SABIA-MAR

Phase A Final Report

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CONAE & AEB/INPE

INDEX

1. INTRODUCTION

1.1. OBJECTIVE

The purpose of this report is to present a summary of the results obtained at the end of the Phase-A of SABIA-Mar Project.

The output of this document should be used as the final document on the Conceptual Desing phase of the development.

1.2. SCOPE

This note sets forth the high level summary of the programmatics and technical aspects developed during the Conceptual Design and Feasibility Phase of the SABIA-Mar Project.

1.3. APPLICABLE DOCUMENTS

- SB-0101-PL-00200-A SABIA-Mar Mission Concept Feasibility working plan draft v5
- SB-040000-RQ-00100-A Initial Mission Requirements & Scenarios
- SB-010100-PL-00200-A Mission Concept and Feasibility Phase – Working Plan
- Top Level Schedule SABIA-Mar
- SB-010500-CR-00100-A Integrated Project Schedule
- SB-030100-PL-00100-A CONFIGURATION MANAGEMENT PLAN vA
- SB-030100-PL-00200-A REVEW PLAN vA
- SB-0101-PL-00100-A SABIAMAR Model Philosophy Plan
- SB-010100-PL-00300 Preliminary Definition Phase B Working Plan
- SABIAMAR Initial Mission Summary
- SB-020200-DS-00100-A Preliminary System Concept
- SB-090200-NT-00100-A Preliminary Technical Budget
- SB-050200-RQ-00100-A Payload Module System Requeriment
- SB-020200-NT-00100-B Mission Analysis & Scenarios
- SB-020200-SP-00100-B SABIA-MAR Preliminary Orbit Specification
- SB-020200-PL-00100-A ORBIT DETERMINATION AND MAINTENANCE PLAN
- SB-020100-LI-00100-A SABIA-MAR PRELIMINARY PROJECT DOCUMENT LIST
- SB-030200-PL-00100-A SYSTEMS SAFETY PLAN vA
- SB-030000-RQ-00100-A SABIA-Mar Safety And Product Assurance Requirements
- SB-030100-PL-00100-A MISSION ASSURANCE PLAN vA
- SB-030500-PL-00100-A EEE PARTS CONTROL PLAN vA
- SB-030500-PL-00200-A MATERIALS & PROCESSES CONTROL PLAN vA
- SB-030600-PL-00100-A CONTAMINATION CONTROL PLAN vA
- SB-040000-RQ-00100-C Preliminary Mission Requirement and Scenarios
- SB-050401-DS-00200-A Payload Module - Structure - Conceptual Design
- SB-050401-DS-00100-A Payload Module - Thermal Control - Conceptual Design
- SB-050403-NT-00200-A SABIAMAR_DDL_ConcDesign
- SB-050403-NT-00100-A Payload Module On-board Computer Conceptual Design

- SB-050400-DS-00100-A Cameras Conceptual Design – Primary & Secondary Cameras
- SB-050407-RQ-00100-A Payload Data Collection Subsystem-rev final
- SB-060200-DS-00100-A Service Module - Preliminary Design
- SB-060500-IC-00100-A MMP Performance and Interface Description
- SB-060500-DS-00100-A Service Module - Preliminary Design
- SB-060404-DS-00100-A Service Module - Power Supply Subsystem - Preliminary Design
- SB-060405-DS-00100-A Service Module - ACDH - Preliminary Design
- SB-060407-DS-00100-A Service Module - TTC - Preliminary Design
- SB-060402-DS-00100-A Service Module - Thermal - Preliminary Design
- SB-060401-DS-00100-A Service Module - Structure - Preliminary Design
- SB-070100-LI-00100-A Launch Vehicles Information Summary
- SB-080000-RQ-00100-A Ground System Functional Requirements
- SB-080200-NT-00100-A Mission Operations Concept
- SB-080300-RQ-00100-A Mission Center Preliminary Requirements
- SB-080300-RQ-00400-A Control Center Preliminary Requirements
- SB-080300-RQ-00200-A TT&C Stations Preliminary Requirements
- SB-080300-RQ-00300-A Payload Station Preliminary Requirements
- SB-080300-NT-00100-A SEGMENTO TERRENO SABIA-MAR ANTENA DE 13M Y ANTENA DE 7M
- SB-090300-PL-00100-A SABIA-Mar Preliminary ATLO Plan

1.4. ACHRONISMS LIST

AD	Applicable Document
AEB	Brazilian Space Agency
CBE	Current Best Estimated
CBERS	China-Brazil Earth Resources Satellite
CCSDS	Consultative Committee for Space Data Systems
CONAE	Comisión Nacional de Actividades Espaciales
CstScen	Coastal & In-land waters Scenario
DCS	Data Collection System (Instrument)
DDL	Payload Module Data Downlink Subsystem
DVM	Design Verification Matrix
FEM	Finite Element Model
FOV	Field Of View
GlbScen	Global Scennario
HSC	High Sensitivity Panchromatic Camera
HRTPC	High Resolution Technological Panchromatic Camera
ICD	Interface Control Drawing
IDS	Interface Data Sheet
INPE	Instituto de Pesquisas Espaciais
LIT	Laboratorio de Integracao y Testes
LV	Launch Vehicle
MAC	Multi-Angle Camera
MMP	Multi Mission Platform
MODIS	
MUS	Multispectral Instrument or Camera

NIR-SWIR	Multispectral Camera covering near and short wave infrared spectral bands
OBC	Payload Module On-Board Computer // Central Electronics
PF	Proto Flight Model
PL	Payload Module
RD	Reference Documents
S/S	Subsystem
SAOCOM	L-band SAR Satellite Mission
SAC	Scientific Applications Satellite
SCD	Data Collect Satellite
Sea-WiFS	
SM	Service Module
SSR	Payload Module Solid State Recorder
TBC	To Be Confirmed
TBD	To Be Defined
TIR	Thermal Camera
UV-VIS	Camera Multispectral covering from the ultra-violet to near infrared, passing thru Visible spectral bands

2. GENERAL OVERVIEW

2.1. BACKGROUND

The Argentinean National Commission on Space Activities (CONAE), the Brazilian Space Agency (AEB), and the Brazilian National Space Development Institute (INPE), are jointly developing the SABIAMAR mission in the framework of a space cooperation program between CONAE & AEB.
Founded in 1994, the Brazilian National Space Agency (AEB) is today under the Ministry of Science, Technology and Innovation, and performs the function of the coordinator and supervisor of all the country's space activities. The Brazilian National Institute for Space Research (INPE) is also under the Ministry of Science, Technology and Innovation, and its space activities in general are coordinated and supervised by AEB. The two Brazilian data collecting satellites (SCD-1 and SCD-2), both developed by INPE under the coordination of AEB, were launched, respectively in 1993 and 1998, from Cape Canaveral, in Florida, USA. AEB and INPE are responsible for the Brazilian participation in the China-Brazil Earth Resources Satellite Program (CBERS), which has already launched the CBERS-1 (1999), CBERS-2 (2003) and CBERS-2B (2007), and plans to launch CBERS-3 later this year. AEB and INPE are also involved, in technical level, in the Brazilian Project of the Geostationary Satellite for Defense and Strategic Communications (SGDC) under the Brazilian public-private company named Visiona Tecnologia Espacial S. A., acting as prime contractor. AEB and INPE are equally responsible for the Brazilian participation in the present SABIA-Mar Project, among other ones.

CONAE, the Argentine National Commission on Space Activities, depends on the Planning Ministry. As the Argentine Space Agency, CONAE is in charge of the development of all major Argentine satellite programs. The first one, SAC-B, was launched in November 1996. A technological satellite, SAC-A, was successfully launched as a secondary payload aboard the Space Shuttle on November 1998. The third Satellite Program, SAC-C, for Earth observation was successfully launched by a Delta II rocket on November 2000 and is still in orbit. The fourth Satellite Program, SAC-D/Aquarius, for Earth observation was successfully launched by a Delta II rocket on June 2011, and performing in-orbit according to the specifications up to know. Additional satellite programs such as SAOCOM-1A & 1-B, SAOCOM-2A & 2-B, and SARE are foreseen for the future, following the guidelines of the Argentine National Space Program.

2.2. PROGRAM HISTORY

The SABIA-Mar Project is being developed based in the Government to Government Agreement for Cooperation in Space Technologies, signed between Argentina and Brazil on April 9th 1996.
The SABIA-Mar Project specifics background could be summarized as follows:

- February 22nd 2008: Highlights on the strategic of the space cooperation between both countries – Decision to proceed with a satellite mission for coastal and global ocean monitoring.
- October 22nd 2009: Instructions for both countries governmental offices and space agencies to identify specific funding sources for the development.

- April 16th 2010: Elaboration of the Project´s basic science requirements, budget estimates
- November 9th 2010: High level roles distribution between both countries
- February 22nd 2012: Agreement on the mission initial science requirements
- November 15th 2012: Formal start of the Feasibility Phase and a Joint Working Group was established.

2.3. MISSION OVERVIEW

Ocean color satellite low and medium resolution data are used to study globally and regionally the ocean's biosphere, its changes in time and how it is affected by and responds to anthropogenic activities. Satellite "ocean color" sensors are necessary to detect and quantify trends in global ocean biogeochemical properties from seasonal to decadal time scales. Half of the Earth’s primary production occurs in the ocean. Ocean color data are a key variable for estimating phytoplankton primary production, which in turn is related to the uptake of carbon dioxide. Quality controlled ocean color observations have also important applications such as monitoring changes in water quality, following coastal sediment transport (erosion), detecting harmful algal blooms, supporting sustainable fisheries and aquiculture activities. These applications are relevant to studies of ocean ecosystems, carbon cycling, marine habitats mapping and coastal hazards.

Climate change studies require continuous and long time series of ocean properties. An analysis of present and scheduled ocean color missions reveals a possible gap in the data from 2015 thru 2019. This data gap is a serious concern in the international community of users of ocean color information. The SABIA-MAR ocean color mission will be an important data provider for the referred period. Besides the contribution to Argentinean and Brazilian regional studies, this mission will benefit the international community.

Apart from chlorophyll concentration other products shall be considered such as photo synthetically active radiation (PAR), fluorescence line height, suspended sediment concentration, light attenuation coefficient, sea surface temperature, among others.

To accomplish the application areas with the requirements imposed by the users, the main instruments on-board SABIA-MAR Satellite/s shall have the capability of observing:

a) Global ocean with low resolution 1 km with a daily revisit, with on board recording capability.

b) Regional coastal and in-land waters area with medium resolution, 200 meters, with four days revisit, real time data; with on board capability recording under specific requirement.

Besides the primary mission previously defined, and depending on available resources on-board (power, mass, volume, storage, data transmission capabilities), the Payload of the satellite should consider other instruments:

- Data Collection System (DCS)
- Multi-Angle Multispectral Camera (MAC)
- High Resolution Technological Panchromatic Camera (HRTPC)

- High Sensitivity Camera (HSC)

In order to take maximum advantage of the resources already established for other missions, the optical sensors of SABIA-MAR will preferably employ compatible spectral bands as established for the Sea-WiFS and MODIS sensor Programs.

The SABIA-MAR Mission concept will take the maximum possible advantage of the previous Argentinean and Brazilian developments.

Besides the observational requirements [Global and Coastal/In-land waters scenarios] the SABIA-Mar mission must use the already developed Multi-Mission Platform for the spacecraft bus, leading constraints in volume, mass, power consumption, and power supply & TM/TC, for the Payload Module equipment.

The Project has finished Phase A at the current date, the Conceptual Design and Feasibility Analyses Phase. Analyses performed during this phase and constraints have demonstrated that two satellites will be required to fulfill with the mission requirements.

Another result obtained at the end of Phase A is that both satellites must follow a Modular Architecture Development, that means the Service Module, under Brazilian responsibilities, and the Payload Module, under Argentinean responsibilities, must follow a close to a parallel development, simplifying interfaces and interactions in order to maintain low development risks @ reasonable cost.

The first of these two satellites is targeted for launch by mid-2018 timeframe, while the second one will be launched about 1 year later, both satellites designed for a five-year mission. The launch services provider was not selected and defined at this stage of the development, but the very preliminary concept of both satellites consider the envelope of the corresponding constraints (dimensions, mass, environments) imposed by several “small class” launch vehicles (LEOLINK-LK2, ROCKOT, PSLV, VEGA, TAURUS, DELTA II, and other possible launchers)

The satellite mission is specifically designed to provide daily global ocean and also daily coastal and in-land waters monitoring and measurements. Multispectral cameras will be implemented as the main instruments to accomplish with the primary mission objectives. The following figure depicts both scenarios showing the two satellites that require to be injected in in the same orbit, 180º one from each other (to fulfill the required 1 day revisit time).

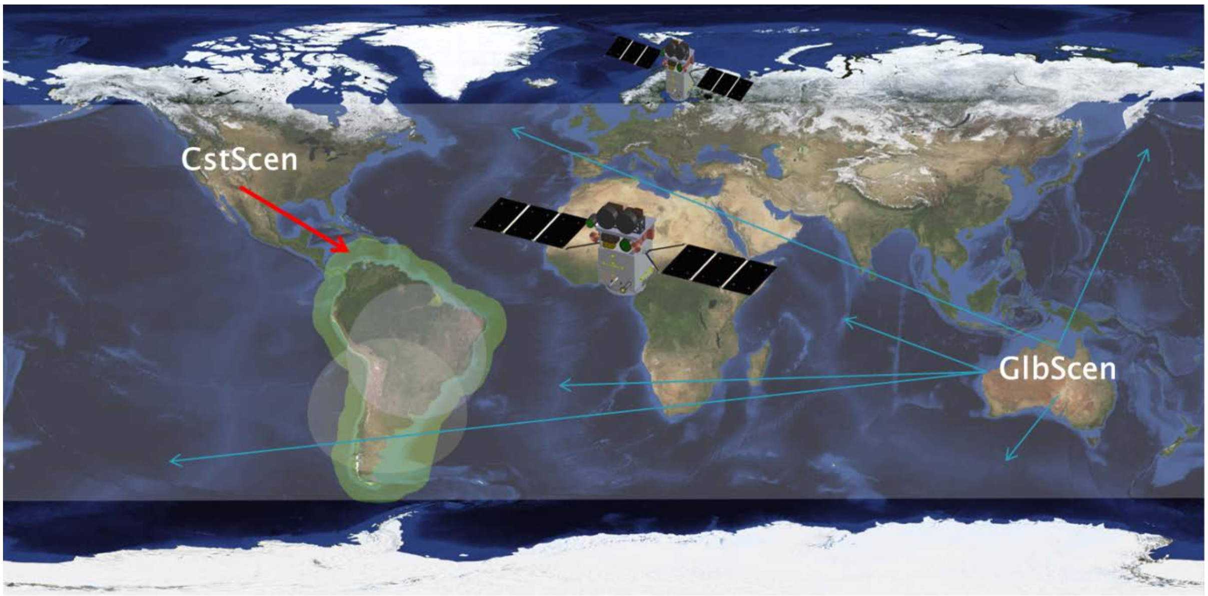


Figure 1 – Mission Scenarios – Global (GlbScen) & Coastal and In-land waters (CstScen)

The Phase A output resulted in the following bands to be implemented for the main instrument on board each SABIA-Mar satellite, covering from the ultra-violet to the thermal bands, passing thru visible, near and short wave infrared spectra:

Band	Wave length [nm]	Bandwidth [nm]	Band	Wave length [nm]	Bandwidth [nm]
B0	380	15	B10	750	10
B1	412	10	B11	765	10
B2	443	10	B12	865	20
B3	490	10	B13	1044	20
B4	531	10	B14	1240	20
B5	555	10	B15	1640	20
B6	620	10	B16	10800	900
B7	665	10	B17	11800	900
B8	680	7.5			
B9	710	10			

Figure 2 – Main Instruments Multispectral bands

2.4. MISSION PRELIMINARY MAIN PARAMETERS

Orbit:	circular-645 km, sun synchronous
	@ 11:45 pm, ascending node
Satellite/s:	Mass ~ 680 kg each satellite
	CONAE contributes with the Payload Module
	AEB/INPE contributes with the Service Module (Multi-mission Platform).
Attitude & Orbit Control:	Three axis stabilized, nadir pointing; maneuvering
	thrusters.
Dimensions (launch configuration):	Ø 2 m height ~ 2.2 m
Communications:	S Band Up and Downlink, X Band Data Downlink
Operational Life:	5 years
Launch Date:	Targeted Launch – Mid-2018 SABIAMAR-1
	Targeted Launch – Mid-2019 SABIAMAR-2
Launch Vehicle:	Not yet defined-decided. Several possibilities
Launch Site:	Depending on the selected launch vehicle.

2.5. SABIA-MAR SATELLITES CONFIGURATION

The SABIA-MAR spacecraft will be designed in a modular approach.

It shall entail the simplest interfaces between the two constituting modules, the Payload and Service Bus Modules.

The Implementation plan for the mission must consider the development in a quasi-simultaneously scheme of both, Payload and Service Modules.

2.6. SABIA-MAR TEAM PARTNERS

SABIAMAR is an international partnership mission. Including the following space Agencies:

- CONAE (Comisión Nacional de Actividades Espaciales – Argentina)
- AEB (Agencia Espacial Brasileira – Brazil)
- INPE (Instituto de Pesquisas Espaciais - Brazil)
- Space Industry from both, Argentina and Brazil

2.7. MISSION DEVELOPMENT

AEB and CONAE are jointly developing the SABIA-Mar Mission comprising two satellites. The whole program, comprising space, ground and application segments, is currently finishing the Feasibility Study Phase (Phase A), which started in the beginning of 2013.

For the joint mission, in general, AEB is providing the SABIAMAR Spacecraft Bus and additional science instruments, while CONAE provides the SABIAMAR Payload Module and additional satellite equipment. Both partners will procure for the launch services for the mission satellites. The satellites, once in orbit, will be jointly controlled and managed from the already available Ground Stations located in both countries.

For both SABIA-Mar-1 and SABIA-Mar-2 satellites, the Spacecraft Bus will be integrated and functional-environmentally tested (to certain extent) at LIT (Laboratório de Integração e Testes - Instituto de Pesquisas Espaciais) in Brazil, while the Payload Module will be integrated and functional-environmentally tested (to certain extent) at CONAE Facilities in the province of Córdoba, Argentina.

For SABIA-Mar-1, and once verified, the Payload Module will be shipped from Argentina to Sao José dos Campos in Brazil (LIT) for the satellite integration there. After completion of all functional and environmental tests at satellite level, the Satellite and the associated Ground Support Equipment will be shipped from Sao Jose dos Campos to the Launch Base. The final satellite checkout and preparations before integration to the launch vehicle will take place in the stand alone processing facilities at the launch base.

For SABIA-Mar-2, and once verified, the Service Module will be shipped from Brazil to Argentina for the satellite integration and tests there. After completion of all functional and environmental tests at satellite level, the Satellite and the associated Ground Support Equipment will be shipped to the Launch Base. The final satellite checkout and preparations before integration to the launch vehicle will take place in the stand alone processing facilities at the launch base.

2.8. CONCEPTUAL DESIGN & FEASIBILITY PHASE OUTPUTS – PHASE A OUTPUTS

During the development of the Project Phase A, the distribution of responsibilities between both partners was worked out achieving a final agreement for the project development. Paragraph 2.1 contains the details of the distribution of roles and responsibilities between both agencies.

Figure 3 presents the 1st level of the Work-Breakdown Structure established at the beginning of Phase A

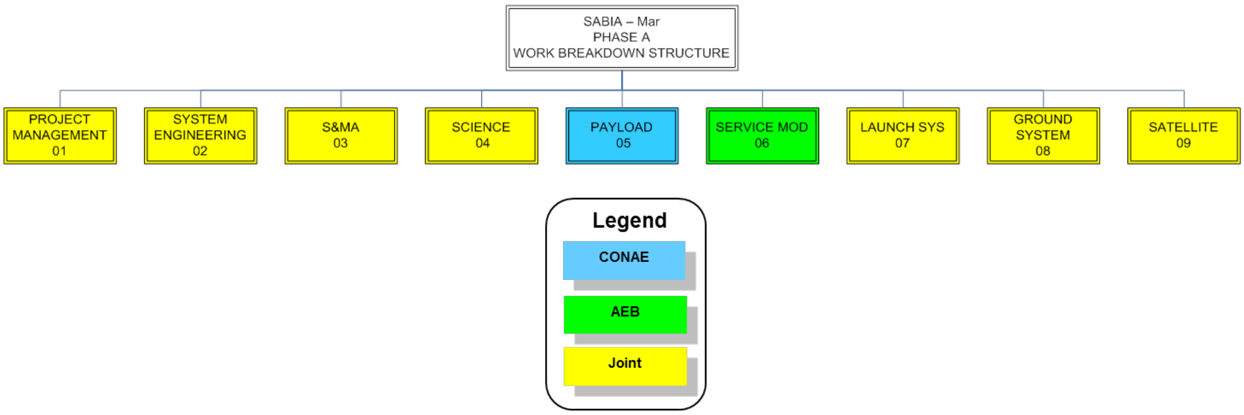


Figure 3 – Phase A Work Breakdown Structure

The following paragraphs of this report summarize the outputs obtained during the development of the Project Phase A, which taked place during 2013.

These results were compiled and documented according to the following table. These documents were grouped following the Project high level WBS created during this phase, as denoted in the table

AREA	DOCUMENT
Project Management	Mission Concept and Feasibility Phase Working Plan
	Project Integrated Schedule
	Mission Cost Evaluation
	Configuration management plan
	Mission Review Plan
	Preliminary Design (Phase B) Working Plan
	Models Philosophy
	Phase A Final Report
System Engineering	Initial System concept
	Preliminary System concept
	Preliminary Technical Budgets
	Payload Module System Requirements
	Preliminary Mission Plan
	Orbit Specification
	Orbital Determination and Maintenance Plan
	Preliminary Project Document List
Safety & Mission Assurance	System Safety Plan
	Preliminary Safety & Product Assurance Requirements
	Preliminary Mission Assurance Plan
	Preliminary EEE Parts Control Plan
	Preliminary Materials & Process Control Plan
	List of Critical Items
	Preliminary Contamination Control Plan
Science	Initial Science Requirements
	Phase A final Science Requirements
Payload Module	Structure Concept Design
	Thermal Control Concept Design
	Data Transmission Concept Design
	On Board Processing Concept Design
	Main Instrument Concept Design
	DCS Concept Design
Service Module	Preliminary Service Module Concept
	MMP Performances and Interfaces Description
	MMP Preliminary Design for SABIA-Mar
	Power Subsystem Preliminary concept
	Attitude Determination & Control Preliminary concept
	Propulsion control Preliminary concept
	C&DH Preliminary concept
	TT&C Preliminary concept
	Thermal Control Preliminary concept
	StructurePreliminary Concept
Launch System	Launch System Concept - Phase A
	Launch System - Letter to contact providers
Ground System	Ground System Functional Requirements
	Operations Concept
	Mission Processing & Archiving Center Prelim Rqmts
	Control Center Preliminary Requirments
	TT&C Stations Preliminary Requirements

	Payload Data Receiving Stations Prelim Rqmts
	Falda del Carmen Ground Station Characteristics
Satellite I&T	Preliminary ATLO Plan

Table 1 –Issued Documents during Phase A

3. PROGRAMATICS

3.1. PROJECT ORGANIZATION

The members of each organizational structure of the Program, nominated by both sides, shall establish its operational mechanism and liaison points.

To preserve the duality of the Argentina-Brazil joint development, the three levels of the SABIA-MAR Program organization structure contain the same number of members from each side, with the same decision authority; according to the structure define hereby.

The organizational chart for the Phase A is depicted in the following figure, and the organization planned for the following Phase B in Figure 5.

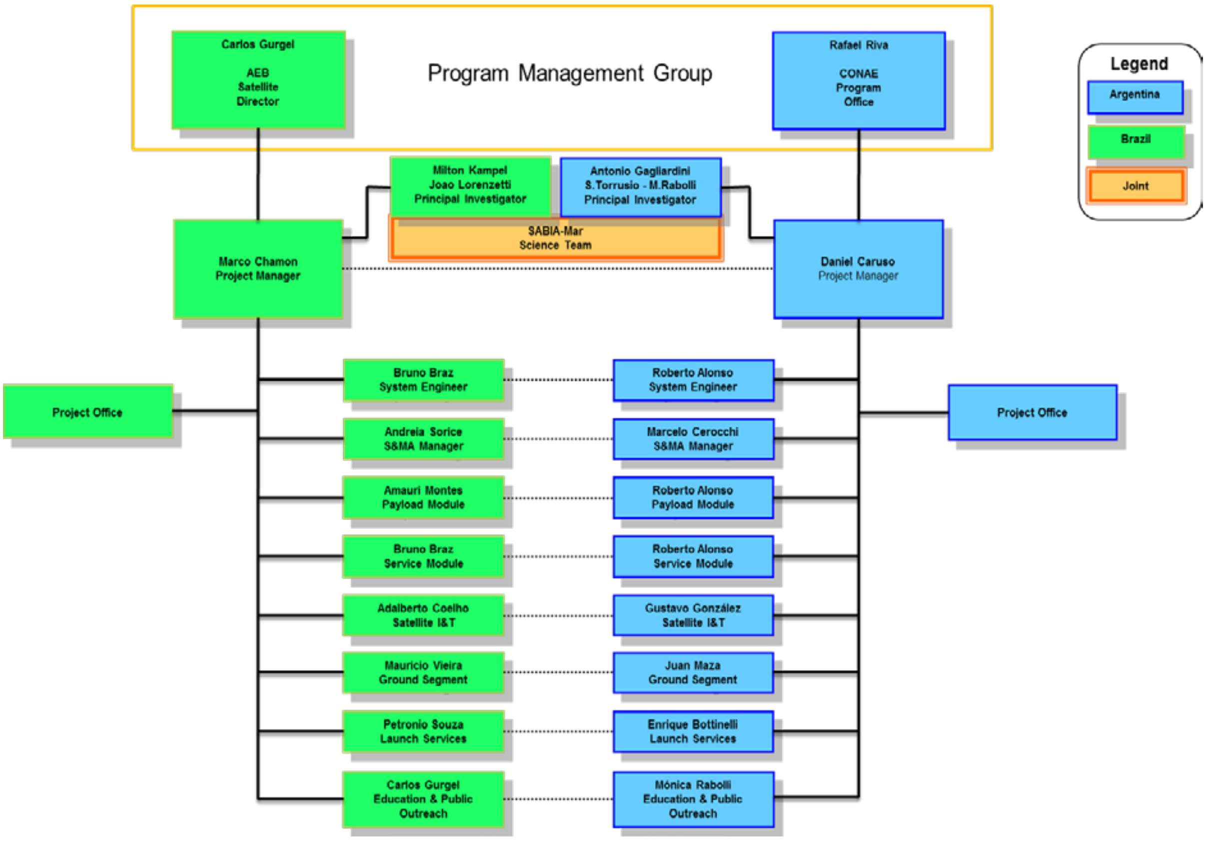


Figure 4 – Phase A Organizational Chart

3.1.1. SABIA-MAR COORDINATION COMMISSION (SCC)

The SABIA-MAR Coordination Commission is the highest decision maker authority for all SABIA-MAR Program subjects. The members of this Commission, from the Brazilian side are designated by AEB and INPE, and from the Argentinean side, by CONAE.

The main tasks of the SABIA-MAR Coordination Committee are:

- To establish the long term Program objectives;
- To establish the overall policies for the application of the SABIA-MAR products;
- To advise the government from both sides on the development of the Program guidelines;
- To resolve conflicts in the context of the SABIA-MAR Program;
- To analyze the progress reports issued by the Program Management Group or Joint Programa Committee (JPC)

3.1.2. SABIA-MAR PROGRAM MANAGEMENT GROUP OR JOINT PROGRAM (JPC)

The JPC coordinates the actions of the four segments of the SABIA-MAR project.

The composition of the JPC is as follows:

- The Chairman of JPC, nominated by, from the Argentinean side, CONAE, and, from the Brazilian side, AEB and INPE;
- Other members nominated, from the Argentinean side, by CONAE, and, from the Brazilian side, AEB and INPE.

The main tasks of the JPC are:

- Working out the budget requirement, the master schedule, planning and work share of SABIA-MAR;
- Managing the development and coordinate the solution of technical problems of SABIA-MAR;
- Coordinating the activities of the four segments of SABIA-MAR: space segment; ground segment; launch services; and applications segment;
- Reporting the progress of SABIA-MAR to the SCC.

3.1.3. PROJECT GROUPS

Each segment of the SABIA-MAR Program will be jointly managed between both partners.

For Satellite & Modules Development the main tasks are:

- The coordination of the establishment of the satellite system and subsystems specifications;

- The coordination of the satellite equipment and subsystems development;
- The coordination of the definition of the satellite interfaces with the other segments of the project;
- The coordination of the project design reviews;
- The coordination of the assembly, integration and test of the satellite;
- The coordination of the project development plan and schedule;
- The enforcement of the product assurance plan;
- The coordination of the contracts signed between the two Parties;
- The issuing of Interface Document between the Space Segment and Ground Image Receiving Station;
- To report the work progress to JPC;
- To implement the project policies issued by the JPC.

For Science Applications the main tasks are:

- Establishment of the image processing software specifications;
- The development of application software and value added products for the SABIA-MAR images;
- To propose marketing and distribution policies for the SABIA-MAR images;
- To report the work progress to JPC;
- To implement the project policies issued by the JPC.

For Ground Segment the main tasks are:

- Establishment of the Mission Centers, Control Centers, TT&C stations and Processing Facilities specifications;
- Issuing the satellite operation handbook;
- The evaluation of the in-orbit status of the satellite;
- The implementation of the joint control and application plan of the satellite;
- The coordination of the satellite to ground TT&C compatibility test;
- To coordinate the user requests for operation of the satellite cameras;
- To report the work progress to JPC;
- To implement the project policies issued by the JPC.

For Launch Services the main tasks are:

- To present launch services candidates for approval from Project Managers and JPC

- Establishment of the satellite interfaces with the launching vehicle;
- Establishment of the launching operation plans;
- To report the work progress to JPC;
- To implement the project policies issued by the JPC.

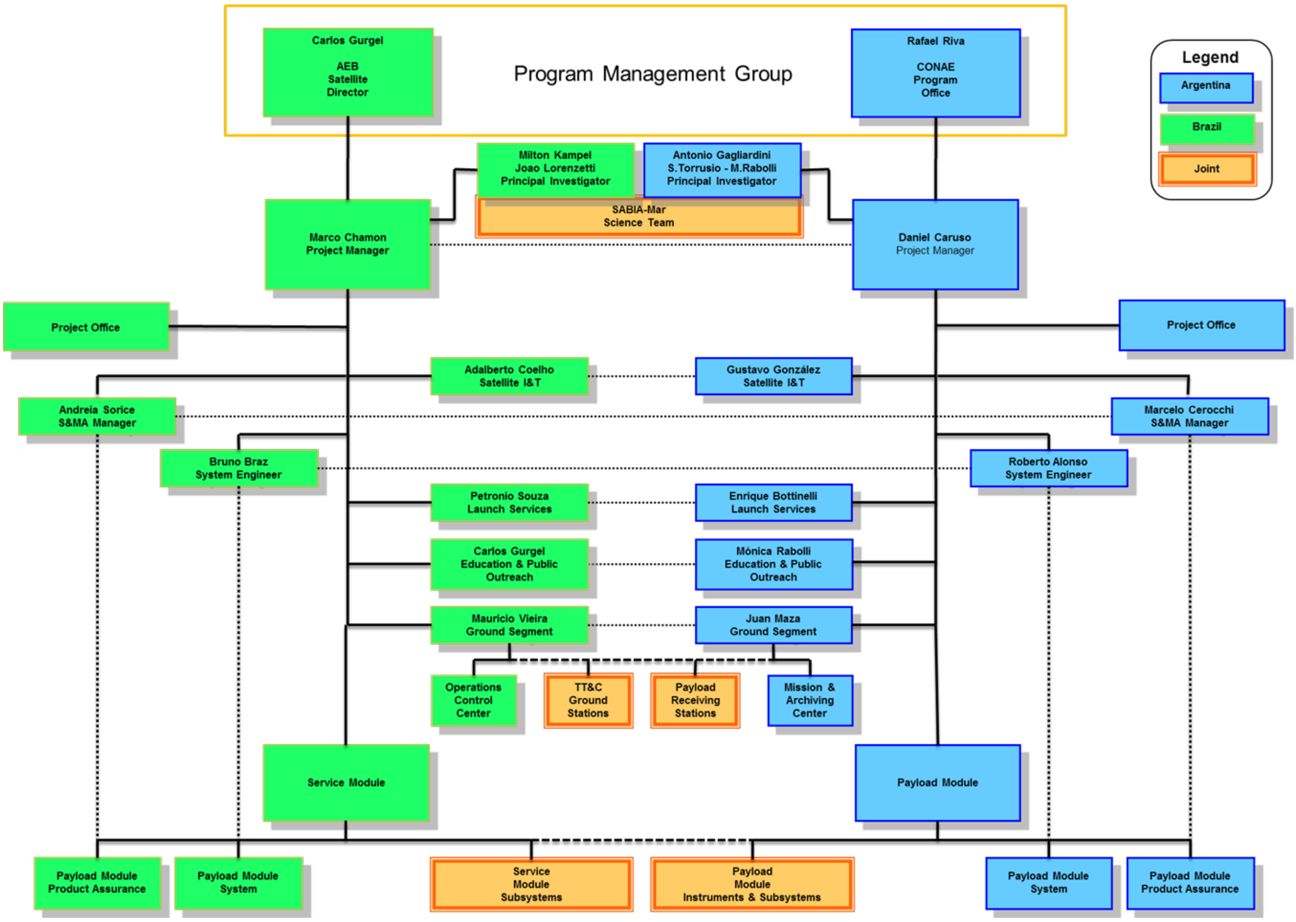


Figure 5 – Phase B Planned Organizational Chart

3.2. SCHEDULE – PROJECT PHASES

Other of the tasks of Phase A was the estimation of the integrated development schedule. The following figure shows the Top Level SABIA-Mar Schedule

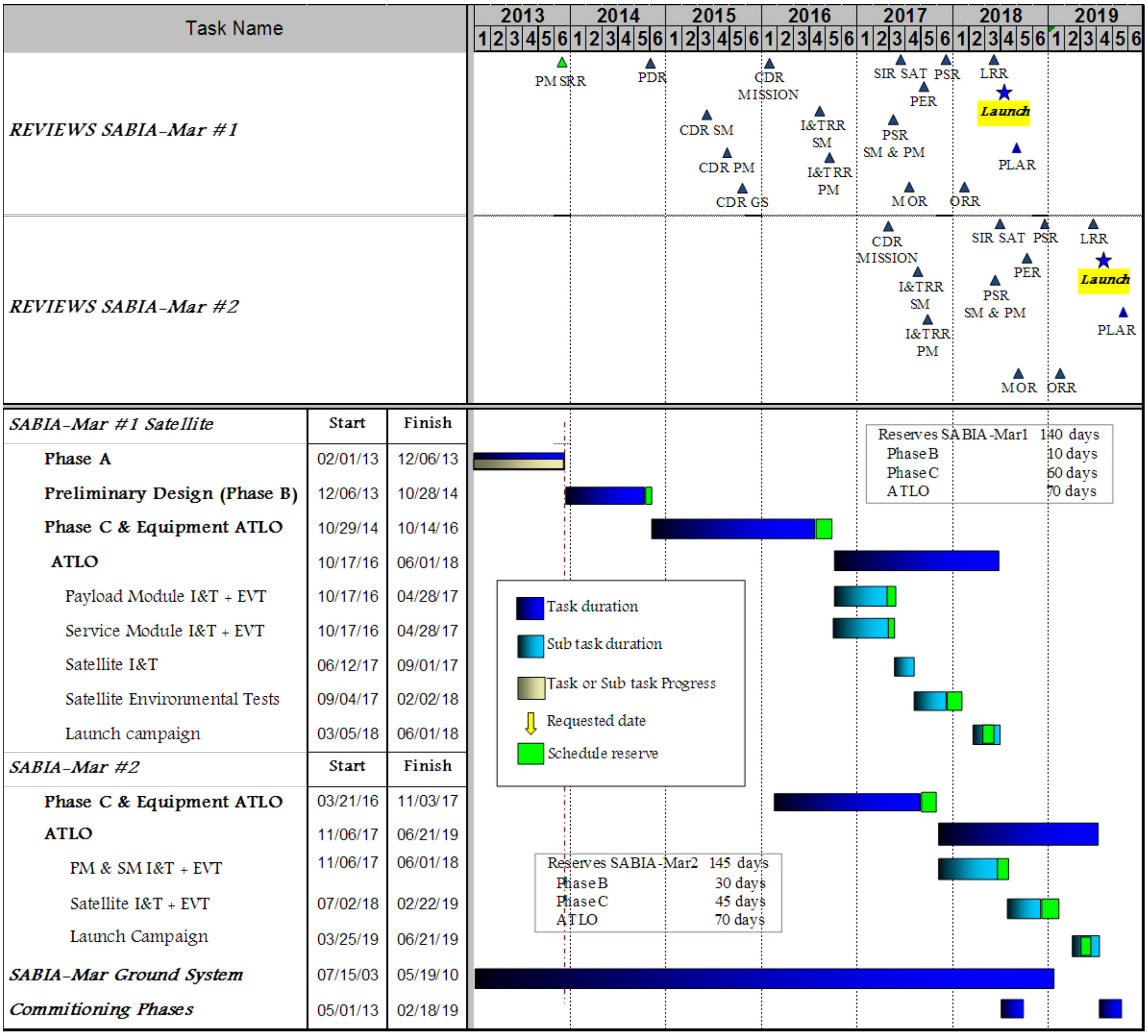


Figure 6 – Project Integrated Top Level Schedule

The development of the SABIA-MAR Program will be carried out in five distinct phases, with content as defined by ESA standard ECSS-M-30A:

- Phase A: Mission Concept and Feasibility
- Phase B: Project Definition – Preliminary Design
- Phase C: Project Development – Detailed Design
- Phase D: Production (Assembly, Test, Launch Operations) – ATLO
- Phase E: Utilization

3.2.1. PHASE A – MISSION CONCEPT AND FEASIBILITY

The aim of Phase A is to establish the Mission Concept, its requirements and feasibility. Phase A documentation will include all project management data.

The main tasks of the SABIA-MAR mission Phase A are:

- Mission definition and characterization in terms of requirements and performances
- Operation environment and its impacts definition
- Project alternative concepts evaluation
- Preliminary project management parameters establishment - organization, cost, work share, schedule, product assurance
- Project critical elements/functions identification

Phase A concluded with a Preliminary Mission Concept and System Requirements Review (PMSRR) and a Phase A Final Report (the present document), and the approval of a Joint Program Committee (JPC), or Program Management Group.

3.2.2. PHASE B – PROJECT DEFINITION, PRELIMINARY DESIGN

Phase B aims at establishing the system configuration and its complete technical specification.

The main tasks of the SABIA-MAR mission Phase B are:

- Mission objectives and user requirements
- System and subsystems configuration and technical specifications
- Requirements for the space and mechanical environmental tests and simulations
- Product assurance plan, quality control and reliability
- Updated project organization, cost, work share and schedule
- Development flow chart for Phases C and D

Phase B will be concluded with a Preliminary Design Review (PDR) and a Phase B Final Report, and the approval of a Joint Program Committee (JPC) or Program Management Group.

3.2.3. PHASE C: PROJECT DEVELOPMENT – DETAILED DESIGN

The main tasks of the SABIA-MAR Mission Phase C are:

- To complete the detailed definition of all system components at space, ground and applications segments.
- To allow a definitive “make or buy” decision for all subsystem equipment
- To start the configuration control for all the project documentation

Phase C will be concluded with a Critical Design Review (CDR) and a Phase C Final Report, and the approval by the Joint Program Committee (JPC) or Program Management Group.

3.2.4. PHASE D: PRODUCTION (ASSEMBLY, TEST, LAUNCH OPERATIONS) – ATLO

Phase D will be devoted for:

- To freeze all system and equipment configurations and specifications
- To manufacture and test all SABIA-MAR satellite equipment, accounting for qualification, flight and spare models.
- To integrate the modules and the satellite, test them, and process at the launch base in preparation for launch, and launch the satellite.

Phase D will be concluded with a Flight Readiness Review (Acceptance Review) and a Phase D Final Report, and with the corresponding launch of the Satellite.

3.2.5. PHASE E: UTILIZATION

During Phase E, the satellite will be firstly checked for both, Payload and Service Modules (IOC), the final required orbit must be acquired (correction of the probable injection errors during launch), and operate the Satellite in orbit, performing data downloads, satellite state-of-health activities, calibration, image quality tests, deliver obtained and processed data to users, etc.

Then, the main tasks of this Phase will be:

- Satellite in orbit test (IOT) for both payload and platform modules
- Mission management from orbit injection to the final operational orbit accomplishment
- Availability of system and resources required to fulfill its operational mission
- Perform image quality test
- Deliver the obtained and processed data to the users

Phase E will be concluded after the in-orbit life time conclusion and a Phase E Final Report preparation and the approval by the Joint Program Committee (JPC) or Program Management Group.

3.3. DETAILS OF THE CONAE/AEB ROLES AND RESPONSIBILITIES

Responsibilities and Tasks Distribution between both Agencies was a task developed during the Phase A

The agreed distribution is based on three aspects:

- Programmatic considerations about each Agency interest as part of their institutional and industrial development
- Technical considerations to minimize the complexity of the required designs, and future implementations / verification tests-analyses
- Budgetary considerations in order to balance the contribution from each Agency

At Programmatic Level joint groups are foreseen during the entire development

- Joint Program Management Group
- Joint SABIA-Mar Science Management Plan development
- Joint SABIA-Mar Project Management
- Joint SABIA-Mar Systems Engineering Team
- Joint SABIA-Mar Mission Assurance Team
- Joint Project Implementation Plan development
- Joint Integrated Schedule development
- Joint Review Team

For Science & Applications Segment Level, CONAE & AEB share the responsibilities for all tasks related to this segment:

- Algorithms development
- Support workshops
- Calibration & Validation: plan and execution
- Data processing and analysis
- Users development
- And all other related activities

At Ground System & Mission Operations Level

- Joint Ground Segment Management and System Engineering
- AEB will be responsible to update & operate CUIABA Ground Station (according to the SABIA-Mar Mission Requirements)
- CONAE will be responsible to update & operate CORDOBA Ground Station (according to the SABIA-Mar Mission Requirements)
- AEB will be responsible to develop & operate the Operations Control Center
- CONAE will be responsible to develop & operate the Mission & Archiving Center
- Joint responsibility for the implementation of the communication link between Ground Stations and Centers
- Joint responsibility for the implementation of the agreements and communication links with external Ground Stations

At Satellite Level:

- CONAE is responsible for the Payload Module – Management, Integration, Functional Tests and Environmental Tests (workmanship and thermal balance)
- AEB is responsible for the Service Module – Management, Integration, Functional Tests and Environmental Tests (workmanship and thermal balance)
- Integration & Tests of one of the satellites will be performed in Brazil
- Integration & Tests of the other satellite will be performed in Argentina
- Joint responsibility for the Launch Campaigns and Services for both satellites

Details for the responsibilties at this level is presented in the following table:

Module	Equipment / Subsystem	CONAE	AEB
SERVICE MODULE PMM	Power Subsystem - Solar Panels /Battery/SADA/PCDU		●
	Propulsion – Tank, Valves, Thrusters, Piping		●
	TT&C Subsystem – Transponders, Diplexer, Antennas		●
	Reaction Wheels - Star Trackers – Gyro		●
	GPS – Receivers & Antennas		●
	Module Structure & Thermal Control		●
	On-board Data Handling + Attitude & Thrusters Control Electronics	●	
	Attitude Actuators – Torque Rods, Magnetometers	●	
PAYLOAD MODULE PL	On-board Computer + Solid State Recorder & Formatter	●	
	X-band Modulators & Antennas	●	
	X-band RF Amplifiers & Filters		●
	Camera UV-VIS		●
	DCS – Electronics, Transponder & Antennas		●
	Camera NIR-SWIR & Camera TIR & Camera HSC & Camera HRTPC	●	
	Camera Multi-Angle	●	●
	Module Structure & Thermal Control	●	

Table 2 – Satellite Level Responsibilities Distribution

3.4. PRELIMINARY IMPLEMENTATION STRATEGY

The preliminary implementation strategy approaches are summarized in the following bullets:

- Contracts
  - Service Module´s Subsystems
  - Payload Module´s Subsystems & Instruments
  - Service Module Integration & Tests
  - Payload Module Integration & Tests

- Satellites I&T – depending on each agency context
- Launch Services
- Ground Segment – depending on each agency context

- Flight hardware procurement
  - Parts, materials, components from foreign companies will be purchased by CONAE on the Argentinean side and by AEB/INPE on the Brazilian side.
  - Parts-material-equipment needed for some development activities could be procured directly by contracted/agreed organizations.
  - Technical and assurance specification prepared by responsible organization and approved by CONAE on the Argentinean side and by AEB/INPE on the Brazilian side
  - Export license approval required for some suppliers will be taked into account on the purchase processes
  - Long lead items will be specifically included in schedule for monitoring and tracking (availability of technical specification, purchase process, key inspection points, hardware acceptance and reception)

- Module & Satellite Level Facilities
  - INPE/LIT
    - Integration & Tests of the Service Modules and SABIA-Mar Satellite #1 or 2
    - Heritage derived from previous Brazilian & SAC Missions
    - Well trained and experienced teams
  - CONAE I&T @ Falda del Carmen
    - Option A for Payload Modules Integration & Tests
    - Heritage derived from SAC-D Instruments testing and SAOCOM SAR Antenna I&T
  - INVAP – SEATSA I&T
    - Option B for Payload Modules Integration & Tests
    - Integration & Tests of the SABIA-Mar Satellite #2 or 1
    - Heritage derived from previous SAC and ARSAT Missions

- TT&C & Payload Data Receiving Stations
  - CUIABA & CORDOBA

- Operations Control Center
  - INPE @ SAO JOSE DOS CAMPOS

- Mission & Archiving Center
  - CONAE @ FALDA DEL CARMEN – CORDOBA

- Logistics
  - Air transportation from Argentina (Córdoba or Bariloche) to Brazil (Sao José dos Campos) will be used for Payload Module flight hardware
  - Air transportation from Sao José dos Campos to Bariloche will be used for Service Module flight hardware
  - Truck transportation from Argentina to Sao José dos Campos will be used for Payload Module Structural Model
  - Air transportation from Córdoba (if option A is implemented for Payload Module I&T) to Bariloche for Payload Module flight hardware
  - Air transportation from Sao José dos Campos and from Bariloche, to the launch base, will be used for Satellites and associated GSE

3.5. MODELS REQUIREMENTS & ASSOCIATED TESTING

According with the Project required models, the following models must be implemented for the equipment to be integrated to the SABIA-Mar Modules:

Mathematical
- CAD 3D
- Simplified structural model to be incorporated to the Payload Module FEM
- Simplified thermal model to be incorporated to the Payload Module thermal model
- Mass properties model (could be an excel file)

Physical
- Structural model, could be a mass dummy
- Engineering model
- Protoflight model (as the project requires 2 satellites, the equipment for one of the satellites could be tested at protoflight levels, while the other could be tested at flight acceptance levels)
- Development models: if it is considered necessary partial development models could be implemented, but are not required by the project.

Figures 7 & 8 show the math and physical models foreseen at equipment, module and satellite levels.

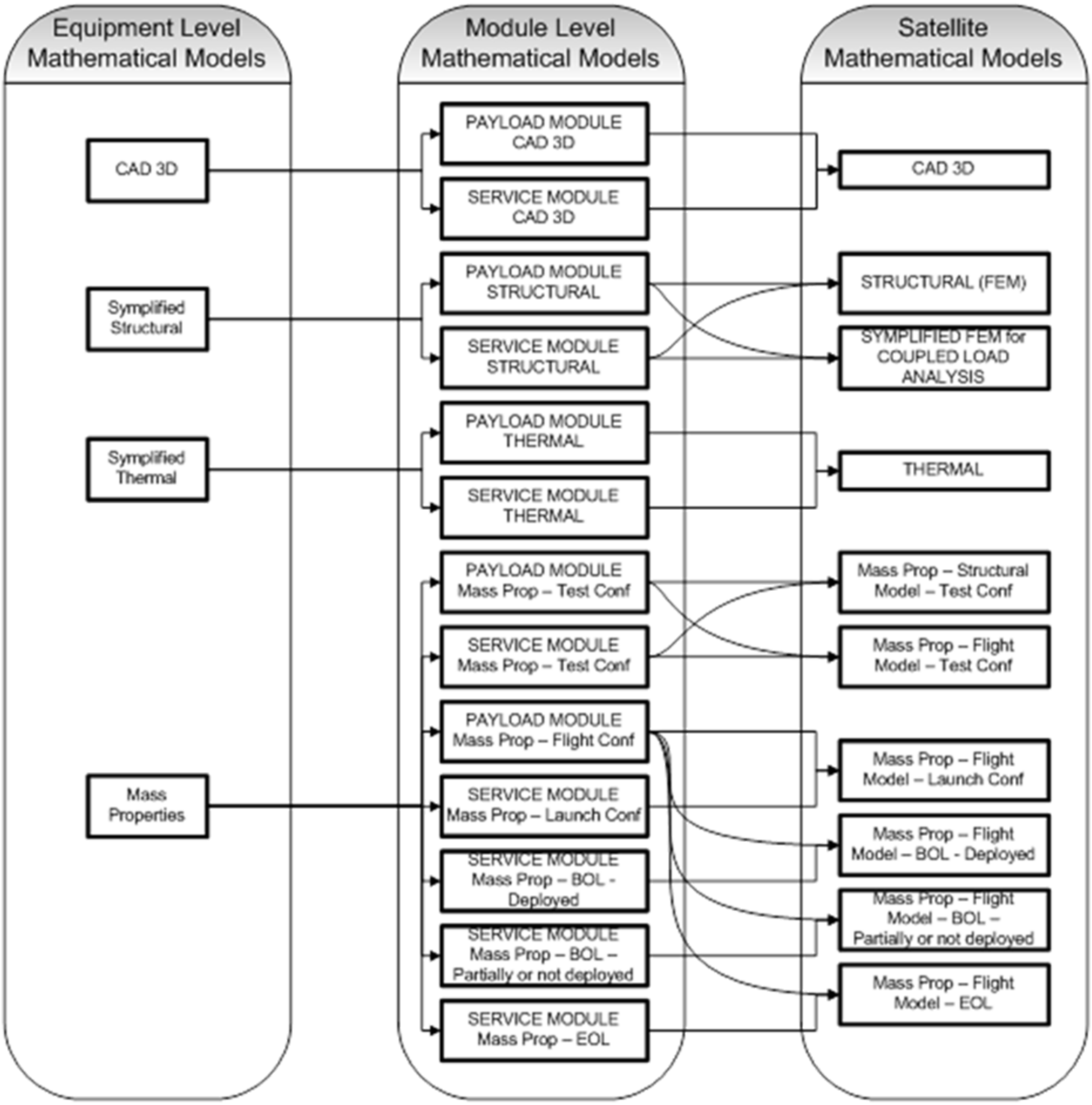


Figure 7 – Mathematical Models

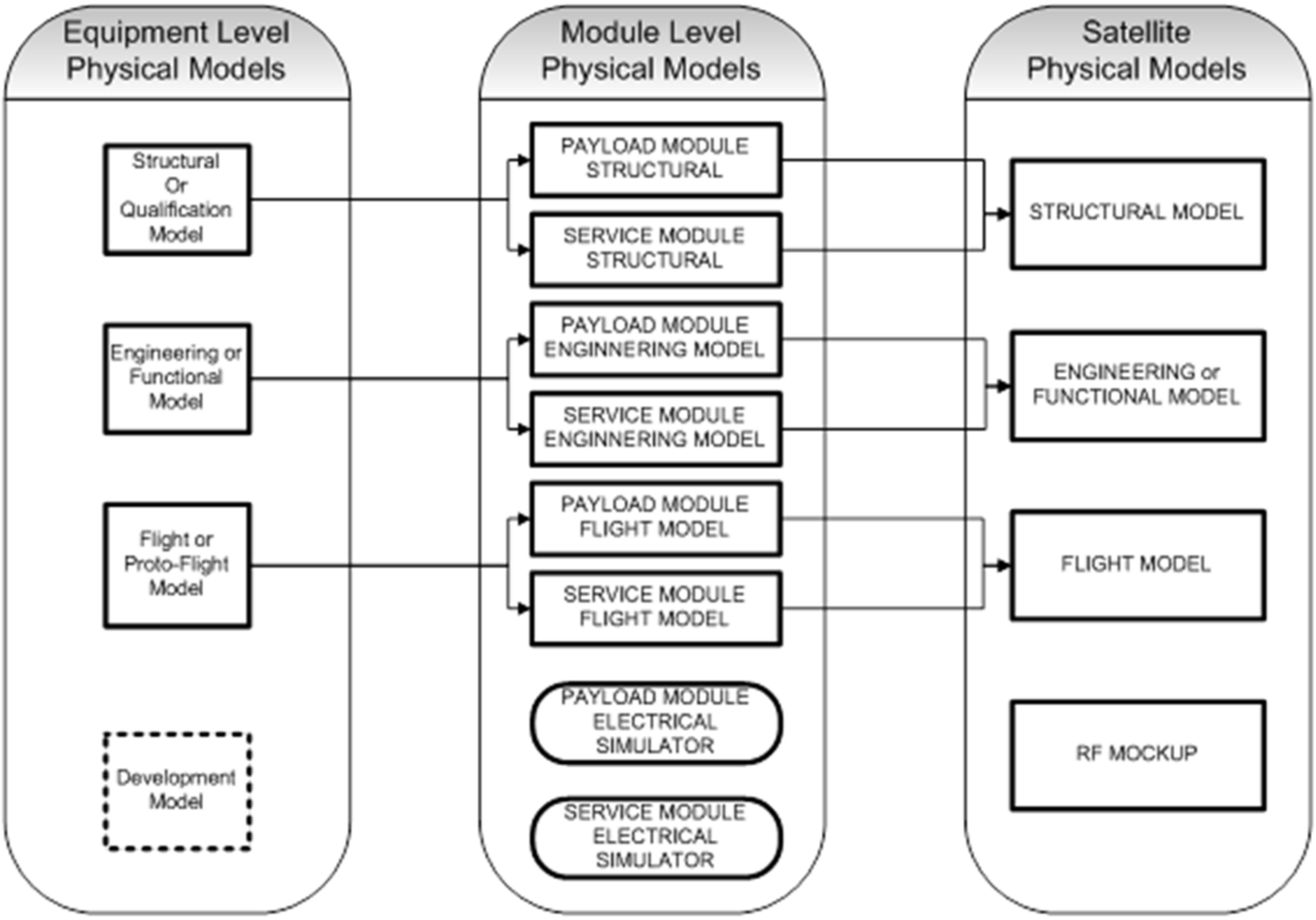


Figure 8 – Physical Models

4. MISSION ANALYSIS

4.1. ORBIT

The nominal orbit defined during the current Phase of the program has the characteristics depicted in the following table.

Type	Sun Synchronous
Orbit Height	645 km
Repeat cycle	4 days repeat cycle – 59 orbits to repeat the ground track – 2716 km between consecutive ground tracks at the Equator.
Descending Node	11:45 am – 93º longitude of the first DN

Table 3 – Orbit Characteristics

Parameters in Table 4 show more details of the nominal obit

Orbit height	645	km
Number Revs to repeat	59	
Long First AN	93	deg
Local time AN	11:45	hh:mm
Orbit period	97,6	min
Satellite velocity	27096,24	km/hr
Ground Track vel	24604,85	km/hr
Satellite velocity	7,53	km/seg
Ground Track vel	6,83	km/seg

Table 4 - Orbit Parameters

4.2. ECLIPSES

Computing the eclipses of each satellite, and considering these eclipses as the "night" when looking to Earth (as a worst case), it results the following summary:

- A total of 59 eclipses in the cycle of 4 days
- A total of 2078.5 minutes of eclipse in the cycle (34.6 hours)
- About 35 minutes with the satellite in eclipse per orbit.

4.3. RF VISIBILITY

The following table depicts the summary of the number of contacts and the RF contact time with each of these stations, during an entire cycle of 4 days, for each of the SABIA-Mar satellites.

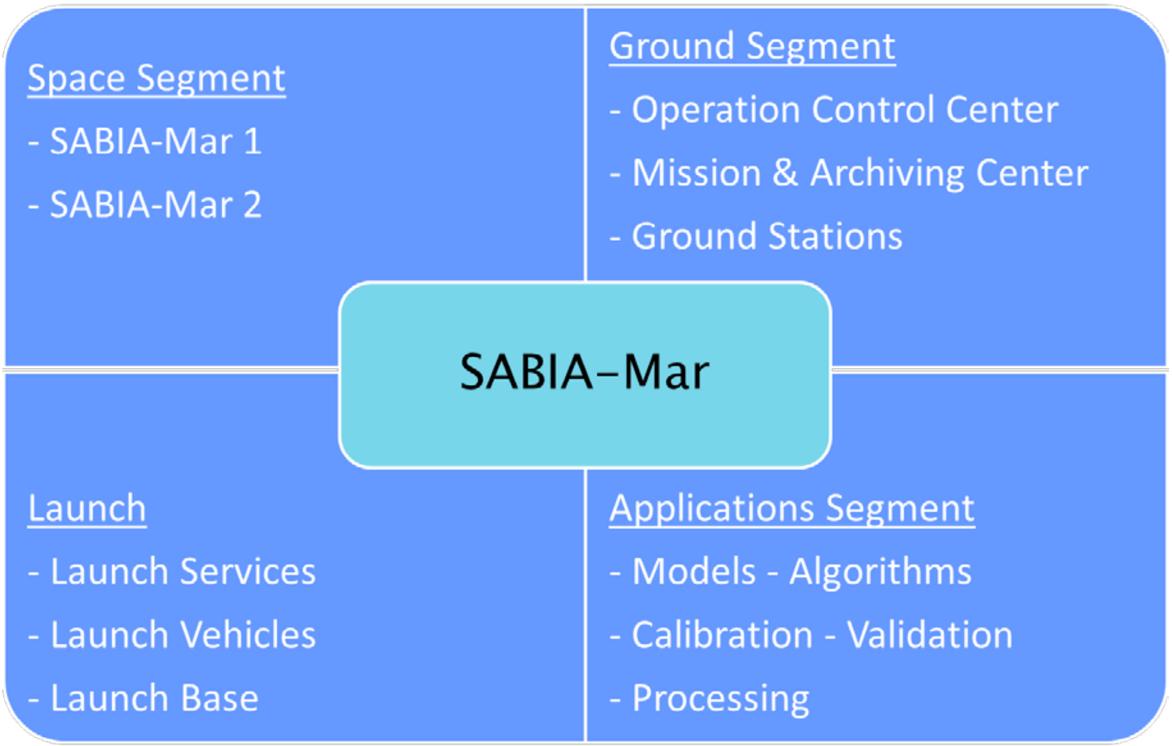
Station	# of contacts in the cycle (4 days)	Total contact time in the cycle (4 days)	Mimimum contact in one cyle of 4 days	Maximum contact in one cyle of 4 days
Cuiabá	15	7270 seg (121 min)	86 seg	652 seg
ETC	16	8460 seg (141 min)	312 seg	654 seg

Table 5 – RF Visibility Contat Time

5. SYSTEM DESCRIPTION

The SABIA-Mar System shall be composed of the following segments:

- The Space Segment, comprising: the SABIA-MAR satellites which shall be designed to be a three-axis stabilized satellite. Each satellite to have a modular architecture, being the Multi Mission Platform developed by AEB the Service Module. The Payload Module will be customized for the mission purposes.
- The Ground Segment will control the satellite, monitor and analyze its performance, coordinate operations for acquisition of images, and to receive, process and distribute/archive the Payload generated data. It comprises the Operations Control Center, the Mission Processing and Archiving Center, the Telemetry, Tracking and Command (TT&C) Stations, and the Payload Data Receiving Stations.



- The Applications Segment for the required functions to allow the correct application of data from SABIA-MAR according to user requirements, and for algorithms development, support workshops, planning and execution of the calibration & validation activities, data processing and analysis, and users development
- The Launch Services System, comprising launch services, launch vehicles and launch facilities

Existing facilities and previous developed assemblies-stages-subsystems shall be used to the maximum possible extent.

The Implementation plan for the mission must consider the development in a quasi-simultaneously scheme of both, Payload and Service Modules.

5.1. SPACE SEGMENT – SATELLITES

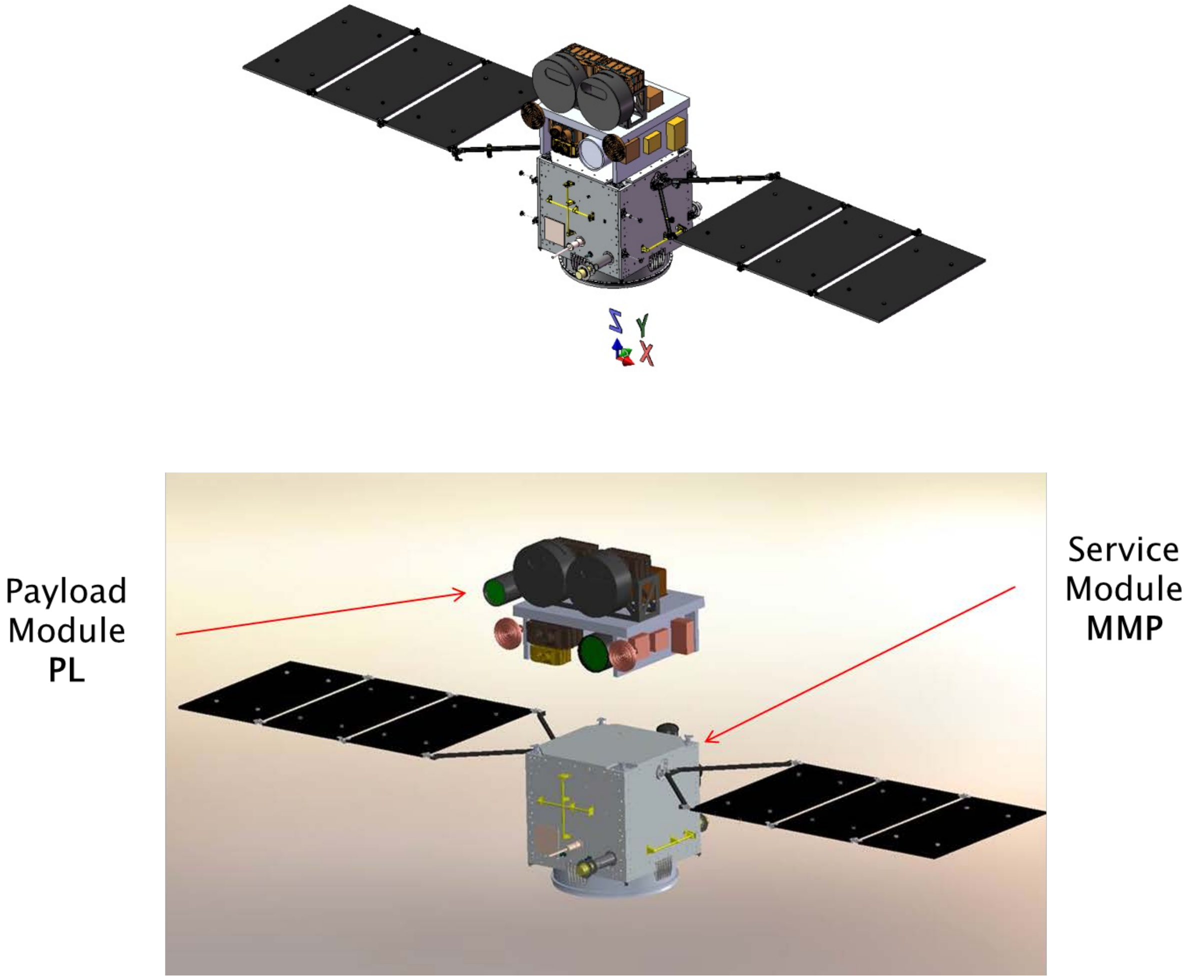


Figure 9 – SABIA-Mar Satellite

As mentioned, each satellite will be developed thru a Modular Architecture. Figure 7 shows the current design of each satellite´s module.

Due to the constraints imposed by the MMP, the two antennas of the DCS Instrument will be mounted on the Service Module´s side (one patch UHF Antenna and another S-band antenna, both shown in the Nadir looking phase of the MMP).

The SABIA-Mar satellite main characteristics are as follows:

- Mass CBE is 563 kg, 686 kg considering contingency
- Envelope Ø 2meters; heigh ~ 2.2 meters
- Design lifetime 5 years

The satellite is divided in the Service Module and the Payload Module. The SM characteristics are based on existing MMP development planned for Amazonia 1 satellite, the first one to use the platform. PL characteristics are the results of the studies and analyses of the phase and on heritage from the commonly used equipments and subsystems, as structure, modulation, encoding and tramission equipments.

Main figures of each module are as follows:

- Service Module
  - Use of the already developed Multi Mission Platform
  - Dry Mass CBE = **292** kg
  - Power consumption (Orbit average) CBE = **276** watts
    With contingency included **304** watts
- Payload Module
  - Mass CBE= **219** kg
  - Power consumption (Orbit average) CBE = **218** watts
    With contingency included ~ **260** watts

5.1.1. SPACECRAFT BUS – SERVICE MODULE

The Multi Mission Platform is a small modular platform, addressing a wide range of Earth observation, science and communication applications.

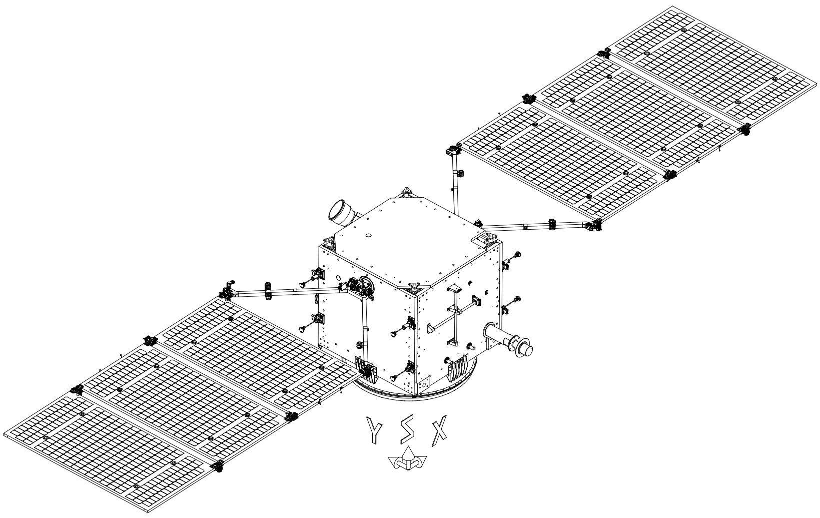


Figure 10 – MMP

The Module will provide all the required services for the SABIA-Mar payload correct operation, accounting for mechanical, electrical, pointing, thermal, boundary control (state of health), engineering data communications (to receive commands and generate housekeeping telemetry), timing and time tagging, and integration / tests needs. The implementation of the Service Module for both satellites is based on the Multi-Mission Platform developed by AEB/INPE, which consists of the following subsystems:

- Structure Subsystem, to provide mechanical support for all SM subsystems, equipment hardware and accessories, the adapter interface with the launch vehicle, and the mechanical interface with the payload module, while withstanding with the fabrication, integration, testing, transportation, launch and orbit environments.
- Power Subsystem, to convert solar energy incident over its photovoltaic solar array wings into electrical energy and to store it in batteries and to provide power control and distribution to the various platform and payload equipment, using a non-regulated power supply architecture.
- Thermal Control Subsystem, to maintain the SM housed equipment to operate within their designed temperature range, under all possible spacecraft attitudes to be experienced during a mission nominal life. Furthermore, to provide a clear and specific thermal interface with the Payload Module.
- Attitude & Orbit Determination and Control Subsystem to provide attitude and orbit control and determination, in a three axis stabilized mode, allowing for Earth pointing attitude, with the specified accuracy for the SABIA-MAR mission and also to provide orbit injection error corrections and orbit maintenance during the entire mission lifetime
- Command and Data Handling Subsystem to provide, for the entire satellite, commanding and housekeeping telemetry acquisition/storage capabilities. The state-of-health of the spacecraft will be under the responsibility of this subsystem.
- Propulsion Subsystem to provide orbit correction maneuvers capability thru the use of a pressurized system composed by a tank, valves to fulfill the correspondent safety requirements, the thrusters as final actuators, and the associated piping.
- Communication Subsystem (TT&C), to provide communications between the platform and the TT&C ground stations in order to ensure capability to monitor and control the spacecraft during all mission phases (S band).

The Multi Mission Platform has a box-shaped configuration with four lateral panels, a lower panel with the launcher interface and a top panel to close the box. The mechanical architecture is design with absence of internal structures to provide an enclosure that eases the irradiative exchanges between the various equipment and leads to a simple and reliable thermal control design.

The MMP has two solar array wings to provide the power generation. Each solar wing is composed for three panels of 735mm x 1429mm, stowed during launch.

The MMP fits in an envelope based on a cylinder of 2055mm diameter and 1075mm height, as described in Figure 9.

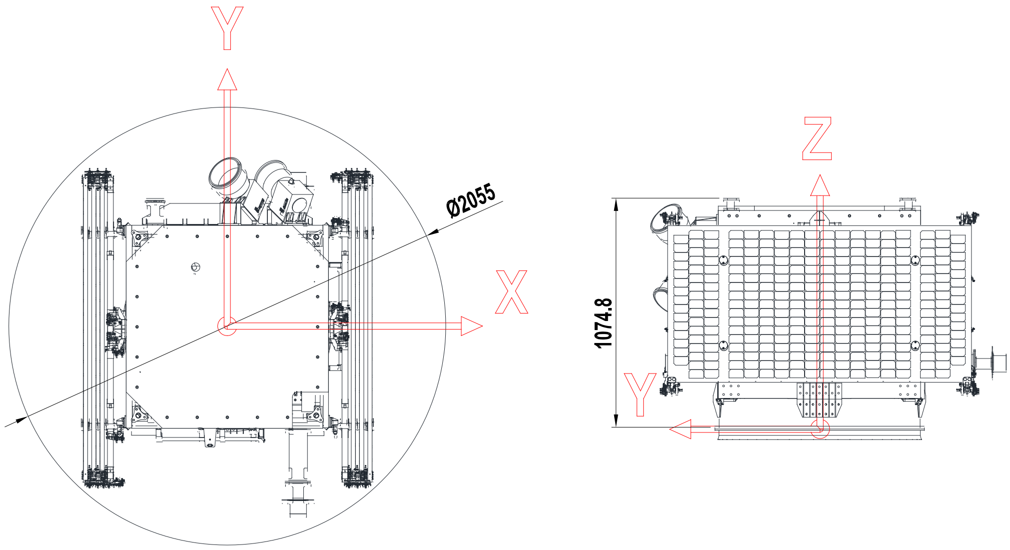


Figure 11 – MMP in Launch Configuration

The general functions of the service module are:

- to receive telecommand and send telemetries
- to determine the satellite attitude
- to control the satellite attitude in a three axis stabilized mode, allowing the spacecraft properly orientation
- to perform orbit acquisition and orbit maintenances
- to perform on board data handling
- to provide on board time
- to execute telecommand
- to provide power for all equipment on board
- to turn on/off equipment
- to provide an adequate structural environment
- to thermally isolate the payload
- to provide the adequate compatibility to the launcher vehicle

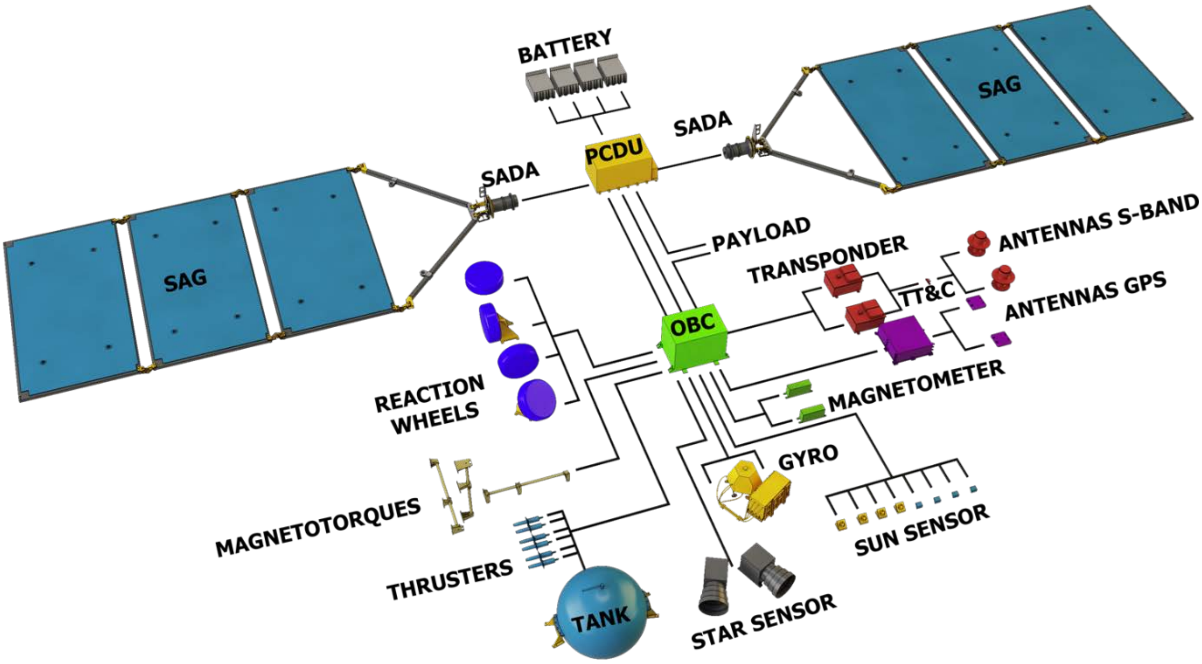


Figure 9 – MMP Block Diagram

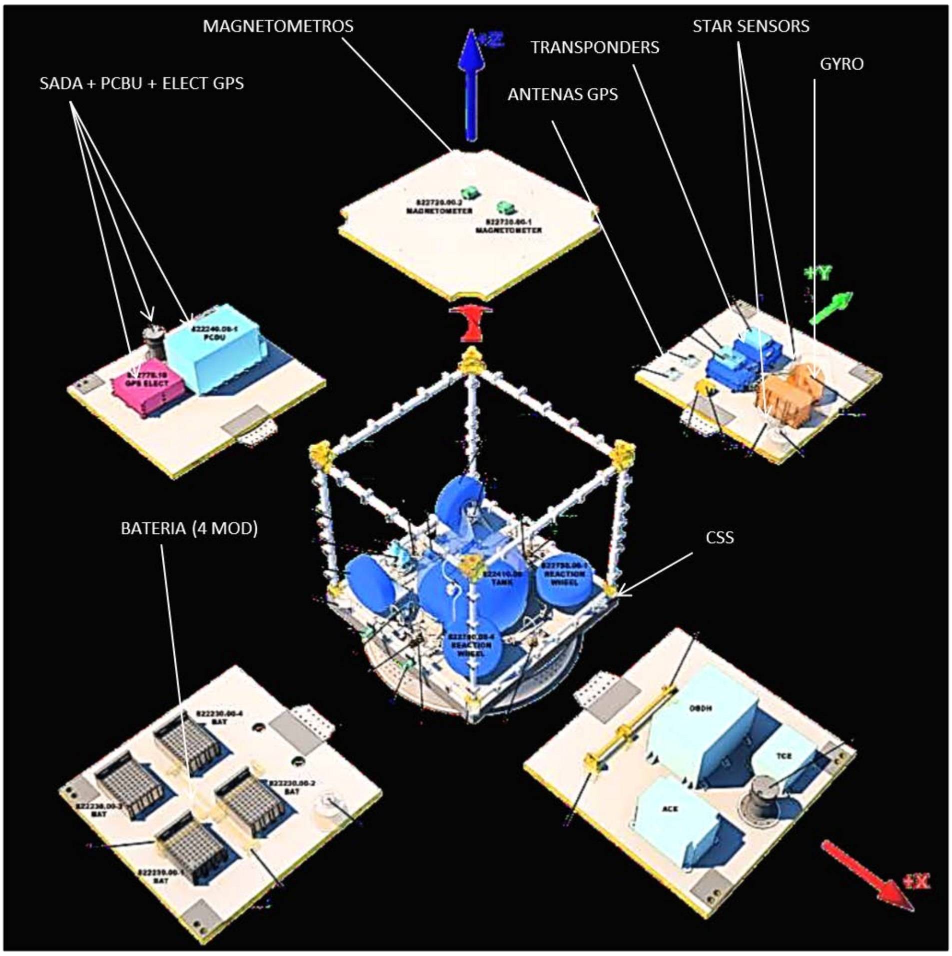
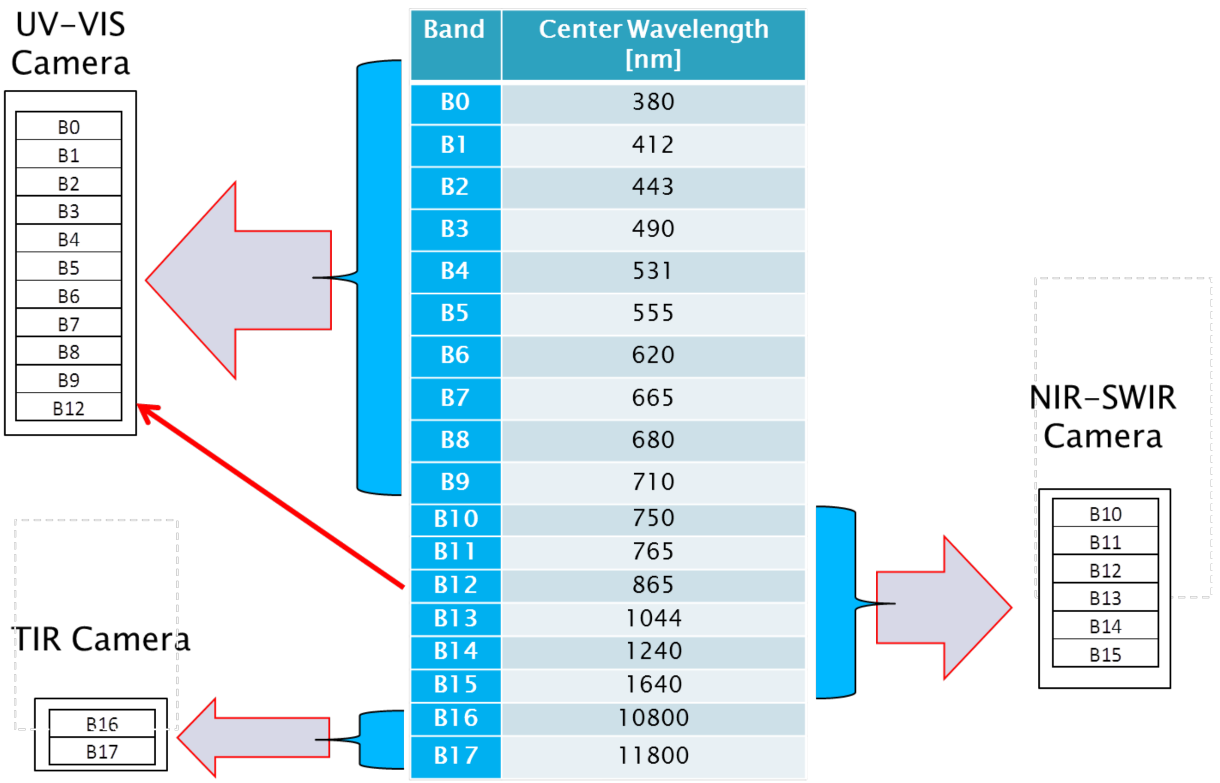


Figure 12 – MMP Exploded View

5.1.2. PAYLOAD MODULE

Analyses performed during Phase A demonstrated that the primary instrument implementation on each of the two SABIA-Mar Satellites is feasible if it is splitted in three Cameras, each one comprissing two Opto-electronics modules. The following figure depicts the spectral bands assignement for each of these cameras, named UV-VIS, NIR-SWIR and TIR.



Band	Center Wavelength [nm]
B0	380
B1	412
B2	443
B3	490
B4	531
B5	555
B6	620
B7	665
B8	680
B9	710
B10	750
B11	765
B12	865
B13	1044
B14	1240
B15	1640
B16	10800
B17	11800

Figure 13 – Main Instrument Implementation

The complete set of instruments is, then, divided in two categories: Primary or Main Instruments and Secondary Instruments. The following bullets summarize the characteristics of each of them:

- Primary Instruments
  - UV-VIS Camera [UV-VIS] — 11 bands – 1350 km - 200/800 m – 16 bits
  - NIR-SWIR Camera [NIR-SWIR] — 6 bands – 1350 km – 400/800 m – 16 bits
  - TIR Camera [TIR] — 2 bands – 1350 km – 400 m – 16 bits

- Secondary Instruments
  - Multi-Angle Camera [MAC] — 4 bands – 1350 km – 500 m – 16 bits
  - Data Collection System [DCS] — UHF uplink / S-band downlink
  - High Sensitivity Camera [HSC] — Panchromatic – 1350 km – 250 m – 12 bits
  - HR Panchromatic Cam. [HRTPC] — Panchromatic – 30 km – 5 m – 8 bits

The UV-VIS is a multispectral camera covering the range from 380-865 nm, the NIR-SWIR is a multispectral camera covering the range from 710-1640nm, and the TIR is a multispectral camera covering the range from 11-12 µm. Those three cameras will operate simultaneuosly; taking images during the illuminated phase of the orbit, when the satellite is passing over the interested areas on ground. Also, the TIR camera will also take images over those selected areas in darkness.

The HSC is a panchromatic camera with high sensitivity to take images in selected areas in darkness. While the operation of this camera will not be simultaneous with the UV-VIS and NIR-SWIR cameras, there will be some overlapping during which all those instruments will operate simultaneously (preliminary analyses show that UV-VIS and NIR-SWIR cameras would require Solar calibration that can be achieved with a simple geometry when satellite is passing over the poles region) .

The HRTPC is a panchromatic camera providing a quite good geometric resolution on ground, and will take images during selected areas, during the illuminated portion of the orbit. This camera will not operate simultaneously with the HSC camera.

The MAC is a multispectral, 4 bands, camera providing angular information of the radiances measured in these bands, taking images during selected areas, during the illuminated portion of the orbit.

Eventhough the DCS Receiver will be operating mainly for the CstScen, the system is designed to allow its operation during all times. DCS receives data messages, generated by on-ground distributed platforms, in UHF, relaying these messages thru its own S-band transponder.

The following bullets summarize the operation of each of the instruments being considered for each SABIA-Mar satellite:

- **UV-VIS** Imaging during sunlight - 200 m over **CstScen** and 800 m over **GlbScen** - 2 days revisit time with first satellite and 1 day with both satellites
- **NIR-SWIR** Imaging during sunlight - 400 m over **CstScen** and 800 m over **GlbScen**– 2 days revisit time with first satellite and 1 day with both satellites
- **TIR** Imaging during sunlight and darkness - 400 m over both scenarios – 2 days revisit time with first satellite and 1 day with both satellites orbiting
- **MAC** Imaging during sunlight – 500 m during some periods over both scenarios
- **HSC** Imaging during darkness – 250 m over **CstScen**
- **HRTPC** Imaging during sunlight– 5 m during short periods of time [~10 minutes per day] over **CstScen**
- **DCS** Receiving and broadcasting messages during passes over **CstScen**

This operation could be satisfied if the Payload Module is implemented considering the following:

- 64 Gbytes of Payload on-board storage capacity, considering a 75% of margin.
- 140 Mbps downlink data rate should be considered for dimensioning of the X-band channel, considering a 70% of efficiency for the total RF visibility tim

The current PL configuration is depicted in the following figure, while a simplified functional diagram is showm in Figure 15.

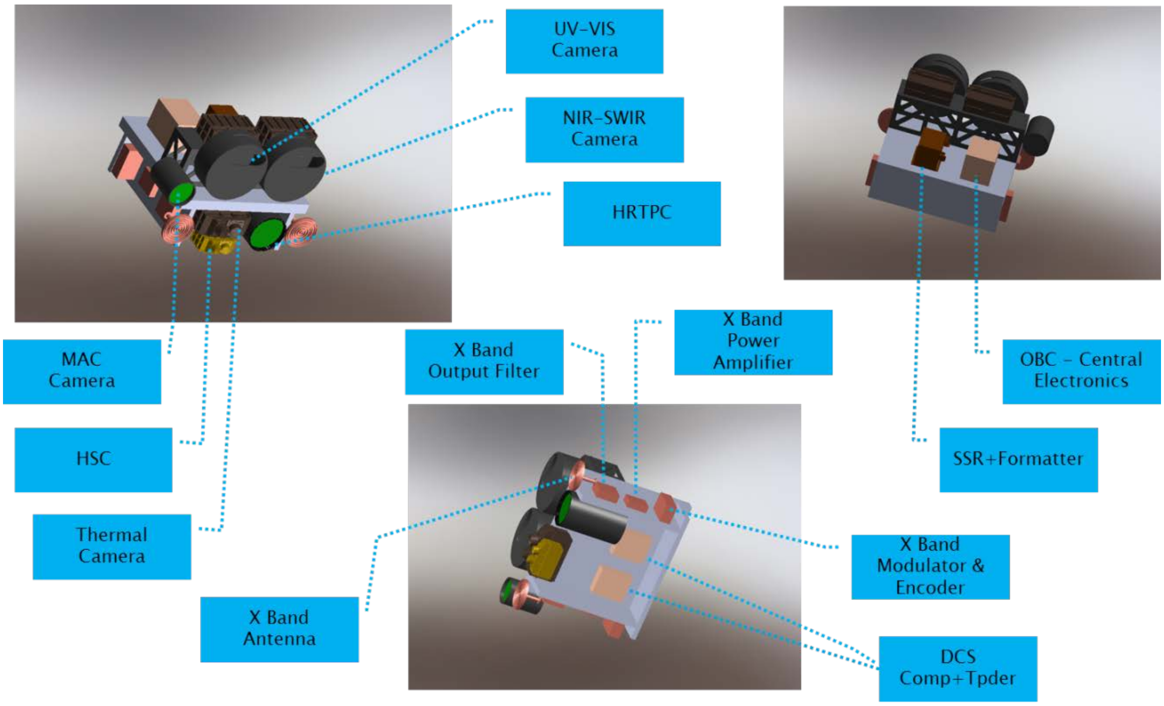


Figure 14 – Payload Module Configuration

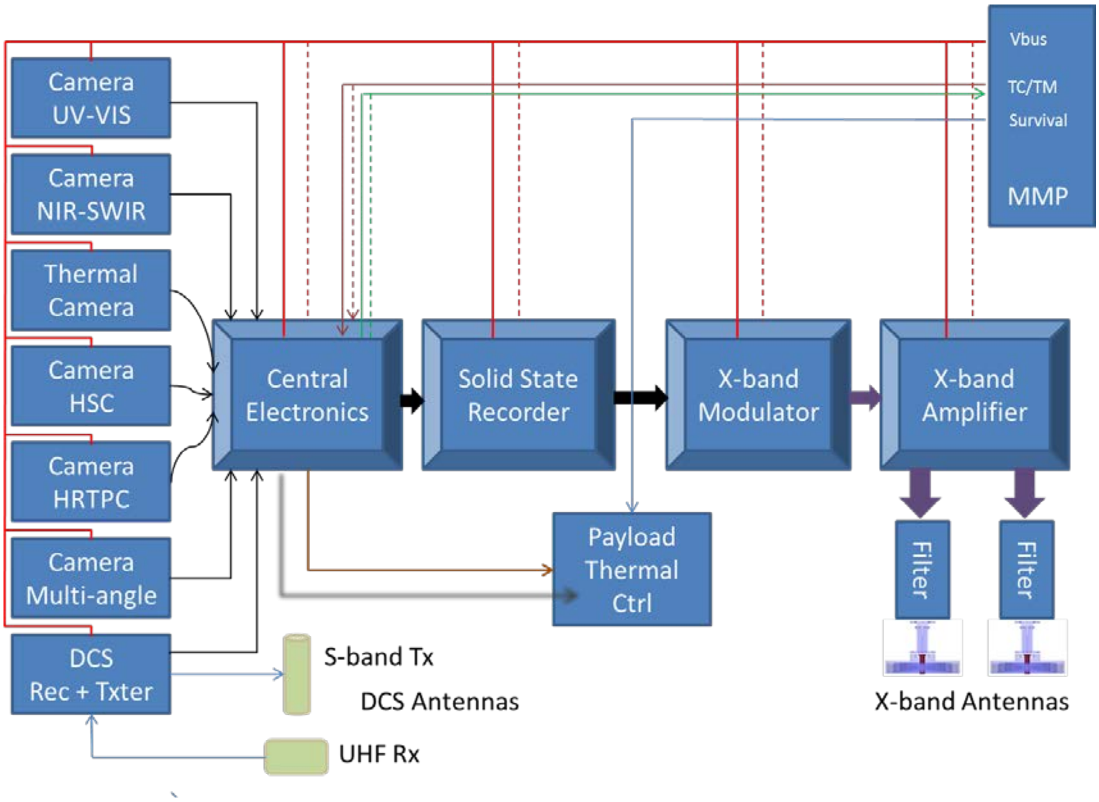


Figure 15 – Payload Module Simplified Functional Diagram

The PL DDL (Data Downlink Subsystem) will provide transmission service in X-band for the SABIA-MAR image data. The process includes data encoding, modulation, scrambling, and RF amplifying. The equipment will be dimensioned such that it is possible to receive the payload data with a G/T ≥ 32 dB/K (TBC) to maintain a link budget with a Bit Error Rate < 1E-6 during RF contacts

The Payload Module Structure shall provide the mechanical support for all instruments and assemblies/subsystems of the Payload Module, interfacing with the Service or Bus Module, in a configuration that meets the corresponding Interface Control Documents of each of them, jointly with the available envelope resulting from the launch vehicle to be selected. The modular design imposes that all elements be centralized and mounted in a self-contained platform to the maximum extent. The PM structure shall be capable of sustaining all, transferred by the Service Module, accumulative static and dynamic load combinations occurring during integration, testing, handling, transportation, launch and orbit maneuvers without any failure or degradation; providing sufficient stiffness to avoid dynamic coupling of the spacecraft vibration modes with those of the launch vehicle; providing the lifting points and transportation interfaces for handling, integration, test and transportation as will be defined in the corresponding ICD.

The Thermal Control Subsystem of the Payload Module shall maintain the housed equipment inside a thermal ambient that satisfy the equipment minimum and maximum operating allowable temperatures. This subsystem will control and maintain the base plate temperatures (temperature at the mechanical mounting interface) within the ranges clearly specified by each housed equipment.

The PL OBC sor Central Electron shall acquire data generated by the instruments (including the associated housekeeping data required for post-processing on ground), and provide storage capabilities on the SSR Units for these data. Download of the stored data, in a LIFO scheme (last in – first out) will be performed after reception of the appropriate commands.

The OBC will generate a minimum set of 9 packets of data to be transferred to the SSR:

- one for each of the Instruments
- one containing the Payload Module housekeeping telemetry collected by the OBC itself
- one containing the orbit, attitude and a portion of the satellite housekeeping telementry, all those acquired by the PMM and transferred to the OBC

The OBC shall insert identification codes, timing information and packets counters on each of these “virtual channels, to allow identification and time tagging after post-processing and demultiplexing on ground.

The SSR unit, besides its storage capabilities (64 Gbytes are required), after reception of the appriate telecommands, will provide formatting of data, compatible with CCSDS, and routing of the output stream to the encoder-modulator-amplifier stages for downloading data. The strategy to be followed by the SSR must be the last-in//first-out, that means that in case that during the RF contact, the data stream being routed to the encoder-modulator-amplifier stages will be the last acquired data from the OBC.

The encoding-modulation-amplification stages will provide the required process compatible with an X-band downlink cannel, meeting accomplishing with required margins for the bit error rates that can be tolerated.

Finally the modulated and amplified X-band signal will be routed to the X-band donwlink antenna to communicate to ground.

Each instrument is being designed in a single stream configuration, but the OBC, the SSR, the Modulator-Enconder, the X-band Amplifier, and the associated Filter and Antenna will account with a “cold redundant” unit, to eliminate the single point of failure in these stages. Also, cross-strapping at the output of the OBC (input of the SSRs) is envisaged enhancing system capabitilies in case of a single failure in the “SSR → Antena” paths, or, to increase the on-board storage capabilities (doubling it) to cover unexpected worst cases.

Finally the two redundant Encoder-Modulator-Amplifier stages will be implemented with two different center frequencies in order to facilitate ITU´s registration (in case of uncovered interferences with other Space or Ground Systems) and to allow duplication of the amount of data that can be downloaded without modification of the Ground Segment. Nominally the system is designed to operate with only one Encoder-Modulator-Amplifier stage.

5.1.3. ASSEMBLY, INTEGRATION & TESTS TO LAUNCH OPERATIONS (ATLO)

The SABIA-MAR program should use a “test as you fly and fly as you test” approach. Mission Assurance (MA) will provide end-to-end oversight of the effort. The SABIA-MAR will be operated, tested, and validated in simulated environments, and the data will be correlated with the results predicted from analysis.

The Payload Module and the Service Module will be developed on separated AIT cycles. After both modules development, integration and functional testing at module level, a final module to module integration and test will be performed. Environmental testing will be performed at Satellite Level.

Each piece of equipment, prior to its integration to the PL or SM, will be subjected, besides its functional verification, to: dynamic tests at proto-flight box level, thermal vacuum cycling tests at proto-flight box level, electromagnetic compatibility tests and mass properties and alignment.

After each step of the integration, an electrical test, at module level, is performed to verify the integrity of the equipment integrated together with the already integrated ones. Once each module is integrated, Full Module Level verification begins with a Comprehensive Performance Test (CPT#1) which establishes the test performance baseline for future comparison and verifies all H/W and S/W functions, and module operations. The mass properties of the Module are then measure, continuing with the dynamic testing. The Dynamic Tests will be performed at workmanship level to verify if the module was integrated correctly and no loss parts are found. After dynamic a Limited Performance Test (LPT#1) is performed. The module is then submitted to the thermal vacuum balance tests (TVT), and during the TVT another Comprehensive Performance

Test (CPT#2) is performed. EMI/EMC tests are performed only at equipment level and are not foreseen at module level.

At satellite level, both modules will follow their mechanical integration and their electrical integration. All electrical paths are verified and instrument test data is acquired. Satellite level verification begins with establishment of initial alignments. An initial satellite Comprehensive Performance Test (CPT#1) is conducted, which establishes the test performance baseline for future comparison and verifies all H/W and S/W functions, satellite modes and operation.

The satellite is then subject to a series of EMC/EMI and Magnetic Balance tests (TBC). A self-compatibility test verifies that RF transmissions and self-generated EMI do not adversely affect other satellite systems. Radiated emission and radiated susceptibility tests measure satellite emissions for compatibility with the Launcher and range requirements as evaluate the effect of external EMI on satellite. The magnetic measurements on the other hand measure in several modes of operation, the satellite's residual magnetic field and compensate it, if necessary, to meet the specified requirements (TBC).

Next, the solar panels are installed on the satellite. They are fully stowed and first motion deployed. The panels are then walked out to their full deployed configuration to assure they have been installed correctly and that no binding or interference occurs during deployment.
With the solar panels installed, the Mass Properties is performed. The satellite is then configured for a series of environmental tests consisting of: acoustic, vibration and pyroshock test. The satellite is powered on in launch configuration and critical parameters are monitored. The Dynamic Tests will be performed to verify if satellite was constructed according to the project to withstand the expected launch environment regarding vibration, acoustic, and shock stresses. Functional aliveness tests after each Dynamic test are performed to verify that no degradation occurred in consequence of the dynamic tests. The Pyroshock Test verifies that the satellite can withstand the expected launch separation environment. Before entering in TVT, another satellite Comprehensive Performance Test (CPT#2) is conducted, to compare the test performance with CPT#1 and verifies all H/W and S/W functions, satellite modes and operation.

The solar panels are then deployed to verify deployment after exposure to launch environments. After the deployment the solar panels are removed and the satellite shall enter in TVT. After removal from Thermal Vacuum chamber a Propulsion leak/flow check is performed. Next alignment measurements are executed in order to compare with initial alignment data to verify that undesirable shifts did not take place through the environmental test programs. A final satellite CPT is repeated to ensure the compliance of the satellite after the environmental test campaign. The final validation is the RF compatibility test to verified end-to-end compatibility between the satellite and ground station equipment and the mission operation the satellite command and control facilities, equipment, command and telemetry database.

5.2. GROUND SEGMENT

The figure below represents the overall architecture of the ground system proposed for SABIA-Mar mission operations.

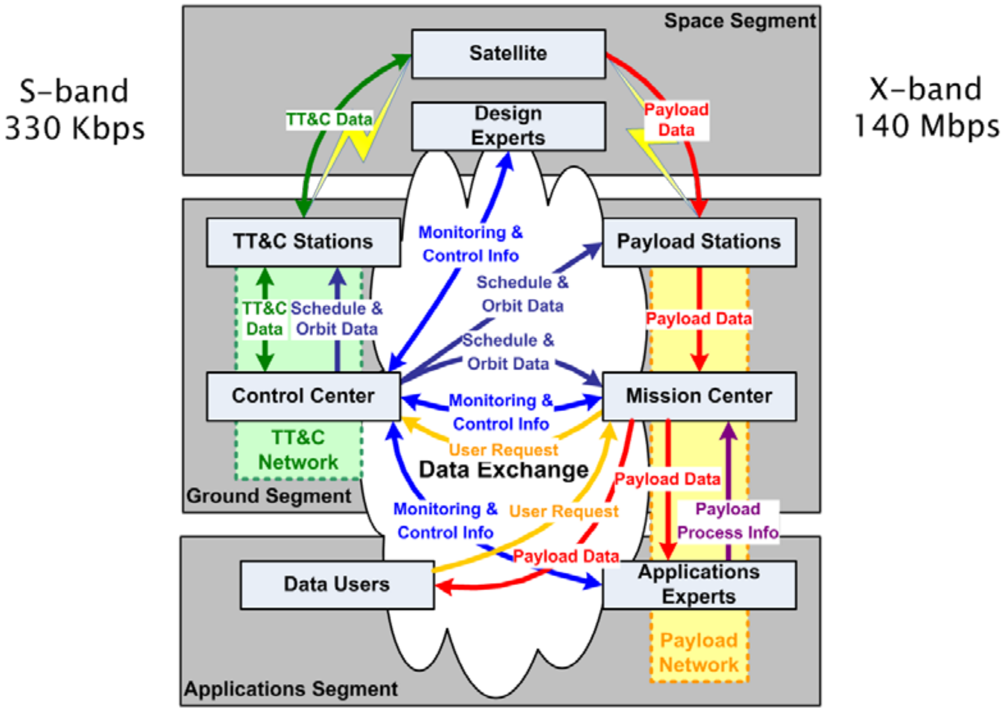


Figure 16 – SABIA-Mar Ground Segment Concept

Each SABIA-Mar spacecraft (Satellite) shall receive telecommands from the Ground System and execute them, generating telemetry accordingly. The Satellite shall also allow ranging and Doppler measurements for the evaluation of orbital parameters (TBC).The Satellite shall transmit S-band platform telemetry to, exchange tracking measurements with, and receive telecommands from (TT&C Data) Telemetry, Tracking and Command Ground Stations (TT&C Station). The Satellite shall transmit X-band payload telemetry (Payload Data) to Payload Data Receiving Stations (Payload Station).

The Payload Station shall receive and store raw Payload Data from the Satellite and forward it to the Mission Center. To point its X-band antenna to the Satellite correctly regarding time and position, andthus receive raw Payload Data, the Payload Station requires the payload operations schedule and the orbital parameters (Schedule&Orbit Data)generated and sent by the Satellite Control Center (Control Center).

The Mission Center shall store and process the raw Payload Datareceived from the Payload Station and keep the resulting processed Payload Data stored in its archives. The Mission Center makes processed Payload Data available to the Data User,who mayaccess the archive through queries to the online catalog, or submit specificdata requests(User Request). The Mission Center shall collect the user's Archive query related to a product catalog and user´s requests, related to acquisition request and that shall be analyzed for approval or rejection by the mission center.

Related to the User´s Archive Query, The Mission Center shall process these requests, approved it and provide the file associated to it to the End User. Related to the User´s request, the Mission Center shall process the request, approved it and generate the Mission Level Plan based on it. In order to generate this plan, the Mission Center shall also receive as input the Control Center Constraints. Also, this Center will be required to approve the final, integrated and consolidated pass plans generated by the Control Center as result of all received requests.

The Control Center shall process TT&C Data to monitor and maintain the Satellite health, to command the Satellite to generate and transmit Payload Data, and to evaluate updated orbital parameters from tracking measurements. The Control Center also prepares the consolidated pass plans for executing platform and payload operations activities, as well as acquiring updated tracking measurements. The Control Center shall send the orbital parameters to the Mission Center, Payload and TT&C Stations. It shall also send the consolidated pass plan, that will be used in the SATCS, to the Mission Center for final approval.

The TT&C Station shall relay TT&C Data exchanged between the Satellite and the Control Center, according to the Scheduling & Pointing Data,in real-time. If the connection between the TT&C Station and the Control Center is lost for any reason, the TT&C Station shall follow the pass plan (Scheduling & Pointing Data) procedures set by the Control Center, store the TT&C Data locally, and send it to the Control Center afterwards.

5.2.1. CONTROL CENTER

This Center shall control the spacecraft operations in order to fulfill the mission objectives. During all phases of the mission the Control Center shall perform the following functions:

- Scheduling of satellite operations in order to take into account the requirements defined by the SABIA-Mar Payload activity program. The Control Center will receive from the Mission Processing and Archiving Center the correspondent requests for all Payload Module related activities to be executed during the next time slot.
- Analysis of the S-band housekeeping telemetry data to monitor the spacecraft status.
- Handling of anomalies detected by satellite monitoring.
- Planning the activities of the Telemetry, Tracking and Command Stations, including foreign Telemetry, Tracking and Command Stations which may be needed to support the initial orbits

The Control Center shall also have functions related to the satellite orbitography with the following functional requirements:

- daily restitution of the orbital parameters in form of ephemeris data to be supplied to the Mission-Processing-Archiving Center and to the Ground Stations
- daily extrapolation of the orbital parameters for the next 72 hours in the form of ephemeris data to be supplied to the Mission-Processing-Archiving Center to allow preparation of the payload activity program.
- Prepare and execute orbit adjustments as required to accomplish with Mission Requirements.

5.2.2. MISSION PROCESSING AND ARCHIVING CENTER

The Mission Center shall perform the following functions:

- Point of contact and administrative relationship with the users.
- Collect the user's Payload Module requests from the catalogue and from specific requests.
- Generate pass plans for the Payload Module elements and transfer it to the Control Center as the formal requests. Also, this Center will be required to approve the final, integrated and consolidated pass plans generated by the Control Center as result of all received requests
- Process the raw data and the ancillary files received from the satellite, archive and distribute information to the final users.
- Receive reports from the TT&C and Data Receiving Stations related to the tasks and results obtained.
- Receive the input requests from the users to generate a consolidated Payload Module pass plans.
- The Center will house the Processing and Archiving Facilities to generate the defined products and to maintain the corresponding data-base for backup purposes, in the form of computer readable files containing the following information as a minimum set:

  a. the raw data received
  b. the satellite ephemeris auxiliary data
  c. the geometric/radiometric correction data
  d. the data identifying the characteristics of the acquired scenes

5.2.3. TELEMETRY, TRACKING AND COMMAND STATIONS

The Telemetry, Tracking and Command Stations will allow, operating in S-band, to send telecommands to the spacecraft and to receive the housekeeping telemetry from it. These stations must have recording capabilities and the resources required to atted passes of the satellite during day and night during the entire mission lifetime in a 24/7 scheme. Already existing TT&C stations may be used.

5.2.4. PAYLOAD DATA RECEIVING STATIONS

The Payload Data Receiving Stations will allow the reception of the Payload Module generated data and to transfer them, using specific and secure ground links, to the Mission-Processing-Archiving Center. Already existing infrastructure may be used to implement this required capability.

5.3. APLICATIONS SEGMENT

In order to support users and to generate new products the Applications Segment has to:

- Generate algorithms
- Image analysis software development
- Users training
- Simulated images production
- Standard value added products definition

- Image calibration and validation planning and implementation

5.3.1. DATA ACCESSIBILITY

All ocean color data shall be available free of charge and should be available for download over the internet. A specific data policy could be defined for commercial applications.

For main camera acquisitions the capability of real time transmission is required.

For near real time applications data latency within 12 hours is required. These applications are fisheries, coastal monitoring and resources management.

Data latency of 24 hours for Level 1 and Level 2 data is required for scientific or non-operational applications.

5.4. LAUNCH SERVICES

During Phase A, the tasks performed in this area have the final objective of identify the more suitable launch vehicles to inject SABIA-Mar satellites into orbit, searching in the offers of the aerospace market without having started, during this phase, any contact with possible suppliers of this service.

The mission requirements for the initial search of the launch services are as follows:

SATELLITE	
Mass:	700 kg
Maximum dimensions:	2000 mm diameter
	2200 mm height
Limit load:	10 g longitudinal (comp./tension)
	3 g lateral
Fundamental frequency	< 26 Hz lateral
	<50 Hz longitudinal
ORBIT – INJECTION PARAMETERS	
Semi-major axis	7026.74 Km
Inclination	97.963 deg
Eccentricity	0.001163
Ascending Node Mean Local Time:	23:45 hs
PROCESSING IN LAUNCH BASE	
Clean Room Requirement:	
Class 10000	During stand-alone integration and tests.
Class 100000	At the launch PAD and in the Launch Vehicle fairing.

Temperature and humidity requirement:

The controlled area must be compatible with a mission having optical and infrared detectors covering from the ultraviolet to short wave infrared wavelengths range.

Additional requirements:

Fueling of the Satellite’s Propulsion Tank with pressurized hydrazine must be provided.

The following table shows the main characteristics and behavior of the vehicles that have been identified. Services suggesting launch vehicles in development are not considered since for SABIA-Mar satellites required launch dates, they will hardly overcome their infant mortality problems that could lead reliability lower than the typical 90 – 95 % in their first launch attemps.

Launcher	Payload Fairing (mm)				Satellite Weight (kg) &		Frequency (Hz)		Injection Error		Launch Base
	Diameter	C/NC	Height	C/NC	650 Km	C/NC	Lat/Long	C/NC		C/NC	
Dneper	2000	C	2650	C	1000(xxkg)	C	10 / 20	C	Altitude:±5.5 Km, Period:±4.0 sec Inclination: ±0.045 deg, LTN:±0.060deg		Baikonur (Kazakhstan), Yasny (Russian Federation, Orenburg)
Falcon 9	4600	C	11400	C	7500 (80kg)	C	10 / 25	C	Perigee ±10km Apogee ±10Km Inclination: ±0.1 deg LTN:±0.15 deg		KSFC(kennedy Space Flight Center) VAFB (Vandenberg Air Force Base)
Cyclone 4	3700	C	8500	C	3450 (22Kg)	C	8 / 20	C	± 6 to 7 Km; inclin. ±0.05 to 0.08; Awr= ±10 deg		Alcantara Launch Center; State of Maranhao, Brasil
Long March	3350	C	8880	C	6500(xxkg)	C	?		Altitude:±10km, Inclinat.: ±0.07deg, LTN:±0.020deg		Xichang(XSLC) ; Jiuquan(JSLC); Taiquan(TSLC) China
Minotaur IV	2055	C	3300	C	1050(18kg)	C	15 / 35	C	Altitude: ± 18.5km Inclination:±0.2 deg		Alaska(Kodiak launch Complex); Cape Canaveral (Florida); VAFB (California; WFF (Wallops Island)
PSLV	2900	C	5400	C	??		20 / 35	C	Altitude: ± 18.5km Inclination:±0.2 deg		Sriharikota , India
Rockot	2380	C	5500	C	1350(xkg)	C	15 / 33	C	Average Alt.±1.5% Inclination:±0.06deg LTN ±0.15deg.		Plesetsk Cosmodrome, Rusia
Taurus	2055	C	4500	C	800 (xkg)	C	??		Altitude: ± 10km Inclinat.:±0.15 deg		KSFC(kennedy Space Flight Center) VAFB (Vandenberg Air Force Base)
TaurusII	3450	C	7000	C	4000(xkg)	C	8 20	C	Altitude: ± 10km Inclinat.:±0.15 deg		Alaska(Kodiak launch Complex); Cape Canaveral (Florida); VAFB (California; WFF (Wallops Island)
Vega	2380	C	5500	C	1500(60kg)	C	≥15 /20≤F≤45		Altitude: 5km±1Σ Inclinat.:±0.05 deg		Guiana Space Center (French Guiana)
Kosmos	Acuerdo a Informe: Cosmos 1,3,3M and 3MU/ SL-8/ C1 Se desprograma en 2012										
AdSV = Adaptador Satélite - Lanzador											

Note: () denotes the estimated launch vehicle-to-satellite adapter mass

Tabla 6 - Characteristics of Identified Launch Vehicles