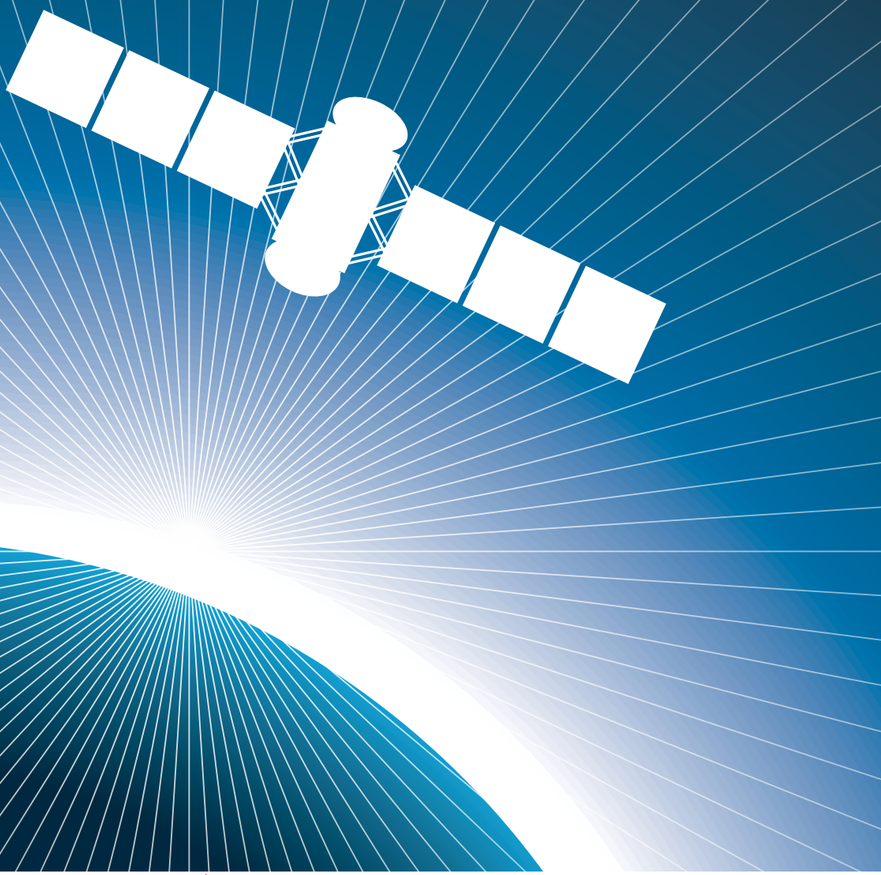
Orbit Plan:
Roadmap for Mexico's
Space Industry



Orbit Plan:
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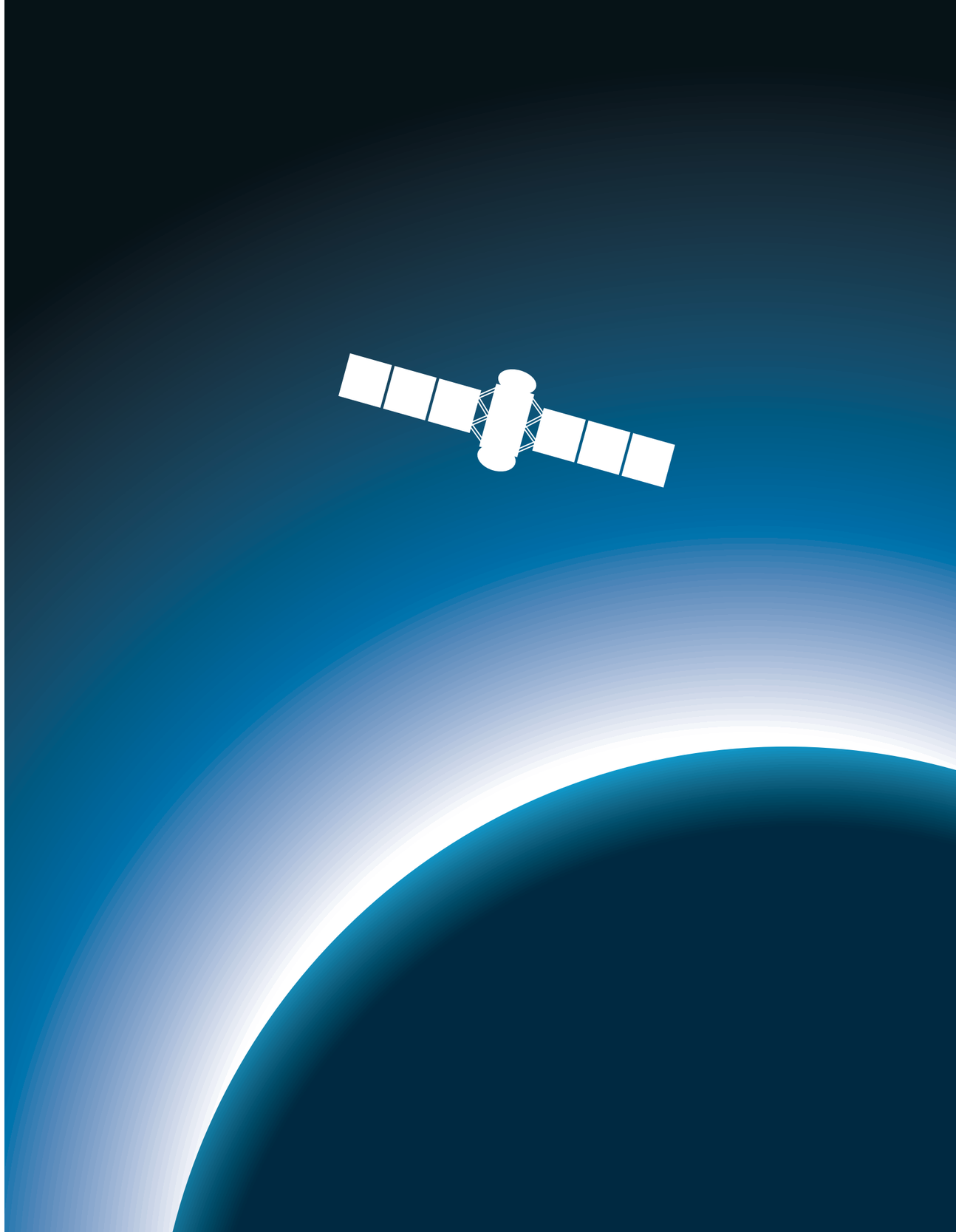

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Presentation

This Orbit Plan (Roadmap of the Mexican Space Industry) was developed collaboratively by the Agencia Espacial Mexicana (AEM), ProMéxico and a work group integrated by representatives and deputies of the academia, the industry and the government (Triple Helix),)who, based on their knowledge, experiences, and expectations, created a document that expresses, in strategic milestones, projects and action programs, the way in which Mexico aims to develop its National Space Industry. This in the context of the Law that creates the Mexican Space Agency as a State instrument, in order to contribute to the national sovereignty and the solution of the great social challenges in matter of security, competitiveness, education, equity, health, digital inclusion and environmental sustainability. Such challenges will be overcomed with the use of science and developed technology in the use and exploration of the Space, and also with the implementation of efficient mechanisms for its development, appropiation and adaptation, furthermore, the development of solutions for benefit of the population and Mexico's positioning in the space economy.

It is important to highlight the participants' contributions, both individual and institutional, during the work sessions, which led to the generation of ideas, opinions and proposals that conform the Orbit Plan. ProMexico and the Mexican Space Agency are grateful for your valuable participation and we are very pleased with the collaborative work and the results obtained.

Dr. Francisco Javier Mendieta Jiménez
General Director
Mexican Space Agency

1. Background

Developed by the Mexican Space Agency (AEM) and ProMéxico, the Orbit Plan uses the roadmap methodology to shape the ideas, opinions and proposals of a multidisciplinary group (represented by the academy, the industry and the government) into a Development Plan for Mexico's Space Industry and framed by the law that created the AEM (Congreso General de los Estados Mexicanos, 2010), the General Guidelines of Mexico's Space Policy (Secretaría de Comunicaciones y Transportes or SCT, 2011) and the Programa Nacional de Actividades Espaciales (PNAE). These documents reflect the Mexican government's intention to formalize the organization of space exploration, use and exploitation activities.

These documents also recognize the work of every actor involved in managing the AEM, including its processes and tasks, such as the publication of the law that created the agency; the integration of a high-level government board; the definition of the guidelines concerning the Mexican Space Policy; the determination of the current national context and the structuring of the proposal for a science and technology program; the creation of a comparative study and analysis of space agencies from other countries; and a list of the current treaties on space.

The creation of the AEM as a decentralized and sectorized public body in the SCT is a reaffirmation of the strategic value of space and the need to have a coordinating body with national and international reach.

The National Space Activities Program 2011 - 2012 is the AEM's strategic instrument and has been developed along five axes:

- ***Axis 1.*** *Human capital training in the space field.*
- ***Axis 2.*** *Scientific research and space technological development.*
- ***Axis 3.*** *Industrial and business development and competitiveness in the space sector*
- ***Axis 4.*** *International affairs, standards and security space issues.*
- ***Axis 5.*** *Financing, organization and information technologies on space issues.*

According to the Planning Law, each axis defines goals, strategies and lines of action. However, dependencies and interactions must be clearly identified. The roadmap methodology provides a mechanism to integrate and document the current situation, showing the target to reach and the requirements along the way.

Using this model, a list of people and institutions with experience in space matters was drawn up in order to create a balanced group with representatives of the academia the industry and the government. The result was a multidisciplinary and diverse trusted group capable of expressing its points of view and securing commitments on behalf of the organizations it represents, in the definition and execution of agreements, projects and activities that are part of the Orbit Plan.

Following the classic process of creating a roadmap in four sessions, ProMéxico held a workshop to present its methodology and to propose the selection of technologies that are relevant for Mexico, beginning with 14 technologies in which the National .Aeronautics and Space Administration (NASA) classifies its space activities. The following four technologies were selected from this group:

a) *Modeling, simulation, information systems and processing.*

b) *Materials, structures, mechanical systems and manufacturing.*

c) *Communications and navigation.*

d) *Scientific instruments, observatories and remote sensing systems.*

2. The Space Economy

Space economy

It is the segment of a country's economy resulting from activities such as exploration, exploitation and use of the outer space. These activities, which employ objects launched and placed in space, include: scientific research; technological development; design, fabrication, manufacturing and operation of telecommunication systems; global positioning systems; and Earth and cosmos observation.

The competition between two important economic the former USSR (Union of Soviet Socialist Republics), and the United States - for their hegemony in the world system, led to major technology developments in every area of human activity, leading to a strong struggle for the conquest of space.

After more than four decades since the arrival of the man to the moon, the challenges of space exploration have led to one of the most innovative industries in history: space, which has become an essential solution provider for major global issues. For example, early warnings of catastrophes caused by natural phenomena; crop monitoring and plague control; food supply security and the strengthening of national security through information services; and supporting the operations of the law enforcement community, intelligence and defense services in the world.

The space industry has revolutionized the way we live, through technologies such as mobile telephony, wireless telecommunications, the Internet, global positioning services, air traffic control and weather monitoring and forecasting systems. Furthermore, the industry has boosted the development of other economic sectors: research and development in the space sector lead to the creation of industrial processes, products and new materials that are used in many industries from medical to automotive, aviation and defense.

The global nature of the space industry has accelerated the development of endogenous capabilities and technology transfers in many countries, leading to the creation of competitive poles in emerging economies. Currently more than 50 countries have their own satellites, and countries such as Russia, China, India and Brazil have become space powers. Over the last six years, for example, Russia's space industry has reemerged; Russia had the largest number of launchess in 2011 (31) and was the only nation to take a tourist into space. Other countries have surprised the world: in 2011, China surpassed the United States in number of launches per year (19 vs 18), and Iran launched a satellite for the first time with its own space technology and is now in a position to offer technology transfer.

The current shift of the traditional poles of the space sector towards large developing economies brings opportunities for Mexico. The creation of both the Agencia Espacial Mexicana (AEM) and a sophisticated aeronautics industry that can represent a potential complement to the space sector, open new doors to create a consensus among the academy, related industries and the government. This alliance enables the Mexican space industry to leverage the strengths of the public and private sectors, select its target markets and niches of opportunity and create innovative projects to become a world-class industry.

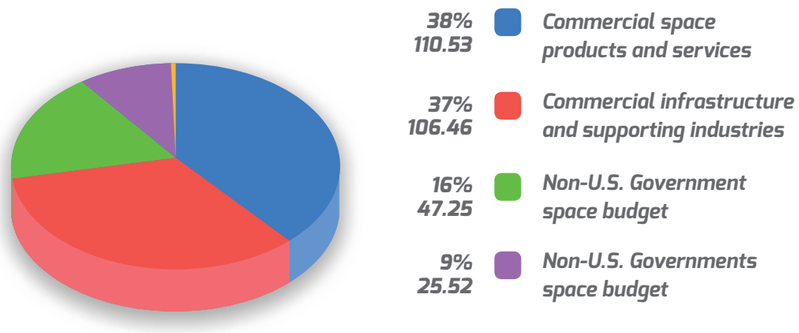
2.1 Characteristics of the Global Market

[1] The overall market space sector includes commercial sales and government budgets worldwide.

According to the Space Foundation, a non-profit organization that supports the space industry through studies and educational programs, the global space market has reported growth for the sixth year in a row, with a value of $289 billion USD in 2011 which represents and expansion of 12, 2% in the last year. Despite / in spite of the global economic crisis affecting several industrial sectors, the global space market has grown 41% in the last five years. This growth is due to the commercial success of the sector and not to the increase in government spending on this area.

According to the report issued by the Space Foundation, the distribution of space activities is divided as follows (See Figure 1):

Figure 1. Global Space Activity 2011 (billions of dollars)



Source: Space Foundation 2012.

Commercial infrastructure and support industries registered the highest growth in 2011 at 22%, sharing 37% of total space activity.This growth was due to an increase in demand for ground stations and equipment, particularly in personal navigation devices and integrated circuits, which generated sales for about $18 billion USD.

Meanwhile, commercial space products and services grew by 9% and remained the sector's widest area, with a 38% share and sales of $110 billion USD. In this segment, more than $9 billion USD resulted from the growth registered in the direct-to-home (DTH) transmission sector, which includes the platforms required for commercial space services and products such as spacecraft manufacture , space platforms, ground equipment, launch services and independent research and development activities.

Commercial infrastructure and support industries recorded the highest growth in 2011 at 22%, sharing 37% of total space activity.

Globally, governments invested $72 billion USD in space programs, which is a 6% increase in government spending in 2011. While countries like Brazil, Russia and India registered an increase of 20 % on their budgets, other space agencies allocated more modest budgets. The European Space Agency (ESA), for example, increased its budget by only 7% in 2011, due to fiscal issues that aaffected certain European member countries. Other countries recorded minimal increases on their budgets or insignificant reductions, like Japan and the United States. Of the $72 billion USD of global government investment, the US government invested $47 billion USD in space projects in 2011, a 1% reduction compared to 2010.

Finally, sales of commercial space transportation services, represented by space tourism companies such as Virgin Galactic and Space Adventures, showed virtually no movement, reporting no commercial space travel in 2011. However, these companies recorded sales issued from future space tourism travelsIn addition, this year a series of tests related to space tourism were announced, suggesting it will become a rising niche for the future space market.[3]

[3] Space Foundation 2012.

2.2 Key Market Segments

This section analyzes the characteristics of the most relevant global space sector segments commercial space products and services; commercial space infrastructure and support industries; and governmental budgets for space programs.

2.2.1 Commercial Space Products and Services

The commercial space products and services sector is the largest in the space industry (38%), with sales of $110.53 billion USD in 2011. It includes satellite communications, satellite navigation and Earth observation. If we consider the North American situation, the area with the highest incomes is that of satellite television, which includes DTH transmission platforms offered by companies such as DirectTV and Dish Network. In North America, DTH transmission platforms have gone from generating $43 million USD in 2006[4] to doubling sales, and are estimated to have generated earnings of $86.42 billion USD in 2011.[5]

The second leading sector for the space industry Is that of satellite communications (voice, data and video), which generated sales of $18.85 billion USD in 2011. Satellite communications include fixed satellite services (FSS) and mobile satellite services (MSS). FSS platforms can be moved but are not functional while they are in transit. Companies such as Intelsat, Eutelsat, SES and Telesat share more than 60% of the international market and the sector is expected to grow dramatically in the Middle East, Africa and Asia Pacific. MSS operate through a mobile application receiver, such as satellite phones and in-flight communications for aircraft, a market that is dominated mainly by Iridium and Globalstar.

[4] International Telecommunication Union ITU, 2010.

[5] Space Foundation 2012.

Another relevant sector for the aerospace industry is that of Earth observation, which generated sales of $2.24 billion USD, including sales of information and added value services. This sector's development is related to the increasing demand for defense, intelligence, surveillance, security, environmental and climate change applications from national governments and military organizations.

Globally, governments are expected to increase their demand for land observation services. However, intelligence agencies of emerging economies exceed the demand for these services in traditional markets. According to an article by Intelligence Online, defense budget cuts have reduced purchases of land observation images by the US National Geospatial-Intelligence Agency (NGA), positioning China as the leading buyer of satellite images on a global level. The increase in demand for Chinese satellite images is expected to benefit European companies such as Astrium GeoInformation Services (EADS affiliate), which makes 30% of its profit from China.[6]

[6] *Indigo Publications, 2012.*

On the other hand, in the next 30 years, the satellite navigation and geolocation services sector is expected to grow significantly. It is divided into personal and vehicle navigation services and location-based services, including telephones with satellite navigation services. The development of new applications and the expansion of existing products and services have been key to the sector's growth.

The sector reported global sales of $89.11 billion USD in 2011. According to several forecasts, in navigation alone the global market is expected to reach $203 billion USD by 2020. However, higher growth is expected in satellite geolocation products, namely the development of services through mobile phone applications that use geographic location capabilities.

2.2.2 Commercial Space Infrastructure and Support Industries

The year 2011 brought important developments in the global space industry. Commercial space infrastructure and support industries recorded $106.46 billion USD in sales. This segment includes satellite manufacturing, launch services, space stations, land stations and related industries and equipment.

The same year, the launch industry increased activities by 14% recording 84 launches around the world: 18 by commercial industries and 66 by national governments. It is estimated that global spending on launches was $8.17 billion USD, where the value of commercial launchings was $1.93 billion USD, a 21% decrease compared to 2010. Russia is still the leader in commercial launches, with ten in 2011, followed by Europe (4), China (2) and cooperation among nations (2).

As for the satellite construction industry, 110 satellites were put in orbit in 2011 (40 commercial), generating sales for satellite manufacturing of $11.9 billion USD ($4.24 billion USD for commercial satellite manufacturing). By the end of 2011, 994 satellites were active in several Earth orbits. It is estimated that more than 1100 satellites will be built in the next decade, with a collective value of $196 billion USD.

The market for land equipment manufacturing and services industry was valued at $99.24 billion USD in 2011, including equipment and services required to operate satellites and manage communications, such as ground network control systems, mobile satellite terminals, video distribution and broadcasting centers and end user equipment.

In the same year, 90% of total sales in the ground segment was made up of navigation and geolocation equipment, including products such as satellite radios, satellite phones, satellite television receptors, satellite navigation chip sets (smartphones), maps and software capabilities.

2.2.3 Government Budgets for Space Programs

Table 1. Distribution of government budgets.

Region / Country	Government budget (millions of dollars)
United States	*47,250*
Europe	*7,180*
Russia	*4,120*
Japan	*3,840*
China	*3,800*
India	*1,490*
France	*1,110*
Canada	*428*
Brazil	*318*
Argentina	*154*
Other	*3,800*
Total	*72,770*

Source: International Telecommunication Union(ITU) 2010; Space Foundation 2012.

Globally, government budgets for space programs have been increasing. In 2011, $72.77 billion USD were allocated to space budgets, that is, 25% of all global purchases on space goods and services. In general, several countries' space budgets have increased: Brazil, India, Russia and countries which have maintained two-digit increases, except for the European Space Agency (ESA).

Globally, the United States represents 65% of government spending on space programs. In 2011, it invested $47.25 billion USD, 1% less than its spending in 2010. From its total government spending, $26.46 billion is for defense-related space activities. In terms of spending on civil operations, the US allocates close to 90% to NASA activities, which had a budget of $18.49 billion USD in 2011.

Europe is the second highest investor in space. In 2011, the ESA, financed by member states of the European Union, had a $5.8 billion USD budget. Meanwhile, the European Commission recorded $1.06 billion in spending on space-related programs during the same period, while the European Meteorological Satellite Organization (EUMETSAT) had a budget of $320 million USD.

Also in 2011, Russia allocated $4.12 billion USD to space through ROSCOSMOS, its national space agency. According to the agency's projections , its budget could reach $7.17 billion USD by 2015. In regard to Japan, the investment in this sector represented $3.8 billion USD, of which more than one-half was addressed to JAXA (Japan Aerospace Exploration Agency). This increased investment in space activities is the result of the Japanese government's goal to improve the capacities of its launch systems in terms of load and performance, in order to become a competitive option in this market.

China is another important investor in the space sector, which allocated $3.08 billion USD in 2011 to its space agency, the Chinese National Space Agency (CNSA). According to China's official space development plan, the country aims at creating a manned space station and increasing earth monitoring, communication and navigation capacities.

In Latin America, Brazil has been consolidated itself as a space power, allocating $318.6 billion USD to its space program in 2011. It is worth highlighting Brazil's close cooperation with China to develop and launch satellites to monitor their territories, facilitating the creation of public policies in areas such as environmental monitoring, agricultural development and urban planning, among others. Argentina has become a renowned player in the sector, as well, with a $154 million USD investment in programs related to its National Space Activities Commission (CONAE).

An accurate knowledge about the international scene helps contextualize space economy and enables readers to appreciate the value and impact of the space sector in the global arena. In addition, it establishes a frame of reference that leads to the definition of value chains in the space sector.

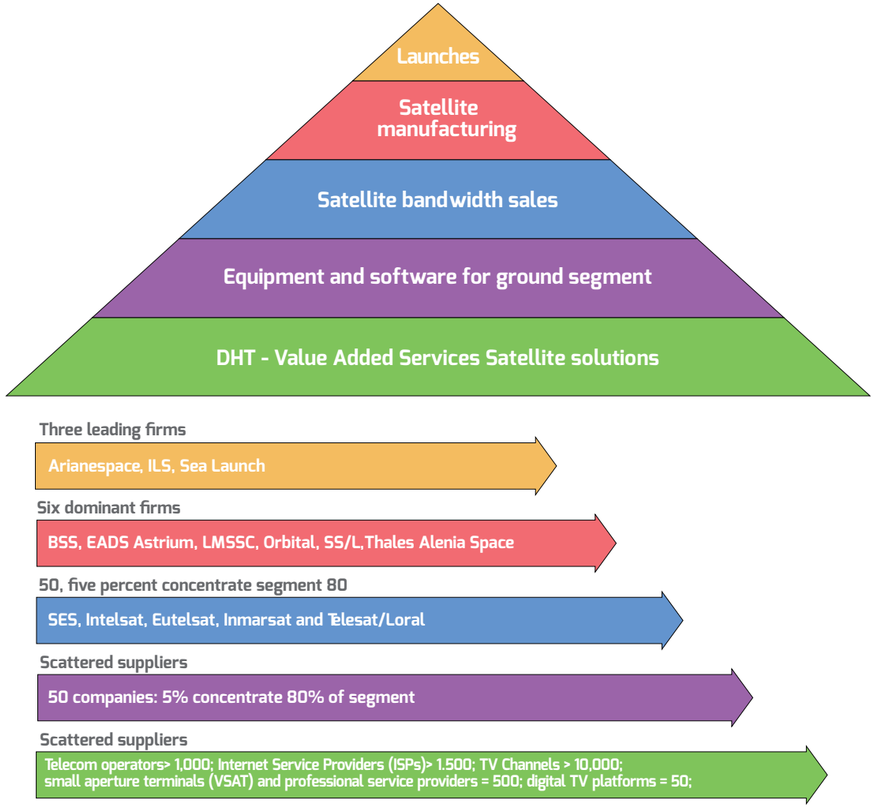
2.3 The Business Structure of the Space Economy

The space economy is divided into (See figure 2): satellite solutions as added value services; equipment and software for the ground segment; bandwidth sales ; satellite manufacturing and launch of space vehicles.

Added value services and satellite solutions are the activities with the largest contribution to the global space industry (57.0%), followed by equipment for the ground segment (31.0%), satellite bandwidth sales (8.0%), satellite manufacturing (2.5%) and launches (1.5%).

There is a close relation in the global space industry Among well capitalized international companies, regional medium-sized companies and small and medium-sized businesses (SMB) with a huge capacity to innovate.

Figure 2. Structure of the space economy.



Source: International Telecommunication Union (ITU), 2010.

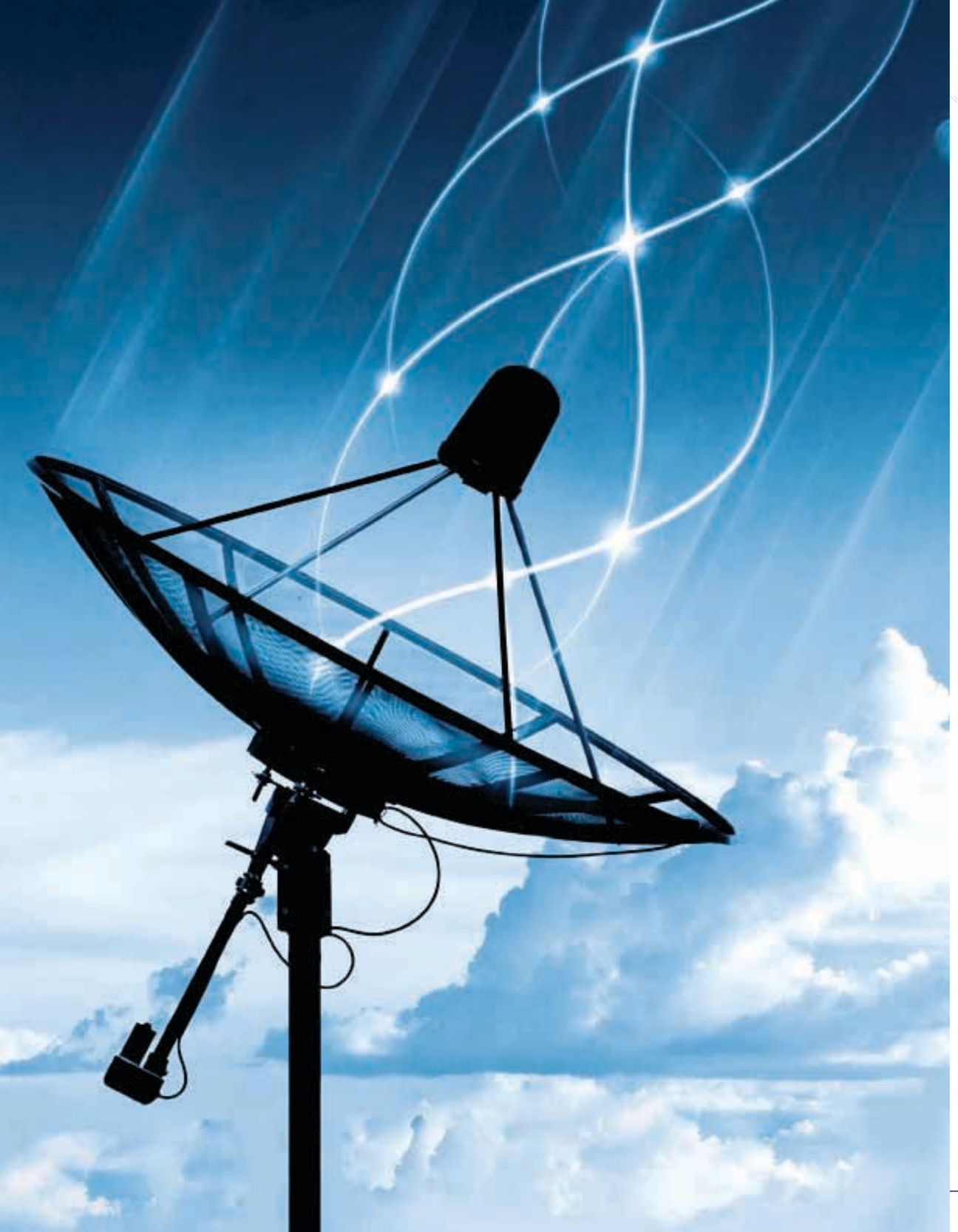
Satellite technology is classified according to its uses and applications: navigation (SATNAV), communications (SATCOM) and Earth observation (EO). In each of these applications 16 macro-segments are defined, which are in turn divided into 49 market niches (See Figure 3).

Figure 3. Market segmentation.

Satellite			
Segments macro	Navigation	Comunication	Earth Observation
	5 segments macro	6 segments macro	5 segmentos macro
	Government	Consumer broadband	Oceanography
	Roads	Mobile communication	Meteorology
	Professional	Satellite networks	Land monitoring
	Consumer	Video Distribution	Security and defense
	Transport	Video Contribution	Natural Resource Management
		Mobile Entertainment	
	17 market segments	16 market segments	15 market segments
Market segments	Defense	IP Direct access	Weather forecast
	Public Safety	Professional Mobile Communication	Professional
	Fleet Management	Asset Tracking Messaging	Coastal / Engineering
	Telematics	Satellite Networks	Transport
	Traffic Management	Defence & security	Customer Service
	Scientific	Rural communications	Cartography
	Agriculture / fishing	Telemedicine	Land Use / Cover
	Asset Management	Contextual selection of topics	Homeland Security / Law Enforcement
	Surveying	Direct to home (DTH)	Humanitarian
	Time and Frequency Dissemination	Satellite News Gathering (SNG)	Disaster management
	Leisure Vessel	Digital Cinema	Environmental monitoring
	General Aviation	TV business	Agriculture
	Outdoor Recreation	Educational TV	Forest
	Location Based Personal Systems	Content Management	Energy
	Commercial aviation	In flight	Water
	Railway routes	Digital audio broadcasting (DAB) / Digital multimedia broadcasting (DMB)	
	Maritime		

Source: International Telecommunications Union (ITU), 2010.

The description of the global space sector market segments, along with the Mexican space industry outlook , provide a guideline to define opportunity niches for Mexico in the global arena. In addition, they facilitate the identification of applications and the discovery of new opportunities for innovation, technology development, industrial development and an increase in competitiveness.



3. Space sector outlook in Mexico

The Mexican space industry emerged in the fifties, during the arising of projects to design rockets and communication systems. These projects would lead to the launch of rockets to study the upper atmosphere (1957) and to the installation of a tracking station in Guaymas, Sonora (1960), which was useful for the system used to track American space flights.

The creation of the National Outer Space Commission (CONEE) in 1962 would lead to the development of important works in telecommunications and rocketry, and these to the creation of specialized frameworks and physical infrastructure to be inserted into newly developing activites in the world.

Currently, Mexico participates in global space projects through the collaboration of higher education institutions such as the Universidad Nacional Autónoma de México (UNAM), the Instituto Politécnico Nacional (IPN), the centers of the Consejo Nacional de Ciencia y Tecnología (CONACYT) and the Universidad del Ejército y Fuerza Aérea Mexicana (UDEFA). Furthermore, in 2010 the Secretaría de Comunicaciones y Transportes (SCT) announced the acquisition of three satellites: *Bicentenario, Centenario and Morelos III*; the first one to support national security and the last two to expand satellite communication connections in Mexico. Several private companies took part in this purchase, giving a boost to the telecommunications sector in Mexico.

In terms of Earth observation, Mexico has access to remote sensing satellite images produced by several satellites and constellations. The Mexico Receiving Estación de Recepción México de la Constelación Spot (ERMEXS) was the first to be installed in the country and has served for prospecting and decision-making activities for the Mexican land sector, and supporting operations of the Secretaría de Marina (SEMAR). The second to be installed in Mexican territory was the Estación para la Recepción de Información Satelital (ERIS), which captures Landsat and MODIS images and has been used in natural disaster prevention and response. The third station, called Estación Virtual de Imágenes de Muy Alta Resolución (EVISMAR) is still being installed.It will allow to obtain satellite images with a 50 cm resolution

In addition, the modernization of the Sistema Satelital Mexicano (MEXSAT) was announced in May 2012. Three telecommunications satellites should begin operating in the near future as a result. The first will be MexSat 3, which will be launched from the French Guyana by ArianeSpace at the end of this administration. The second, MexSat 1, will be launched by International Launch Services (ILS) from Kazakhstan between 2013 and 2014. The third satellite is the MexSat 2, whose launch has not yet been finalized. Theses satellites will be used to integrate entities into a national security system through a wide satellite communications platform throughout the territory.[7]

Landsat images and MODIS

They are satellite images obtained from }instruments placed in the Landsat satellites (remote sensing program for Earth observation) and operated by NASA, in coordination with the U.S. Geological survey. MODIS (Moderate Resolution Imaging Spectroradiometer) is an instrument on board two satellites: Terra EOS AM (morning observation) and Aqua EOS PM (evening observation). For further information, visit: landsat.gsfc.nasa.gov modis.gsfc.nasa.gov

[7] *Secretaría de Comunicaciones y Transportes 2010-2012; Group Formula, 2012.*

Endogenous Mexican Space Industry:
It is the space industry that operates in Mexico with its own technology.

With regard to Mexico's endogenous space industry, the country is well positioned in the satellite services sector, with companies that operate Geographic Information Systems (GIS); GPS tracking and monitoring technology for security applications; geo-location; satellite telecommunications and Internet; and design and implementation of computer applications and mobile satellite terminals to leverage the capacity of the new MexSat 1 and 2 satellites.

3.1 SWOT Analysis

The SWOT (strengths, weaknesses, opportunities and threats) analysis shows the Mexican space industry's current situation compared to the rest of the world and identifies areas that must be leveraged or improved to consolidate a world-class space sector. The results of the SWOT analysis of the Mexican space sector established by the Orbit Plan task force are showed below.

Swot Definitions

Internal Analysis
Strenghts: Positive and manageable characteristics
Weaknesses: Negative and manageable characteristics

External Analysis
Opportunities: Positive and unmanageable factors.

Threats: Negative and unmanageable factors.

Figure 4. SWOT Analysis

Strengths

1. *Experience in other sectors such as aerospace and manufacturing.*
2. *Human resources, specifically engineering and technical development talent.*
3. *Experience in connection with various academic groups and international agencies.*
4. *High level universities and research and development centers.*
5. *Federal funding and fiscal benefits.*
6. *Innovation Program by Secretaría de Economía (SE) and the Consejo Nacional de Ciencia y Tecnología (CONACYT)*
7. *Defined strategy on a national level and regional clusters.*
8. *Laws for intellectual property protection.*
9. *Important concentration/reserve of human talent.*
10. *Supply development capabilities.*
11. *Established research centers.*

Opportunities

1. *Development of new communications technologies.*
2. *Geographic location and proximity to the US market (North America Free Trade Agreement or NAFTA).*
3. *Space tourism.*
4. *International connections.*
5. *Significant interest from international agencies to collaborate with Mexico.*
6. *Increase in the volume of high-level projects with the international community.*
7. *Growing global need for specialized human talent.*

Weaknesses

1. *Lack of a strategy for the sector's development.*
2. *Poor perception of the sector's potential.*
3. *Limited coordination among the triple helix.*
4. *Defficient approach between the academy and the industry's needs.*
5. *Few enterprises specialized in high space technology.*
6. *Low specialization in human resources.*
7. *Low budget directed to the sector.*
8. *Low research and development applied to de industry.*
9. *Brain drain (human capital flight)*
10. *Need for development of a local supply chain.*
11. *Lack of interaction among research centers.*
12. *Need to develop specialized human resources.*

Threats

1. *Competition from other countries*
2. *Development of space industry in emergent countries, such as Korea, China and India.*
3. *High risk in the country because of insecurity.*
4. *Economical and technological transfer protectionism from other countries.*
5. *Constant world economic crisis.*
6. *High-risk investment sector*

Source: Unidad de Inteligencia de Negocios (UIN), ProMéxico, 2012.

The work group determined that the main strength of Mexico's space industry is its experience, associated with its advanced aerospace sector and manufacturing capacities. Its second strength lies in engineering and technology talent, which is one of the pillars for a space industry that requires high technology sophistication and innovation.

When combining these two strengths with the opportunities to develop new communication technologies and create research, development and innovation (R&D+i) and considering Mexico's strategic geographic location next to one of North America's leading space markets, it is clear that Mexico has the potential to become a privileged player in the region.

It is interesting that work group found an opportunity in supplying development . This is logical, since in previous exercises such as the Flight Plan: Roadmap of the Mexican Aerospace Industry and local strategies like the Regional Aerospace and Defense Roadmap of Baja California and Chihuahua, supplier development was identified as a fundamental milestone for the development of the aerospace industry. The aviation and space industry are closely related since their development requires constant innovation to generate added value. The development of local suppliers is, therefore, essential to give support to large emerging and experienced companies that could possibly settle in Mexican ground. . Moreover, it is important to boost

the creation of added value in the aerospace sector by articulating value chains that include talent and best design, engineering and advanced manufacturing practices, and incorporate them into space projects.

On the other hand, the double role played by human talent and communications in the SWOT analysis is remarkable, because it shows both the strength of having laboratories and research spaces and the staff that livens them up and the lack of not only specialization among these talented individuals, but also communication among research centers and laboratories. It is due to this situation that we are aware of the actual potential and scope of opportunity that we count on to turn these two weaknesses into growth opportunities for the sector. The previous observation led the work team to design milestones and projects to transform these weaknesses into strengths for the Mexican space sector.

The main weaknesses found through the SWOT analysis are the lack of strategy to further the sector; the lack of awareness of its real potential and a poor coordination among sectors that are part of the triple helix to create industrial groupings (clusters) and articulate regional and national development. One of the advantages of the roadmap methodology is that it identifies the main weaknesses in areas of government, industry and academia, and proposes projects to develop the sector, identify and respond to its inhibiting factors and appoint individuals in charge of carrying out and fulfilling improvement goals..

The threats identified are related to the economy of international space markets, represented by the competitive atmosphere created by the sector's new development poles: the emerging economies of Brazil, Russia, India and China (BRIC). Another phenomenon in the international arena is a trend towards greater economic protectionism and non-tariff barriers, added to national security restrictions that pose new obstacles to technology transfer in the sector. To offset these threats, we must find specific vocations and niches where the Mexican industry is competitive, supported by industrial development projects that consider the potential markets where the Mexican offer should be focused on.

3.2 SWOT Correlation Matrix.

The SWOT correlation matrix (See figure 5) measures the relationships between the strengths and weaknesses identified during the SWOT analysis. It is based on the hypothesis that the stronger the relationship between strengths and weaknesses, the more they end up grouping (becoming part of a whole) and expanding their importance (correlated strengths with the capacity to reduce weaknesses).

In this analysis, the most important strengths detected are the National Innovation Program, the creation of the Agencia Espacial Mexicana (AEM), funds and resources granted to the sector and the export control system - all of which fall in the category of government mechanisms for sector development. It is worth noting that the roadmap methodology seeks to create consensus on the most important players and strategic milestones of the sector (academia, government and private initiative), and the management of projects that can support its development.

On the other hand, we observed that the main concentration of weaknesses, constituted by under-specialized human resources, poor application on Research, Development and Innovation (R+D+I) and low added value within the sector, are related to the space sector's competitiveness.

The great advantage of the SWOT is that it highlights the strengths in which the work group should focus on, in order to reduce any existing weaknesses.

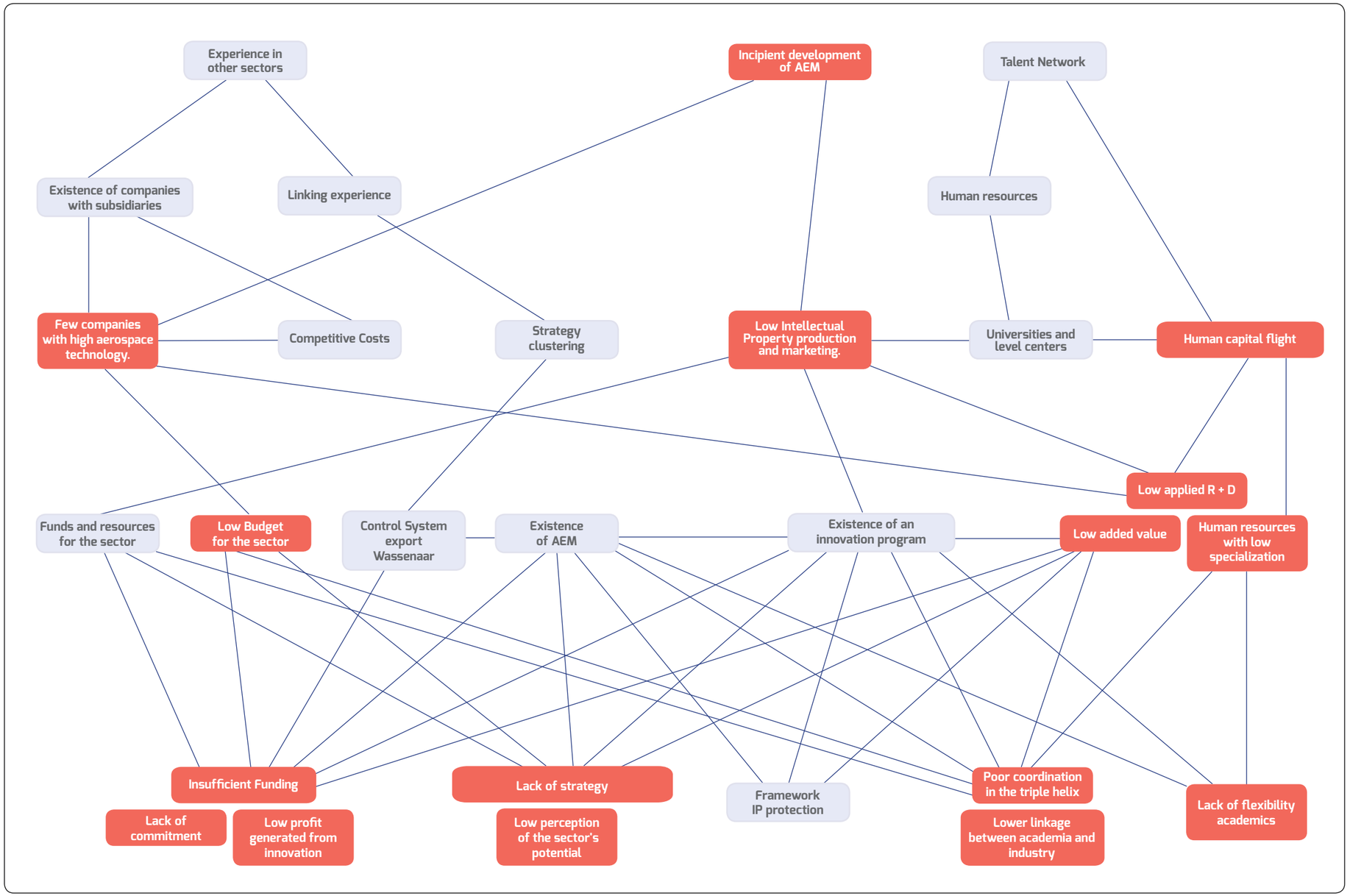
Analyzing the milestones and projects, which are explained later in the document, shows that they include projects which contribute to mitigating the sector's weaknesses. For example, Milestone II proposes attracting an enterprise with technological capabilities to complete space projects. This milestone contains projects that directly attack the issues of low added value and under-specialized human resources in the sector.

The strategy proposed is about attracting a foreign company, or establishing a joint venture between an existing Mexican company and a foreign business. The goal is to attract technologies and industrial processes that do not exist locally in Mexico, and further technological sophistication and sustainable development in the Mexican space industry.

Milestone IV, which proposes the creation of an institute for the innovation of materials with space applications, aims at increasing research and development skills on advanced materials. The idea is to allocate funds for its construction through a Public-Private Partnership (PPP) pattern in order to involve the triple helix. Another goal is to make a study that determines global trends and future demands for advanced materials in the aerospace sector, from a global commercial angle based on the development of new materials.

Finally, the work team proposed to identify funds and resources for the sector and to make the most of the National Innovation Program, given that the cooperation among the Triple Helix reflected in exercises, such as the Orbit Plan, increases the possibilities to access to this kind of government mechanisms, as long as it is clearly demonstrated how the project contributes to the sector's development on a national scale.

Figure 5. SWOT Correlation Matrix

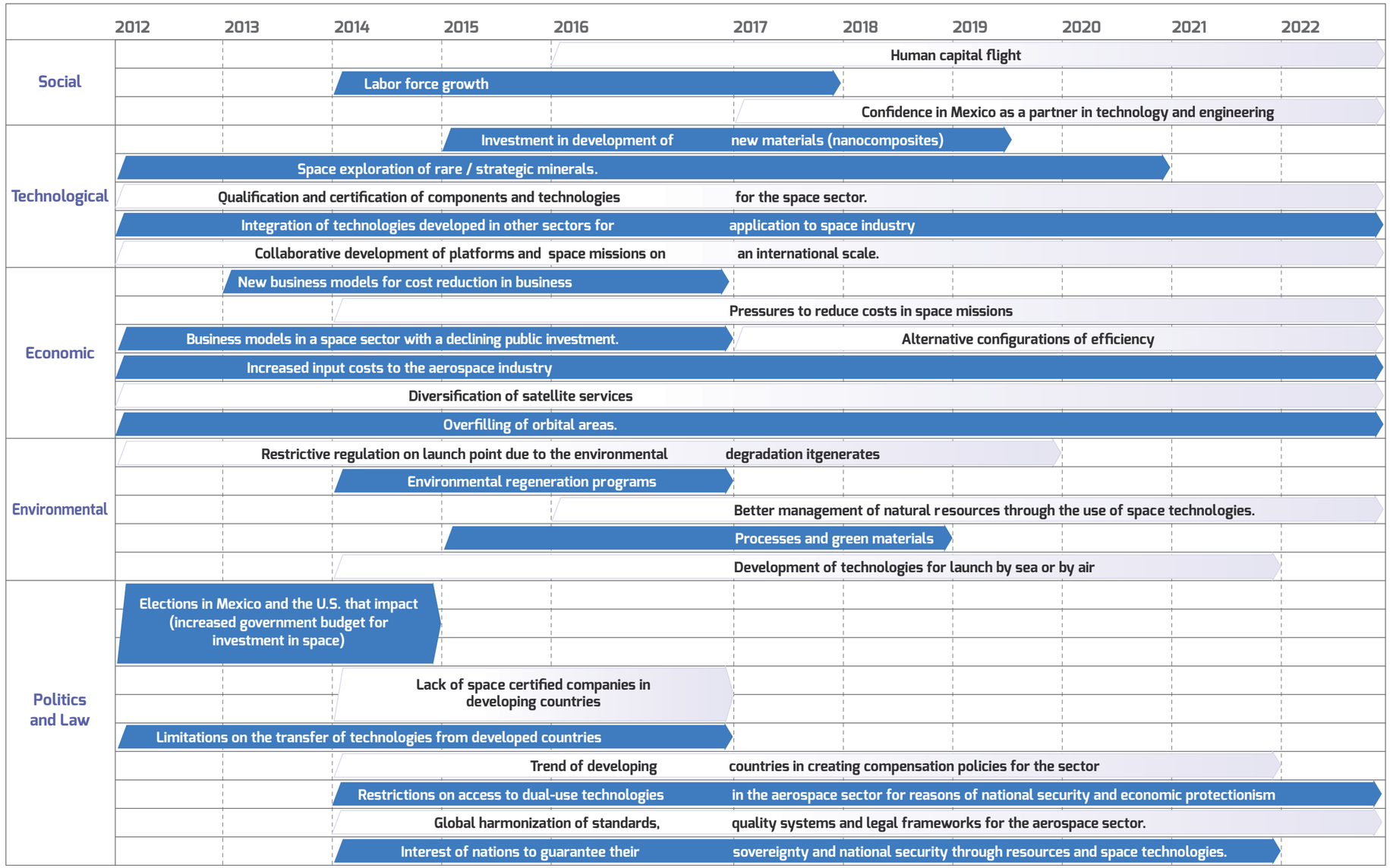


Source: Unidad de Inteligencia de Negocios (UIN) ProMéxico, 2012.

3.3 World Trends of the Space Sector and Implications for Mexico.

A trend is a behavioral pattern in specific markets, over a certain time frame that covers the social, technological, environmental, economic, talent management and political-legal contexts. The list below reflects the main global trends in the space sector, as identified by the work team.

Figure 6.



Source: Unidad de Inteligencia de Negocios (UIN) ProMéxico, 2012.

3.3.1 Development of New Poles in the Global Space Sector

The first trend identified is economic and refers to the growth of new players in the space sector. It can be seen, particularly, in large emerging economies like China, Brazil and India, or reemerging economies like Russia. The trend can be favorable if we consider that the growth of more competitive poles in the world is displacing the traditional poles of the space sector such as North America, Europe and Japan.

According to the Space Foundation, many countries with a mature space industry also have a productive population that is close to retirement, causing concern due to the loss of talent forged through decades of experience. Given this situation, recruitment and training become necessary tools to maintain the current capabilities of countries with a space industry. Mexico has the highest number of engineering graduates per capita in the American continent. In addition, it has a high level of technological sophistication, competitive prices and a growing aerospace sector, which make it an extremely appealing trade partner for maintaining the competitiveness of the classic space poles that require talent and strategic alliances. Mexico could serve, for example, as an integrating platform and creator of added value for industrial triangulations among North America, Europe and Japan.

[8] *Space Foundation 2012.*

3.3.2 Complementarity of Other Industries for Space Sector Development

In terms of technological development, the work team identified the future integration of technologies from other industries to the space sector. Because the space industry in Mexico is growing, it is easy to forecast that the aerospace sector, which has a well-established presence in Mexico, will act as a platform for its development. The industries are complementary and businesses in the aerospace sector also carry out projects and activities within the scope of the space sector.

3.3.3 Interest of Nations in Ensuring Sovereignty and National Security through Space Resources and Technologies

It is a fact that during the development of the global space industry there was a strong complementarity between the development of new space technologies and the creation of systems to ensure state sovereignty and national security of nations. Nowadays, this complementarity persists and it is used around the world. A recent study carried out in the United States proves that investing in satellite Earth observation technologies, georeference services and disaster monitoring systems creates economic efficiencies for governments which exceed spending allocated to create such information. According to this study, the creation of information to monitor climate and early warnings for disaster prevention results in annual income of $31.5 billion USD for the US government compared

[9] *Booz Allen Hamilton, "The Military Space Program. A Brief History", 2007.*

to the $5.1 billion USD it costs to create such information.

Currently, Mexico has access to images provided by optical Earth observation satellites that belong to the SPOT constellation, through the ERMEXS, ERIS and EVISMAR stations. This constellation is used for prospecting and making decisions related to crop monitoring, urban growth, changes in vegetation cover and support of intelligence operations for the Secretaría de Marina (SEMAR). With the development of new industrial capacities in the space sector in Mexico, new endogenous space systems could be created to contribute to national security, reducing risks in food production and supply, health, education, civil protection and governance processes.

[10] *Organisation for Economic Co-operation and Development (OECD), 2011.*

3.3.4 Space technologies become more accessible and improve everyday life

Over the years, space technologies become more and more accessible to mankind and they improve its quality of life. For example, telephones with a Global Positioning System (GPS) technology are commonly used and enable city dwellers to improve their daily route planning. Likewise, many services have space platforms, such as telecommunications, where Internet and satellite TV and radio access becomes easier. Finally, another type of technology directly affecting daily life is weather forecasting. Through satellite technology and ground monitoring, man has been able to forecast the weather and develop early warning systems for weather-related disasters. Regarding Mexico, as these space technologies become more accessible to man, they also tend to be more accessible for the whole Mexican space industry. This means that the country could seek the integration of space technologies all over the world to respond to local needs like field monitoring and prevention of disasters caused by natural or technological phenomena.

4. Strategic Milestones and Projects

A strategic milestone is a goal or objective based on the prospective analysis of trends. For a milestone to be considered strategic, it must be:

S	-	**Specific.**
M	-	**Measurable.**
A	-	**Aggressive but attainable.**
R	-	**Relevant.**
T	-	**Time framed.**

The Orbit Plan focuses on a series of strategic milestones that are defined based on an exhaustive analysis performed by the work team. This section describes those milestones and includes the projects and the work plan defined for their achievement.

4.1 Milestone I: Validation, Standardization and Certification Center for world-class space product testing laboratories (Completion date: 2015).

Definition of legal entities and negotiations to establish a multi-institutional entity that operates a laboratory network for the development, standardization and certification of space products and components within the triple helix pattern. **(Execution time: 6 months)**

Goal and description: To define timeframes for activities to develop the national network of testing, certification and product development laboratories used by the space industry and academic groups. This activity defines the development of several actions to match the interests of the various institutions involved in the testing-laboratories network and their participation in standardization processes.

Support and benefits: There are projects to install infrastructure laboratories in the public and private sectors, which could form a testing-laboratories network to constitute a collegiate space certification body. The strategy is national, and therefore requires a regional approach to complete the census and explore ways in which potential players can collaborate.

Deliverable 1.1: *Corporate strategy report and legal entity*

Project 1.2: Studying the of current international regulations, including standardization and certification by the leading space agencies

(Execution time: 12 months)

Goal and description: To define standards applicable to in the development of space products.

Currently there are several standards to be met in space product development. However, there are no general international regulations for space technology. In addition, although there are international initiatives related to nano satellites, like CubeSat, there is no equivalent model for other types of spacecraft.

To facilitate the development and execution of missions in which national institutions participate, it is necessary to develop a work plan that rationalizes tests and requirements.

Support and benefits: To establish an international standard framework that enables Mexico to select and implement better practices in standardization and certification of product tests and technology development.

Deliverable: 1.2 *Comparative study of current international standards (Technical report)*

Project 1.3: Studying the potential market (national and international) with the companies to be integrated or developed in the country, in order to establish a business and financing model that profitably maintains the establishment of the lab network

(Execution time: 12 months)

Goal and description: To define a strategy to promote the Mexican space industry. The project requires a study of the state-of-the-art and technological trends of the space industry. This will help to determine promotion strategies for the country and make them compatible with the business model of companies that are created or brought in to develop tests and certifications for space components. Following the plan to penetrate national and international markets, promotion, conversion, introduction and test development models will be established, as well as the market for testing and standardization services.

Support and benefits: This activity will provide an overview of the development of the Mexican space industry, and establish the guide for a series of actions related to human resources, laboratories, linking, regulations, financing and establishment of business opportunities.

Deliverable 1.3: *Market study and business model (Technical report)*

Project 1.4: Selection of minimum standards and their potential integration in Mexico

(Execution time: 6 months)

Goal and description: To create a group that studies the standard frameworks of the world's leading space agencies, identifying, customizing, adapting and adopting those minimum standards that are aligned with national projects to develop materials, products and software, among others, for which a global potential was previously determined.

The standards identified will be the frame of reference for research, development and technological innovation in materials, products and software which contain a certain degree of national component.

The project also covers the development of Mexican standards which serve as reference for the many space agencies, in areas where Mexico's potential was detected. The goal is to develop the standardization, testing and certification infrastructure for businesses united in a triple helix to develop the materials, products and software, among others, for which Mexico has potential. In addition, the project will lead to the creation of a world-class testing and certification industry capable of exporting these kinds of services.

Support and benefits: The development and establishment of a standard framework and the related testing and certification infrastructure, will benefit the development of high-level human resources and the national space industry.

Deliverable 1.4: *Technical report and standards project*

Project 1.5: Development of laboratory standardization and accreditation bodies

(Execution time: 24 months)

Goal and description: To develop and establish a standardization body and a framework to accredit testing labs and certification bodies that are part of the National Center for High Technology Certification and Standardization. The creation of the standardization body and the accreditation framework can be completed based on the Ley Federal sobre Metrología y Normalización (LFMN).

Normalización y Certificación Electrónica (NYCE) heads this project, offering its expertise and facilities to set up one or more working groups, in areas where Mexico is potentially competitive.

The offer can be complemented by institutions such as the Centro Nacional de Metrología (CENAM) and other bodies that join the effort to establish a networking framework.

Support and benefits: To create labs that can service the industry and the scientific and technological development group.

Deliverable 1.5: *Opening of standardization and accreditation bodies (Technical report)*

Project 1.6: Creation or refurbishing of space services and technology laboratories

(Execution time: 24 months)

Goal and description: To contribute to the development of the Mexican space sector by operating a network of space testing and technology laboratories to perform assays, tests and evaluations of space parts, components and systems. The project also aims to promote the development and improvement of design and manufacturing processes of components required in equipment.

The laboratories will require human resources specialized in international regulations, and the design of a development strategy for R&D+i activities supported by academic institutions and collaboration networks, to approach issues that are relevant to the sector.

Support and benefits: Operating the laboratories will translate into supporting the competitive improvement of businesses in the sector, obtaining international certifications and customizations for Normas Mexicanas (NMX), implementing certified labs and training human resources.

Deliverable 1.6: *Network of space technologies test laboratories (Results report)*

Project 1.7: Development of projects to enable imports, exports and technology transfer in the space sector **(Execution time: 24 months)**

Goal and description: To implement projects which strengthen the use and development of foreign trade. The project is not limited to laboratories; it is more a question of industrial policy in the sector where industry and government players intervene to negotiate with governments from other countries and trade blocs.

Support and benefits: To leverage opportunities arising from current trade agreements, by strengthening the capacity for trade management and promotion, technology transfer and investment attraction, as well as quality management and the competitiveness of space products and services. This must be reflected in a better business climate for companies in the sector.

Deliverable 1.7: *Development of space sector businesses and companies (Technical report)*

Summary of Milestone I deliverables:

- ***1.1*** *Corporate strategy and legal figure report*
- ***1.2*** *Comparative study of current international regulations (Technical report)*
- ***1.3*** *Market and business model study (Technical report)*
- ***1.4*** *Technical report and standards project*
- ***1.5*** *Opening of standardization and accreditation bodies (Technical report)*
- ***1.6*** *Network of space technologies testing laboratories (Technical report)*
- ***1.7*** *Development of space sector businesses and companies (Technical report)*

4.2 Milestone II: To establish a business with the technological capacity to design and develop space projects under a Public-Private Partnership (PPP) model, that is both the core and interface with participants in space projects (Date of completion: 2014)

Project 2.1: Project 2.1: Analysis of national capabilities and opportunity niches in the space global market

(Execution time: 6 months)

Goal and description: To perform a study to learn about the capacities of products, human resources, infrastructure and technologies in Mexico.

This project will determine the best financing method for its execution, participate in the call for bids to obtain the selected fund and, finally, conduct the study.

Support and benefits: The study will help identify businesses with a similar working logic to Mexican companies, that will help articulate global value networks. It will also help identify the needs and niches of opportunity to develop businesses, bodies and institutions that participate as suppliers, increasing the competences of professional training and participation.

Deliverable 2.1: *Study of national capabilities and global niches*

Project 2.2: Legal structure and organic statute (Anchor business)

(Execution time: 6 months)

Goal and description: To complete a study on the market segments and niches of interest of space development in Mexico. To visit companies with potential and interest to participate, or expand their participation in these segments and niches. Finally, to complete a business plan with one, three and five-year financial projections with a development and launch of products and services prospective for these segments and niches.

Support and benefits: The project will help identify potential markets and the position of endogenous companies, enabling a better selection of market niches to be leveraged by the Mexican space industry.

Deliverable 2.2: *Legal structure and organic statute*

Project 2.3: Definition of the business plan under the PPP pattern, including scope and dimensions, types of investment and partnership

(Execution time: 6 months)

Description and goal: To carry out an analysis of experiences in projects and developments with triple helix involvement, and studies on legal structures of simple forms of trade partnerships and participation that are accepted by current regulations for academia, industry and government, with the participation of potential players.

After completing this exercise, develop a proposal of PPP models, consortiums and other combined legal structures that facilitate the entity's operation, governance and dissolution, if applicable.

Support and benefits: This project's benefit lies in research through a benchmark, the best grouping model for establishing a business that is skilled in space programs in Mexico.

Deliverable 2.3: *Business plan*

Project 2.4: Creation of a seed company based on defined scope

Goal and description: To identify and contact potential partners, domestic and international, to present the project to create an anchor business for space development in Mexico.

Once established, to present the studies conducted and sign letters of intent or general collaboration agreements with parties interested in exploring participation possibilities.

As follow-up to this project, to create an executive presentation on the business plan, and the formation of a seed company to present to potential partners and investors for the first round of financing.

Support and benefits: The knowledge of business models in the Mexican space sector will help attract businesses, domestic and international, which supply high technology.

Deliverable 2.4: *Constituted business and initial financing*

Project 2.5: Space infrastructure project in PPP model, leveraging the capacity to respond to or develop technological demand for R&D+i through the design and management of multilateral and multidisciplinary projects

(Execution time: 6 months)

Goal and description: To articulate the R&D+i chain to meet the country's needs and leverage the capacities and niches of opportunity, develop business, bodies and institutions as suppliers and outline competences for professional training in this activity.

By measuring Mexico's capacities in the aerospace sector, taking into account products, human resources, infrastructure and technologies, we can identify strengths, needs, market niches and opportunities, and the context in which leading companies operate. Thus, a business model emerges with the dimensions, scope and partnership and investment modalities that enable the formation of a business which establishes the conditions to develop and market space projects nationally and internationally.

ProMéxico will be the entity responsible for promoting this activity and, led by the AEM, the business, possibly within a PPP, will be the basic mechanism for incorporating the wealth of the nation's space-related R&D+i into production chains.

Support and benefits: The expertise and knowledge of businesses and research centers with capacities in terms of products, human resources, infrastructure and technologies, as well as those with a potential in the area, supported by the AEM and ProMéxico within the framework of the Programa Nacional de Actividades Espaciales (PNAE).

The project will enable the discovery of the wealth of capacities (human capital, added value, infrastructure, products and technology) applicable to the Mexican space industry, and the identification of niches of opportunity and possible strategic partnerships that are set up through a determined business model. It will also promote national and

international participation in the creation of offers and projects based on established requirements, offering Mexican bodies and businesses the possibility of joining the space sectorvalue chains and positioning themselves in the global market.

Deliverable 2.5: *Space infrastructure project in PPP model*

Summary of Milestone II deliverables:

- ***2.1*** *Study of national capacities and global niches*
- ***2.2*** *Legal structure and organic statute*
- ***2.3*** *Business plan*
- ***2.4*** *Formed business and initial financing*
- ***2.5*** *Space infrastructure project in PPP model*

4.3 Milestone III: Milestone III: Integrating a low-orbit multifunction satellite platform with 50% of critical technologies developed in Mexico (Execution date 2017)

Project 3.1: Creation of the group in charge of managing the development of the multifunction satellite platform

(Execution time: 6 months)

Goal and description: To create an Administrative Technical Group (ATG) to coordinate activities to develop a multifunction LEO satellite platform on a national level.

The ATG will focus on:

- *Developing the strategic planning for the development stages of the satellite platform.*
- *Identifying national and international financing sources for the project's execution.*
- *Making a preliminary diagnosis of human resources and national academic, industrial, government and infrastructure capacities that can help develop the stages of the satellite platform.*
- *Proposing international cooperation agreements that foster technology transfer to our country.*
- *Identifying and proposing technology transfer mechanisms that facilitate the export and import of devices created during the process.*
- *Identifying national needs and users of the satellite platform services, to define the scope and priorities of the services.*
- *Handling any procedures and permit applications with national and international institutions required to launch an object into space.*

Support and benefits: The coordination of technological, financial, planning and project execution guidelines, and the obtaining of and compliance with applicable regulations to ensure the quality of technology, technology transfer and successful development of the project.

Deliverable 3.1: *Integration of the ATG*

Proyecto 3.2: Specifications and design of the multifunction satellite platform

Goal and description: To create the technical group for the project, formed by scientists and technologists, who will be part of the task forces which define the technical specifications of the multifunction LEO satellite platform, and the conceptual design of all its modules. In addition, they will specify and design a set of strategic interest payloads to carry out a first Mexican satellite mission.

Mission analysis: To create specifications for the satellite mission, considering orbit parameters for a LEO micro-satellite, and subsystem modes of operation and useful remote sensing payloads for observation, transmission, processing and exploitation of the satellite information. At the same time, launch windows must be projected based on world availability of rockets and platforms.

Platform and subsystem design: To create specifications and the preliminary design of the platform's subsystems, useful payloads and electromagnetic compatibility and reliability analysis, as well as space validation and qualification procedures for the satellite platform. The platform must include the following subsystems:

- *Mechanical structure.*
- *Electric power system and storage.*
- *Orientation, stabilization and control system.*
- *Telemetry, telecommand and telecommunications system.*
- *On board/in flight computer.*
- *Ground station and infrastructure for satellite tracking and control.*

In addition, timeframes for the development and delivery of engineering and/or flight prototypes and models for the component modules and the integrated platform must be scheduled.

Useful payloads of interest for the country include:

- *High resolution remote sensing camera (1m).*
- *High resolution synthetic aperture radar (1m).*
- *Ka band bidirectional radiofrequency radio link (20-30GHz).*
- *Bidirectional optical communication links.*

On the other hand, it is important to have a minimum of financial support to sustain this stage of the project.

Support and benefits: The support of the interdisciplinary group of experts from the country's academic, government and business sectors will reinforce the development of this stage of the project. The group has solid experience in satellite module and subsystem development, having completed institutional projects such as SATEX 1, CONDOR, HUMSAT and SENSAT. The preliminary specifications and design stage will enable a technical document to be drafted for the satellite platform and useful payloads considered for the satellite mission. The document will also define subsystem specifications, as well as the development plan for every component of the platform.

Deliverable 3.2*:* Specifications and design of the satellite platform

Project 3.3: Preliminary design, mission and financing of a satellite platform

Goal and description: To review the preliminary design of the satellite platform to define the executive project of manufacture, space testing, validation and certification of all the component modules. To also review the specifications and design of the set of useful payloads of strategic interest for a first Mexican satellite mission.

Technical groups will continue to be coordinated by the project's ATG.

The executive project will establish commitments, goals and responsibilities of the task forces to meet a schedule of deadlines and deliverables. They will include satellite modules, subsystems and systems and their validation and certification protocols, as well as the relevant technical documentation.

The first Mexican satellite mission must consider the following useful payloads: an optical camera to obtain images with 1-meter spatial resolution; a synthetic aperture radar in X band with 1-meter spatial resolution; a Ka band bidirectional radiofrequency communications link for bandwidth communications and atmosphere propagation studies; and a bidirectional high speed optical communications link.

The technical document on the satellite platform and useful payload will be created to successfully comply with the launch and operation standards of a first Mexican mission. The document will prove the project's technical and economic viability, and will be the negotiating base for its financing.

The ATG will promote the project to obtain funding to complete it, whether from public or private entities.

Detailed review of the analysis of the mission: Definitive orbital parameters will be generated from the preliminary specifications of the satellite mission. They must consider the modes of operation of the devices and useful payloads for a first Mexican mission, all in terms of the availability of launch windows and launch rockets.

From the beginning of the project, concrete actions must be proposed to analyze and negotiate the launch perspectives for the satellite platform. This schedule will establish the development and delivery timeframes of engineering and/or flight prototypes and models for the component modules and the integrated platform.

Support and benefits: The support of the interdisciplinary group of experts from Mexico's academic, government and business sectors. Their experience in technological development will support the progress of the LEO satellite platform project in Mexico. The group currently has an initial core of members who will address the specification and design of the proposed satellite platform.

The interdisciplinary group will create a document that includes a cost estimate for the platform's development and launch which will be the basis of negotiation for the funding for the project.

Deliverable 3.3: Preliminary design, mission and funding of a satellite platform

Project 3.4: Construction and integration of a micro-satellite for a first Mexican mission

Goal and description: After settling the funding sources for the project, to propose and appoint a technical coordinating commission, comprising two specialists, to oversee and follow-up on the project. This commission must supervise, evaluate and receive the deliverables of the various suppliers of the satellite modules, and coordinate the integration stage, up to the micro-satellite's space quality certification.

Once manufactured, the subsystems will undergo electromagnetic compatibility and reliability analyses to ensure their integration. They will also undergo space validation, qualification and certification tests, as an essential requirement for the launch stage and operation in space. Meanwhile, the tests will be adapted to the engineering and/or flight model of space validation and certification established to assemble the launch rocket. In addition, the platform and modules must pass vibration, stress, radiation and electromagnetic compatibility (EMC) tests. Finally, to receive space qualification and certification, there must be infrastructure with internationally certified validation and certification.

Support and benefits: The construction of satellite modules, useful payloads and satellite integration will be completed thanks to the work of the groups responsible for their creation. These groups, attached to academic institutions and/or businesses, will

provide the satellite modules to the integrating institution or business. The integrated micro-satellite will undergo all space qualification and certification testing using the country's existing specialized infrastructure.

Finally, the construction and integration of the micro-satellite will result in a product with high material and intellectual content, ready to be launched and operated from Mexico, with strategic applications for high resolution remote sensing and bandwidth communications in national territory.

Deliverable 3.4: *Construcción y prueba del micro-satélite de la primera misión mexicana*

Project 3.5. Launch

Goal and description: To launch, as a first Mexican satellite mission, a LEO micro-satellite with high national content in terms of critical technologies and high impact useful payloads, in compliance with international regulations.

To hire the launch company or agency which offers the closest orbit service to the one defined in the mission's analysis, to launch the satellite platform. The transfer of the platform to the final orbit will determine the need for an on-board propulsion system. The conceptual design of the platform must, therefore, include the propulsion system, which will require the correct coordination of every on-board subsystem. Once the micro-satellite is in the target orbit, it will be put into operation to ensure the mission is accomplished. Initial tests include in-flight operation tests and the hand-over of the satellite's control to the ground station(s) in Mexico. The useful life of the satellite will be determined by the mission and reliability analyses performed during the subsystems' development. A very important aspect is forecasting the de-orbit (moving out of the original orbit) of the satellite at the end of its useful life, or guaranteeing its disintegration on re-entering the atmosphere, avoiding collisions with other nearby objects or satellites.

Support and benefits: Once the satellite platform's conceptual design is done, the technical group of launch prospects will take care of the negotiating, hiring and scheduling of the launch. The technical group will contact satellite launch businesses or agencies to project launch conditions for 2017, as well as protocols and regulations in order to provide this information to the other technical groups, particularly the space testing, qualification and electromagnetic compatibility team. These factors will help establish the conditions and requirements for the design and construction of the platform, to ensure space qualification and certification.

Finally, the main benefit of this task is to put the satellite in the desired orbit, leave it in operation, transfer control to the relevant entities and guarantee the safety of other objects in low orbit.

Deliverable 3.5: Launch of the micro-satellite's first mission

Summary of Milestone III deliverables:

- ***3.1*** *Form the Administrative Technical Group (ATG)*
- ***3.2*** *Specifications and design of the satellite platform*
- ***3.3*** *Preliminary design, mission and funding of a satellite platform*
- ***3.4*** *Satellite construction and testing for the first mission*
- ***3.5*** *Launch of the micro-satellite's first mission*

4.4 Milestone IV: Creation of a PPP institute to coordinate the triple helix for innovation in advanced materials with aerospace applications (Completion date: 2014)

Project 4.1: Perform a diagnosis of national capacities (human, material and financial) in the development of advanced materials for the space industry

Goal and description: To perform a study of human capacities, materials market and existing funding in the development of advanced materials for the space industry. To research existing support in the public and private sectors.

Support and benefits: The study will provide information on the national capacity for the development of advanced materials for the space industry, and materials to be developed to supply the sector's future demand.

The project will show the position held by Mexican talent in terms of advanced materials production, which will enable the identification of market niches and necessities to develop. It will also help perform a prospective analysis of new materials that will be required by the industry, and to identify the type of materials that need to be developed to supply the domestic and international markets. Finally, the study will include information on existing funding for the development of new materials, with a view to creating an advanced materials development center.

Deliverable 4.1: Diagnosis of advanced materials capacities

Project 4.2: To create mechanisms to promote the development of human capital in advanced materials, granting incentives to higher education and research institutions, to increase human resource training in the space sector (incentives will be granted by a public-private consortium)

Goal and description: To create a research center aimed at developing specific materials (fiber reinforced composites and alloys) and high technology experimental systems (construction of a rocket prototype).

The center must operate around an established scientific and industrial platform to avoid a giant investment in equipment and facilities, and in the training and hiring of high level human resources.

The formation of the research center will require the:

- *Specialization of researchers in the areas of space materials.*
- *Creation of a space materials research and development center in a city with an established scientific and industrial platform. Jiutepec, Morelos, is a viable option because it is at mid-altitude between Mexico City and sea level. A high technology center has been identified in this area of great value and potential for the realization of space projects and programs.*
- *Development of the launch systems required and strengthening of the country's scientific and technological potential.*
- *Creation of a science and technology development program that comes into effect between September and October 2012, with the participation of two or three guest specialists from the Space Research Institute of the Russian Academy of Sciences and the Bauman Moscow State Technical University. In addition, a cycle of specialized lectures; the organization of a series of courses on the development, calculation and construction of propulsion systems; the definition of research projects, and the determination of the appropriate propulsion system for Mexico's industrial and technological reality.*

Support and benefits: Mexico still lacks a high technology materials development center capable of meeting space quality and quantity requirements. There are laboratories which conduct studies that could be applied to the industry in general. Escuela Superior de Ingeniería Mecánica y Eléctrica (ESIME), Unidad Azcapotzalco (AZC), Sección de Estudios de Posgrado e Investigación (SEPI) of the Instituto Politécnico Nacional (IPN), through joint actions with high technology companies, is one of the institutions that could promote research and development activities in fields required by space engineering.

Deliverable 4.2: Program to further advanced materials research

Project 4.3: To consult the aerospace sector to identify its short and medium-term demands for advanced materials, and match them with the academic offering to provide solutions for their development

The institute will begin by addressing the demands for advanced materials in the aerospace sector and will then shift from aeronautics to space. Some materials to consider are Kevlar-carbon, aluminum, titanium and their alloys.

Goal and description: To make a list of advanced materials used by the aerospace industry to measure their short and medium-term demand. To define the advanced materials to be considered, with the aid of industry representatives. In a first stage, it is suggested to use composite materials such as Kevlar-carbon, aluminum, titanium and their alloys. Later, to identify certain industries/businesses to be surveyed on the current and estimated five-year demand for these materials. Finally, to conduct research to obtain more information on the selectedmaterials, such as import data.

To identify, within the academic sector, entities with the capacity or interest in developing materials that are unavailable on the Mexican market or are not manufactured by local companies. Subsequently, to obtain the directory of the academic sector and its R&D centers to identify those that might be interested in the project and invite them to participate. To create a document that incorporates the commitments, agreements, minutes and other follow-up instruments to keep track of the directory.

To match, as far as possible, research centers with the fund(s) or funds to carry out the developments. A financing fund database will have to be obtained or developed to find the company with the appropriate funding.

Support and benefits: Knowledge of the current industry demand for advanced materials and its possible growth in the next five years, categorized by type of material. This will help determine the market volume for this type of materials and whether investment in their development might be profitable.

Strengthening of the R&D centers of academic institutions that participate in the program, by becoming involved in the possible design and development of these materials, and in the training of specialists in the area.

Strengthening and development of parts manufacturing in the Mexican aerospace industry, which will result in local customers and expansion abroad.

Deliverable 4.3: Demand and investment for advanced materials development

Project 4.4: To perform global research on materials that have been developed for space applications in order to determine their application in ground areas and propose developments or devices based on these materials

Goal and description: To conduct an investigation on the advanced materials developed in various parts of the world, originally for space applications, and search for possible applications in the national aerospace industry and Mexican industry in general.

To identify the advanced materials to be used through patent offices, materials institutes, space agencies and industry, to begin the investigation with a technological and economic perspective.

Support and benefits: Identification of existing advanced materials in the global industry, categorized by type of material, and requirements for their potential manufacturing in Mexico or on a small scale for research purposes and prototype development. Definition of the profitability of investment in the development of said materials in Mexico.

Complementation of research carried out by the R&D centers of academic institutions involved in the program, with advanced materials developed in other countries.

Development and manufacturing of parts and components for the aerospace industry, and for the Mexican industry in general, which will enable the product offering to be expanded both locally and internationally.

Deliverable 4.4: Research on the state-of-the-art of advanced materials

Project 4.5: To develop the business plan for the Advanced Materials Institute

Goal and description: To develop a business plan that includes the elements and strategy to follow to demonstrate the feasibility and profitability of the Advanced Materials Institute.

To gather data on the market, current and future demand and the evolution of demand. To complement this information with data on the demand for advanced materials included in project 4.3. To gather data on the environment, complemented with data from project 4.1. Finally, to consider the potential increase of skilled human capital with the figures from project 4.2 and complement the information with data on material global development from project 4.4.

The plan will also consider the competition analysis that will include data from national and foreign entities with a profile equal or similar to that of the Institute.

Furthermore, the product and/or service development strategy must be defined, establishing which will be pursued, their related prices and their promotion.

The Institute's physical infrastructure must be designed, considering working areas such as laboratories, offices, testing area, storage areas and parking. In the first stage, the design will meet the demands resulting from the development of products and/or services. Meanwhile, customizations to the Institute's infrastructure must be completed within a period of no less than five years.

Finally, the plan must include an economic analysis that considers price structure, budget, investment expenses, sales projections, results, balance, cash flow and financing sources, among other elements.

Support and benefits: Information on the current state of the advanced materials industry in Mexico and the world, which will facilitate a better definition of products and services to be offered by the Institute.

Definition of the scope of the project to create the Advanced Materials Institute and its feasibility.

Establishment of the bases to support strategies that lead the Institute to fulfill its goals and obtain funding from various sources.

Deliverable 4.5: Business plan for the Advanced Materials Institute

Project 4.6: To articulate national capacities by creating an open innovation platform (InnoCentive model)

Goal and description: To apply the open innovation model, based on crowd sourcing, which invites the public to develop a type of technology in exchange for economic compensation.

This model has been successful for companies like InnoCentive, which have worked with companies like Boeing, Procter&Gamble and Nestlé, to outsource their R&D activities. InnoCentive publishes its clients' issues as "challenges" and gathers the proposals of volunteers who bid to offer the ideal solution. Finally, candidates who contribute the best solutions receive economic compensation.

Support and benefits: Reduction of time and costs to complete the R&D project. Incorporation of solutions provided by external agents to obtain solutions outside the institution's classic perspective.

Deliverable 4.6: Open innovation platform

Summary of Milestone IV deliverables:

- **4.1** *Diagnosis of advanced materials capacities*
- **4.2** *Program to support advanced materials research*
- **4.3** *Demands and investments to develop advanced materials*
- **4.4** *Research on the state-of-the-art of advanced materials*
- **4.5** *Business plan for the Advanced Materials Institute*
- **4.6** *Open innovation platform*

4.5 Milestone V: Mexico will have a 1% share in the space industry (one billion dollars) (Completion date: 2017)

Project 5.1: Generation and integration of a map of transversal and complementary capacities towards space projects

Goal and description: To identify Mexico's manufacturing capacities and existing processes. To begin in highly integrated regions with a base of companies with certified quality levels in their areas of competence, and which can provide certainty to space projects. The scope of the project will include complementary survey, analysis and territorial vocation.

To establish the bases of competition to participate in bids and/or projects, according to manufacturing and processing capacities or, when applicable, offer the guarantee to establish a company that sees in Mexico an already-established production value chain that is ideal for supplier development.

Support and benefits: Knowledge of both the current offering of the space industry in Mexico and its players. Information exchange among sector players to keep them up-to-date on their complementary universe in Mexico. Identification of competences and capacities to strengthen knowledge on the projects that the country will be able to address.

The content of the industry representatives survey should be designed and defined in an accessible, friendly and easy to respond way. Bodies, chambers, institutes and similar businesses (or that have shown interest in participating and including the industry in their area of influence) will take part in creating the survey. The results of the survey will provide a first X-ray of the industry that supports the space sector in Mexico.

Deliverable 5.1: Map of existing transverse capacities in Mexico

Project 5.2: Creation of a space forum in Mexico

[Project leader: Eugenio García. Completion time: 2 months]

Goal and description: To identify or develop a space forum in Mexico. An example might be the Sociedad Mexicana de Ciencia y Tecnología Aeroespacial (SOMECYTA) forum to be held in September 2012. This forum could be an excellent catalyst and receiver of initiatives, projects and redefined actions for those interested in participating in the space sector.

Support and benefits: The consolidation and institutionalization of a forum that groups the various players (government, education entities, research centers and industry) to establish criteria and define actions to follow, based on complementary actions that are taken along the way.

The correct promotion of this forum will attract participants who uphold the search for solutions, inhibitors, issues, challenges and existing opportunities in the Mexican space sector.

Deliverable 5.2: Report on a space industry forum

Project 5.3: Participation in international space events

Goal and description: To identify one to three international space events, in order to organize a Mexican business mission which evaluates potential alliances with international firms or attractive projects in the sector.

To use these events to promote the AEM as a receiving agent and a promoter of space projects in Mexico.

Support and benefits: Support from bodies, chambers, institutes and related companies to enrich this survey and prioritize the most important.

Knowledge of meeting points of the space industry, events attended by decision-makers and precision shots to space projects, considering limited economic resources for trips abroad. The project will also allow Mexico's capacities to be promoted in the space sector and areas where the Mexican industry can participate to become a supplier to integrating companies, by organizing workshops.

Support required:

- *Budget to cover travel expenses, participation and related material.*
- *Additional budget to support the industry's participation in international space events, to capture business.*

Deliverable *5.3:* Technical report of international projects with business potential for the Mexican space industry

Project 5.4: Mapping / Identification of satellite integrators

Goal and description: To identify the leading satellite integration companies in the United States and Europe, to learn about their profile and organic culture towards the sustainability of satellite projects executed or completed in emerging markets.

Also, to identify the main attributes of the satellite industry, to learn about entry barriers, quality standards, human competences and tests required to make an added value proposal to satellite integrating companies that shows Mexico's industrial capacity to develop their space projects.

Support and benefits: Executing precision shots and approaching flagship companies in the space sector that are capable of generating a multiplying effect in terms of industrial spillover and certainty towards Mexico. Finally, the 80/20 Pareto formula will enable efforts in approach, validation and specific results to be channeled.

Support required:

- *Each company's technical specifications to identify a point of contact and make the relevant presentations as part of the AEM.*
- *Workshop to learn about areas that can be delegated to supply.*
- *Constant feedback on our strategic and industrial development plan.*
- *Budget for workshops that will be carried out as part of international events identified in goal 1 of this diagnosis stage.*

Deliverable 5.4: Mapping of national satellite integrators

Summary of Milestone V deliverables:

5.1 *Map of existing transverse capacities in Mexico*

5.2 *Report on a space industry forum*

5.3 *Report of international projects with business potential for the Mexican aerospace industry*

5.4 *Mapping of national satellite integrators*

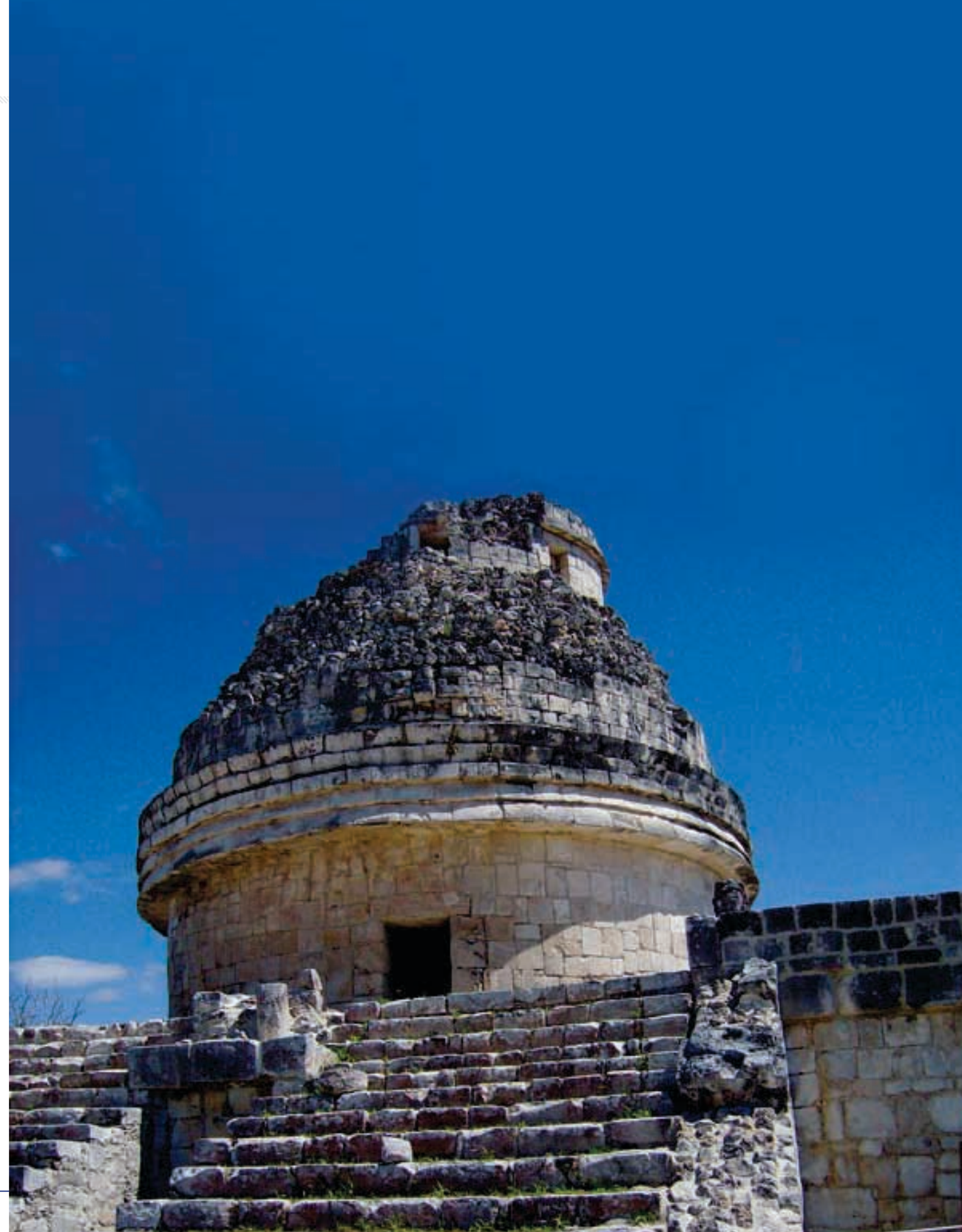
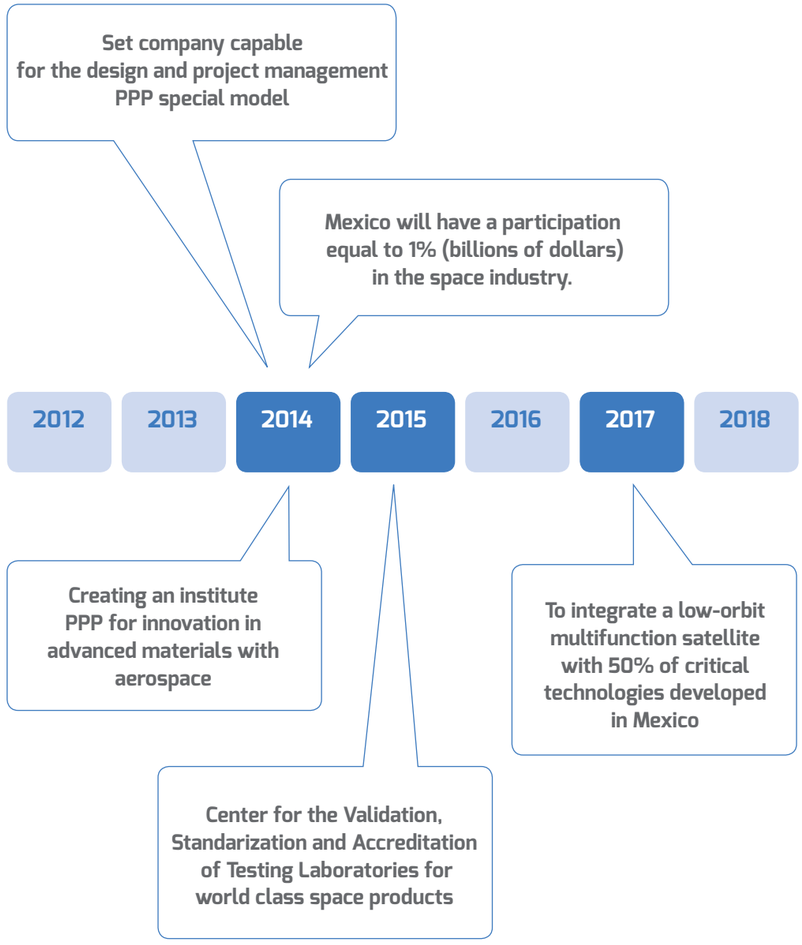
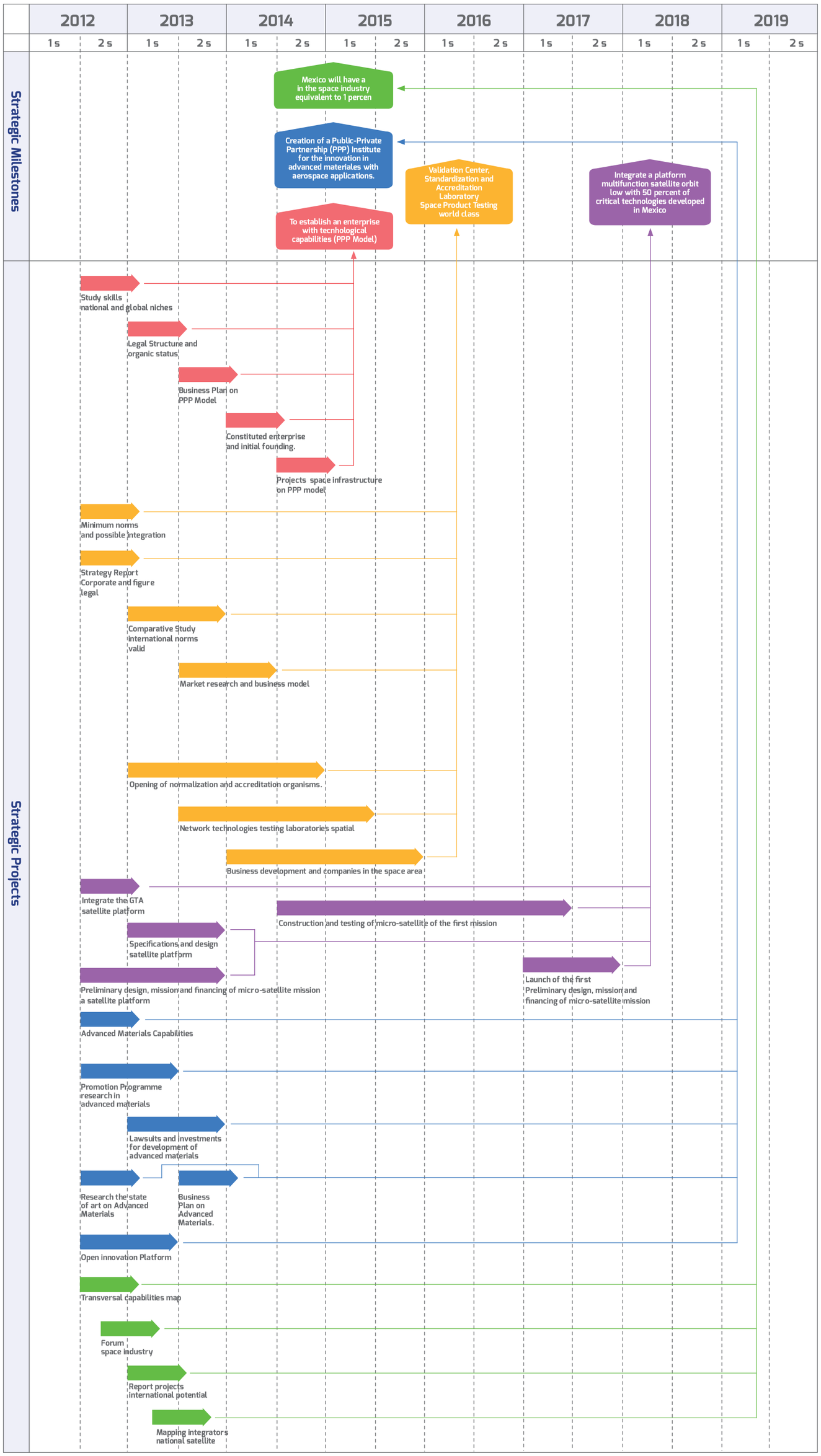


Figure 7. Graphical summary of milestones and deliverables

Milestones	Deliverables	Months	2012	2013	2014	2015	2016	2017
Center for Validation, Standardization and Certification of World-Class Space Product Test Laboratories	1.1 Corporate strategy / legal figure	6						
	1.2 Current international regulations	12						
	1.3 Market study and business model	12						
	1.4 Minimum regulations	6						
	1.5 Opening of a standardization body and one of accreditation	24						
	1.6 Network of space technologies testing laboratories	24						
	1.7 Business and company development in space area	24						
The establishment of a company with capacities to design and manage space projects with Public-Private Partnership (PPP) model	2.1 Study of national capacities and global niches	6						
	2.2 Legal structure and organic statute (anchor businesses)	6						
	2.3 Business plan in PPP model	6						
	2.4 Formed company and initial financing	6						
	2.5 Space infrastructure projects in PPP model	6						
To integrate a low-orbit multifunction satellite platform with 50% of critical technologies developed in Mexico.	3.1 Integrate the Administrative Technical Group (ATG) for the satellite platform	6						
	3.2 Platform specifications and design	12						
	3.3 Preliminary design, mission and funding of a satellite platform	12						
	3.4 Construction and testing of the satellite for the first mission	36						
	3.5 Launch of the satellite for the first mission	12						
Creation of a Public-Private Partnership institute for innovation in advanced materials with aerospace applications	4.1 Capacities in advanced materials	6						
	4.2 Program to promote research in advanced materials	9						
	4.3 Demands / investments in advanced materials development	6						
	4.4 Research on state-of-the-art advanced materials	6						
	4.5 Business plan for the Advanced Materials Institute	6						
	4.6 Open innovation platform	12						
Mexico will have a 1% share in the space industry (one billion dollars in five years)	5.1 Map of transverse capacities	6						
	5.2 Report on a space industry forum	2						
	5.3 Report on projects with international potential	2						
	5.4 Mapping of national satellite integrators	3						

Figure 8. Timeline of strategic milestones




2012
2013
2014
2015
2016
2017
2018
2019
1s
2s
Strategic Milestones
Strategic Projects
Mexico will have a in the space industry equivalent to 1 percen
Creation of a Public-Private Partnership (PPP) Institute for the innovation in advanced materiales with aerospace applications.
Validation Center, Standardization and Accreditation Laboratory Space Product Testing world class
Integrate a platform multifunction satellite orbit low with 50 percent of critical technologies developed in Mexico
To establish an enterprise with tecnhological capabilities (PPP Model)
Study skills national and global niches
Legal Structure and organic status
Business Plan on PPP Model
Constituted enterprise and initial founding.
Projects space infrastructure on PPP model
Minimum norms and possible integration
Strategy Report Corporate and figure legal
Comparative Study international norms valid
Market research and business model
Opening of normalization and accreditation organisms.
Network technologies testing laboratories spatial
Business development and companies in the space area
Integrate the GTA satellite platform
Construction and testing of micro-satellite of the first mission
Specifications and design satellite platform
Launch of the first Preliminary design, mission and financing of micro-satellite mission
Preliminary design, mission and financing of micro-satellite mission a satellite platform
Advanced Materials Capabilities
Promotion Programme research in advanced materials
Lawsuits and investments for development of advanced materials
Research the state of art on Advanced Materials
Business Plan on Advanced Materials.
Open innovation Platform
Transversal capabilities map
Forum space industry
Report projects international potential
Mapping integrators national satellite

Conclusions:

The Orbit Plan is an X-ray image of the Mexican space sector and establishes the steps to take in the next five years to boost its growth. The above in terms of laboratory validation, standardization and accreditation infrastructure; critical technologies; research and development (R&D); the creation of a Mexican satellite platform to observe the Earth through the development of instrumentation, useful payloads, applications, links and other aspects of relevant technology development to enhance national capacities and competences.

The Orbit Plan's strategic milestones gather the opinions of leaders of the Mexican space sector, as well as the steps to follow to build its future in an integral way and with projects of great vision.

Due to its strategic nature, the orbit plan is a living document that requires frequent feedback and updating. It also demands flexibility to adapt to the major changes in the space market. This, to keep the pulse of the environment, provide strategic lines to follow and coordinate academia, industry and government efforts in space and related areas.

The most representative goal of the orbit plan for the Mexican space sector is the integration of a multi-function low Earth orbit satellite platform which achieves 50% of critical technologies developed in Mexico (Milestone 3). This goal reflects the interaction and sum of all the milestones and projects that make up the Orbit Plan, created under an inclusive vision for achieving the proposed activities and outcomes.

The orbit plan's most ambitious goal is to increase the share of the Mexican space sector in the global space industry, to reach 1% of the national gross domestic product (GDP) in five years (only in 2011 it was one billion dollars). This will be of crucial importance in defining how to plan and integrate strategic projects with the consensus of the players of the triple helix; international networks of knowledge, innovation and financing are coordinated with those of strategic alliances; legal work structures are established and the financing schemes implemented which are required to support the projects.

Mexico is committed to the development of the space sector and will work to create collaboration spaces, join efforts, communicate players, seek out investments and resources to position itself as an attractive pole of space development, internationally renowned for its capacity to coordinate and execute works with high socio-economic impact, quality and innovation.

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