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ELECTRONICS SYSTEM ENGINEERING Flat-Sat for IGOSat

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Trabajo de titulación de posgrado presentado como requisito
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ELECTRONICS SYSTEM ENGINEERING Flat-Sat for IGOSat

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RESUMEN

El presente documento presenta el informe de pasantía final de mí, Juan Andrés VALVERDE JARA, en el Máster 2 ESECA del ENSEEIHT, yo cumplí con una pasantía de 6 meses en el Proyecto IGOSat en el Equipo de Electrónica Espacial como Ingeniero de Sistema Electrónico (Flat-Sat) y de prueba electrónico en el laboratorio (APC) Laboratoire Astroparticules & Cosmologie de la Universidad Paris Diderot en la ciudad de París en Francia entre el 8 de marzo de 2019 y el 30 de septiembre de 2019.

El presente documento escribe mis tareas sobre hacerme cargo de las interfaces eléctricas y de comunicación satelitales completas, tanto en un punto de vista de prueba como preparación de documentos técnicos.

Trabaje en un entorno multicultural parte de un equipo de 10 pasantes de diferentes orígenes.

Como ingeniero de sistema electrónico de este equipo, yo fui el punto de contacto para todo lo relacionado con el punto de vista del sistema electrónico del satélite.

Escribí, gestioné y actualicé documentos técnicos como el Documento de control de interfaz, el Documento de especificación de arneses de satélite, el Documento de atribución de pines de satélite y documentos de procedimientos de prueba.

Desde el punto de vista de la prueba, diseñé placas de interfaz para el satélite en KiCad y probé el Sistema de Energía Eléctrica (EPS) del satélite junto con otro interno.

Palabras clave: Nanosatélite, Flat-Sat, Interconexión, CubeSat,

ABSTRACT

The present document introduces the final internship report of Master 2 ESECA - ENSEEIHT student Juan Andres VALVERDE JARA fulfilled on a 6 months internship at the IGOSat Project in the Electronics Team as Electronics System Engineering (Flat-Sat) of Paris Diderot University and the city of Paris between the 8th Mars 2019 and the 30th September 2019.

This document writes my tasks about taking charge of the complete satellite communication and electrical interfaces, both from a test point of view and in the preparation of technical documents.

I worked in a multicultural environment part of a team of 10 interns from different backgrounds. As an electronic system engineer for this team, I was the point of contact for everything related to the viewpoint of the satellite electronic system.

I wrote, managed and updated technical documents such as the Interface Control Document, the Satellite Harness Specification Document, the Satellite Pin Attribution Document, and test procedure documents.

From the point of view of the test, I designed interface plates for the satellite in KiCad and tested the Electric Power System (EPS) of the satellite along with an internal one.

Key words: Nanosatellite, Flat-Sat, Interconnections, CubeSat,

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INTRODUCTION

1.1 Background of report

As part of the one year studies in the master degree of **Aéronautique et Espace Parcours type: <<Master of Science - ELECTRONIC SYSTEMS FOR EMBEDDED AND COMMUNICATING APPLICATIONS - ESECA>> year 2** per the requirement of the Institut National Polytechnique de Toulouse INP-ENSEEIHT at Toulouse, it is mandatory for students in the Specialized Masters of the Conférence des Grandes Écoles to perform an graduation internship in a Company or Laboratory from 4 to 6 months following Master and it could be from February to the end of September 2019.

The report is written one month before the end of the internship by the student who is part of the award of the degree certificate. I did a six months internship between the 8th Mars 2019 and the 30th September 2019 at Paris Diderot University, specifically at the Astro Particle and Cosmology (APC) Laboratory. I was assigned to the Electronics Team as Electronics System Engineering (Flat-Sat) in the IGOSat Project. The main task is to understand and work with each subsystem and each payload to integrate it into the complete satellite system making the correct interconnection and test it.

The internship helps students to be able to carry out the entire engineering mission taking into account scientific, technical, economic, environmental, organizational and humans aspects, on the other hand helps to implement a project management approach, demonstrate initiative and respond to the proposed situation in a relevant way and be able to report on a project and defend its results by adapting to the target audience.

1.2 Terms of reference and acronyms

- IC –Integrated Circuit
- DUT – Device Under Test
- EUT – Equipment under test
- IGOSat – Ionospheric Gamma-ray Observation Satellites
- EQM – Engineering, Qualification Model
- FM – Flight Model
- EM – Engineering Model
- STR – Structure
- SCI – Scintillator Payload
- ADCS – Attitude Determination Control System
- GPS – Global Positioning Services
- OBC – On-Board Computer
- TEL – Telecommunication
- EPS – Electrical Power System
- AIT – Assembly, Integration, and Testing
- SE – System Engineering
- ICD – Interface Control Documents
- EPS – Electrical Power Supply
- CNES – Centre National Etude Spatiale
- ME – Mechanical Engineer
- (P)-POD – (Poly) – Picosatellite Orbital Deployer

- ISIS – Innovation Solutions in Space
- RBF – Remove Before Flight
- KS – Kill-Switch
- SCL – Serial Clock
- SDA – Serial Data
- UART – Universal Asynchronous Receiver Transmitter
- SPI – Serial Peripheral Interface
- MISO – Master Input Slave Output
- MOSI – Master Output Slave Input
- SiPM – Silicon Photomultiplier
- MC – Microcontroller
- FW – Firmware
- MPPT – Maximum Peak Power Tracking

1.3 Profile of the organization

1.3.1. Background.

Some years ago, the interest in CubeSat projects has been incrementing because of the advantage of being low cost for promising scientific results. Paris Diderot University created a Student Space Centre in 2014 to get involved in the development of nanosatellites. Some institutions have co-operated to deliver this student space mission at Paris Diderot Campus:

- APC – Laboratoire Astroparticule & Cosmologie
- IPGP – Institut De Physique Du Globe De Paris
- CNES – Centre national d'études spatiales in the French educational satellite program JANUS – Jeunes en Apprentissage pour la réalisation de Nanosatellites au sein

des Universités et des écoles de l’enseignement Supérieur

1.3.2. Igosat project (NGUYEN, 2018).

IGOSat - Ionospheric & Gamma-ray Observation Satellite is the first CubeSat student at the Paris Diderot University. The mission operates in a quasi-polar orbit at 650km from the earth and it is based on two objectives (two payloads):

1. A dual-frequency GPS receiver for the study of the total electronic content (TEC) of the ionosphere, a region of the terrestrial atmosphere located between 60 and 800 km altitude by GPS occultation, measuring the phase shift of L1 and L2 signals.
   i. L1: general frequency of 1575.42 MHz
   ii. L2: general frequency of 1227.60Mhz
2. A scintillator and a silicon photomultiplier SiPM for the study of the gamma-ray spectrum (energy between 20keV to 2MeV) and electrons (energy between 1MeV to 20MeV) in aurora areas and above the South Atlantic Anomaly (SAA) by using the XGRE/TARANIS example which is currently under development in APC.

IGOSat satellite began in 2012 with a feasibility study called *Phase 0* and completed in 2014. After, the feasibility and the preliminary definition called *Phase A* and *B* respectively followed with a phase B review in June 2016 with the architectural design, the structural model and the thermal model as well as the ground installation was completed. Following this, the detailed design of all subsystems called *Phase C* has been completed in September 2017. Till the date, the project is in the Production / Qualification of the system called *Phase D*, aiming to deliver the Flight Model on the ground, we are currently working on the integration and testing of the subsystems. The use/operation called Phase E, which marks the launch and start of IGOSat satellite operations, is expected by the end of 2020. The duration of the mission will be one year after the launch. The end of the useful life of the satellite, phase F, is expected before 2044, a date governed by the law of space operations that postulates that the satellite must be de-orbited no later than 25 years after its launch. Throughout the years of development, more than 200 students from all over the world have collaborated in the project.

1.3.3. Cubesat (NASA, 2017) (JANUS; CNES, 2016).

Artificial satellites vary in size and cost depending on the use. According to NASA we have large satellites with a mass more than 1000 kg, medium-sized satellites between 500 - 1000 kg and small satellites that are classified in Minisatellites between 100 - 500 kg, Microsatellites between 10 - 100 kg, Nanosatellites (*CubeSats are in this category*) between 1 - 10 kg and Picosatellites less than 1 kg.

The CubeSat standard defines specific criteria that control factors such as shape, size, and weight. Due to the standardized aspects, the companies produce the components in mass and it makes the development small expensive and reduces the cost related to the transporting and the deploying. The standard allowing to combine cubic units. The “unit” is 1U and it means a 100 mm cube with a mass of approximately 1 – 1.33 Kg and an approximate power of 1W. We can find sizes to 1.5U, 2U, 3U, 6U and 12U with a lifetime from 1 to 2 years (or more). **IGOSat** was set out to be a 3U (three units).

The nanosatellites are widely used for the pedagogic frame for the futures space engineers, the validation of technologies in orbit, scientific missions, interplanetary scientific missions, new applications for the civil society and the defense (constellations of observation of the Earth, listening, etc.

1.3.4. Igosat project overview.

The whole IGOsat project is defined clearly by the graph below:

The Flight Segment (FS) consists of three CubeSat units where we have payloads and platforms.

The Ground Segment (GS) comprises the infrastructure required for the ground command, control, communications, operations, data archiving and distribution.

The Launch Accommodation Segment includes the Launch Vehicle (called P-POD for CubeSats) and the related infrastructure at the launch site.

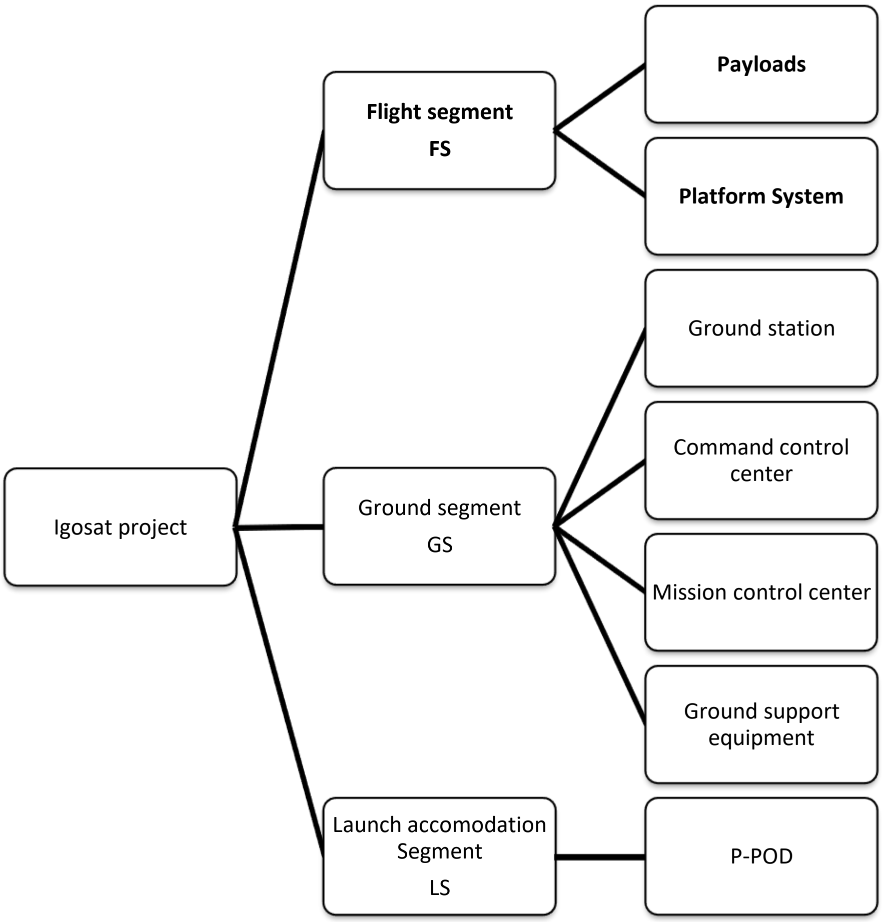


Figure 1. IGOSat Project Overview

1.3.5. Flight system architecture.

In IGOSat the Flight Segment Architecture comprises two payloads and five support platforms, with the OBC as the central unit of information and distribution for any flight control and the EPS as the central power supply for the whole satellite system.

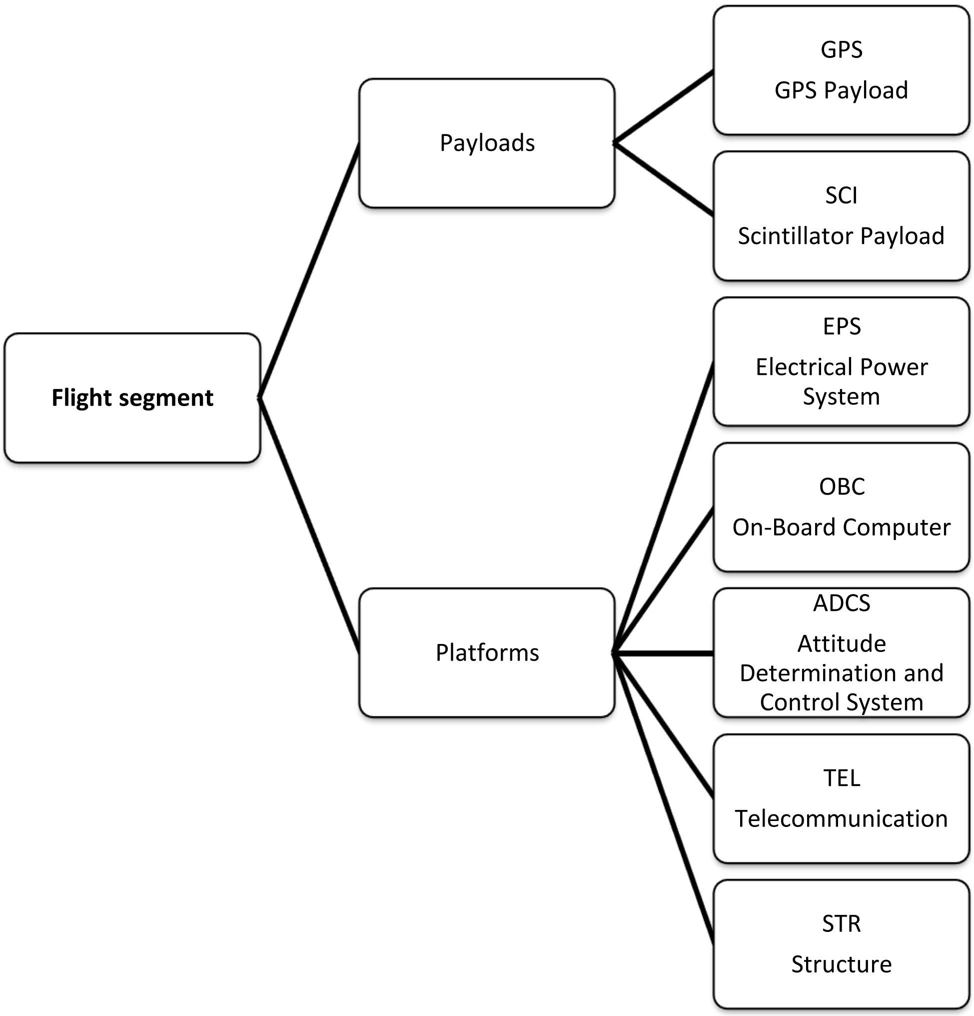


Figure 2. IGOSat Flight Segment Architecture – Full product tree

DESCRIPTION OF THE PROJECT

2.1 Igosat flight segment architecture

The IGOSat Flight Segment Architecture is comprised of two payloads and five support platforms but, each payload or support platform is composed of different elements such as PCBs, sensors, actuators, etc. In this section, I put in context each of them with its components.

2.1.1. Sci – scintillator payload.

The scintillator payload is being developed by IGOSat and it is composed of two printed circuit boards: Support board (it contains the Detector) and the EASIROC board.

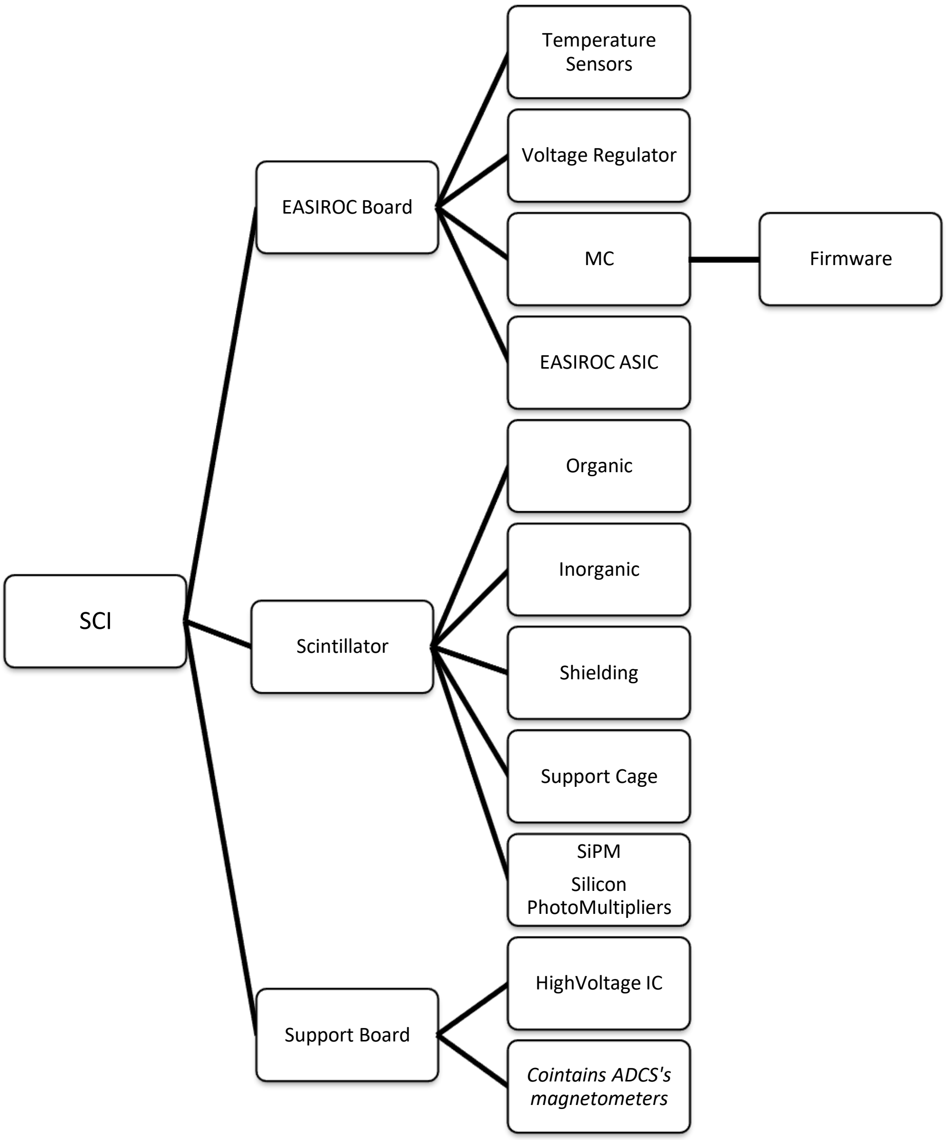


Figure 3. SCI Payload conceptual diagram

The detector of IGOsat has a goal to identify gamma-ray from 200keV to 2MeV and electron from 1MeV to 20MeV. It is made of scintillator materials that are organic and inorganic; read out by Silicon PhotoMultipliers (SiPM).

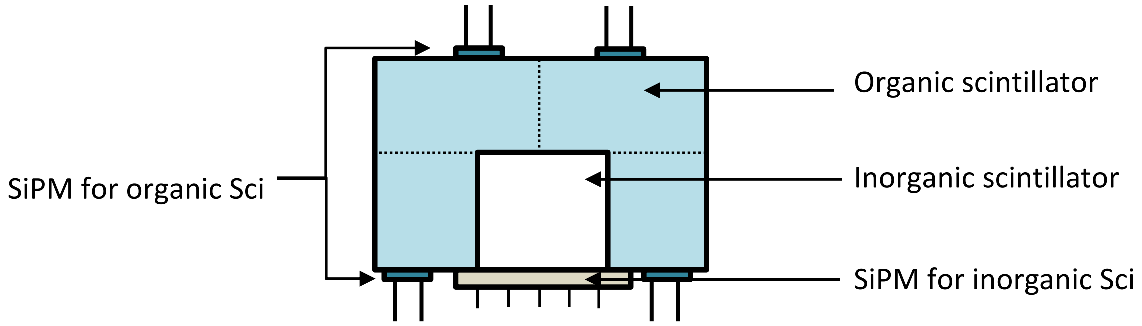


Figure 4: Scintillator and SiPM schematic

The raw output signals from the SiMP (Silicon PhotoMultiplier) are treated and analyzed by the EASIROC ASIC board developed by the CNRS Omega team and after manipulated and send it by the microcontroller to the OBC.

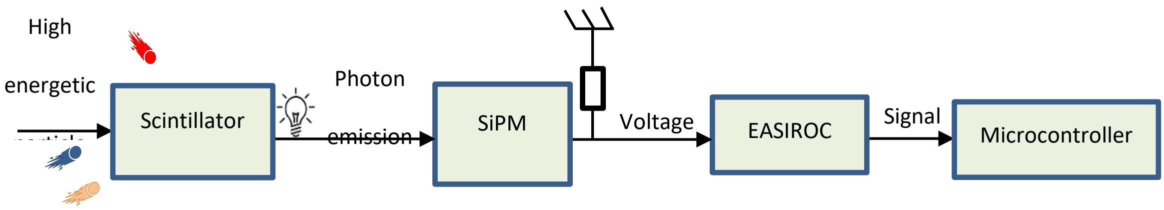


Figure 5: General schematics of the detection system

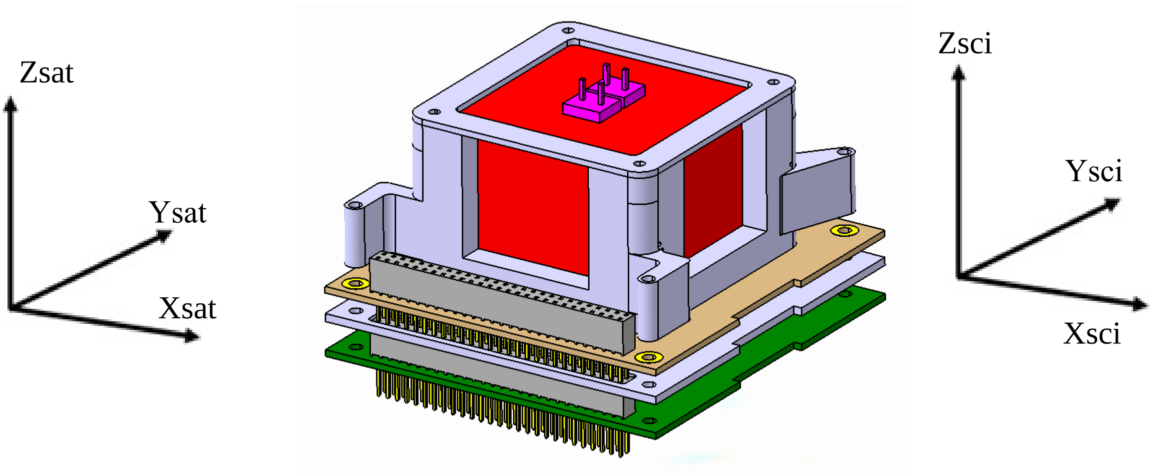


Figure 6: SCI (TOP: detector and support board, MIDDLE: shielding BOTTOM: EASIROC Board), with the reference frames

2.1.2. Tel – telecommunications platform.

The telecommunication platform was designed by ISIS and it is composed of two boards: the communication board and the antenna board

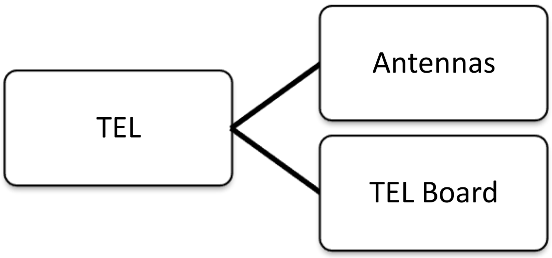


Figure 7. TEL conceptual diagram

In this document, the Telecommunications platform corresponds to the space segment because it refers to the hardware, firmware, antennas and the printed circuit board place onboard the satellite. (Aristotle Space & Aeronautics Team, s.d.)

The telecommunication card used to send and receive remote commands via antennas. The following types of data are exchanged between the space and ground segment:

- Telemetry: Diagnostic information regarding the state of the satellite
- Telecommand: Commands from the ground station to the satellite
- Payload: Scientific data stemming from the experiment

The telecommunication antennas are four, two UHFs for the Downlink (broadcast) and two VHF for the Uplink (reception).

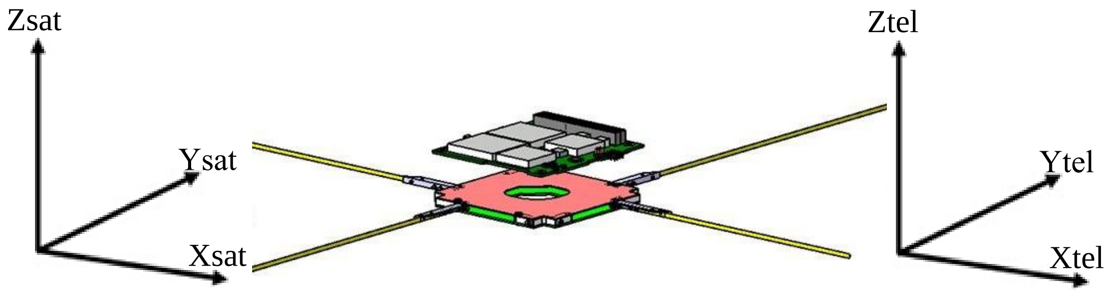


Figure 8: TEL (TOP: Communication Board, BOTTOM: Antenna Board "deployed") and the reference frames

2.1.3. Obc – on-board computer platform.

The OBC was designed by ISIS and it is composed of two printed circuit boards: the OBC board and the FM Daughterboard.

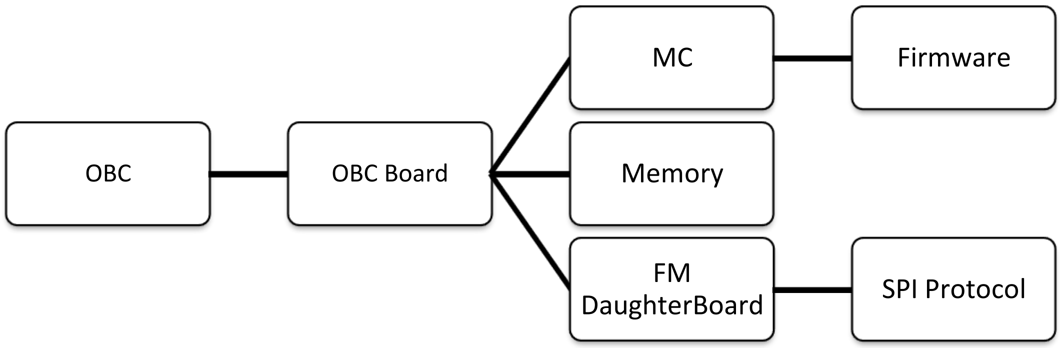


Figure 9. OBC conceptual diagram

The term OBC means On-Board Computer and this system provides processing capability to the satellite, it is the unit where the On-Board Software runs the functions like attitude and orbit control, telecommands execution or dispatching, housekeeping telemetry gathering, and formatting, onboard time synchronization and distribution, failure detection, isolation, recovery, etc. (ESA, s.d.)

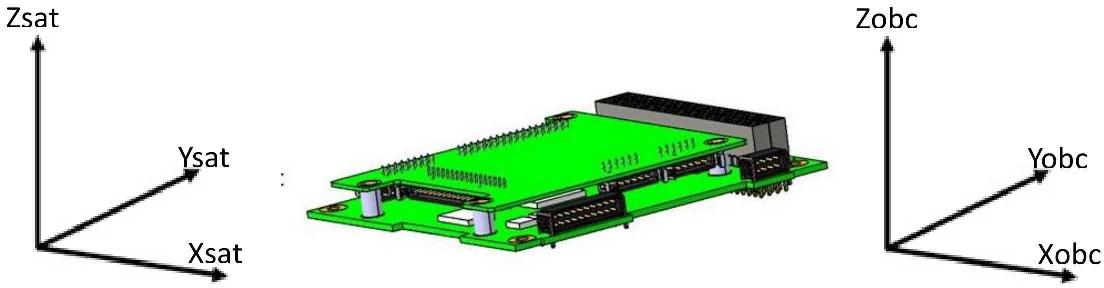


Figure 10: OBC (TOP: FM Daughterboard, BOTTOM: OBC Board) and the reference frames

2.1.4. Adcs – attitude determination and control platform.

The ADCS platform is being developed by IGOSat and it is composed of the ADCS board (including actuators like the air coil and Ferro coil) and the reaction wheel (it is another actuator).

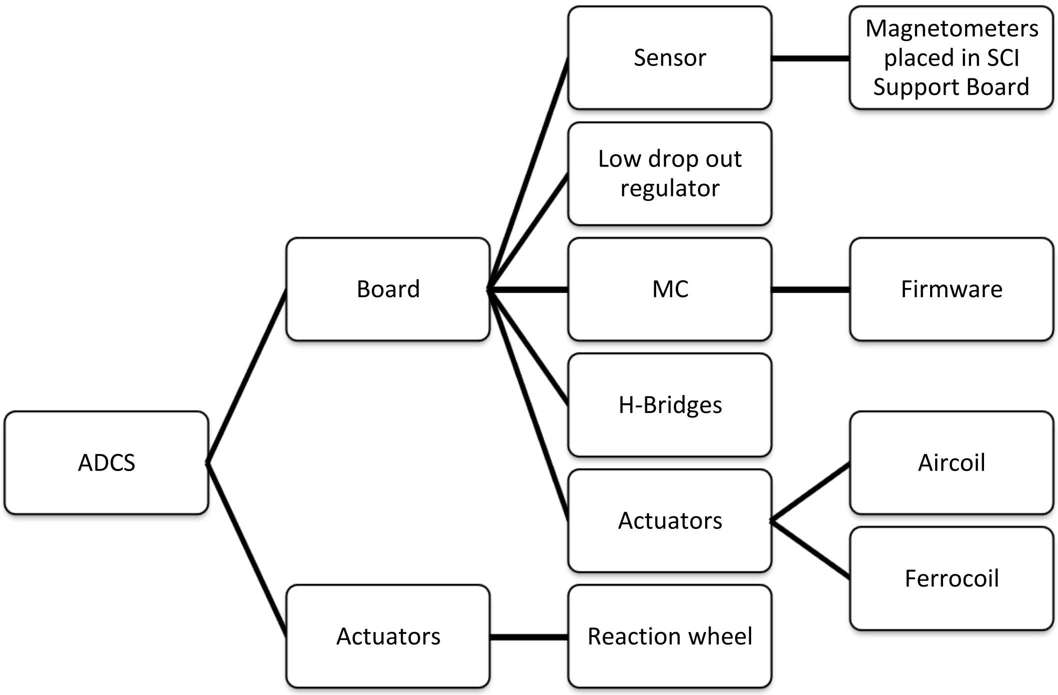


Figure 11. ADCS conceptual diagram

The Attitude Determination and Control System (ADCS) ensures the correct orientation of the satellite. It involves *Actuators* to move in space, *Sensors* are the altitude source, *The Controller* collects and processes the data and *the PC104 connector* permits to communicate with sensors and it also distributes the voltage coming from the power supply. (ECE Paris, s.d.)

The reaction wheel will be connected to the ADCS, it is used at a constant speed as an inertia wheel. It makes it possible to align the moment of inertia of the reaction wheel with the orbital moment of inertia of the satellite. The work of the magneto couplers to correctly orient the satellite is then facilitated.

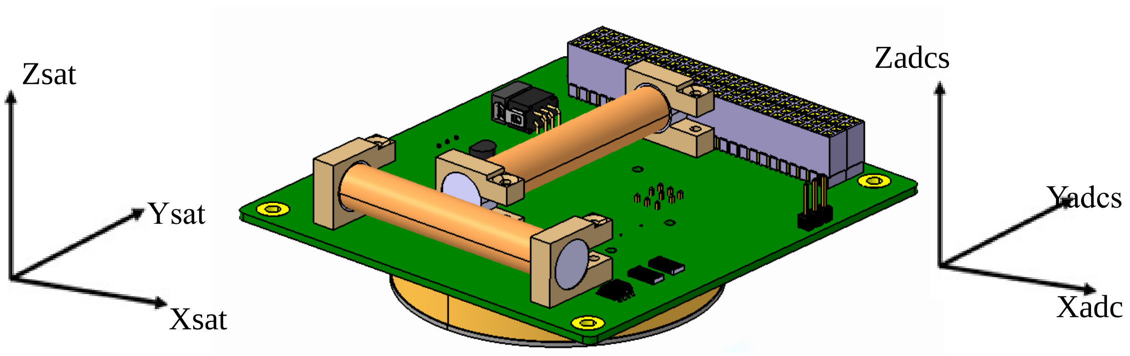


Figure 12: ADCS and the reference frames

Note: Reaction wheel is not represented

2.1.5. **Eps – electrical power source platform.**

The EPS is being developed by IGOSat and it is composed of two printed circuit boards: the Battery Board and the Power Board.

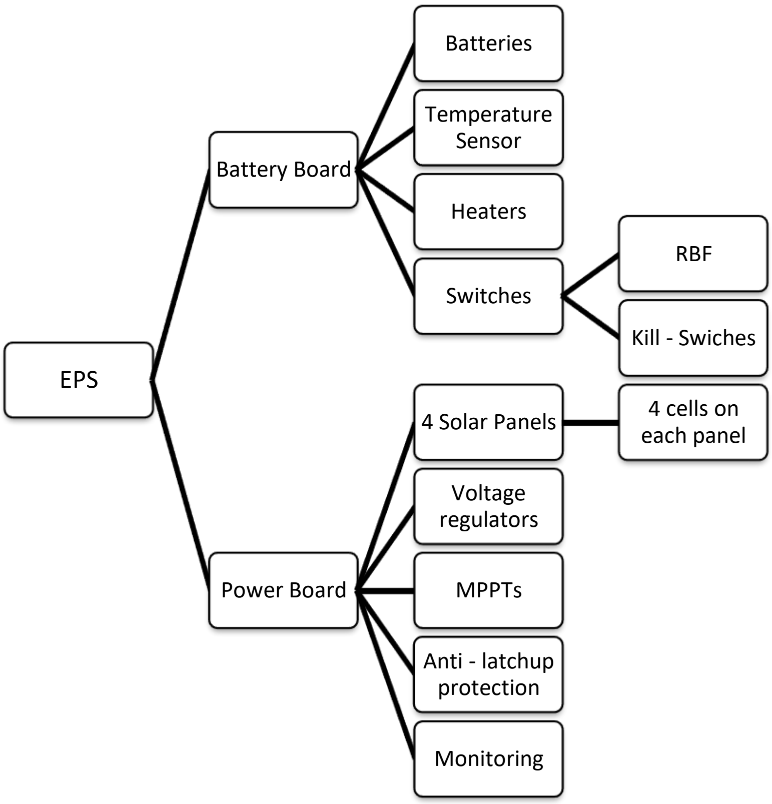


Figure 13. EPS conceptual diagram

The Power Board is used to deliver different stable voltages for the entire CubeSat electrical power needs (subsystems and payloads). This board consists mainly of voltage converters and protection circuits. (Ibrahim, 2012)

The "Kill Switch" and the RBF (Remove before flight) will be connected to this card, whose role is to disconnect the batteries from the satellite when it will be embarked on the P-POD (Poly Picosatellite Orbital Deployer) inside the launcher until release into orbit.

The battery card is recharged by 6-cell solar panels on each longitudinal side of the satellite.

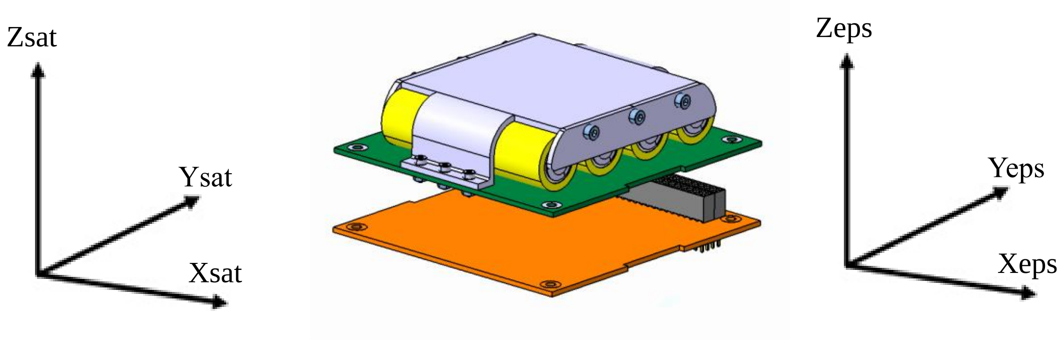


Figure 14: Illustration of EPS (TOP: Battery Board, BOTTOM: Power Board), the reference frame of the EPS

Note: Solar panels are not represented

2.1.6. Gps – global positioning system payload.

The GPS payload was developed by Pumpkin, Inc. and it is composed of the GPSRM printed circuit board and the GPS Antenna.

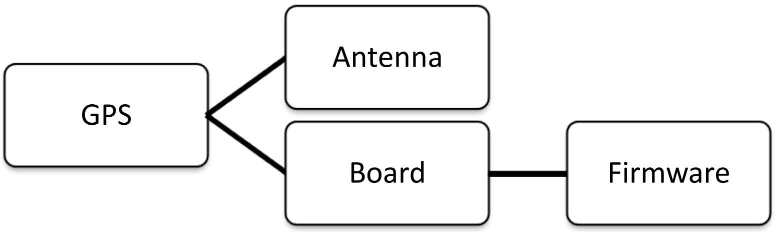


Figure 15. GPS conceptual diagram

The main function of the GPS instrument is to provide useful data to calculate the absolute Slant Total Electron Content (STEC), which means the TEC along the ray path between IGOSat and a given GPS satellite.

The GPS antenna receives satellite signals from the GPS constellation.

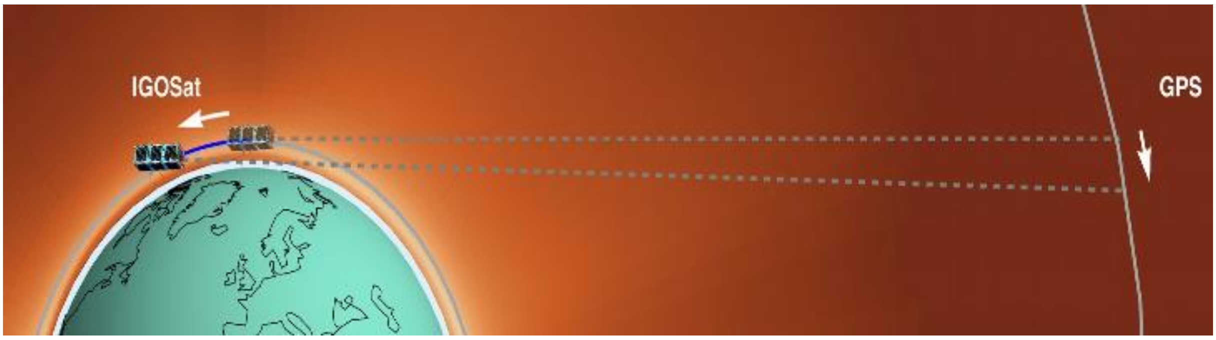


Figure 16. Radio occultation schema

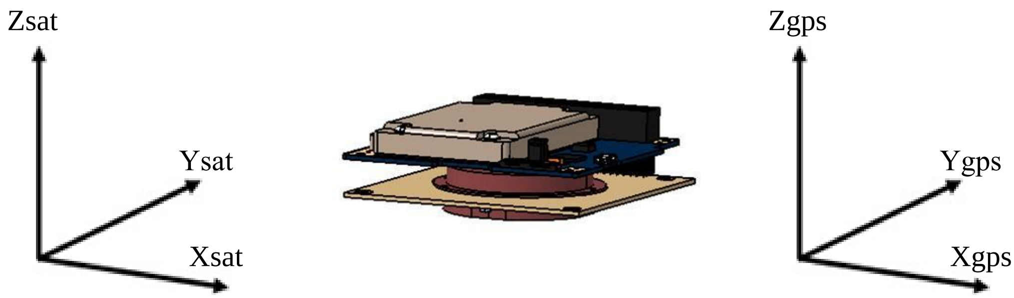


Figure 17: GPS (TOP: GPSRM Board, BOTTOM: Antenna) and the reference frames

2.1.7. Str – structure.

The Structure is composed of the Skeleton and the Mass balance.

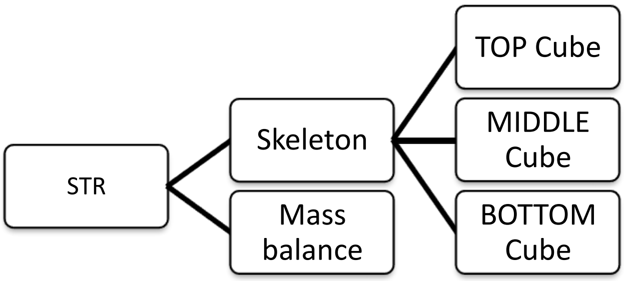


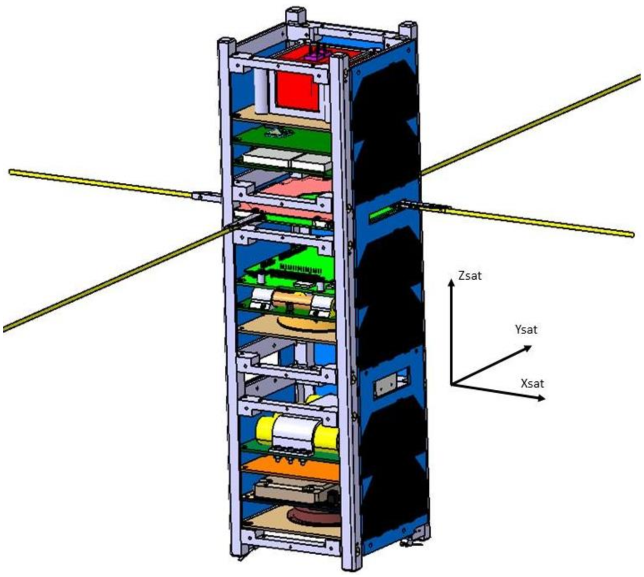
Figure 18. STR conceptual diagram

The skeleton is designed by IGOSat following the standard 3U CubeSat (California Polytechnic

State University, 2014). This structure gives us the maximum flexibility, accessibility, and integration to stacks of PCBs, or other modules, to be mounted inside the chassis. (ISIS)

The mass balance helps the nanosatellite to reduce the magnitude of the on-orbit external disturbing torques, re-locating the center of mass (CoM) as close as possible to the geometrical center of the spacecraft. (Humberto, 2018)

The axis x is collinear with the long axis of the connectors PC 104. The axis z is collinear with the axis of the length of the satellite directed from the bottom of the latter (Antenne GPS) upwards (Scintillator payload). The axis y comes to terminate the coordinate system orthogonal to the axes z and x.



The IGOSat 3U CubeSat system layout

CUBE 1 – Top:

- SCI
- TEL

Antenna Card - Between Top – Middle

CUBE 2 – Middle

- OBC
- ADCS

Reaction Wheel - Between Middle – Bottom

CUBE 3 – Bottom

- EPS
- GPS

Figure 19. IGOSat assembled model view with the reference frame

2.2 General and specific goals of the internship

In my internship agreement, the general goal is ELECTRONICS SYSTEM ENGINEERING FLAT-SAT

In my internship agreement, the specific goals are:

- Writing of test protocols and electronic unit tests
- A global test of the satellite model "on-table“
- Verification and validation of the results in comparison with the specifications

2.3 State of the art

During the internship period, I was assigned to the Electronics Team composed by General Electronics, the EPS and Flat-Sat. This team is responsible for the design, development, function, and testing of the sub-systems and the payloads electronics in the flight segment. The job assigned to me is related to the integration of the systems and the payloads, the Flat-Sat test for the whole satellite.

Igosat Team 2019 is composed by an international squad where the members are from all over the world, the team is composed by Duy K. DGUYEN (Vietnam) in the Scintillator payload, Flavien GUICHOU (France) in the GPS payload, Yanli HE (China) in the General Electronics, Imad AYOUB (Argelia) in the EPS (Electrical Power System), Juan VALVERDE (me) (Ecuador) in the Electronics System Engineer - Flat-Sat, Quân Anh BÙI (Vietnam) in the Mechanics, Leo COIC (France) in the ADCS (Attitude Determination and Control System), Corentin GUIGNOT (France) in the Mechanics and Thermic, and Amar BOULENOUAR (Argelia) in the EASIROC.

At the beginning of the internship period, I followed the instructions of the Project Manager reading and reviewing the documentation of the project. I read the Definition Files that are documents related to the operation of payloads and platforms and that are all managed internally. Next, the documents that I had to handle are the INTERFACE CONTROL DOCUMENT (ICD) and the SYSTEM ENGINEERING Assembly, Integration and Testing that are internal master documents and describe the entire system.

2.4 Problematic

I realized that some parts of my documents need further analysis since everything must be defined before integration and testing. Extracting information from both the Definition Files and the support of the team members, I started by performing the SUBSYSTEM TECHNICAL CHARACTERISTICS of the payloads and the platforms. For the integration, I created a new document with the pin attribution in each cube of the CubeSat, and then I designed documents with the description of all the required harnesses, this led me to make a complete IGOSat scheme with arrows that describe all the interconnections. Because of not finding a feasible solution to interconnect two PC104, the idea of using Couplers, which I designed to meet the specifications, was consolidated. In the testing stage, I gave support for the integration of the solar panel and the EPS. In the integration, I am working with the Space Mechanical Engineer and my work will end with the power budget of the system.

2.4.1. Challenge and limitations.

I must be kept in constant monitoring of the changes that are made in the subsystems as well as the mechanical part.

I have the challenge of working in a cross-development environment carrying out the documentation of the integration/processes/testing/etc. under IGOSat standard.

A cross-development environment has the challenge of dependence related to the manufacturer's deadlines and the time that the development takes.

I have the challenge of developing high-level documentation to communicate in a simple, structured and easy form to everyone who needs to work or understand the project.

DEVELOPMENT

3.1 Subsystem technical characteristics.

The next table resumes the payloads and support platforms voltage supply and communication needs, I extracted this information from the Definition Files and the support of the team members.

System	Subsystem	Voltage Supply needs (DC) [V]				Communication needs			
		3,3	5	Vbatt (7,2)	Others	I2C	SPI	UART	Others
SCI	Detector				54				Analog
	Support board	x	x		2,5	x	x	x	Analog
	EASIROC Board	x		x		x	x		
TEL	TRXVU Board			x		x			
	Antenna Board	x				x		x	RF
OBC	OBC	x	x			x		x	
	Daughterboard						x		
ADCS	ADCS Board			x		x	x		
	Magnetorquers (Located in the SCI Support Board)	x				x			
	Reaction wheel	x				x			
	Magnetometers	x				x			
EPS	Battery board					x			
	Powerboard			x	SP	x			
	Solar Panel					x			
GPS	GPSRM Board	x	x			x		x	RF
	Antenna				2.5 to 16				RF

Where:
RF Radio Frequency
SP Solar Panels

Table 1. Current rating approximation for the subsystems

The next table resumes the payloads and support platform's current rating approximation, the Scintillator payload current rating is not yet determined. I extracted this information from the

Definition Files and the support of the team members.

System	Subsystem	Typical	Notes
TEL	TEL	410mA@8V	MAX 600mA@8V with Rx and Tx ON
	TEL Antenna	9mA@20°C	0,56A@3,3V Deployment 3 s
OBC	OBC	115mA	380mW@3,3V
	Daughterboard		Included in the ADCS board
ADCS	ADCS board	500mA	Estimate
	Reaction Wheel		Included in the ADCS board
EPS	OBC	115mA	380mW@3,3V
	Daughterboard		Included in the ADCS board
GPS	GPSRM board	300mA	
	Antenna		Included in the GPSRM board

Table 2. Current rating approximation for each payload and support platform in IGOSat

3.2 Interconnections design.

We have payloads, platforms, sensors, antennas and actuators located in a fixed place inside the flight segment of IGOSat in one of the three cubes but, they need some requirements to work correctly, for example, data transmission, power supply from the EPS, etc. To perform the integration and to connect the payloads and the platforms between them, the satellite has two types of interconnections: Harnesses and Connectors.

I worked permanently with the Project Manager support to compile all the information related with the payloads and platforms coming from ISIS documentation for the TEL platform (Communication and Antenna board) and the OBC platform (included the FM Daughterboard), CubeSat Kit and PUMPKIN documentation for the GPS payload and the IGOSat interns experience with Ial documentation compiled by previous interns that worked in Definition Files, System Engineering (Assembly, Integration, and Testing) and ICD (Interface and Control Document) which are sources of project information. For the mechanical requirements, I had the help of the mechanical space engineer and the Project Manager.

The next figure presents us with the complete interconnections diagram of the whole satellite.

This is an electronic document for IGOSat Team, it is called “INTERCONNECTIONS DOCUMENTATION”.

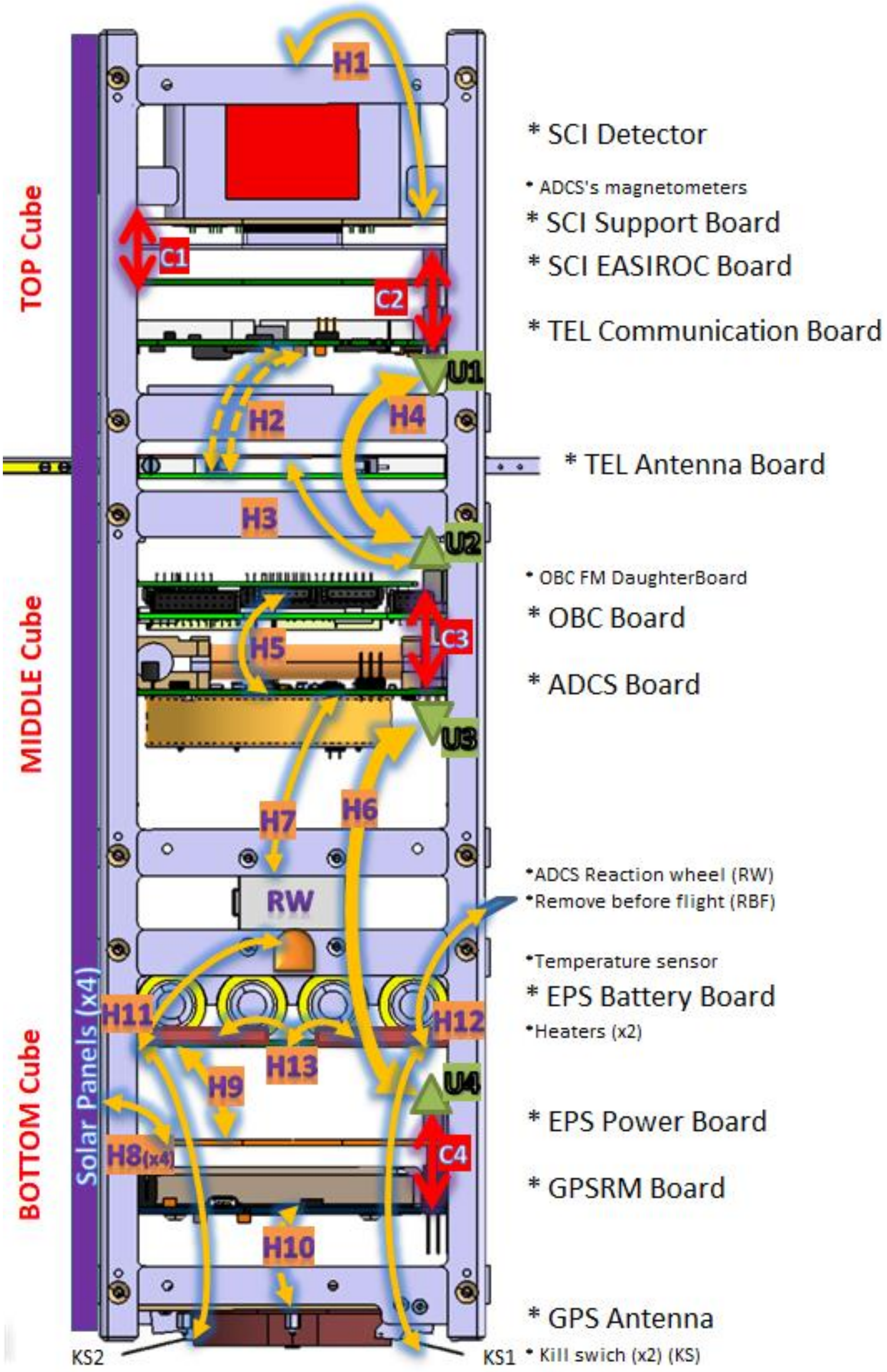


Figure 20. Stack connectors, couplers, and harnesses in the whole satellite

COUPLERS (from stack PC104) *in green color*		
LABEL	From	To
U1	TEL Communication Board	OBC Board
U2	OBC Board	TEL Communication Board
U3	ADCS Board	EPS Power Board
U4	EPS Power Board	ADCS Board

Table 3. Couplers in the whole satellite

CONNECTORS (Stack PC104) *in red color*			
LABEL	Type	From	To
C1	*54-pines*	SCI Support Board	SCI EASIROC Board
C2	PC 104	SCI EASIROC Board	TEL Communication Board
C3	PC 104	OBC Board	ADCS Board
C4	PC 104	EPS Power Board	GPSRM Board

Table 4. Connectors in the whole satellite

HARNESSES *in orange color*			
LABEL	Type	From	To
H1	Wires	SCI Detectors	SCI Support Board
H2	*Radio Freq.*	*TEL Communication Board*	*TEL Antenna Board*
H3	Wires	U2	TEL Antenna Board
H4	Wires	U2	U1
H5	Wires	FM DaughterBoard	ADCS Board
H6	Wires	U3	U4
H7	Wires	Reaction Wheel	ADCS Board
H8	Wires	Solar Panels	EPS Power Board
H9	Wires	Battery Board	EPS Power Board
H10	*Radio Freq.*	*GPSRM Board*	*GPS Antenna*
H11	Wires	Battery Board	Kill-Switches
H12	Wires	Remove before flight	EPS Battery Board

Table 5. Harnesses in the whole satellite

3.2.1. Pin attribution and stack connectors documentation in subsystems.

The CubeSat standard was developed around the PC-104 connector specification where we can accommodate PCB cards to be stacked vertically in a 100 mm profile for 1U CubeSat's. PC104 allows various data transmission protocols. A single pin permits a current of 5.2 Amperes (SAMPTEC). PC104 connectors are located in almost all sub-systems of IGOSat. (Consortium, PC/104 Embedded, 2008) (DEBES, 2011)

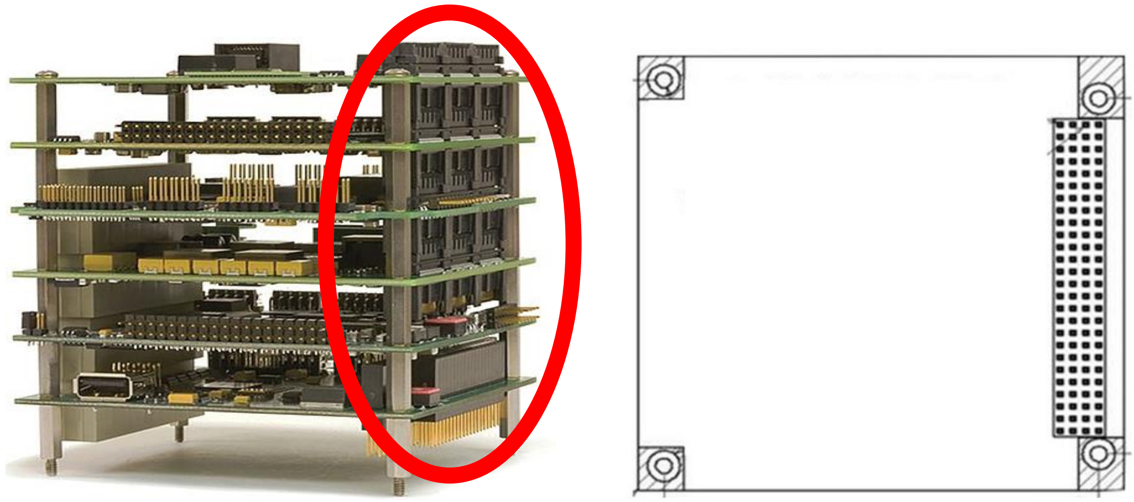


Figure 21. PC-104 stack and a PCB format drawing for Cubesat

To describe each stack connector and each pin in the connector we took reference in the 3U that CubeSat has but, that is a part of the complete electronic document called "PIN ATTRIBUTION AND STACK CONNECTORS DOCUMENTATION IN SUBSYSTEMS" that presents the pin attribution in every subsystem of the whole satellite, the document diagrams contain comments that explain the type and operation of each pin.

In the case of the TOP cube Figure 22; it has two stack connectors a 54-pin for the Support board, a PC104 connector specification for the EASIROC board, and a PC104 connector specification for the TRXVU board. The 54-pins connector makes an interconnection between the SCI Support board and the EASIROC board, and the PC104 connector makes an interconnection between the EASIROC board and the TRXVU board.

In the case of the MIDDLE cube Figure 23, it has a PC104 stack connector that makes an interconnection between the OBC board and the ADCS Board.

In the case of the BOTTOM cube 7Figure 24, it has a PC104 stack connector too that makes an interconnection between the EPS Power board and the GPSRM Board.

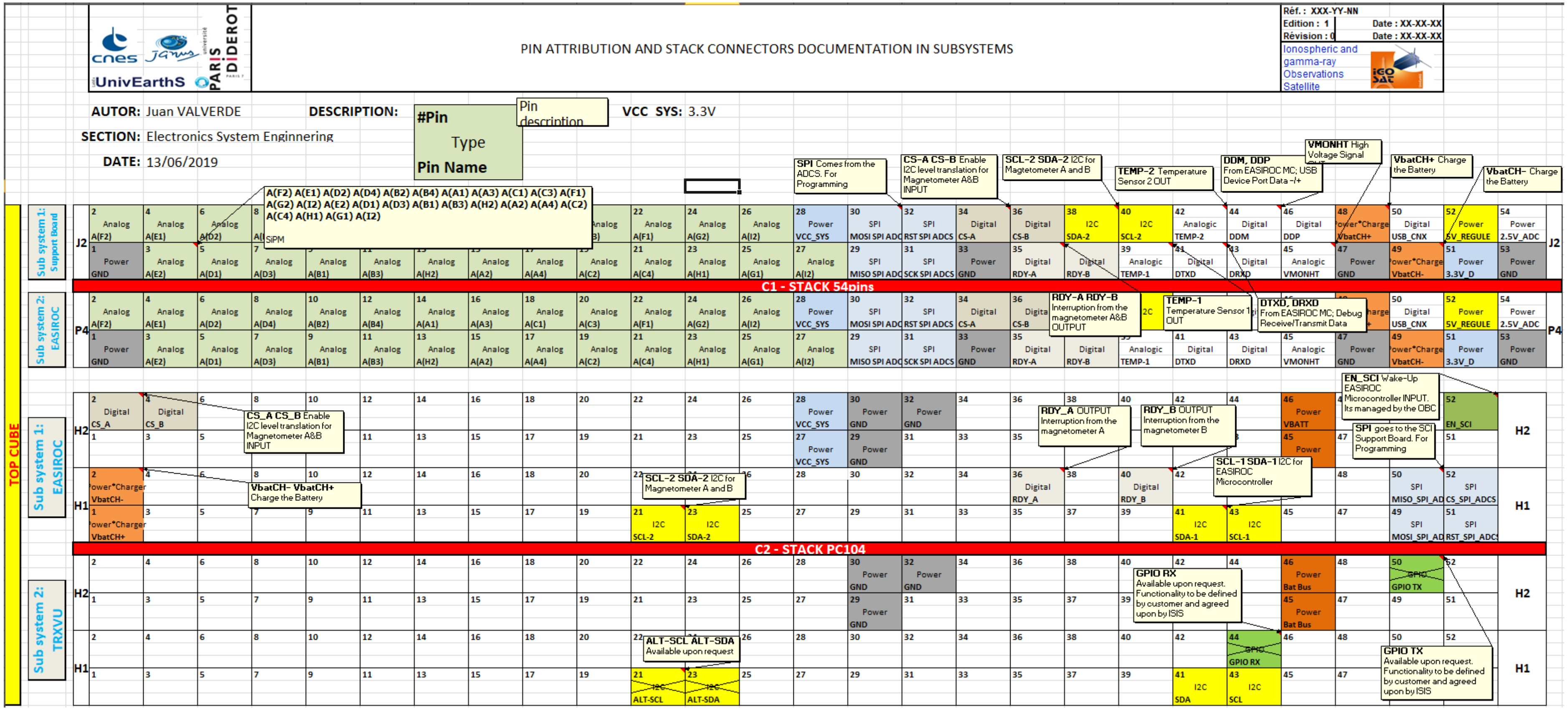


Figure 22.TOP cube stack connectors documentation

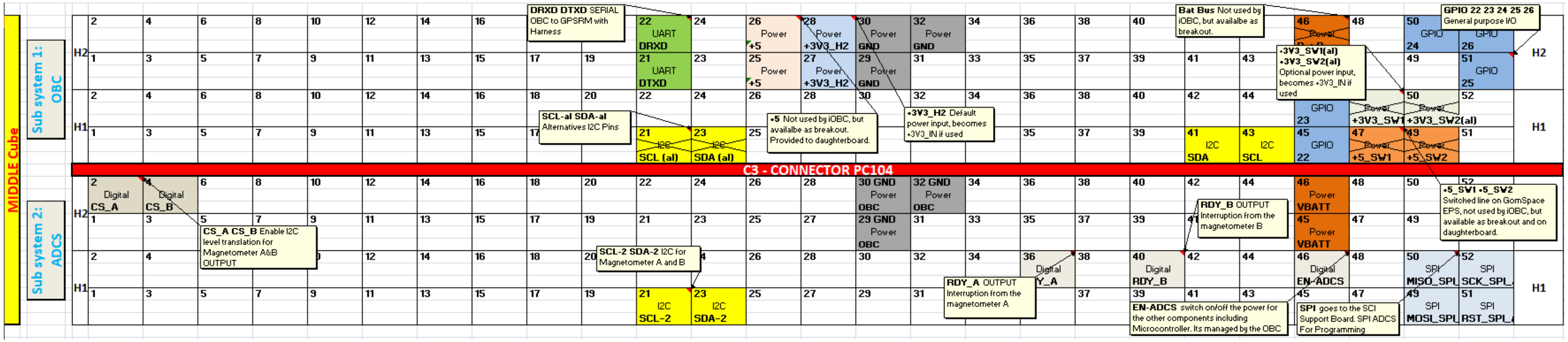
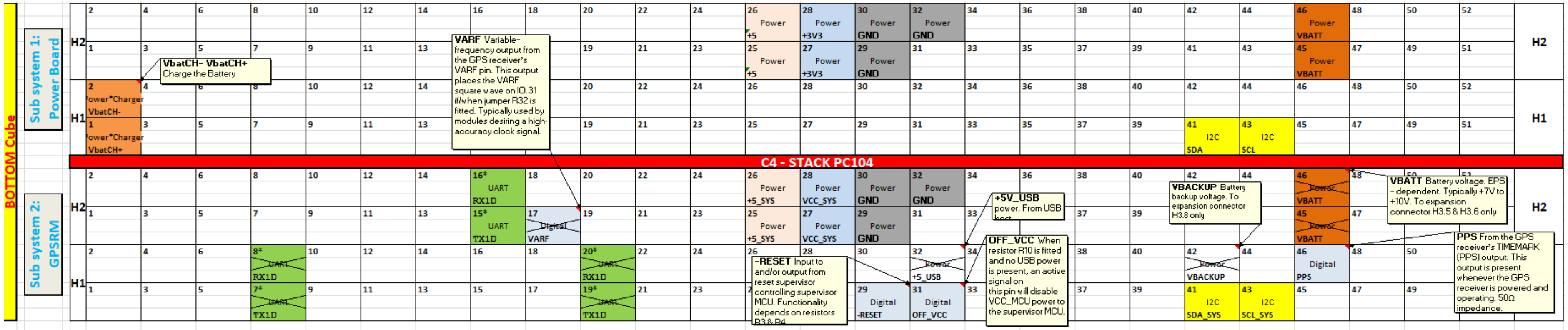


Figure 23. MIDDLE cube stack connectors documentation



* We need a harness to make a SERIAL communication between OBC - GPS and configure the UART pins

RECOMENDATION: Only use one pair of jumpers at the same time for the serial communication for the GPSRM

Quote FROM THE GPS DATASHEET page 20: N.B. For proper operation, a maximum of one pair of jumpers (R26 & R29, R27 & R30, or R28 & R31) should be fitted at any time. Fitting more than one pair of jumpers may damage the GPSRM 1. Jumpers are to be soldered in place by a qualified technician

JUMPERS		NAMES		CONNECTOR	
Tx	Rx	Tx	Rx	Tx	Rx
R26	R29	IO.5	IO.4	H1.19	H1.20
R27	R30	IO.17	IO.16	H1.7	H1.8
R28	R31	IO.33	IO.32	H2.15	H2.16

7Figure 24. BOTTOM cube stack connectors documentation

3.2.2. Harnesses design.

The harnesses give us more flexibility to interconnect the different payloads, platforms, sensors, antennas and actuators in the flight segment of IGOSat. A harness is an assembly of electrical wires which transmit signals or electrical power between the ends.

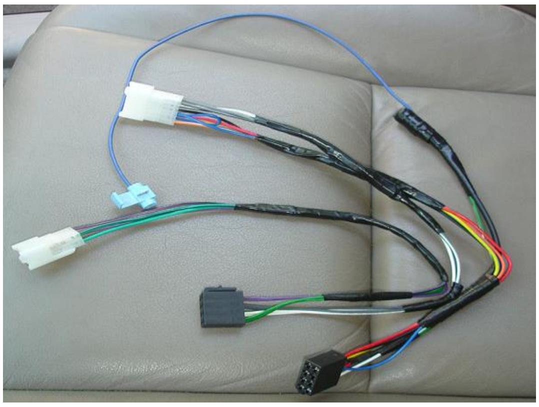


Figure 25.Harness used for EPS testing

I choose the cable BS 3G 201 Type-A #28 AWG because it covers the current necessary to feed the payloads and the platforms and it has an aerospace standard so it is manufactured by many space companies.

The next figures present us each harness design and description in a document called "DOCUMENTATION OF WIRE(S) / HARNESS(ES)", it contains the information related to the construction, fixation, location, connectors, wire distance, pin references, etc. Figure 20. shown us the complete interconnections diagram of the whole satellite, it is called "INTERCONNECTIONS DOCUMENTATION".

cnes · Janus · Université Paris Diderot · UnivEarthS	DOCUMENTATION OF WIRE(S) / HARNESS(ES)	**Réf. : XXX-YY-NN** **Edition : 1** **Date : XX-XX-XX** **Révision : 0** **Date : XX-XX-XX** Ionospheric and Gamma-ray Observations Satellite

AUTOR: Juan VALVERDE
SECTION: Electronics System Enginnering
DATE: 17/05/2019
DIAGRAM:

DESCRIPTION:

LABEL	Type	From	To
H1	Wires	SCI Detectors	SCI SupportBoard

FROM				Fixation	HARNESS: Connector			HARNESS: Wire				HARNESS: Connector			Fixation	TO			
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
SCI support board	J12	1	K (I2)	Solder + Adhesive + Heat Shrink Tubing				28	BS 3G 210 -	Black	35mm				Solder + Adhesive + Heat Shrink Tubing	1 (Index Mark)	K	SIPM - P6	Detector
		2	A (I2)					28	BS 3G 210 -	Blue	35mm					2	A		
	90120-0764	3	K (I1)					28	BS 3G 210 -	Brown	35mm					1 (Index Mark)	K	SiPM - P11	
		4	A (I1)					28	BS 3G 210 -	Red	35mm					2	A		

Figure 26. Documentation for the harness H1

cnes · Janus · Université Paris Diderot · UnivEarthS	DOCUMENTATION OF WIRE(S) / HARNESS(ES)	**Réf. : XXX-YY-NN** **Edition : 1** **Date : XX-XX-XX** **Révision : 0** **Date : XX-XX-XX** Ionospheric and Gamma-ray Observations Satellite

AUTOR: Juan VALVERDE
SECTION: Electronics System Enginnering
DATE: 17/05/2019
DIAGRAM:

DESCRIPTION:

LABEL	Type	From	To
H2	*Radio Freq.*	*TEL Communication Board*	*TEL Antenna Board*

FROM				Fixation	HARNESS: Connector			HARNESS: Wire				HARNESS: Connector			Fixation	TO			
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
TEL	J2 - RX (VHF)	1-Center pin	RF in	PlugIn	MMCX - RF UHF/VHF	1	ISIS	ISIS			60 mm	ISIS	1	MMCX - RF UHF/VHF	PlugIn	1-Center pin	RF out	J2	Antenna
		2-Shield	GND			2	ISIS	ISIS			60 mm	ISIS	2			2-Shield	GND		

FROM				Fixation	HARNESS: Connector			HARNESS: Wire				HARNESS: Connector			Fixation	TO			
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
TEL	J3 - TX (UHF)	1-Center pin	RF out	PlugIn	MMCX - RF UHF/VHF	1	ISIS	ISIS			60 mm	ISIS	1	MMCX - RF UHF/VHF	PlugIn	1-Center pin	RF in	J3	Antenna
		2-Shield	GND			2	ISIS	ISIS			60 mm	ISIS	2			2-Shield	GND		

Figure 27. Documentation for the harness H2

DOCUMENTATION OF WIRE(S) / HARNESS(ES)

Réf. : XXX-YY-NN
Edition : 1 | Date : XX-XX-XX
Révision : 0 | Date : XX-XX-XX
Ionospheric and Gamma-ray Observations Satellite

AUTOR: Juan VALVERDE
SECTION: Electronics System Enginnering
DATE: 24/07/2019

DESCRIPTION:

HARNESSES			
LABEL	Type	From	To
H3	Wires	U2	TEL Antenna Board
H4	Wires	U2	U1

DIAGRAM:

FROM				Fixation	HARNESS										Fixation	TO			
					Connector			Wire				Connector							
Coupler / Board	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Coupler / Board
		1	VbatCH+			1	Crimp Cont	28	BS 3G 210 T	Black	TBD	Crimp Conta	1			1	VbatCH+		
		2	VbatCH-			2	Crimp Cont	28	BS 3G 210 T	Blue	TBD	Crimp Conta	2			2	VbatCH-		
		3	SCL-2			3	Crimp Cont	28	BS 3G 210 T	Brown	TBD	Crimp Conta	3			3	SCL-2		
		4	SDA-2			4	Crimp Cont	28	BS 3G 210 T	Red	TBD	Crimp Conta	4			4	SDA-2		
		5	RDY_A			5	Crimp Cont	28	BS 3G 210 T	White	TBD	Crimp Conta	5			5	RDY_A		
		6	RDY_B			6	Crimp Cont	28	BS 3G 210 T	Grey	TBD	Crimp Conta	6			6	RDY_B		
		7	SDA-1			7	Crimp Cont	28	BS 3G 210 T	Violet	TBD	Crimp Conta	7			7	SDA-1		
		8	SCL-1			8	Crimp Cont	28	BS 3G 210 T	Pink	TBD	Crimp Conta	8			8	SCL-1		
		9	MOSI_SPI_A			9	Crimp Cont	28	BS 3G 210 T	Orange	TBD	Crimp Conta	9			9	MOSI_SPI_A		
		10	MISO_SPI_A			10	Crimp Cont	28	BS 3G 210 T	Yellow	TBD	Crimp Conta	10			10	MISO_SPI_A		
	J1	11	RTS_SPI_AD			11	Crimp Cont	28	BS 3G 210 T	Green	TBD	Crimp Conta	11			11	RTS_SPI_AD	J1	
		12	SCK_SPI_AD	PlugIn + Jackscrews	H4	12	Crimp Cont	28	BS 3G 210 T	Green/Yell	TBD	Crimp Conta	12	H4	PlugIn + Jackscrews	12	SCK_SPI_AD		U1
U2	M80-5002405	13				13	Crimp Contact					Crimp Conta	13			13		M80-5002405	
		14			M80-4612405	14	Crimp Contact					Crimp Conta	14	M80-4612405		14			
		15	CS_A			15	Crimp Cont	28	BS 3G 210 T	Black	TBD	Crimp Conta	15			15	CS_A		
		16	CS_B			16	Crimp Cont	28	BS 3G 210 T	Blue	TBD	Crimp Conta	16			16	CS_B		
		17	3,3V_1			17	Crimp Cont	28	BS 3G 210 T	Brown	TBD	Crimp Conta	17			17	3,3V_1		
		18	3,3V_2			18	Crimp Cont	28	BS 3G 210 T	Red	TBD	Crimp Conta	18			18	3,3V_2		
		19	GND_1			19	Crimp Cont	28	BS 3G 210 T	White	TBD	Crimp Conta	19			19	GND_1		
		20	GND_2			20	Crimp Cont	28	BS 3G 210 T	Grey	TBD	Crimp Conta	20			20	GND_2		
		21	GND_3			21	Crimp Cont	28	BS 3G 210 T	Violet	TBD	Crimp Conta	21			21	GND_3		
		22	Bat Bus_1			22	Crimp Cont	28	BS 3G 210 T	Pink	TBD	Crimp Conta	22			22	Bat Bus_1		
		23	Bat Bus_2			23	Crimp Cont	28	BS 3G 210 T	Orange	TBD	Crimp Conta	23			23	Bat Bus_2		
		24	EN_SCI			24	Crimp Cont	28	BS 3G 210 T	Yellow	TBD	Crimp Conta	24			24	EN_SCI		

FROM				Fixation	HARNESS										Fixation	TO			
					Connector			Wire				Connector							
Coupler /	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Coupler /
		1	3,3V_1			1	Crimp Cont	28	BS 3G 210 T	Green	TBD	rimp Contac	1			1	Vcc		
		2	SDA-1			2	Crimp Cont	28	BS 3G 210 T	Green/Yell	TBD	rimp Contac	2			2	SDA_A		
		3	GND_1			3	Crimp Cont	28	BS 3G 210 T	Black	TBD	rimp Contac	3			3	GND		
	J2	4				4	Crimp Contact					Crimp Contac	4			4	SDA_B	J1	
		5	GND_2	PlugIn + Jackscrews	H3	5	Crimp Cont	28	BS 3G 210 T	Blue	TBD	rimp Contac	5		PlugIn + Jackscrews	5	GND	Omnetics 9 pins	TEL Antenna
U2	M80-5001005	6	3,3V_2			6	Crimp Cont	28	BS 3G 210 T	Brown	TBD	rimp Contac	6	H3		6	Vcc		
		7	SCL-1		M80-4611005	7	Crimp Cont	28	BS 3G 210 T	Red	TBD	rimp Contac	7			7	SCL_A	A29100-009	
		8				8	Crimp Contact					Crimp Contac	8	A28000-009		8	SCL_B		
		9	GND_3			9	Crimp Cont	28	BS 3G 210 T	White	TBD	rimp Contac	7			9	GND		
		10				10	Crimp Contact					Crimp Contac	8						

Figure 28. Documentation for the harness H3H4

DOCUMENTATION OF WIRE(S) / HARNESS(ES)	Réf. : XXX-YY-NN
	Edition : 1 Date : XX-XX-XX
	Révision : 0 Date : XX-XX-XX
	Ionospheric and Gamma-ray Observations Satellite

AUTOR: Juan VALVERDE
SECTION: Electronics System Enginnering
DATE: 17/05/2019
DIAGRAM:

DESCRIPTION:

HARNESSES			
LABEL	Type	From	To
H5	Wires	FM DaughterBoard	ADCS Board

FROM				Fixation	HARNESS: Connector			Wire				Connector			Fixation	TO			
Coupler / Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Coupler / Subsystem
		1	GND			1	Crimp Contact												
		2	AIN0			2	Crimp Contact												
		3	AIN1			3	Crimp Contact												
		4	AIN2			4	Crimp Contact												
		5	AIN3			5	Crimp Contact												
		6	GND			6	Crimp Contact												
		7	AIN4			7	Crimp Contact												
		8	AIN5			8	Crimp Contact												
		9	AIN6			9	Crimp Contact												
		10	AIN7			10	Crimp Contact												
		11	GND			11	Crimp Contact												
		12	SPI1_NPCS0			12	Crimp Contact												
		13	SPI1_NPCS1			13	Crimp Contact												
		14	SPI1_NPCS2			14	Crimp Contact												
		15	GND			15	Crimp Contact												
	Conn - J5	16	SPI1_SPCK			16	Crimp Conta	28	BS 3G 210 T	Black	35mm	Crimp Conta	1			1	SPI_SPCK		
FM Daughter Board	*Harwin M80-8513442*	17	SPI1_MOSI	PlugIn + Jackscrews	M80 - 8883405	17	Crimp Conta	28	BS 3G 210 T	Blue	35mm	Crimp Conta	2	TBD	PlugIn	2	SPI_MOSI	J x	ADCS
		18	SPI1_MISO			18	Crimp Conta	28	BS 3G 210 T	Brown	35mm	Crimp Conta	3			3	SPI_MISO		
		19	GND			19	Crimp Contact												
		20	GPIO0/D8			20	Crimp Contact												
		21	GPIO1/D9			21	Crimp Contact												
		22	GPIO2/D10			22	Crimp Contact												
		23	GPIO3/D11			23	Crimp Contact												
		24	GND			24	Crimp Contact												
		25	GPIO4/D0			25	Crimp Contact												
		26	GPIO5/D1			26	Crimp Contact												
		27	GPIO6/D2			27	Crimp Contact												
		28	GPIO7/D3			28	Crimp Contact												
		29	GND			29	Crimp Contact												
		30	GPIO8/D4			30	Crimp Contact												
		31	GPIO9/D5			31	Crimp Contact												
		32	GPIO10/D6			32	Crimp Contact												
		33	GPIO11/D7			33	Crimp Contact												
		34	+3V3_SENSE			34	Crimp Contact												

Figure 29. Documentation for the harness H5

DOCUMENTATION OF WIRE(S) / HARNESS(ES)	
Réf. : XXX-YY-NN	
Edition : 1	Date : XX-XX-XX
Révision : 0	Date : XX-XX-XX
Ionospheric and Gamma-ray Observations Satellite	

AUTOR: Juan VALVERDE
SECTION: Electronics System Enginnering
DATE: 24/07/2019

DESCRIPTION:

HARNESSES			
LABEL	Type	From	To
H6	Wires	U3	U4

DIAGRAM:

FROM				Fixation	HARNESS										Fixation	TO			
					Connector			Wire				Connector							
Coupler / Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Coupler / Subsystem
U3	J1 M80-5012005	1	VbatCH+	Plugin + Jackscrews	M80-4612005	1	Crimp Conta	28	BS 3G 210 Ty	Black	TBD	Crimp Conta	1	M80-4612005	Plugin + Jackscrews	1	VbatCH+	J1 M80-5012005	U4
		2	VbatCH-			2	Crimp Conta	28	BS 3G 210 Ty	Blue	TBD	Crimp Conta	2			2	VbatCH-		
		3	SDA			3	Crimp Conta	28	BS 3G 210 Ty	Brown	TBD	Crimp Conta	3			3	SDA		
		4	SCL			4	Crimp Conta	28	BS 3G 210 Ty	Red	TBD	Crimp Conta	4			4	SCL		
		5	GPIO22			5	Crimp Conta	28	BS 3G 210 Ty	White	TBD	Crimp Conta	5			5	-RESET		
		6				6	Crimp Contact					Crimp Conta	6			6			
		7				7	Crimp Contact					Crimp Conta	7			7			
		8	DTXD			8	Crimp Conta	28	BS 3G 210 Ty	Grey	TBD	Crimp Conta	8			8	RX1D		
		9	DRXD			9	Crimp Conta	28	BS 3G 210 Ty	Violet	TBD	Crimp Conta	9			9	TX1D		
		10	5V_1			10	Crimp Conta	28	BS 3G 210 Ty	Pink	TBD	Crimp Conta	10			10	5V_1		
		11	5V_2			11	Crimp Conta	28	BS 3G 210 Ty	Orange	TBD	Crimp Conta	11			11	5V_2		
		12	3,3V_1			12	Crimp Conta	28	BS 3G 210 Ty	Yellow	TBD	Crimp Conta	12			12	3,3V_1		
		13	3,3V_2			13	Crimp Conta	28	BS 3G 210 Ty	Green	TBD	Crimp Conta	13			13	3,3V_2		
		14	GND_1			14	Crimp Conta	28	BS 3G 210 Ty	Green/Yello	TBD	Crimp Conta	14			14	GND_1		
		15	GND_2			15	Crimp Conta	28	BS 3G 210 Ty	Black	TBD	Crimp Conta	15			15	GND_2		
		16	GND_3			16	Crimp Conta	28	BS 3G 210 Ty	Blue	TBD	Crimp Conta	16			16	GND_3		
		17	Bat Bus_1			17	Crimp Conta	28	BS 3G 210 Ty	Brown	TBD	Crimp Conta	17			17	Bat Bus_1		
		18	Bat Bus_2			18	Crimp Conta	28	BS 3G 210 Ty	Red	TBD	Crimp Conta	18			18	Bat Bus_2		
		19	GPIO24			19	Crimp Conta	28	BS 3G 210 Ty	White	TBD	Crimp Conta	19			19	OFF_VCC		
		20	GPIO25			24	Crimp Conta	28	BS 3G 210 Ty	Grey	TBD	Crimp Conta	24			20	PPS		

Figure 30. Documentation for the harness H6

cnes · Janus · Université Paris Diderot · UnivEarthS	DOCUMENTATION OF WIRE(S) / HARNESS(ES)	**Réf. : XXX-YY-NN** **Edition : 1** **Date : XX-XX-XX** **Révision : 0** **Date : XX-XX-XX** **I**onospheric and **G**amma-ray **O**bservations **Sat**ellite

AUTOR: Juan VALVERDE
SECTION: Electronics System Enginnering
DATE: 17/05/2019

DESCRIPTION:

HARNESSES			
LABEL	Type	From	To
H7	Wires	Reaction Wheel	ADCS Board

DIAGRAM:

FROM				Fixation	HARNESS										Fixation	TO			
					Connector			Wire				Connector							
Coupler / Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Coupler / Subsystem
Reaction Wheel	CubeWheel connector *Samtec TFM*	1	PGND	Fixed							35mm	Crimp Conta	1	SFSDT-07-30 G-03.00-SS	PlugIn	1	GND	J3	ADCS
		2	PGND								35mm	Crimp Conta	2			2	GND		
		3	V_Bat								35mm	Crimp Conta	3			3	VBATT_PRO		
		4	V_Bat								35mm	Crimp Conta	4			4	VBATT_PRO		
		5	DGND								35mm	Crimp Conta	5			5	GND		
		6	3V3								35mm	Crimp Conta	6			6	.+3.3V		
		7	UART_TX								35mm	Crimp Conta	7			7	UART_TX		
		8	UART_RX								35mm	Crimp Conta	8			8	UART_RX		
		9	Enable								35mm	Crimp Conta	9			9	Enable		
		10	I2C_SCL								35mm	Crimp Conta	10			10	SCL		
		11	I2C_SDA								35mm	Crimp Conta	11			11	SDA		
		12	DGND								35mm	Crimp Conta	12			12	GND		
		13	CANH								35mm	Crimp Conta	13			13			
		14	CANL								35mm	Crimp Conta	14			14			

Figure 31. Documentation for the harness H7

cnes, Janus, Paris Diderot, UnivEarthS	DOCUMENTATION OF WIRE(S) / HARNESS(ES)	Réf. : XXX-YY-NN Edition : 1 — Date : XX-XX-XX Révision : 0 — Date : XX-XX-XX Ionospheric and Gamma-ray Observations Satellite

AUTOR: Juan VALVERDE
SECTION: Electronics System Enginnering
DATE: 17/05/2019

DESCRIPTION:

HARNESSES			
LABEL	Type	From	To
H8	Wires	Solar Panels	EPS Power Board

DIAGRAM:

FROM				Fixation	HARNESS: Connector			HARNESS: Wire				HARNESS: Connector			Fixation	TO			
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
Solar Panels SP_Xsat+	J1 M80-5300642	1	SDA	PlugIn + Jackscrews	M80-4610642	1	Crimp Conta	28	BS 3G 210 Ty	Black	TBD	Crimp Conta	1	M80-4610642	PlugIn + Jackscrews	1	SDA	J1 M80-5300642	EPS Alimentation Board
		2	3v3			2	Crimp Conta	28	BS 3G 210 Ty	Blue	TBD	Crimp Conta	2			2	3v3		
		3	SCL			3	Crimp Conta	28	BS 3G 210 Ty	Brown	TBD	Crimp Conta	3			3	SCL		
		4	GND			4	Crimp Conta	28	BS 3G 210 Ty	Red	TBD	Crimp Conta	4			4	GND		
		5	GND			5	Crimp Conta	28	BS 3G 210 Ty	White	TBD	Crimp Conta	5			5	GND		
		6	V_SP			6	Crimp Conta	28	BS 3G 210 Ty	Grey	TBD	Crimp Conta	6			6	V_SP		

FROM				Fixation	HARNESS: Connector			HARNESS: Wire				HARNESS: Connector			Fixation	TO			
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
Solar Panels SP_Xsat+	J1 M80-5300642	1	SDA	PlugIn + Jackscrews	M80-4610642	1	Crimp Conta	28	BS 3G 210 Ty	Black	TBD	Crimp Conta	1	M80-4610642	PlugIn + Jackscrews	1	SDA	J8 M80-5300642	EPS Alimentation Board
		2	3v3			2	Crimp Conta	28	BS 3G 210 Ty	Blue	TBD	Crimp Conta	2			2	3v3		
		3	SCL			3	Crimp Conta	28	BS 3G 210 Ty	Brown	TBD	Crimp Conta	3			3	SCL		
		4	GND			4	Crimp Conta	28	BS 3G 210 Ty	Red	TBD	Crimp Conta	4			4	GND		
		5	GND			5	Crimp Conta	28	BS 3G 210 Ty	White	TBD	Crimp Conta	5			5	GND		
		6	V_SP			6	Crimp Conta	28	BS 3G 210 Ty	Grey	TBD	Crimp Conta	6			6	V_SP		

FROM				Fixation	HARNESS: Connector			HARNESS: Wire				HARNESS: Connector			Fixation	TO			
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
Solar Panels SP_Xsat+	J2 M80-5300642	1	SDA	PlugIn + Jackscrews	M80-4610642	1	Crimp Conta	28	BS 3G 210 Ty	Black	TBD	Crimp Conta	1	M80-4610642	PlugIn + Jackscrews	1	SDA	J9 M80-5300642	EPS Alimentation Board
		2	3v3			2	Crimp Conta	28	BS 3G 210 Ty	Blue	TBD	Crimp Conta	2			2	3v3		
		3	SCL			3	Crimp Conta	28	BS 3G 210 Ty	Brown	TBD	Crimp Conta	3			3	SCL		
		4	GND			4	Crimp Conta	28	BS 3G 210 Ty	Red	TBD	Crimp Conta	4			4	GND		
		5	GND			5	Crimp Conta	28	BS 3G 210 Ty	White	TBD	Crimp Conta	5			5	GND		
		6	V_SP			6	Crimp Conta	28	BS 3G 210 Ty	Grey	TBD	Crimp Conta	6			6	V_SP		

FROM				Fixation	HARNESS: Connector			HARNESS: Wire				HARNESS: Connector			Fixation	TO			
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
Solar Panels SP_Xsat+	J2 M80-5300642	1	SDA	PlugIn + Jackscrews	M80-4610642	1	Crimp Conta	28	BS 3G 210 Ty	Black	TBD	Crimp Conta	1	M80-4610642	PlugIn + Jackscrews	1	SDA	J10 M80-5300642	EPS Alimentation Board
		2	3v3			2	Crimp Conta	28	BS 3G 210 Ty	Blue	TBD	Crimp Conta	2			2	3v3		
		3	SCL			3	Crimp Conta	28	BS 3G 210 Ty	Brown	TBD	Crimp Conta	3			3	SCL		
		4	GND			4	Crimp Conta	28	BS 3G 210 Ty	Red	TBD	Crimp Conta	4			4	GND		
		5	GND			5	Crimp Conta	28	BS 3G 210 Ty	White	TBD	Crimp Conta	5			5	GND		
		6	V_SP			6	Crimp Conta	28	BS 3G 210 Ty	Grey	TBD	Crimp Conta	6			6	V_SP		

Figure 32. Documentation for the harness H8

cnes · JANUS · PARIS DIDEROT · UnivEarthS	DOCUMENTATION OF WIRE(S) / HARNESS(ES)	Réf. : XXX-YY-NN Edition : 1 Date : XX-XX-XX Révision : 0 Date : XX-XX-XX Ionospheric and Gamma-ray Observations Satellite

AUTOR: Juan VALVERDE
SECTION: Electronics System Enginnering
DATE: 17/05/2019
DIAGRAM:

DESCRIPTION:

HARNESSES			
LABEL	Type	From	To
H9	Wires	Battery Board	EPS Power Board

FROM				Fixation	HARNESS										Fixation	TO			
					Connector			Wire				Connector							
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Subsystem	Reference	Pin	Label
Battery Board	Con-	1	VBATT-LOAD			1	Crimp Conta	28	BS 3G 210 Ty	Black	60mm	Crimp Conta	1			1	VBATT-LOAD	J16	EPS Alimentation Board
	Battery1	2	VBATT-LOAD		M80 -	2	Crimp Conta	28	BS 3G 210 Ty	Blue	60mm	Crimp Conta	2	M80 -		2	VBATT-LOAD		
		3	GND		4611242	3	Crimp Conta	28	BS 3G 210 Ty	Brown	60mm	Crimp Conta	3	4611242		3	GND	M80-	
	M80 -	4	GND			4	Crimp Conta	28	BS 3G 210 Ty	Red	60mm	Crimp Conta	4			4	GND	5301242	
	5301242	5	3V3			5	Crimp Conta	28	BS 3G 210 Ty	White	60mm	Crimp Conta	5			5	3V3		
		6	3V3	Plugin + Jackscrews		6	Crimp Conta	28	BS 3G 210 Ty	Grey	60mm	Crimp Conta	6		Plugin + Jackscrews	6	3V3		
		7	SCL			7	Crimp Conta	28	BS 3G 210 Ty	Violet	60mm	Crimp Conta	7			7	SCL		
		8	SCL			8	Crimp Conta	28	BS 3G 210 Ty	Pink	60mm	Crimp Conta	8			8	SCL		
		9	SDA			9	Crimp Conta	28	BS 3G 210 Ty	Orange	60mm	Crimp Conta	9			9	SDA		
		10	SDA			10	Crimp Conta	28	BS 3G 210 Ty	Yellow	60mm	Crimp Conta	10			10	SDA		
		11	Chrg+			11	Crimp Conta	28	BS 3G 210 Ty	Green	60mm	Crimp Conta	11			11	Chrg+		
		12	Chrg+			12	Crimp Conta	28	BS 3G 210 Ty	Green/Yello	60mm	Crimp Conta	12			12	Chrg+		

Figure 33. Documentation for the harness H9

cnes Janus PARIS DIDEROT UnivEarthS	DOCUMENTATION OF WIRE(S) / HARNESS(ES)	Réf. : XXX-YY-NN Edition : 1 Date : XX-XX-XX Révision : 0 Date : XX-XX-XX Ionospheric and Gamma-ray Observations Satellite

AUTOR: Juan VALVERDE
SECTION: Electronics System Enginnering
DATE: 17/05/2019
DESCRIPTION:

HARNESSES			
LABEL	Type	From	To
H10	*Radio Freq.*	*GPSRM Board*	*GPS Antenna*

DIAGRAM:

FROM				Fixation	HARNESS										Fixation	TO			
					Connector			Wire				Connector							
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
GPSRM Board		1		PlugIn		1		Tallysman			40mm		1		PlugIn	1			GPS Antenna
		2				2		Tallysman			40mm		2			2			

Figure 34. Documentation for the harness H10

cnes Janus PARIS DIDEROT UnivEarthS	DOCUMENTATION OF WIRE(S) / HARNESS(ES)	Réf. : XXX-YY-NN Edition : 1 Date : XX-XX-XX Révision : 0 Date : XX-XX-XX Ionospheric and Gamma-ray Observations Satellite

AUTOR: Juan VALVERDE
SECTION: Electronics System Enginnering
DATE: 17/05/2019
DESCRIPTION:

HARNESSES			
LABEL	Type	From	To
H11	Wires	Battery Board	Kill-Switches

DIAGRAM:

FROM				Fixation	HARNESS										Fixation	TO			
					Connector			Wire				Connector							
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
Battery Board	KS2 - MOLEX 22032021	1	VBATT-LOAD	Solder + Adhesive + Heat Shrink	*TBD*	1		28	BS 3G 210 Ty	Black	90mm		1		Solder + Adhesive + Heat Shrink	1	Common	2	Kill Swich1
		2	Chrg+			2		28	BS 3G 210 Ty	Blue	90mm		2			2	NC		

FROM				Fixation	HARNESS										Fixation	TO			
					Connector			Wire				Connector							
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
Battery Board	KS2 - MOLEX 22032021	1	VBATT-LOAD	Solder + Adhesive + Heat Shrink	*TBD*	1		28	BS 3G 210 Ty	Black	90mm		1		Solder + Adhesive + Heat Shrink	1	Common	2	Kill Swich2
		2	Chrg+			2		28	BS 3G 210 Ty	Blue	90mm		2			2	NC		

Figure 35. Documentation for the harness H11

cnes · Janus · Université Paris Diderot · UnivEarthS	DOCUMENTATION OF WIRE(S) / HARNESS(ES)	**Réf. : XXX-YY-NN** **Edition : 1** **Date : XX-XX-XX** **Révision : 0** **Date : XX-XX-XX** Ionospheric and Gamma-ray Observations Satellite

AUTOR: Juan VALVERDE
SECTION: Electronics System Enginnering
DATE: 17/05/2019

DESCRIPTION:

HARNESSES			
LABEL	Type	From	To
H12	Wires	Remove before flight	EPS Battery Board

DIAGRAM:

FROM				Fixation	HARNESS										Fixation	TO			
					Connector			Wire				Connector							
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
Battery Board	RBF1 -MOLEX 22032021	1	VBATT-LOAD	Solder + Adhesive + Heat Shrink Tubing	*TBD*	1		28	BS 3G 210 Ty	Black	40mm		1		Solder + Adhesive + Heat Shrink Tubing	1	Common	1	RBF
		2	VBATT-LOAD			2		28	BS 3G 210 Ty	Blue	40mm		2			2	NC		

Figure 36. Documentation for the harness H12

3.2.3. Couplers.

The coupler is a printed circuit board introduced to the IGOSat Flight model to interconnect the PC104 connector specification to a harness in the flight segment of IGOSat. A single pin in the couplers to connect a harness permit a current of 3A@25°C and 2.2A@85°C (HARWIN , 2019). The next figures present us a document called "DOCUMENTATION OF COUPLERS DESIGN", the document presents the PC104 information in the different payloads and platforms that helps us to choose the correct digital signals and electrical power signals to design the couplers.

DOCUMENTATION OF COUPLERS DESIGN

Réf. : XXX-YY-NN
Edition : 1 Date : XX-XX-XX
Révision : 0 Date : XX-XX-XX
Ionospheric and Gamma-ray Observations Satellite

AUTOR: Juan VALVERDE
SECTION: Electronics System Enginnering
DATE: 17/05/2019
DESCRIPTION: Documentation that helps us to choose the correct signals and electrical power to design the couplers

Sub System				INTERCONNECTION		Sub System			
TEL Board (connection with EASIROC Board)				from: U1_TEL_to_OBC		OBC (connection with ADCS)			
Reference	TEL	EASIROC	Pin	to:U2_OBC_to_TEL	to:TEL Antenna	Pin	OBC	ADCS	Reference
		VbatCH+	1	VbatCH+		1			
J1 -H1		VbatCH-	2	VbatCH-		2			J1 -H1
			3			3			
			4			4			
			5			5			
			6			6			
			7			7			
			8			8			
			9			9			
			10			10			
			11			11			
			12			12			
			13			13			
			14			14			
			15			15			
			16			16			
			17			17			
			18			18			
			19			19			
			20			20			
	ALT-SCL	SCL-2	21	SCL-2		21	SCL (al)	SCL-2	
			22			22			
	ALT-SDA	SDA-2	23	SDA-2		23	SDA (al)	SDA-2	
			24			24			
			25			25			
			26			26			
			27			27			
			28			28			
			29			29			
			30			30			
			31			31			
			32			32			
			33			33			
			34			34			
			35			35			
		RDY_A	36	RDY_A		36		RDY_A	
			37			37			
			38			38			
			39			39			
		RDY_B	40	RDY_B		40		RDY_B	
	SDA	SDA-1	41	SDA-1	SDA-1	41	SDA		
			42			42			
	SCL	SCL-1	43	SCL-1	SCL-1	43	SCL		
	GPIO RX		44			44			
			45			45	GPIO 22		
			46			46	GPIO 23	EN-ADCS	
			47			47	+5_SW1		
			48			48	+3V3_SW1(al)		
		MOSI_SPI_A	49	OSI_SPI_ADCS		49	+5_SW1	MOSI_SPI_A	
		MISO_SPI_A	50	ISO_SPI_ADCS		50	+3V3_SW1(a	MISO_SPI_A	
		RTS_SPI_AD	51	TS_SPI_ADCS		51		RTS_SPI_AD	
		CS_SPI_ADC	52	CS_SPI_ADCS		52		SCK_SPI_AD	

Sub System				INTERCONNECTION		Sub System			
TEL Board (connection with EASIROC Board)				from: U1_TEL_to_OBC		OBC (connection with ADCS)			
Reference	TEL	EASIROC	Pin	to:U2_OBC_to_TEL	to:TEL Antenna	Pin	OBC	ADCS	Reference
			1			1			
J1-H2		CS_A	2	CS_A		2		CS_A	J1-H2
			3			3			
		CS_B	4	CS_B		4		CS_B	
			5			5			
			6			6			
			7			7			
			8			8			
			9			9			
			10			10			
			11			11			
			12			12			
			13			13			
			14			14			
			15			15			
			16			16			
			17			17			
			18			18			
			19			19			
			20			20			
			21			21	DTXD		
			22			22	DRXD		
			23			23			
			24			24			
			25			25	+5		
			26			26	+5		
		VCC_SYS	27	3.3V_1	3.3V_1	27	+3V3_H2		
		VCC_SYS	28	3.3V_2	3.3V_2	28	+3V3_H2		
	GND	GND	29	GND_1	GND_1	29	GND	GND	
	GND	GND	30	GND_2	GND_2	30	GND	GND	
			31			31			
	GND	GND	32	GND_3	GND_3	32	GND	GND	
			33			33			
			34			34			
			35			35			
			36			36			
			37			37			
			38			38			
			39			39			
			40			40			
			41			41			
			42			42			
			43			43			
			44			44			
	Bat Bus	Bat Bus	45	BatBus_1		45	Bat Bus	VBATT	
	Bat Bus	Bat Bus	46	BatBus_2		46	Bat Bus	VBATT	
			47			47			
			48			48			
			49			49			
	GPIO TX		50			50	GPIO 24		
			51			51	GPIO 25		
		EN_SCI	52	EN_SCI		52	GPIO 26		

Figure 37. PC104 Documentation to design the coupler U1_TEL_to_OBC and U2_OBC_to_TEL

Sub System				INTERCONNECTION		Sub System			
ADCS Board (connection with OBC Board)				from: U3_ADCS_to_EPS	to: U4_EPS_to_ADCS	EPS (connection with GPSRM)			
Reference	ADCS	OBC	Pin			Pin	EPS	GPSRM	Reference
			1	VbatCH+		1	VbatCH+		
J1 -H1			2	VbatCH-		2	VbatCH-		J1 -H1
			3			3			
			4			4			
			5			5			
			6			6			
			7			7		~~TX1D~~	
			8			8		~~RX1D~~	
			9			9			
			10			10			
			11			11			
			12			12			
			13			13			
			14			14			
			15			15			
			16			16			
			17			17			
			18			18			
			19			19		~~TX1D~~	
			20			20		~~RX1D~~	
	SCL-2	~~SCL (a1)~~	21			21			
			22			22			
	SDA-2	~~SDA (a1)~~	23			23			
			24			24			
			25			25			
			26			26			
			27			27			
			28			28			
			29			29		-RESET	
			30			30			
			31			31		OFF_VCC	
			32			32			
			33			33			
			34			34			
			35			35			
	RDY_A		36			36			
			37			37			
			38			38			
			39			39			
	RDY_B		40			40			
		SDA	41	SDA		41	SDA	SDA_SYS	
			42			42			
		SCL	43	SCL		43	SCL	SCL_SYS	
			44			44			
		GPIO 22	45	GPIO 22	-RESET	45			
	EN-ADCS	GPIO 23	46			46		PPS	
		~~+5_SW1~~	47			47			
		~~+3V3_SW1(a~~	48			48			
	MOSI_SPI_A	~~+5_SW1~~	49			49			
	MISO_SPI_A	~~+3V3_SW1(a~~	50			50			
	RTS_SPI_ADCS		51			51			
	SCK_SPI_ADCS		52			52			

Sub System				INTERCONNECTION		Sub System			
ADCS Board (connection with OBC Board)				from: U3_ADCS_to_EPS	to: U4_EPS_to_ADCS	EPS (connection with GPSRM)			
Reference	ADCS	OBC	Pin			Pin	EPS	GPSRM	Reference
			1			1			
J1-H2	CS_A		2			2			J1-H2
			3			3			
	CS_B		4			4			
			5			5			
			6			6			
			7			7			
			8			8			
			9			9			
			10			10			
			11			11			
			12			12			
			13			13			
			14			14			
			15			17		VARF	
			16			18			
			17			19			
			18			20			
			19			21			
			20			22			
		DTXD	21	DTXD	RX1D	16		RX1D	
		DRXD	22	DRXD	TX1D	15		TX1D	
			23			23			
			24			24			
		+5	25	5V_1		25	+5	+5_SYS	
		+5	26	5V_2		26	+5	+5_SYS	
		+3V3_H2	27	3.3V_1		27	+3V3	VCC_SYS	
		+3V3_H2	28	3.3V_2		28	+3V3	VCC_SYS	
	GND	GND	29	GND_1		29	GND	GND	
	GND	GND	30	GND_2		30	GND	GND	
			31			31			
	GND	GND	32	GND_3		32	GND	GND	
			33			33			
			34			34			
			35			35			
			36			36			
			37			37			
			38			38			
			39			39			
			40			40			
			41			41			
			42			42			
			43			43			
			44			44			
	Bat Bus	~~Bat Bus~~	45	BatBus_1		45	VBATT	~~Bat Bus~~	
	Bat Bus	~~Bat Bus~~	46	BatBus_2		46	VBATT	~~Bat Bus~~	
			47			47			
			48			48			
			49			49			
		GPIO 24	50	GPIO 24	OFF_VCC	50			
		GPIO 25	51	GPIO 25	PPS	51			
		GPIO 26	52			52			

Figure 38. PC104 Documentation to design the coupler U3_ADCS_to_EPS and U4_EPS_to_ADCS

After that, I used the documentation and the KiCAD software to design the different couplers. I choose the connectors with the series M80 – 853 XX 42 for vertical type and M80 – 851 XX 42 for horizontal type from HARWIN, these connectors even if they do not have space certification, these connectors are the best option for our application because nano-Sats do not require the same level quality than standard space mission because we do not have the same funding and because the mission duration is very much shorter so they are widely used in CubeSats. For the PC104 connector standard, I chose the connectors that meet the electrical, electronic and mechanic requirements.

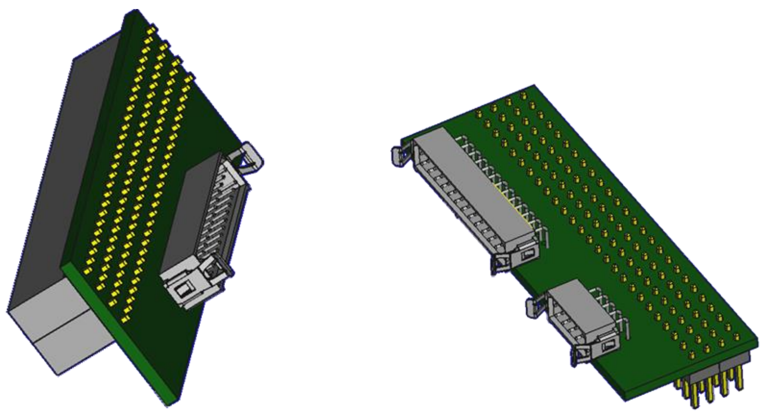


Figure 39. Coupler U1_TEL_to_OBC (left) and U2_OBC_to_TEL (right)

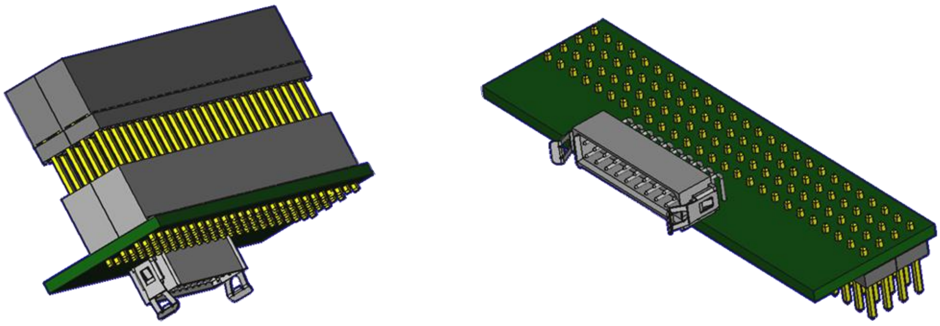


Figure 40. Coupler U3_ADCS_to_EPS (left) and U4_EPS_to_ADCS (right)

3.3 Assembly, integration, and testing.

The AIT Procedure (Assembly, Integration and Testing Procedure) provides information with definition documents and testing proposal optimized to be applied to track the testing procedure of IGOSat along with providing the base for quality controlling sub-systems validation and corresponding progress.

The system will go through the Functional Engineering Model Test, also referred to as Flat-Sat that provides a base platform for system integration, connecting IGOSat as an assembly for validating, troubleshoot and validate the functionality of the system before the final integration on the Flight Model.

The AIT has divided the testing procedure to surround the two most important flight supporting equipment on-board, the OBC – On-Board Computer, and the EPS – Electronic Power System. Considered to be the "heart and brain" of the satellite, processing data and providing electrical power to the entire system. The OBC and EPS will act as a master hub, where other subsystems will subsequently be added to the platform until the full assembly is reached.

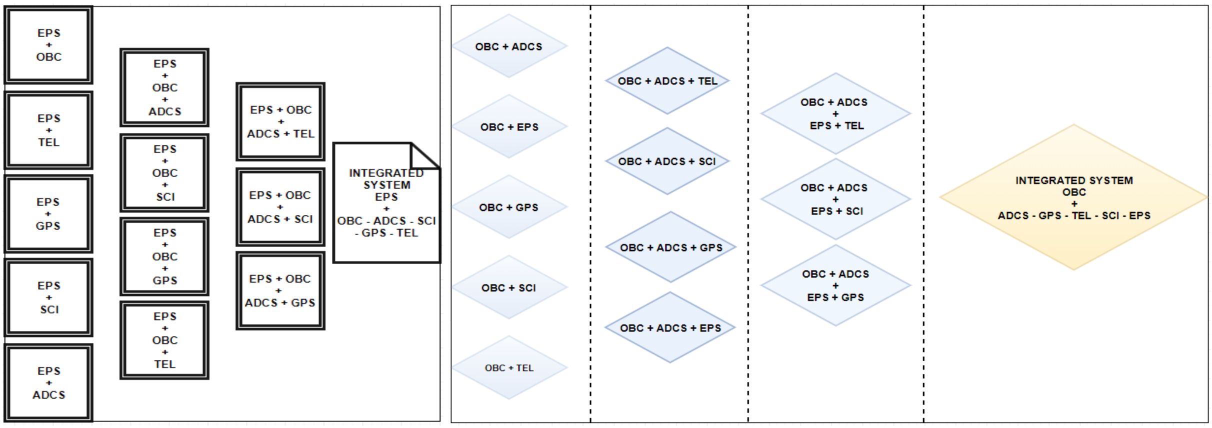


Figure 41. Functional Model Engineering Test for OBC (left) and EPS (right)

The EPS consists of the Alimentation Board, Battery Board, and Solar Panels combined in a closed loop is the main power provider of the entire IGOSat system. In this internship, I gave support for the integration of the solar panel to the EPS.

In the integration, I am working with the Space Mechanical Engineer, we are changing some connectors orientation, defining the part number, etc.

My job in this internship will end with the power budget of the systems.

CONCLUSIONS

Thanks to this internship in Electronics System Engineer Flat-Sat in IGOSat, I can work around the whole satellite system, I like it so much because I like to keep in touch with the whole project and not just a part of this.

To describe documents that can be understood by all team members, they must be in the same language since we do not all come from the same science branches.

It is important to be constantly informed of all payloads, support platforms, and the mechanical part since a change in one subsystem could affect another.

A cross-development environment has the challenge of dependence related to the manufacturer's deadlines and the time that the development takes.

4.1 Recommendations

At the beginning of the internship, it was a little difficult for me to understand the operation, location, and interconnection of each system, so I hope that with this document I can introduce IGOSat issues to the following inmates in an easier way.

4.2 Perspectives

I am very grateful to IGOSat for giving me the opportunity to approach the space sector of which I have always been curious, although in my country we have a good level in science, we cannot agree to be part of projects like this that fulfill great purposes and they consolidate in countries like France that give great importance to research and development.

The work experience I had in my country helped me a lot in this internship, and I discovered that I have new skills and I hope to continue developing them.

IGOSat has helped me to see beyond and that is why the perspective I have in the future is to take the opportunity of one year VISA that the French government gives me to look for a job or a doctorate here in France related to the space from which I can continue learning and contributing with what I can to research and development in this beautiful field of science.

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