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DEVELOPMENT OF THE SATELLITE PLATFORM QUETZAL FOR MONITORING THE POLLUTION EMISSION COLUMN AND THE REMOTE SENSING OF NATIONAL TERRITORY

Carlos Romo Fuentes, Ph.D., National Autonomous University of Mexico, Juriquilla, Querétaro, carlosrf@unam.mx
Jorge Alfredo Ferrer Pérez, Ph.D., National Autonomous University of Mexico, Juriquilla, Querétaro, jferrerp@unam.mx
Saúl Daniel Santillán Gutiérrez, Ph.D., National Autonomous University of Mexico, Juriquilla, Querétaro, saulsan@unam.mx
José Alberto Ramírez Aguilar, Ph.D., National Autonomous University of Mexico, Juriquilla, Querétaro, dulbet2000@yahoo.com
Rafael Guadalupe Chávez Moreno, M.Eng., National Autonomous University of Mexico, Juriquilla, Querétaro, rchavez@comunidad.unam.mx

Abstract

The project Quetzal was born for the need to have pollution monitoring for Mexican cities and Latin America territory in a daily basis. The project envisaged the development of a small satellite constellation for having more comprehensive information about pollution patterns in several cities of the region. The Project has been granted by the National Council of Science and Technology for a first stage of development. The funding has been used to obtained electronic equipment and instrumentation in order to integrate some of the satellite subsystems such as the attitude control, telecommunications and information handling and processing, as first proposals. The project not only has technical objectives but academicals as well, such as the integration of different groups of students at different levels, the creation of new subjects in academic programs, new infrastructure at the laboratories, the consolidation of the aerospace group in the High Technology Unit of the Engineering School of the University, at the Juriquilla Campus of the UNAM. As it is multidisciplinary project the efforts to gather and to identify the strengths in the different groups in the university has been a challenging labor for the collaboration not only in the UNAM but also there are colleagues in other institutions that would like to participate. The lessons learned and the first results of the project will be presented, as well as the efforts to establish the basic infrastructure we had to build in order to develop some of the subsystems, and the collaboration with the National Laboratory of Space and Automotive Engineering and the Thematic Network of Space Science and Technology of CONACYT.

Keywords: microsatellite, prototypes, subsystems, pollution, multidisciplinary, academic.

Acronyms/Abbreviations

CIDESI: Centro de Ingeniería y Desarrollo Industrial
CIATEQ: Centro de Tecnología Avanzada
CENAM: Centro Nacional de Metrología
CINVESTAV: Centro de Investigación y de Estudios Avanzados del IPN
UAT: Unidad de Alta Tecnología de la Facultad de Ingeniería de la UNAM
SAGARPA: Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación
SCT: Secretaría de Comunicaciones y Transportes
SEDENA: Secretaría de la Defensa Nacional
LPET: Space Propulsion and Thermo-vacuum Laboratory
EMC LAB: Electromagnetic Compatibility Laboratory
LNIEA: Laboratorio Nacional de Ingeniería Espacial y Automotriz
MIT: Massachusetts Institute of Technology
MISTI: MIT International Science and Technology Initiatives
RedCyTE: Thematic Network of Space Science and Technology of CONACYT.

1. Introduction

The satellite project Quetzal has the satellite mission of monitoring the pollution column over Latin American Cities and the photographing of national territory in the visible and infrared spectrum in an orbit of 700km approximately. This project is aligned with the National Plan of Space Activities and the use of images for civil protection of the Federal Government.

Technological independence will be addressed by putting together important and determined efforts from different academic and technological institutions in the country as CIDESI, CIATEQ, CENAM, CINVESTAV, UAT, etc., where the capabilities of each one will be used to develop different systems of the platform in

addition of promoting a strategy of partnership and cooperation between the members of the consortium.

The orbit designed to fulfill this mission covers, as number one priority, the national territory, which allows the satellite flight over the national territory and to have line of sight several times a day allowing communication links with the satellite to download important information in order to implement civil protection measures and activation of security protocols.

In addition, it is proposed to establish a relationship of international cooperation with different countries where the Quetzal satellite will orbit, aiming to make use of their earth stations, whereby the downloading of information increases, which will generate an international data network for the distribution and use of information acquired by the scientific instruments that are planned to place aboard the Mexican satellite platform.

The proposal is aligned with the policy of the Federal Government and works for the joint development of the national early warning system for civil protection[3,4]. As part of the work an important aspect is that information could flow safely to the agencies that make decisions about: SAGARPA, SCT, SEDENA, Mexican Navy, etc., as well as in government agencies and municipal ones.

The general objectives of the project are:

Design, construction, integration and performance testing of a satellite platform whose mission is to monitor the column particulate pollutants and remote sensing on national territory, which provide information for the definition of pollution sources on Earth and to help the establishment of public policies for mitigation and control of greenhouse gases on Mexico, for this goal some of the subsystems prototypes will be initiated and proposed.

Definition of space mission parameter considered as priority national territory coverage that provides the most passes and longer link to receive information on the ground.

1.1 Academic programs

Through the development of the satellite platform it is considered the study and research of the following areas related to the design, construction and operation of satellites, allowing the planning of seminars and courses for training and preparation of human resources in the UNAM:

• Methods for designing artificial satellites;
• Electromagnetic Compatibility Analysis of sub systems onboard satellites;
• Attitude determination and stabilization systems;
• telecommunications and telemetry systems;
• onboard data handling, process computer and software;
• power supply subsystems;
• Integration techniques of the satellite;
• thermal regulation systems;
• Operation of the satellite;
• certification flight tests of the satellite;
• Space Environment;
• Project management;
• Structural and mechanical interface with the launcher;
• Sustainability of the project (actions to take in the terminal phase of the satellite)

1.2 Development of State of the art facilities

The project supports the activities to develop space and ground infrastructure required to meet the space mission, dedicated to strengthening observation infrastructure of the country in environmental and civil protection.

As part of the Space Program of the UNAM, the different groups participated in other funding program to consolidate the National Laboratory for Space and Automotive Engineering in Mexico (LNIEA), in which, some of the installed infrastructure has the state of the art facilities to realize acceptance and certification space tests such as vibration test, electromagnetic compatibility test, thermal vacuum and thermal cycling tests, as well the ISO 5 clean room for electronic systems integration.

The prototypes realized are meant to be tested in this laboratories.

1.3. Mexican Space Agency collaboration

The support provided from the AEM consisted in the identification of companies that provide and distribute different components and electronics such as sensors and microcontrollers, solar panels, cells and batteries, epoxy materials and glues, shielding materials for high energy particles radiation.

For the other hand the Agency has given legal and regulatory support to obtain the corresponding permissions of frequency usage and operation of earth stations, due to the latest modification of the Telecommunications Laws in Mexico.

Another important aspect to remark is the collaboration programs that the Agency has with other countries, in order to stablish international cooperation within the project.[4]

2. Methods

To carry out the research project and the development of the satellite platform the procedures described in the Russian standard for space projects is being followed, such as GOST 2.103-68 / ST SEV 208-

75 [1], this standard can be resumed in the following stages:

Technical proposal – consists in the prototype analysis, patent research and marketing, training and analysis of alternative variants, report differences between two versions of one or satellite, selection of the parameters of construction and assembly, technical and economic analysis, definition of the relevant technical tasks to a technological proposal.

Sketch Project - consists of the physiognomic sketch of the product to build (working principles, application areas, measures and parameters of mass and energy consumption, cost effectiveness and resources), preparation and testing of models.

Technological project - involves the design documentation of the final version of the product and prototype development of the product.

Work project - is the generation of documentation for the preparation and testing of the flight version and the documentation for its production, correction of documentation from the test results of the acceptance testing of the flight version.

To be highly effective in developing the project, the work sequence is subject to constant feedback and communication between different developer subgroups, participation of project members will always be present during and at the time of generation and submission of proposals covering the restrictions and requirements established in the mission.

An important factor in the project is the collaboration stablished with the colleagues from the MIT, with whom the starting conception of the project was born, in 2010, through the MISTI Program at that institution.

The direct collaboration is with the Space Systems Laboratory and the Propulsion Laboratory. Academic exchanges, presentations and seminars were performed between groups. The colleagues from MIT shared their experiences in the field and showed how they applied the methodology presented in the SMAD in their projects[5].

The review of literature, documents and standards continues to be able to propose a methodology for space technology development in Mexico, which take into account the national political, financing, technological, commercial and academic status.

3. Results

Working and developing groups were defined according the main capabilities of the researchers, such as the EMC, Telecommunication, Thermal Control, Propulsion, Structures, Data Handling and Process groups were formed.

The definition of the main payload imposes the technical requirements of the secondary payload, in our case the prototypes of the designed subsystems were designed to be integrated using a modularity scheme, which allows to define different operation ranges in the technical characteristics of the prototypes.

The existing infrastructure responds the testing needs of this project and the testing protocols will be defined in the next stages, which will be an outstanding contribution to the testing procedures in the National Laboratory.

The implementation of the subsystems of the secondary payload has given the opportunity to project new equipment and tools in the laboratories, such as the development of the attitude control systems algorithm testing stand and flat table.

The establishment of new procedures in the laboratories that contemplate in advance the testing stages of the project has been a concurrent topic in the project.

Through this project several outcomes related with training high qualified young specialist from undergraduate up to postdoctoral researchers had been attained.

There has been participation in national initiatives for sharing the obtained knowledge through local references [8-9].

4. Discussion

Through this project many challenges have been vanquished, from the implementation of new methodologies and technics in the design process till the establishment of logistic procedures for delivery of components.

There has been a very interesting process to establish collaboration with other institutions, since there are many administrative mechanisms imposed in each one. The definition of commitments has been a critical and important issue solved in the deals with new partners.

The fact of not being attached to one type of structure neither a satellite platform has given the opportunity to skip many restrictions in the design process, but also knowing and studying the different models and types in the market provided ideas for innovation of subsystems.

The multitasking capabilities of each one of the colleagues in the project have been challenged to be involved in new fields of knowledge, such as legal sphere, international collaboration, components providing process, import/export acquisitions, delivery logistic administration, and not to be just in the engineering sphere. This situation is understandable for academic project leaders in the field.

Trusting in the work of the groups has been essential in the project, engineering process cannot be just a machinery process, the human relationships during the project has been a clue for the following stages.

5. Conclusions

In Mexico, the development of space technology is not just a follow the manual process, since there is no methodology that covers all economical disadvantages that an academic institution has. Moreover, it is the opportunity to create a Mexican design process to assure original designs in short time as a national integration standard.

This project fostered the development of crucial subsystems such as telecommunications, attitude control, structure, thermal control, propulsion, as well as earth segment facility, more over the project represented the angular stone to design and integrate precertification state of the art facility in Mexico, as well the development of techniques never before implemented in the country for academic purposes.

In addition, the project is part of a paramount effort done by the AEM to create original space missions designed, integrated and tested in the country by Mexican specialists.

This is part of the new worldwide paradigm to build low cost satellites equivalent to those biggest mission which consider high investment of resources and long time period for development.

Finally, it is clear that this project is not only a technical initiative, but also is been translated as several assets to impact nationwide aerospace field in Mexico.

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