart, among other functionalities (Afonso, 2015).

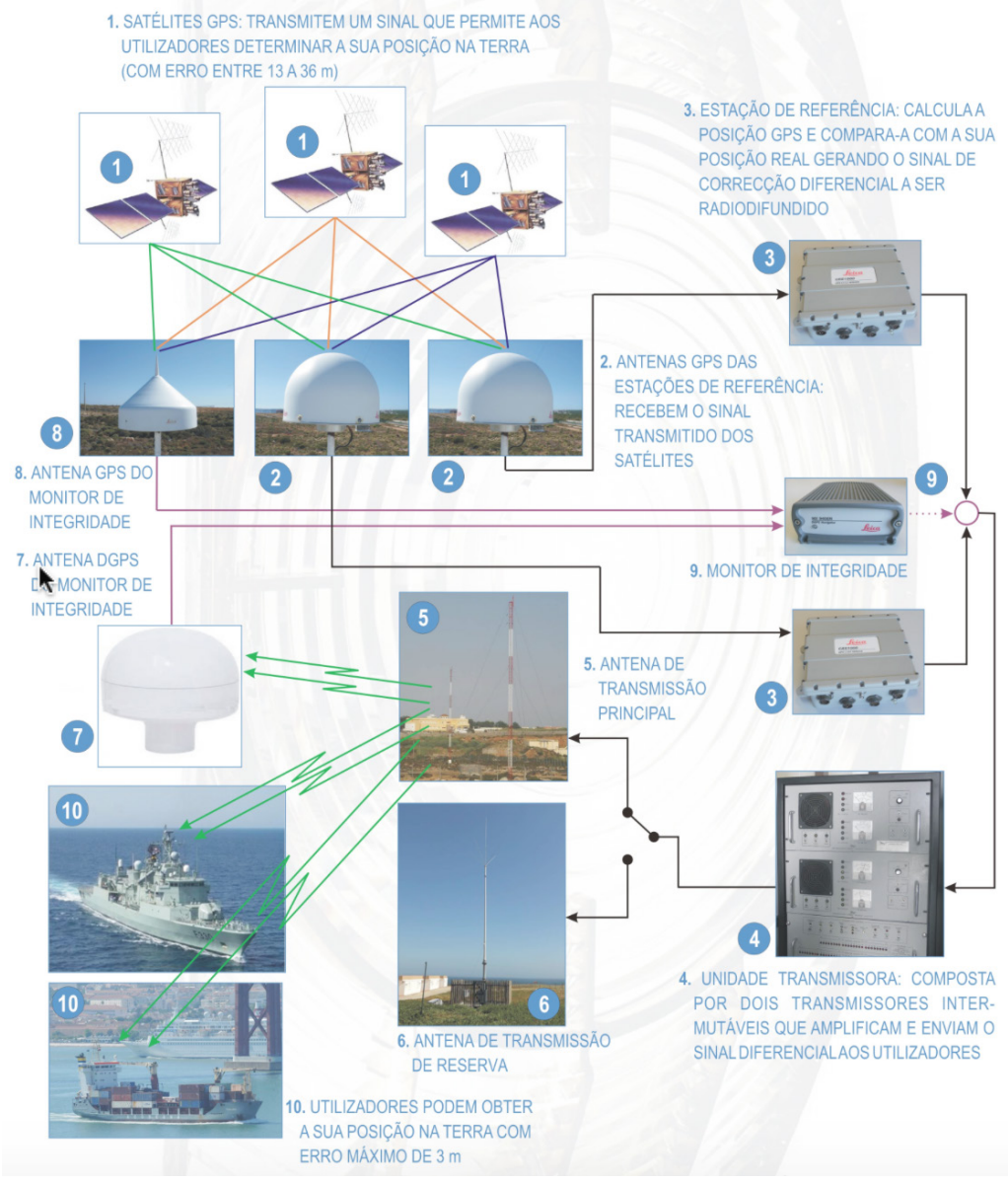

Figure 3 - Differential GPS Station

Source: (Direção de Faróis, 2012).

production. These stations are spread throughout continental Portugal, and their purpose is to perform real time corrections for GNSS positioning and/or provide data for post-processing.

The AF uses civilian and military GPS for several Weapons Systems (WS), mainly for aeronautical navigation, as shown in the Table below:

Table 1 - Use of GPS Service by the AF

WS	Navigation Systems	Level of dependence
P-3C CUP+	6 redundant navigation solutions: - 2 inertial; - 2 by GPS P(Y); - 2 mixed.	Due to the presence of redundant systems, there is no dependence on the P(Y) GPS signal for navigation. In some cases, a decrease in precision may be registered (Ferreira, 2015).
C-295	Mixed navigation system (P(Y) and inertial GPS).	Failure to capture P(Y) GPS signal would result in positioning errors during the mission (cumulative errors in the inertial sensor are no longer compensated by GPS) (Magalhães, 2015). During search missions in vast, distant areas, accumulated errors may cause forces to exit the bounds of the defined area. The precision of the launch of paratroopers and cargo may be compromised.
C-130	- 2 independent inertial navigation systems. - P(Y) GPS for non-integrated navigation.	In the absence of P(Y) GPS signal, operations would have to be planned in greater detail and the intelligence gathered by other sensors would have to be checked more frequently (Ferreira, 2015), (Gonçalves, 2015).
EH-101	Mixed navigation system (P(Y) and inertial GPS).	Loss of capabilities, or total inability to navigate in several scenarios: long range over water, tactical navigation, etc. It may have a serious impact, particularly in Search and Rescue missions (Diniz, 2015).
F-16	Aircraft: Mixed navigation system (P(Y) and inertial GPS).	Failure to obtain P(Y) GPS signal would lead the system to stop receiving positioning updates, and geo-localisation precision would degrade in direct proportion to flight time. Even with degraded navigation precision, the missions would not be cancelled (Gaiolas, 2015a).
	Weapons systems: Some of the SA F-16 weapons systems use P(Y) GPS signals, either exclusively through guided bomb units (GBU-31), or laser guided bombs (GBU-49).	Failure to obtain P(Y) GPS signal by the GBU-31 results in decreased precision (from a Circular Error Probable lower than 5 meters to 30 meters or less), although it can still be used. The GBU-49 can be used solely with laser guidance (Gaiolas, 2015b).

Table 1 - Use of GPS Service by the AF (cont.)

SA	Sistemas de Navegação	Grau de dependência
Falcon 50	Mixed navigation system (GPS and inertial).	If an aircraft loses GPS signal, it will result in the loss of its Enhanced Ground Proximity Warning System (warning capability in the event of a collision course with the terrain) (Magalhães, 2015). Navigation would be maintained, with the error intrinsic to the inertial system. In operational terms, only the missions carried out with low coverage by radio support would be compromised, although they could still be carried out (Estrela, 2015).

Source: (Author, 2015).

Aircraft navigation systems can be exclusively inertial or mixed. With a mixed navigation system, more technologically advanced aircraft combine GPS signal with inertial signal, thereby reducing the latter's intrinsic error and increasing precision. Most WS use the P(Y) GPS signal[11] in their mixed navigation system, as well as in the guidance system for some of the weapons in the F-16 SA.

In the AF, the use of PNT data in aeronautical navigation is not limited to the WS in use. The civilian GPS signal is currently used for navigation in the field of Research, Development and Innovation, in particular in the research line of Unmanned Aerial Vehicles (UAVs).

b. Earth surface imagery

Satellites capture earth surface imagery which can be used for several ends and in different activities, both in civilian society and in the Defence sector.

This type of imagery is not currently used by the Navy. However, a project proposal has been submitted to the IH, entitled *Modelo Altimétrico Remoto do Litoral Nacional* (MARLIN) [Remote Altimetric Model of the National Coastline], which will employ this type of imagery (Artilheiro, 2015).

The Army, specifically the IGeoE, uses satellite earth surface imagery in the international project Multinational Geospatial Co-Production Program (MGCP). This project aims to develop a global geographic information system. For that purpose, it uses high resolution satellite imagery, from which cartographic intelligence is produced. The intelligence acquired is essentially used for support to weapons systems, military operations, humanitarian aid, and disaster situations. The countries participating in the project can access the intelligence they need according to their strategic interests, based on the areas they contribute [12] (IGeoE, 2015).

[11] The F-50 SA is an exception, as it uses the civilian GPS signal for navigation.

[12] As it had previously produced 23 cells, by February 2015 Portugal had a credit of 92 cells (IGeoE, 2015).

In addition to being involved in the MGCP project, the IGeoE provides internal geographic support to operations planning, for which it relies both on cartographic support and on the SIGOPMIL geographic information system. This information system uses this type of imagery indirectly, as the software on which the program is based includes cartographic information from satellite imagery (IGeoE, 2015).

The AF uses earth surface imagery mainly to prepare meteorological forecasts. The images are obtained from a protocol with the *Instituto Português do Mar e da Atmosfera* (IPMA) [Portuguese Sea and Atmosphere Institute], which in turn obtains them from the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) (Santana, 2015).

Satellite imagery is used indirectly by the three branches of the AAFF in their use of cartography and geo-intelligence[13] in operational planning. Geo-intelligence is obtained from organizations to which Portugal belongs or through agreements or protocols with third countries or entities.

One example is the intelligence made available by the European Union Satellite Centre (EUSC). This body produces intelligence from the analysis of satellite imagery and geospatial intelligence, which is used in decision support, planning, and operational implementation. Naturally, this intelligence is provided to the European Union (EU) and its Member States, as well as to other institutions such as the United Nations, and countries with which there are agreements such as Iceland, Norway and Turkey (UESC, n.d.).

In the opinion of Lt. Col. César Rodrigues[14] (2013, cited in Marado 2014, p.A-7), Portugal uses 20 to 30 products from the EUSC each year. The requests focused mainly on areas in Guinea, the Balkans, southern Portugal and Morocco, and are intended to meet the needs of the AAFF, of the *Guarda Nacional Republicana* [National Republican Guard], and of the National Authority for Civil Protection. The *Centro de Informações e Segurança Militares* [Centre for Military Intelligence and Security] of the EMGFA is the body responsible for disseminating geospatial intelligence to support the planning and conduct of military operations (Ministério da Defesa Nacional, 2014).

With regard to the Alliance, the NATO Intelligence Fusion centre, of which Portugal is a signature member, provides intelligence on an area relevant for operations, including satellite imagery (Menezes, 2013 cited in Marado, 2013, p.247).

Table II briefly presents the use of earth surface imagery in the different activities and operations carried out in the sector.

[13] Source: (Pinto, 2015), (Ramos, 2015), (Diniz, 2015), (Gaiolas, 2015a), and (Gonçalves, 2015).

[14] At the time, a military attaché and political-military representative of the Portuguese Permanent Representation to the EU, and a member of the EUSC Administrative Council.

Table II - Use of Earth Surface Imagery in the Defence Sector

Branch	Activity or operation	Description
Army	MGCP Programme	The MGCP aims to build a global geographic information system at a 1-50000 or 1-100000 scale. The project is being developed by the Defence Agencies of 31 countries, the majority of which belong to NATO. The MGCP produces vectorial geographic Earth data from high resolution satellite imagery provided by the National Geospatial-Intelligence Agency (NGA) (IGeoE, 2015)
	SIGOPMIL Geographic Intelligence System	SIGOPMIL provides geographic support to operations planning. The system is based on software acquired from the Environmental System Research Institute, which allows cartographic information to be added to satellite imagery (IGeoE, 2015).
Navy	Hydrographic Institute – Marlin Project (approval pending)	The project's goal is to monitor the bathymetric evolution of the coastline. Earth surface satellite imagery will be used for that purpose. It proposes to use images from European programme Galileo. Due to the constant natural changes in the coastline, and the difficulty in collecting data in these areas, satellite imagery provides an alternative which facilitates this analysis, allowing for greater frequency in updating data. Application submitted to a financing programme under the former Direção-Geral de Armamento e Infraestruturas de Defesa [Defence Directorate-general of Armament and Infrastructure] in September 2014 (Artilheiro, 2015).
AF	Meteorological Forecasts	Earth surface imagery collected by geostationary and polar orbit 'weather' satellites is of crucial importance for meteorological forecasts. The Instituto Português do Mar e da Atmosfera (IPMA) is the entity responsible for providing meteorological intelligence for national defence purposes (Ministério da Agricultura, do Mar, do Ambiente e do Ordenamento do Teriitório, 2012). Satellite imagery is included in the meteorological intelligence provided to the AF by the IPMA1 (Santana, 2015).
	Mission planning	If both cartography and geo-intelligence were not available, the mission planning process would be slower and more difficult (Diniz, 2015), (Gaiolas, 2015a), (Gonçalves, 2015).

Source: (Author, 2015).[15]

[15] As a national organization in the field, the IPMA has been a member of EUMETSAT since 1986. Thus, AF users with the required equipment for receiving these images have been provided with a 'digital key' (Santana, 2015). The IPMA provides the Navy with intelligence on wind field forecasts, which will be used to prepare meteorological and oceanographic forecasts. The data collected with the Navy's ondographs is later provided to the IPMA, enabling the verification and validation of the models used and of the forecasts prepared by both Institutes (Artilheiro, 2015). The Army does not receive intelligence from the IPMA, relying on open sources on the web when it requires meteorological intelligence for planning an operation (Ramos, 2015).

c. Satellite communications

Satellite communications are being increasingly used by the Defence sector for data and voice transmission. These communications are contracted to private service providers, or by accessing military satellite communications (see Annex). Both the EMGFA and the branches of the AAFF contract private service providers, but only the EMGFA contracts communications to military satellites (X band)[16] .

The Navy uses military satellite communications (X band) in the Frigates, the Submarines and in the Replenishment Ship. Nearly all naval assets are equipped with the Global Maritime Distress and Safety System (GMDSS), which provides InMARSAT coverage beyond the 300-mile line (Simões, 2015).

Satellite communications are particularly important to the Army and to the National Deployed Forces (FDN)[17] . This was evidenced in the mission in Afghanistan, as the orography of certain regions only allowed for satellite communications. In these situations, other types of communications, such as HF, cannot be deemed redundant. It should also be noted that, in this type of operations, non-military communications, although encrypted, are contracted to civilian companies (Afonso, 2015).

Table III - Use of Earth Surface Imagery in the Defence Sector

Tipo de comunicações	Meios e/ou equipamentos	Contracted organizations	Contractor organization
Navy			
Militares, Banda X	Vasco da Gama class frigates; Bartolomeu Dias class ships; Bérrio ship and submarines	Intergovernmental agreement	EMGFA (Simões, 2015)
GMDSS[18] – (INMARSAT C / F77 / FLEET BROAD BAND)	All naval assets except corvettes	INMARSAT	Marinha / Comando Naval (Pinto, 2015)

[16] The contracted communications are managed by the EMGFA, with about 40% of these communications allocated to the Deployed National Forces serving under its operational command, and the remaining 60% allocated to the Navy (Simões, 2015).

[17] The FND that include battalion level constituted forces.

[18]The Global Maritime Distress and Safety System (GMDSS) uses terrestrial communication, satellite technology and radio communications on ships to guarantee rapid communication with search and rescue authorities in emergency situations (Inmarsat, 2015).

Table III - Use of Earth Surface Imagery in the Defence Sector (cont.)

Tipo de comunicações	Meios e/ou equipamentos	Contracted organizations	Contractor organization
Army			
Civilian, without military specifications	Antennas, transceivers and modems - off the shelf	Telecommunications market	Army (technical and contractual responsibility of the *Direção de Comunicações e Sistemas de Informação* [Communications and Intelligence Systems Directorate] and of the *Comando da Logística* [Logistics Command], respectively) (Afonso, 2015)
Military (X band)	*Sistema de Informação e Comunicações Tático* (SIC-T)[19]	Foreign company, under a governmental agreement	EMGFA (Afonso, 2015) and (Coelho, 2013, p.16)
Air Force[20]			
Commercial Satellite Communications	Aerial Assets: C-295, P-3C CUP+ and EH-101, in the SIFICAP configuration. Portable equipment	Telecommunications market	Aerial Command (Viana, 2015) and (Diniz, 2015)
	VANT (occasional corrections to flight plans in long range open water flights)		CLAFA/DEP (former CIAFA) (Morgado, 2015)

Source: (Author, 2015).[19][20]

The importance of satellite communications, as well as of the technology associated with it, is reflected on the training provided at the Military Academy, specifically in a research project by the *Centro de Investigação da Academia Militar* (CINAMIL) [Military Academy Research Centre]. The project, entitled *Estação de Comunicações e Rastreio de Satélites*

[19] The Army developed project Sistema de Informação e Comunicações Tático (SIC-T) [Tactical Intelligence and Communications System], in which one of the modules, Rearlink, has the capacity to carry out military satellite communications, among others (Afonso, 2015).

[20] In the future, AF aircraft may be equipped with the Controller Pilot Data Link Communications (CPDLC) system, which establishes communications between air traffic control and an aircraft via satellite (EUROCONTROL, 2013).

[Communications and Satellite Tracking Station][21], aims to provide a deeper, more practical education to the students of the Military Academy, familiarizing students with space capability by giving them the opportunity to participate in projects for antennas, and software and hardware development, as well as to further their expertise on radio propagation (Santos, 2014).

The AF uses satellite communications aboard some aerial assets (see Annex) and in aerial deployments.

The Iberia Station, NATO, (EIN) located in Fonte da Telha, Setúbal, is also a Portuguese satellite communications asset. The station is part of a NATO satellite communications anchoring network, that is, it is included in the ground segment of the military satellite communications system (X band) which Portugal has access to. The space segment is secured by contracting services to a foreign company, which is only possible thanks to an agreement between the Portuguese government and the government of this company's home nation, under the auspices of NATO (Simões, 2015).

Due to the restructuring underway at the NATO Communications and Information Agency (NCIA), the EIN will be deactivated in the near future[22], compelling Portugal to find an alternative solution to its military satellite communications needs. This solution is currently being implemented, and the process is expected to have been completed by late 2017. Portugal will acquire the ground segment, namely antennas, their respective control centres, and a fibre optics network that will not only interconnect the various elements in the system, but also the system to the EMGFA and to the branches (Melo, 2016).

This project aims to provide a solution to the deactivation of the EIN and to increase national independence in the field, as well as to diversify satellite communications in the Defence sector. With regard to independence, Portugal will be able to orient the antennas in this new system according to national needs, focusing especially on strategic interest areas, or in areas where national operations are taking place. This is not possible at the moment, as the NCIA is responsible for those decisions, regardless of national interests. As for increasing diversity, the solution will enable communications on frequencies other than X band, such as KU and KA band. The advantage of establishing communications on these bands is lower costs and higher bandwidths (Melo, 2016).

The new system will also imply: redundancy, as there will be several independent antennas; increased efficiency in the management of this type of communications, as each branch will be afforded a degree of autonomy in the management and allocation of satellite communications[23]; lower operational costs derived from centralized management, significantly reducing the human assets involved (Melo, 2016).

[21] The project aims to develop a nano-satellite tracking station. The project is being developed in partnership with Instituto Superior Técnico, the organization producing the satellite. The CINAMIL station will provide data that, combined with data produced by other stations, will cover the entire range of the satellite's orbit (Santos, 2014).

[22] A date has not yet been determined, but the acquisition is expected to happen either in late 2017 or in 2018 (Melo, 2016).

[23] In the event that extraordinary communications are needed, the Communications and Crypto Centre of the EMGFA will be responsible for managing those needs (Melo, 2016).

Access to the space segment will be obtained by contracting private service providers, through an agreement or a partnership with the governments of these providers' home countries, as is already being done. However, the characteristics of the new system, which allow simultaneous communication with several geographic areas, will make it possible to establish agreements for solutions in several areas of the world (Melo, 2016).

d. The sector's dependence on data from space capability

Once an analysis of the sector has been made regarding the use of data from space capability, it is necessary to analyse the outcomes and to assess whether we are in the presence of dependence.

The level of dependence on PNT data, as well as the impact of lack of access to that data is heterogeneous across the Defence sector. The Navy's use of the P(Y) GPS signal for precise navigation, as in navigating in straits and in armed conflict areas, is considered vital. Open signal cannot be relied upon in situations of this type as, in addition to being less precise, it can be denied, or errors can be introduced (Pinto, 2015).

In terms of cartography, the IH considers its use of the GPS signal to be crucial due to the precision that can be obtained after the differential correction of the signal (Artilheiro, 2015). The IGeoE also considers the use of GNSS data crucial for cartographic production, as it enables a high degree of accuracy. Using classic topographic methods[24] would translate into significant losses in accuracy (IGeoE, 2015).

The Army only uses the GPS signal for support to navigation. In Afghanistan, when the signal was occasionally denied or jammed, the operation was carried out by relying on navigation charts. The positioning of units on the ground is still in its experimental phase; therefore, this type of dependence cannot yet be measured (Ramos, 2015).

The dependence of aerial navigation on this type of signal is determined by the level of redundancy in the navigation system equipped in the aerial asset or the weapons guidance system. Lack of access to PNT signal translates into loss of precision, the impact of which will depend on the characteristics of the system in question; however, this does not mean missions will have to be cancelled, only that the difficulty in accomplishing them will increase. With regard to VANT, navigation is fully dependent on the GPS signal (Morgado, 2015).

The lack of access to earth surface satellite imagery has considerable influence on cartography, in particular with regard to project MGCP. Other solutions may be proposed to replace this type of imagery, such as aerial photography or images captured by unmanned Aerial Systems. However, the characteristics provided by these solutions are different from those provided by satellites: the geographic area covered is smaller and the resolution is generally higher (IGeoE, 2015).

[24] All IGeoE personnel are trained in classic topography in order to maintain a degree of independence from the use of GNSS technology.

The lack of access to satellite imagery by the AF would decrease the precision of meteorological forecasts in about 20%, with short term forecasts (up to 6 hours), also known as nowcasting, registering a decrease of up to 60% (Santana, 2015).

Both the Navy and the Army consider satellite communications especially important for FND and C2 operational contexts. Aside from the Afghanistan example mentioned above, dependence on this type of communications was also registered on mission Atalanta, as technical malfunctions resulted in satellite communications being down for a week, leading to suggestions being considered for the replacement of the naval assets (Pinto, 2015). However, it should be noted that the Navy still relies on radio communication as a way to ensure redundancy, even if it is only partial (Pinto, 2015).

The Navy also relies on the Metocmil system to ensure redundancy in satellite communications. Because not all naval assets have satellite communication capabilities, and due to the high costs involved, the IH developed an alternative to provide meteorological and oceanographic information to naval assets. The above information is compressed and encrypted for radio broadcast, after which it is processed aboard the vessel (Artilheiro, 2015).

Satellite communications are not considered essential for aerial operations, as aircraft are equipped with redundant communications systems. However, these systems may not be as fast and their data transmission capacity is lower (Ferreira, 2015). The AF, like the other two branches of the AAFF, also considers that satellite communications boost C2 capability. Not only because they offer an alternative to radio communications, but because they are not limited by orography. Another example were the events occurred in an evacuation mission in Libya, where the C-130 crew's only way of communicating with Air Command was via satellite, as no other means were available (Gonçalves, 2015).

The implementation of the system that will replace the communications anchoring in the EIN will lead to new dynamics in satellite communications in the Defence sector. These new dynamics will not only reinforce what is already being done, but will also provide this type of communications to the Portuguese AAFF in a more efficient and encompassing manner.

In essence, while alternatives to the use of data from space capability are being developed, such as the Metocmil system, and alternative systems such as HF communications or classic topography are still maintained, there is a high degree of dependence on this type of data. This dependence can be seen in the several uses for data from satellite communications in Portuguese military operations outside national territory and in the use of these images for cartography and meteorological forecasts. These findings answer the starting question.

Conclusion

The present research paper is a reflection on Space, more specifically on the relationship of data from space capability with the Defence sector in Portugal. Thus, we have attempted to answer the following question: 'What is the Portuguese Defence sector's level of dependence on data from space capability?'

In order to understand the concepts upon which this research is based, we began by defining what is Space and by conceptualizing space capability. In spite of several possible approaches, both from a system and technological assets perspective and from an applicability perspective, we chose to adopt the concept of military capability specified by the DMPDM as a starting point for the concept of space capability.

As the object of this research is the Defence Sector in Portugal today, the next step consisted in understanding the concept of National Defence. This concept is currently at the heart of the general discussion on what is National Security, and, among other issues, how Defence should be seen today, in a time when the distinctions between internal and external security have been put into question.

Due to the wide scope of this sector, first we identified the institutions which would be included in this research: The EMGFA and the AAFF. These institutions are the actors of national military operations, and as such it is relevant to examine how space technology is used in those operations. The use of this technology contributes to the operational product of the AAFF and to the performance of their missions.

The next step was to know in detail how space plays a role in the Defence sector. The interviews conducted with several experts were crucial to achieve that purpose. This data collection instrument allowed us to ascertain what data from space capability is used, and in what activities. The data in question can be PNT data; earth surface imagery captured from space and satellite communications. The activities in which this data is used are diverse, and how it is used differs among the branches of the AAFF; however, there are similarities.

PNT data is used by all three branches for maritime, terrestrial or aerial navigation, although in different ways. The Navy considers this type of data very important in situations where precision is required, while the AF generally navigates by mixed systems which rely on this data. For the Army, the use of PNT data in navigation is mainly for support purposes. Both the IH and the IGeoE acknowledge the importance of this type of PNT data for precision and accuracy in the cartographic production process.

Earth surface satellite imagery is also used in the cartographic production process, namely in the IGeoE's participation in project MGCP. In the Navy, the use of this type of imagery is not yet widespread, although this may yet occur should project MARLIN become a reality. In the AF, these images are used directly in meteorological forecasts.

Satellite communications are used by the three branches of the AAFF, both to communicate with the FND and in their activities outside national territory. In the Navy, the main naval assets are equipped for satellite communication (X band) and most assets are equipped with GMDSS, which has InMARSAT coverage. In the Army, satellite communications are particularly important in the context of the FND. In the AF, some aerial assets have satellite communication capability, and this type of communication is used during aerial deployment. This type of communication provides all branches with unique features, which are vital in certain situations such as the examples described in the Atalanta mission, in Afghanistan and in Libya, which occurred with Navy, Army and AF personnel, respectively.

Access to satellite communications is provided by contracting both civilian and military communications services. Thus, contracts with civilian communications providers can be carried out by the branches or by the EMGFA; however, only the EMGFA can contract military communications (X band).

With the deactivation of the EIN and the subsequent development of a national solution, change is on the horizon for military satellite communications in the Defence sector. In the future, Portugal will hold the terrestrial segment of this capability, increasing autonomy, diversity and flexibility in the management of this type of communications and of the system itself. Autonomy means that Portugal will be able to decide the orientation of the antennas according to its interests and needs, which does not currently happen, as the NCIA is in charge of this type of decision.

Diversity means that the future system will have the capacity to establish communications in KU and KA band, in addition to X band. This translates into a broader range of options available to the AAFF, but it also means costs will be reduced and the bandwidth available will increase.

Communications management will become more efficient, as each branch will be able to manage their allocated bandwidth independently. The system itself is technologically advanced, which allows it to be managed centrally, keeping operational costs low.

Access to the space segment will be ensured by agreements or partnerships, as is being done today. However, the new system will open up a wider range of options, and it will be possible to communicate with more than one region of the globe.

Once the process of collecting data on the sector was concluded, this data was then analysed with the purpose of assessing the level of dependence. It was found that there is dependence regarding PNT data, although this happens in a heterogeneous manner. In the Navy, access to this type of data is considered vital to precision maritime navigation, while the AF does not consider it crucial for aerial navigation, using it solely to increase precision. The VANT are the exception within the AF, as they are wholly dependent on PNT. In the Army, navigation by PNT data is only used for support, and as such there is no dependence.

The same cannot be said about cartographic production. Both the IH and the IGeoE consider PNT data essential for precision and accuracy in their cartographic products. Lack of access to earth surface imagery would also have a considerable impact in the process of cartographic production, although only in terms of the participation by the IGeoE in the MGCP international project.

In the AF, lack of access to earth surface imagery would translate into loss of precision in meteorological forecasts. However, both the AF and the other branches use earth surface imagery indirectly through cartography and geo-intelligence. In this case, the impact of lack of access to these images would be felt on missions planning, making it slower and more difficult.

Finally, our findings regarding satellite communications were more homogeneous throughout the sector. It was found that this type of communication is very important in the FND and C2 operational contexts, mainly in the Navy and the Army. Although it is also present, this dependence is not as pronounced in the AF, as there are other systems of communication aboard the WS.

Considering the importance of satellite communications and the inevitable deactivation of the EIN in the near future, Portugal was compelled to build a solution to meet this need. As such, a system is being implemented which not only surpasses the EIN's solution, but increases the autonomy, scope and efficiency of satellite communications in the Portuguese Defence sector. Although the country will be better equipped to carry out this type of communications in a more encompassing and independent manner, responding to its specific interests and needs, the sector's dependence on this type of data will remain high.

In general, and with regard to PNT data, to earth surface satellite imagery and to satellite communications, we concluded that the sector is dependent on data from space capability. A few initiatives to develop alternatives to this type of data have also been analysed; however, it was found that these cannot yet be considered true alternatives, thus the sector's degree of dependence remains unchanged.

With the starting question answered, we must now identify the issues that were not covered, leaving a suggestion for future reflections. The first issue stems from the delimitation of the Defence sector, as it is not circumscribed to the EMGFA and the branches of the AAFF, and it would therefore be relevant to develop the same reflection process for the other actors in the sector.

As for military operations, specifically with regard to superiority of intelligence in a theatre of operations, the relationship between the data obtained from space capability and the preparation and decision making process at the operational level will undoubtedly be the object of a future reflection.

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