**TRENDS IN SMALL SATELLITE SYSTEM IN MEXICO**

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# ABSTRACT

A technological development of space in Mexico is proposed. Up to date, satellites are design, build and launch to the space by other countries. Satellites worked at an academic level to achieve this objective, a State policy is necessary to integrate basic and applied scientific research carried out by the country's institutions in the productive sector.

Small satellites for education institutions and research centers are currently being designed and built because of the relatively low cost compared to the geostationary ones that cover the American Continent. However, there was a lack of regulatory management, permits, launching bases, and systemic integration in companies.

Therefore, in order to obtain a Systemic Model was the production of a situation diagnosis with the corresponding planning.

Keywords: Small satellites, scientific research, State policy

# HEADING

One way to classify satellites is by their mass; the big ones weigh more than 1000 kg; the medium ones from 500 to 1000 kg; the small ones less than 500 kg. Table 1 shows its characteristics of small satellites.

The Universidad Autónoma de México (UNAM) in 1995 launched into space its microsatellite called UNAMSAT 1. This satellite was destroyed at the time the Russian rocket that was carrying it exploded; due to the fact, it had a backup called UNAMSAT B of 10.7 kg, it was put in orbit for Russia in 1996, and after one year the control was lost (Gaceta UNAM, 1996).

 Cubesat standards are nanosatellites of 10 by 10 by 10 cm with standardized specifications that have been developed for more than 10 years; Due to its relative low cost some institutions, people and the productive sector in Mexico are dedicated to its construction (Robles, 2017).

Table1: Report ITU-R SA.2312-0; Characteristics, definitions and spectrum requirements of picosatellites and nanosatellites, as well as systems composed of such satellites

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Denomination | Mass kg | Potentialof bus (w)  | Cost (USD) | Dimentions | Development (years) |  Órbit | Duration(years) |
| Minisatellite | 100-500 | 1000 | 30-200M | 3-1 | 3-10 | GEOMEOLEOHEO | 5-10 |
| Microsatellite | 10-100 | 150 | 10-150M | 1-5 | 2-5 | LEOHEO | 2-6 |
| Nanosatllite | 1-10 | 20 | 100T-10M | .1-1 | 1-3 | <1 |
| Picosatellte | .1-1 | 5 | 50T-2M | .05-.1 |
| Femtosatellite | <.1 | 1 | 50T | .01-.05 | 1 |

However, in order to achieve technological development (TD), a systemic integration with the productive sector is necessary; coordination between construction and launches; manage frequencies and permits before the United Nations Organization (UNO) and the International Telecommunications Union (ITU) through the Ministry of Communications and Transportation (MCT) and the Federal Institute of Telecommunications(FIT).

## Developing - System model

A model is a series of steps or it can be an elaborated mathematical structure that represents the problem abstractly, it allows a conceptualization of the problem by which a solution will be advanced. In this sense, the models are a methodology to look for solutions (Van Gigch, 2008). Any systemic model (SM) can be designed in five phases, as shown in Table 2.

Table 2. Phases and Sub-phases of the Systemic Model for TD

|  |  |  |
| --- | --- | --- |
| **Number** | **Phases of the systemic model** | **Sub phases of the MS for the DT** |
| I | Analysis of the information | 1.Anlysis of the international space system2.Analysis of the Mexican space system |
| II | Detection of the problem | 3.Diagnosis of the Mexican space system |
| III | Proposed solution | 4.Proposal of solution for the TD |
| IV | Plan to solve the problem and project the system to corresponding objective | 5. Mision, Vision and Values for the TD6.Strategies for the TD 7. Plan of action for the TD |
| V | Evaluation and results | 8. Evaluation and results of the TD |

These phases and sub- phases can be included in three stages: entrance, black box and output. In Fig. 1, the SM for the TD is presented based on the three stages and with five determined phases, which at the same time are divided into eight sub- phases.

## Sub- phase 1: Analysis of the development of the international space system

The success of the international spatial TD is due mainly to the intervention of the State of the countries that have achieved it through the space agencies such as the National and Space Administration (NASA) of the United States of America (USA); the Russian Federal Space Agency (ROSCOSMOS); the National Space Administration of China (NSA), and the European Space Agency (ESA).

Based on work done, among others, by Voss, (2011) Meacham, (2013) Ellis, (2010). Lucena, (2011). The space agencies are considered as a strategy of the State policy of each country; strengthen basic and applied research, educational institutions and research centers, particularly space research, and link and integrate the industrial space sector.

The national security, defense and marine agencies have their own development, based on basic and applied scientific research since any technological advantage is the main strategy of the armed forces, however they participate and collaborate with the space agencies, resulting in great impact on the TD.

The space agencies of each developed country or community have a close relationship with each other and therefore, participate in joint space projects. The analysis of the development situation of the international space system (DISS) should allow the definition of the key success factors for the spatial TD, taking into account internal and external factors that are inside or out of control.

## Sub- phase 2. Analysis of the Mexican space system

The Mexican State founded and cancelled, such as the National Commission on Outer Space (NCOS), 1962-1977; this agency developed space research that resulted in the launching of rockets and space balloons. The Mexican Institute of Communications (MIC), 1987-1997, was the interlocutor and promoter of research efforts in educational institutions (Méndez, 2009). Currently, the Mexican Space Agency (MSA), which began operating in 2010, has the same objectives as the previous two, which consist of promoting scientific space research in order to promote the TD; that is to say, the purpose to which one wants to arrive is said but it is not said how to do it.

The programs and projects generated in the higher education institutions and research centres arise and disappear, such as the Autonomous University of San Luis Potosí (AUSLP), which launched its first rocket before the USA launched its first satellite. Explorer 1, and two months after the Union of Soviet Socialist Republics (USSR) launched their first satellite, Sputnik 1; the University Program for Space Development Research (UPSDR), was cancelled after designing to build and put into orbit its satellite in 1995, UNAMSAT 2; the SATEX project (Poveda, 2009), which started 22 years ago and has no results to date.

## Sub- phase 3: Diagnosis of the Mexican space system (MSS).

Here are some research questions to determine the diagnosis of MSS

1. Did Mexico initiate its space research after the countries that have had technological space development?

Answer: Mexico began these activities at the same time as the USSR and the USA (Poveda, 2009).

 2. Does Mexico have financial resources to start the TD?

Answer: Yes, 1600 million dollars were paid for designing the last three Mexican satellites of the Mexsat project to build and launch in other countries (García, 2012). On the other hand, Russia built a space launch base in French Guiana at a cost of 361 million dollars (Space Daily, 2004). Therefore, if you have the financial resources to build the base of spatial launch (BSL).

1. Are there national researchers?

Answer: Yes, based on the SCImago Journal & Country Rank report for the year 2013, Mexico ranks 28 internationally and the second in Latin America, after Brazil.

1. In Mexico, basic and applied scientific research is integrated systemically in the productive sector?

Answer: No, scientific research is stored mainly in educational institutions; unlike the developed countries that have systemically integrated the productive sector (Nelcy, 2009) based on their goals, objectives and market strategies.

 Based on the questions, it is determined that there is no TD in Mexico. since, for example, the Mexican satellites that cover the ITU assigned orbits are designed, built and launched in other countries; because the basic and applied scientific research has no connection with the productive sector of the country.

## Sub- phase 4. Proposal for the TD

It is necessary a State policy that systematically integrates basic and applied scientific research in the productive sector in Mexico, in order to avoid the failures that have occurred to date in the Mexican space policy.

The Mexican state as the regulator of the economy and the leader of national policy, correlated with the international one, can establish the policy of integrating scientific research into companies, as well as promoting public and private investment to found self-financing companies that generate wealth, which can be public, mixed, or private initiative, which integrate. systemically the basic and applied scientific research that allows the TD in order to provide efficient, fast, safe and cheap service that meets the demand of national and international users.

## Sub -phase 5. Mission, Vision, Values ​​and Objectives of the proposal Mission

The core of Mexican space policy must have deep social roots; promote social development, welfare, integration and national development. Interconnect with the national and international communications system to rationally provide space services.

Strengthen, through the TD, national security, technological infrastructure for the efficient coverage of communications in all regions of the country, as well as educational, ecological, cultural and social programs.

## Vision

Generate profitable companies that provide workers, professionals, researchers and graduates of the educational infrastructure of all areas of knowledge, the opportunity to participate in TD to reduce technological dependence and impact on the political, economic and social development of Mexico, achieving results through the rationalization of resources.

## Values

 Integrity. Act and communicate with responsibility, honesty and transparency inside and outside companies.

Aspiration. Act with passion and a sense of urgency, impose challenges and achieve goals and objectives in order to reduce political and social economic conflicts.
Human Resources. They are the backbone of organizations, for this reason should seek within the company the welfare of them: Natural resources. No company is justified but takes care of and improves the ecology and environment.

Sub phase 6. Strategies for the TD.

In a systemic approach, strategies are a means to achieve long-term objectives, from three to five years, and generally cause the transformation of the system. On the other hand, if the approach is for a continuous improvement of the system, the strategies can be short-term, that is, less than two years (Van Gigch, 2008).

 The strategies contemplate the strategic goals and objectives (Fred, 2008) for the development of the MSS, through its external and internal development. Strategies can be used to combine the strengths of opportunities (SO), which allow us to know the strengths of the SS to take advantage of the opportunities presented by the international community in the area of ​​space communications; as well as take into account the strengths against external threats with the combination of strength threats (ST). In the same way, the strategies corresponding to the combinations are obtained: opportunities weaknesses (OW) and threats weaknesses (TW) (David, 2008).

## Sub- phase 7.Strategic plan

In this sub- phase, the design of the strategic plan is proposed, which must be based on coherence, with all that has been shown in previous phases. The strategic plan for the TD, indicates how technological management should be carried out, that is, allows the Mexican State to implement decisions on policies, plans, programs, projects, etc. related to the creation, diffusion, transfer and use of technology.

## Sub- phase 8: Technological development

With this sub- phase we close our SM for the TD, that is, we perform the corresponding feedback by joining the TD phase (output) with the sub- phases.
1 and 2 corresponding to the analysis of the developments of the international and national space systems. At the end of the cycle we can modify each of the five phases that at the same time contain the eight sub-phases.

Fig. 1. Systemic Model for the Technological Development

**Validation of the SM for the TD**

Based on the SM for the TD, proposed in Fig. 1, we began to validate it, based on the concepts of the Wiener model (1948), the Mathematical Theory of Information of Shannon (1948) and the General Theory of Systems by Bertalanffy (1968).

 If we know the input (I) and the output (O) of a system, then we can design what is in the box represented by (B), Fig.1. The meaning of the box is that we do not know what exists within it, so model designers are free to propose infinite solutions as long as the output is the expected response, which in the case at hand, is the TD. beginning with the construction of a launch base-space in Mexico since the model can be applied to any particular system

**Conclusions**

Based on what has been described, this document concludes that achieving technological development in Mexico is essential to reduce the political, economic and social conflicts that are taking place in the country. It is feasible to have TD since there are all the resources such as higher education institutions, research centers, researchers.

 In order to achieve this, the Mexican State must carry out an effective and efficient reform that allows the integration of basic and applied scientific research in companies. In the case of space communications systems in Mexico, Mexican satellites that have provided communications services since 1985 to date were designed, built and launched in other countries because scientific research is not integrated into the productive sector.

The technological management for the Mexican space system is proposed to be based on the construction of a space launch base (SLB) that allows international competition, due to a better location, with respect to the USA, Russia, China, Japan, etc. due to the nearer proximity to the Ecuador; This situation has as a consequence, among other factors, satellite fuel savings, longer duration and useful payload as well as lower launch cost.

The SLB will bring as a consequence the foundation of satellite construction companies, mainly in the southeast area due to the convenience of avoiding the transport of satellites from faraway places, thus avoiding greater cost and deterioration of them, as well as companies that produce fuels and components for the TD of the MSS.

The satellite TD generates considerable income. The Association of the Satellite Industry (ASI), published its 17th report on the behaviour of the sector in 2013. The study conducted by Tauri Group, mentions that the growth of the satellite industry grew by 3% significantly both globally and in the US with revenues of 195.3 billion dollars in 2013. The industry grew by 3%, higher than the US economic growth of 2.8% and the global average of 2.4%. The satellites contribute 60% of the income of the space industry, 320,000 million dollars, and 4% percent of the income of the telecommunications industry that was five billion dollars.

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