## UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

# **Colegio de Posgrados**

# **ELECTRONICS SYSTEM ENGINEERING Flat-Sat for IGOSat**

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# HOJA DE APROBACIÓN DE TRABAJO DE TITULACIÓN

## **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):

- 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.





#### 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.



Figure 19. IGOS at 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.

Custom	Subsystem	Voltage Supply needs (DC) [V]				Communication needs			
System		3,3	5	Vbatt (7,2)	Others	12C	SPI	UART	Others
	Detector				54				Analog
SCI	Support board	х	х		2,5	х	х	х	Analog
	EASIROC Board	х		х		х	х		
TEI	TRXVU Board			х		х			
IEL	Antenna Board	х				х		х	RF
OBC	OBC	х	х			х		х	
OBC	Daughterboard						х		
	ADCS Board			х		х	х		
	Magnetorquers								
ADCS	(Located in the SCI Support Board)	х				х			
	Reaction wheel	х				х			
	Magnetometers	х				х			
	Battery board					х			
EPS	Powerboard			х	SP	х			
	Solar Panel					х			
CDS	GPSRM Board	х	x			х		х	RF
GPS	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	
TEI	TEL	410mA@8V	MAX 600mA@8V with Rx and Tx ON	
IEL	TEL Antenna 9mA@20°C		0,56A@3,3V Deployment 3 s	
	OBC	115mA	380mW@3,3V	
UBC	Daughterboard		Included in the ADCS board	
	ADCS board	500mA	Estimate	
ADCS	<b>Reaction Wheel</b>		Included in the ADCS board	
EDC	OBC	115mA	380mW@3,3V	
EPS	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	L From To					
U1	<b>TEL Communication Board</b>	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	Туре	From	То				
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	Туре	From	То			
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.

			cnes UnivE	<del>روسہ آر</del> arthS							PIN ATTF	RIBUTIO	N AND ST	ACK CON	NECTOR	S DOCUM	IENTATIC	ON IN SUE	BSYSTEN	۸S					Réf.: XXX- Edition: 1 Révision: 0 Ionospheri gamma-raj Observatio Satellite	YY-NN Dat C and / ns	e : XX-XX-XX e : XX-XX-XX		
			AUTOR:	Juan VA	LVERDE		DESCRI	PTION:	#Pin		Pin <u>descrintic</u>	n	VCC SYS:	3.3V															
		SE	ECTION:	Electron	nics Syste	m Enginn	ering		Ту	vpe															VMOR	IHT High			
			DATE:	13/06/2	019				Pin Na	me						SPI Comes ADCS. For	from the	CS-ACS-E 12C level tran: Magnetomet	B Enable slation for er A&B	SCL-2 SDA- Magtetometer	A and B	TEMP-2 Te	emperature IT	DDM, DDP From EASIRD Device Port D	CMC; USB		VbatCH+ C the Battery	harge	batCH- Charg
			2		- /	A(F2) A	(E1) A(D2) / (I2) A(E2) /	A(D4) A(B2) A(D1) A(D3)	A(B4) A(A1 A(B1) A(B3	) A(A3) A(C1 ) A(H2) A(A2	) A(C3) A(F ) A(A4) A(G	1) 2)	22	24	1		20		24	1.	20					-	50		
H	tem 1 Board		Analog A(F2)	Analog	Apalog A(D2)	A(C4) A	(H1) A(G1)	A(12)				Analog B)	Analog A(F1)	Analog A(G2)	Analog A(12)	Power VCC SYS	SPI MOSI SPI ADO	SPI RST SPI ADCS	Digital	Digital CS-B	12C SDA-2	12C SCL-2	Analogic TEMP-2	Digital	Digital	vver*Charg	Digital	Power	Power 2.5V ADC
Η	noqqui	12	1 Power	3 Analog	5 Analog	7 Analog	Analog	Analog	Analog	Analog	Analog	Analog	21 Analog	23 Analog	25 Analog	27 Analog	29 SPI	31 SPI	33 Power	35 Digital	Digital	39 Analogic	41 Digital	43 Digital	45 Analogic	47 Power	49 Power*Charge	51 Power	53 Power
-	S.		GND	A(E2)	A(D1)	A(D3)	A(B1)	A(B3)	A(H2)	A(A2)	A(A4)	A(C2)	A(C4)	A(H1)	A(G1)	A(12)	MISO SPI ADO	SCK SPI ADCS	GND	RDY-A	RDY-B	TEMP-1	DTXD	DRXp	VMONHT	GND	VbatCH-	3.3V_D	GND
	stem 2: IROC	PA	2 Analog A(F2)	4 Analog A(E1)	6 Analog A(D2)	8 Analog A(D4)	10 Analog A(B2)	12 Analog A(B4)	14 Analog A(A1)	16 Analog A(A3)	18 Analog A(C1)	20 Analog A(C3)	22 Analog A(F1)	24 Analog A(G2)	26 Analog A(12)	28 Power VCC_SYS	30 SPI MOSI SPI ADO	32 SPI RST SPI ADCS	34 Digital CS-A	36 Bl Digita In CS-B O	<b>JY-A RDY-I</b> erruption from agnetometer A JTPUT	3 the 20 &B	TEMP-1 Temperature S OUT	iensor 1 i Fror Rec	K <b>D, DRXD</b> n EASIROC MC; eive/Transmit E	Bebug harg	50 Digital USB_CNX	52 Power 5V_REGULE	54 Power 2.5V_ADC
E	sub sy EAS		1 Power GND	3 Analog A(E2)	5 Analog A(D1)	7 Analog A(D3)	9 Analog A(B1)	11 Analog A(B3)	13 Analog A(H2)	15 Analog A(A2)	17 Analog A(A4)	19 Analog A(C2)	21 Analog A(C4)	23 Analog A(H1)	25 Analog A(G1)	27 Analog A(12)	29 SPI MISO SPI ADO	31 SPI	33 Power GND	35 Digital RDY-A	Digital RDY-B	Analogic TEMP-1	41 Digital DTXD	43 Digital DRXD	45 Analogic VMONHT	47 Power GND	49 Yower*Charge VbatCH-	51 Power 3.3V D	53 Power GND
		-																								EN_SCI	/ake-Up		
			2 Digital CS A	4 Digital CS B	6	8 CS_ACS_B	10 Enable	12	14	16	18	20	22	24	26	28 Power VCC SYS	30 Power GND	32 Power GND	34	36 RDY	38 A OUTPUT	40 BDY.	42 B OUTPUT aption from the	44	46 Power VBATT	4 Microcontr Its manage	oller INPUT. d by the OBC	52 EN SCI	
CUBI	S a	H2	1	3	5	Magnetometer NPUT	A&B	11	13	15	17	19	21	23	25	27 Power	29 Power	31	33	35 magr	netometer A		etometer B		45 Power	47 Support Program	Board. For Iming	51	H2
<b>D</b>	syst		2	à	£	8	10	12	14	16	18	20	22 SCL-2 S	DÁ-2 I2C for	ľ	VCC_SYS 28	GND 30	32	34	36 Digital	38	40 Digital	42 S	CL-1 SDA-1 ASIROC licrocontroller	12C for	48	50 SPI	52 SPI	-
	e Sub	H1	VbatCH-			Charge the Ba	attery						Inagrietor	leter Maritob	<mark>,</mark>					RDY_A		RDY_B			┲╼╾┙		MISO_SPI_AD	CS_SPI_ADC	5 H1
			1 Power*Charge MostCH+	3 r	5	7	9	11	13	15	17	19	21 12C	23 12C	25	27	29	31	33	35	37	39	41 12C	43 12C	45	47	49 SPI	SPI SPI	
			- Bucchi							1			0022	00112	C2 - S	TACK PC	104						JUN 1				intest of the		
			2	4	6	8	10	12	14	16	18	20	22	24	26	28	30 Power	32 Power	34	36	38	40 GPIO I	42 RX	44	46 Power	48	50	52	-
	ä E –	H2	1	3	5	7	9	11	13	15	17	19	21	23	25	27	GND 29 Power	GND 31	33	35	37	39 Function by custo	nality to be defi omer and agree	ned ed	Bat Bus 45 Power	47	GPIOTX 49	51	H2
H	syste RXVL		2	4	6	8	10	12	14	16	18	20	22 ALT-SC		26	28	GND 30	32	34	36	38	40	42	44	Bat Bus 46	48	50	52	
	s du s	HI											Available	upon request										GPIO RX	-		SPIO TX Available upon r	equest.	н1
	-/		1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41 12C	43 12C	45	47	un otionality to by customer and ipon by ISIS	lagreed	

Figure 22.TOP cube stack connectors documentation

											DRXD DTX	D SERIAL										ſ	Bat Bus Not	used by			G	PIO 22 23 24 25	26
			2	4	6	8	10	12	14	16	OBC to GPSI	BM with	22	24	26	28	30	32	34	36	38	40	iOBC, but avail	albe as	46	48	50 Ge	eneral purpose I/O	
											Harness		UART		Power	Power	\ Power	Power					breakout.		Pewer		GPIO	GPIU	7
													DRXD		+5	+3¥3_H2	GND	GND							242 01/16-0	_	24	26	/
		HZ.	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	•343_5¥ (al)		49	51	H2
	<b>E</b>												UART		Power	Power	Power								Ontional power inpu			GPIO	
													DTXD		+5	+3V3_H2								t	becomes +3V3_IN i	F		25	
	S E		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44 (	used		50	52	
	s																	- 2V2 LI2 D.	and a						GPIO	Bower	Rewel	1	
											SCL-al S	DA-al			+5 Not	used by iOBC, I	ut	• 3 • 3_ mz Dei nower input be	comes						23	+3V3_SW	+3V3_5W	/2(al)	
Q	S I	H1	1	3	5	7	9	11	13	15	17 Alternative	es I2C Pins	21	23	25 availab	e as breakout.		+3V3 IN if used		35	37	39	41	43	45	47	49	51	HI
3													<u></u>	2#26~	Provide	d to daughterb	ard.						120	12C	GPIO	Pewer	Permi	1	
O													SCL (al)	SDA (al)									SDA	SCL	22	+5_SW1	+5 <u></u> S₩2		
"															C3 - CON	NECTOR	PC104												
										10	40	00	22	24	26	20	20 CND	22 CMD	34	36	20	40	40	44	40	40	=0	50	
0			2	4	6	8	10	12	14	16	18	20	22	24	20	20	30 6110	32 0110	37	50	30	40	42	44	46	48	50 -	5/ 5 0110	
adi			2 Digital	Bigital	6	8	10	12	14	16	18	20	22	24	20	20	Power	Power	54	50	30	40	42	44	46 Power	48	50 .5	SV1+5_SV2	20200
MIDD			2 Digital CS_A	Bigital CS_B	6	8	10	12	14	16	18	20	22	24	20	20	Power OBC	Power	54	50	30	40	42	OUTPUT	Power VBATT	48	50 +5 SM	SV1 +5_SV2	Space
MIDD	ä	H2	2 Digital CS_A 1	NA Digital CS_B 3	5	8	10 9	12	14	16	18	19	22	24	25	20	Power OBC 29 GND	Power OBC 31	33	35	37	39	42 AT	OUTPUT on from the	Power VBATT 45	48	50 -5 Sw 49 av	SV1 +5_SV2 vitched line on Gom PS, not used by iOB( ailable as breakout	Space D, but and on
MIDD	5 E	H2	2 Digital CS_A 1	Bigital CS_B 3	6 5 CS_A CS_1	8 7 B Enable I2C	9	12	14	15	18	19	21	23	25	27	Power OBC 29 GND Power	Power OBC 31	33	35	37	39	42 RDY_B	OUTPUT on from the meter B	46 Power VBATT 45 Power	48	50 -5 Sw EF 49 av da	SV1+5_SV2 vitched line on Gom S, not used by iOB( ailable as breakout ughterboard.	Space D, but and on
MIDD	tem 2: CS	H2	2 Digital CS_A 1	H Bigital CS_B 3	5 CS_A CS_I level translati	8 7 B Enable I2C on for	9	12	13	15	18	19	21	23	25	27	Power OBC 29 GND Power OBC	Power OBC 31	33	35	37	39	42 <b>BDY_B</b> Interrupti magneto	a output on from the meter B	46 Power VBATT 45 Power VBATT	48	50 -5 Sw 49 av da	SV1+5_SV2 vitched line on Gom PS, not used by iOB( ailable as breakout ughterboard.	Space D, but and on
MIDD	ystem 2: NDCS	H2	2 Digital CS_A 1 2	A Bigital CS_B 3	6 5 CS_A CS_ level translati Magnetormet	8 7 B Enable I2C on for er A&B	9	12	13	15	17	20 19 20 SCL-2 S	21 DA-2 I2C for	23	25	27	Power OBC 29 GND Power OBC 30	Power 0BC 31 32	33 34	35	37	39	42 A BDY_B Interrupti magneto	0UTPUT on from the meter B	46 Power VBATT 45 Power VBATT 46	48 47 48	50 -5 Sw 49 av 6a 50	SVI +5_SV2 vitched line on Gom PS, not used by iOB( ailable as breakout ughterboard.	Space C, but and on
MIDD	system 2: ADCS	H2	2 Digital CS_A 1 2	A Bigital CS_B 3 4	6 5 CS_A CS_ level translati Magnetomet OUTPUT	8 7 B Enable I2C on for er A&B	9 9	12	13	16	18 17 18	20 19 20 SCL-2 S Magneto	21 DA-2 I2C for neter A and B	23	25 26	27 28	Power OBC 29 GND Power OBC 30	Power OBC 31 32	33 34	35 36 Digital	37	40 39 40 Digital	42 An Interrupti magnetic	44 OUTPUT on from the meter B	46 Power VBATT 45 Power VBATT 46 Digital	48 47 48	50 -5 50 49 av 50 SP/	SVI +5_SV2 vitched line on Gom 25, not used by iOB ailable as breakout ughterboard.	Space C, but and on
MIDD	ub system 2: ADCS	H2	2 Digital CS_A 1 2	A Bigital CS_B 3	6 5 CS_A CS_ level translati Magnetomet OUTPUT	8 7 B Enable I2C on for er A&B	10 9	12	14	16	18 17 18	20 19 20 SCL-2 S Magnetor	21 DA-2 I2C for neter A and B	24 23 4	25	27	Power OBC 29 GND Power OBC 30	Power OBC 31 32 BD	33 34 Y_A OUTPUT	35 36 Digital Y_A	37	40 39 40 Digital RDY_B	42 A BDY_B Interrupti magneto	99 OUTPUT on from the meter B 44	46 Power VBATT 46 Digital EN-ADCS	48 47 48	49 50 50 SP MISO_SP	SVI -5_SV2 vitched line on Gom '5, not used by IOB ailable as breakout - ughterboard. SPI L SCK_SPL	Space C, but and on
MIDD	Sub system 2: ADCS	H2 -	2 Digital CS_A 1 2	A Digital CS_B 3 4 4 3	6 5 CS_A CS_ level translati Magnetomet OUTPUT	8 7 B Enable 12C on for er A&B	10 9 0	12 11 12 11	14 13 14 14	16 15 16 16	18 17 18 18	20 19 20 SCL-2 9 Magnetor	21 DA-2 I2C for meter A and B	23 4 23	25 26 25	27 28 27	Power 0BC 29 GND Power 0BC 30	BD Power OBC 31 32 32 31 32	33 34 Y_A OUTPUT	35 36 Digital Y_A	37 38 37	40 39 40 Digital RDY_B 39	42 RDY_B Interrupti magnetc 42 41	44 courput on from the meter B 44 43	45 Power VBATT 45 Power VBATT 46 Eligital EIN-ADCS 45	48 47 48 47	50 55 49 49 49 50 50 50 50 49 49	SVI +5_SV2 vitched line on Gom S, not used by iOB0 ailable as breakout ughterboard. 52 SPI L_SCK_SPL 51	Space C, but and on H1
MIDD	Sub system 2: ADCS	H2 .	2 Digital CS_A 1 2	A Bigital CS_B 3 4 4 3	6 5 CS_A CS_ level translati Magnetomet OUTPUT 5	8 7 B Enable I2C on for er A&B	10 9 0	12 11 12 12 11	14 13 14 14 13	16 15 16 15	18 17 18 17	19 20 SCL-2 S Magneto	21 DA-2 I2C for meter A and B 21 I2C	23 4 23 120	25 26 25	27 28 27	Bower         OBC           29 GND         Power           0BC         30           23         23	BC BND Power OBC 31 32 31 32 31 Inter mag	33 34 Y_A OUTPUT rruption from the pretometer A	35 36 Digital Y_A	37 38 37	40 39 40 Digital RDY_B 39 EN-ADCS	42 RDY_B A Interrupti magnetc 42 42 41 switch on/off t	44 courpert on from the meter B 44 43 he power for	45 Power VBATT 45 Power VBATT 46 Digital EN-ADCS 45 SPI goes to	48 47 48 47 the SCI	50 50 49 av 50 50 50 SP MISO_SP 49 SPI	SVI +5_SV2 vitched line on Gom 's, not used by IOB( allable as breakout ughterboard. SPI LSCK_SPL 51 SPI	Space C, but and on H1
MIDD	Sub system 2: ADCS	H2 (	2 Digital CS_A 1 2	A Digital CS_B 3 4	6 5 CS_A CS_ level translati Magnetomet OUTPUT 5	7 B Enable I2C on for er A&B	9 9 9 9	12 11 12 12	14 13 14 13	16 15 16 15	18 17 18 17	20 19 20 SCL-2 S Magneto 19	21 DA-2 I2C for neter A and B 21 I2C SCL-2	23 4 23 23 23 23 23 22 5DA-2	25 26 25	27 28 27	Power OBC 29 GND Power OBC 30	32 31 32 31 BD BD BD BD BD BD BD BD BD BD	33 34 Y_A OUTPUT ruption from the metometer A	35 36 Digital	37 37 38 37	40 39 40 Digital RDY_B 39 EN-ADCS the other cor	42 RDY_B A Interrupti magnetc 42 41 switch on/off t mponents inclu	44 courpert on from the meter B 44 43 he power for ding	45 Power VBATT 45 VBATT 46 Digital EIV-ADCS 45 SPI goes to Support Boar	48 47 48 47 the SCI d. SPI ADCS	50 50 49 49 49 50 50 MISO_SP 49 5Pl MOSL_SP	SVI -5_SV2 vitched line on Gom- 's, not used by iOB( aliable as breakout. ughterboard. SPI 1_SCK_SPL 51 SPI 2_SPI 4_RST_SPL	Space C, but and on H1

Figure 23. MIDDLE cube stack connectors documentation

_		-					-		-		-								-		-								
		2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	
															Power	Power	Power	Power							Power				
											<u> </u>				+5	+3V3	GND	GND							VBATT				
	- P	H2	1	3	5	7	9	11	13	VARE Variable-	from	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	H2
	<b>E 0</b>			101-00		Ľ.	1			the GPS receiver	's				Power	Power	Power								Power				
	2 8			Charge	the Batteru	· · · · · · · · · · · · · · · · · · ·				VARF pin. This or	utput				45	+31/3	GND								VBATT				
	S L			Criarge	The Dattery		10	12	14	places the VARF	· -	20	22	24	15	1993	20	22	24	26	20	40	42	44	46	40	50	52	
-	S S	1 1	£ 	4	0	•	10	12	14	square wave on I	0.31	20	22	24	20	20	50	52	34	50	30	40	42	44	40	40	50	32	
	- <u>e</u> S		ower Charge	ſ						it/when jumper H	52 is										-								
a	5 6	H1	VbatCH-			-				ntted. Typically u modulos dosiring	sed by								_			_						_	H1
q			1	3	5	7	9	11	13	acouraoy clock s	ional	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	
3		· · · · ·	ower*Charge	r					_		-gride												12C	12C					
ž		1	VbatCH+																				SDA	SCL					
5															C4 - S	TACK PC	:104												
P		2	2	4	6	8	10	12	14	16*	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	BATT Ballo	E2	
E										UART					Power	Power	Power	Power					VBACKUP Bat	tery	Pawac		dependent T	unically +7V to	
S										RX1D		V			+5_SYS	VCC_SYS	GND	GND	+	5V_USB			backup voltage. T	0	VBATT	+	10V. To expan	sion	
-	8	H2	1	3	5	7	9	11	13	15*	17	19	21	23	25	27	29	31	33 / P	ower. From USB	37	39	expansion connect H3.8 onlu	tor	45	47 0	onnector H3.	5 & H3.6 only	H2
	5 3									UART	Device				Power	Power	Power		1 / 100	×			r toto oning		Enter	1 [			
	2 E									TX1D	VARE	_			+5 5Y5	VCC SYS	GND			E VCC When					VRATT			PPS From the	GPS
-	S S	1	2	4	6	Q#	10	12	14	16	19	20*	22	24	26	29	30	22	24/ 1951	stor B10 is fitted	29	40	42	¥	46	49	50	receiver's TIME	EMARK
-	<b>S</b> (7	1 1	-	-		-	-					THAT			-RESET	Input to	~		7 and	no USB power			- Down	-1	Digital			(PPS) output.	This
	<u>व</u> ~					DY1D	-					DVID	-		and/or out	put from		US USD	V/ is pr	resent, an active			VDACKUD	4	Digital			output is prese	ent
	ร	H1			-	TAID			-	45	47	AATD AGT	-		reset supe	rvisor			sigr	nalon	07		VBACKUP		PP3	47	-	whenever the	GPS
-		1	1	3	5		- 9	11	13	15	1/	19*	- 21	23	4 controlling	supervisor	29	31	33 this	pin will disable	37	39	41	43	45	4/	49	operating, 500	2
-						Lanenci	-					- UTAINE	-	-	MCU. Fund	otionality	Digital	Digital	the	supervisor MCLL	_		120	120		-	-	impedance.	
_						TX1D						TX1D			B38 B4	mesistors	-RESET	OFF_VCC	die die	supervisor moo.			SDA_SYS	SCL_SYS					
		•	• We need	a harness t	to make a SE	RIAL commu	nication b	etween OBC	- GPS and c	onfigure the U	ART pins																		
			RECOMEND	ATION: Only	y use one pa	air of jumper	s at the sa	me time for	the serial o	communication	n for the (	PSRM																	
		(	Quote FROM	A THE GPS D	DATASHEET p	age 20: N.B.	For proper	operation, a	maximum	of one pair of	jumpers	R26 & R29, R2	7 & R30, or R	28 & R31) sh	ould be fitted	d at any tim	e. Fitting mo	re than one	e pair of ju	mpers may dar	mage the G	PSRM 1. Jur	npers are to be	e soldered i	n place by a	qualified to	echnician		
		J	IUMPERS		NAMES		CONNECT	OR																					
		1	Тх	Rx	Tx	Rx	Tx	Rx																					
		F	R26	R29	10.5	10.4	H1.19	H1.20																					
		F	R27	R30	10.17	10.16	H1.7	H1.8																					
			R28	R31	10.33	10.32	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".

Uni	s Jan vEarth						DOCUI	MENTA	TION OF	WIRE(S)	/ HARNE	ESS(ES)					Réf.: XXX Edition: 1 Révision: 1 Ionospheric Gamma-ray Observatior Satellite	-YY-NN Date 0 Date and 15	: XX-XX-XX : XX-XX-XX
	AUTOR:	Juan VALVER	DE																
	SECTION:	Electronics S	/stem Enginn	ering								DESCRIPTION:	LABEL	Type	Fr	om		Го	
	DATE:	17/05/2019											H1	Wires	SCI Detector	5	SCI SupportB	oard	
	DIAGRAM:																		
	50	~							HAR	NESS									
1	FR	OM		Fixation		Connector			w	ïre			Connector		Fixation			0	
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
SCI support		1	K (I2)	Solder +				28	BS 3G 210 -	Black	35mm				Solder +	1 (Index Mark)	K		Detector
board	J12	2	A (12)	Adhesive +				28	BS 3G 210 -	Blue	35mm				Adhesive +	2	А	SIPIM - P6	
	00120.0764	3	K (I1)	Heat Shrink				28	BS 3G 210 -	Brown	35mm				Heat Shrink	1 (Index Mark)	К	CIDNA D14	
	90120-0764	4	A (I1)	Tubing				28	BS 3G 210 -	Red	35mm				Tubing	2	А	SIPIVI - P11	

#### Figure 26. Documentation for the harness H1

Uni	s jaw						DOCUI	MENTAT	TION OF V	VIRE(S)	/ HARNE	SS(ES)					Réf.: XXX Edition: 1 Révision: 1 Ionospheric Gamma-ray Observatior Satellite	-YY-NN Date 0 Date and	: XX-XX-XX : XX-XX-XX
	AUTOR:	Juan VALVER	DE																
	SECTION:	Electronics S	stem Enginne	ring							0	ESCRIPTION:	LABEL		Fr		٦		
	DATE:	17/05/2019											H2	Radio Freq.	TEL Commu	nication Board	TEL Antenna	Board	
	DIAGRAM:																		
	ED.	oM							HARN	ESS							-	0	
	FR			Fixation		Connector			Wir	e			Connector		Fixation			0	
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
7.51	10 01 (1015)	1-Center pin	RF in		MMCX - RF	1	L ISIS	ISIS			60 mm	ISIS	1	MMCX - RF		1-Center pin	RF out	12	
IEL	J2 - KX (VHF)	2-Shield	GND	Plugin	UHF/VHF	2	2 ISIS	ISIS			60 mm	ISIS	2	UHF/VHF	Plugin	2-Shield	GND	- J2	Antenna
	ED.	<b></b>							HARN	ESS								-0	
	FR	UIVI		Fixation		Connector			Wir	e			Connector		Fixation			0	
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
TEL	12 TV (11115)	1-Center pin	RF out	Divela	MMCX - RF	1	LISIS	ISIS			60 mm	ISIS	1	MMCX - RF	Divela	1-Center pin	RF in	12	Antonio
IEL	12 - 1X (UHF)	2-Shield	GND	Plugin	UHF/VHF	1	2 1515	ISIS			60 mm	ISIS	2	UHF/VHF	Plugin	2-Shield	GND	13	Antenna

Figure 27. Documentation for the harness H2

Uni	ی vEarth						DOCU	MENTA	TION OF	WIRE(S)	/ HARNE	ESS(ES)					Réf.: XXX Edition: 1 Révision: 1 Ionospheri Gamma-ra Observatio Satellite	-YY-NN Date D Date c and y ms	: XX-XX-XX : XX-XX-XX
	AUTOR	Juan VALVE	ERDE																
	SECTION	Electronics	s System Eng	innering							0	DESCRIPTION:			HARN	IESSES			1
	DATE	24/07/2019	9										LABEL	Туре	Fre	om	1	o	
													H3	Wires	U2		TEL Antenn	a Board	
													H4	Wires	U2		U1		
L	DIAGRAM																		
	FR	OM							HAR	NESS							1	ro	
0	1			Fixation		Connector			w	ire			Connector		Fixation		-		10
Coupler /	L .	-																	Coupler /
Board	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Board
		1	VbatCH+	-		1	Crimp Conta	28	BS 3G 210 T	Black	TBD	Crimp Conta	1	-		1	VbatCH+	4	
		2	VbatCH-	-		2	Crimp Conta	28	BS 3G 210 T	Blue	TBD	Crimp Conta	2	-		2	VbatCH-	4	
		3	SCL-2	-		3	Crimp Conta	28	BS 3G 210 T	Brown	IBD	Crimp Conta	3	-		3	SCL-2	4	
		4	SDA-2	-		4	Crimp Conta	28	BS 3G 210 1	Red	IBD	Crimp Conta	4	-		4	SDA-2	4	
		5	RDY_A	-		5	Crimp Conta	28	BS 3G 210 T	White	TBD	Crimp Conta	5	-		5	RDY_A	4	
		6	RDY_B			6	Crimp Conta	28	BS 3G 210 T	Grey	TBD	Crimp Conta	6	4		6	RDY_B	4	
		7	SDA-1			7	Crimp Conta	28	BS 3G 210 T	Violet	TBD	Crimp Conta	7			7	SDA-1	4	
		8	SCL-1			8	Crimp Conta	28	BS 3G 210 T	Pink	TBD	Crimp Conta	8			8	SCL-1		
		9	MOSI_SPI_/	4		9	Crimp Conta	28	BS 3G 210 T	Orange	TBD	Crimp Conta	9			9	MOSI_SPI_/	4	
		10	MISO_SPI_/	4		10	Crimp Conta	28	BS 3G 210 T	Yellow	TBD	Crimp Conta	10			10	MISO_SPI_/	4	
		11	RTS_SPI_AD			11	Crimp Conta	28	BS 3G 210 T	Green	TBD	Crimp Conta	11			11	RTS_SPI_AD	1 11	
		12	SCK_SPI_AD	Plugin +	H4	12	Crimp Conta	28	BS 3G 210 T	Green/Yell	TBD	Crimp Conta	12	H4	PlugIn +	12	SCK_SPI_AD		
U2	M90	13		Jackscrews		13	Crimp Conta	act				Crimp Conta	13		Jackscrews	13		1480	01
	1VIOU-	14			M80-	14	Crimp Conta	act				Crimp Conta	14	M80-		14		E00240E	
	5002405	15	CS_A		4612405	15	Crimp Conta	28	BS 3G 210 T	Black	TBD	Crimp Conta	15	4612405		15	CS_A	5002405	
		16	CS_B			16	Crimp Conta	28	BS 3G 210 T	Blue	TBD	Crimp Conta	16	1		16	CS_B	1	
		17	3,3V_1			17	Crimp Conta	28	BS 3G 210 T	Brown	TBD	Crimp Conta	17	1		17	3,3V_1		
		18	3,3V_2			18	Crimp Conta	28	BS 3G 210 T	Red	TBD	Crimp Conta	18	1		18	3,3V_2	1	
1		19	GND_1			19	Crimp Conta	28	BS 3G 210 T	White	TBD	Crimp Conta	19	1		19	GND_1	1	
1		20	GND 2			20	Crimp Conta	28	BS 3G 210 T	Grey	TBD	Crimp Conta	20	1		20	GND 2	1	
		21	GND 3			21	Crimp Conta	28	BS 3G 210 T	Violet	TBD	Crimp Conta	21	1		21	GND 3	1	
1		22	Bat Bus 1			22	Crimp Conta	28	BS 3G 210 T	Pink	TBD	Crimp Conta	22	1		22	Bat Bus 1	1	
1		23	Bat Bus 2			23	Crimp Conta	28	BS 3G 210 T	Orange	TBD	Crimp Conta	23	1		23	Bat Bus 2	1	
1		24	EN SCI	1		24	Crimp Conta	28	BS 3G 210 T	Yellow	TBD	Crimp Conta	24	1		24	EN SCI	1	
			_																
		~							HAR	NESS								-	
	FR	UW		Fixation		Connector			w	ire			Connector		Fixation			0	
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 Conta	28	BS 3G 210 T	Green	TBD	rimp Contac	1			1	Vcc		
1		2	SDA-1			2	Crimp Conta	28	BS 3G 210 T	Green/Yell	TBD	rimp Contac	2	1		2	SDA_A	1	
1		3	GND 1			3	Crimp Conta	28	BS 3G 210 T	Black	TBD	rimp Contac	3	1		3	GND	1	
		4				4	Crimp Conta	act			(	Crimp Contac	4	1		4	SDA B	11	
	J2	5	GND_2	Plugin +		5	Crimp Conta	28	BS 3G 210 T	Blue	TBD	rimp Contac	5	1	Plugin +	5	GND	1	
U2		6	3,3V_2	Jackscrews	H3	6	Crimp Conta	28	BS 3G 210 T	Brown	TBD	rimp Contac	6	H3	Jackscrews	6	Vcc	Omnetics 9	IEL
	M80-	7	SCL-1			7	Crimp Conta	28	BS 3G 210 T	Red	TBD	rimp Contac	7	1		7	SCL_A	pins	Antenna
	5001005	8			M80-	8	Crimp Conta	act			(	Crimp Contac	8	A28000-009		8	SCL_B	A29100-009	
		9	GND_3		4611005	9	Crimp Conta	28	BS 3G 210 T	White	TBD	rimp Contac	7	1		9	GND		
		10				10	Crimp Conta	act			(	Crimp Contac	8	1					

Figure 28. Documentation for the harness H3H4

	<u>چ</u> vEarth						DOCU	MENTAT	FION OF	WIRE(S)	/ HARNE	ESS(ES)					Réf.: XXX Edition: 1 Révision: Ionospher Gamma-ra Observatio Satellite	-YY-NN Date 0 Date ic and ay ons	: XX-XX-XX : XX-XX-XX
	AUTOR	Juan VALVE	RDE																
	SECTION	Electronics	System Engi	innering								DESCRIPTION:			HARN	IESSES			
	DATE	17/05/2019											LABEL	Туре	Fr.	om	4.D.00. D	0	
	DIAGRAM												H5	Wires	FM Daught	erBoard	ADCS Boar	3	
	DIAGNAM								HAR	NESS								-	
	FR	ом				Connector			W	lire			Connector					ro	
Coupler /				Fixation											Fixation				Coupler /
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
		1	GND			1	Crimp Conta	act											
		2	AINO			2	Crimp Conta	act										]	
		3	AIN1			3	Crimp Conta	act										_	
1		4	AIN2			4	Crimp Conta	act										_	
		5	AIN3			5	Crimp Conta	act						-				-	
		6	GND			6	Crimp Conta	act						-				4	-
		7	AIN4			7	Crimp Conta	act						-				-	-
		8	AINS			8	Crimp Conta	act						-				-	
		10				10	Crimp Conta	act						-				-	
		11	GND			11	Crimp Conta	act						1				-	
		12	SPI1 NPCS0			12	Crimp Conta	act						1				-	
1		13	SPI1 NPCS1			13	Crimp Conta	act						1				1	
1		14	SPI1_NPCS2			14	Crimp Conta	act						1				1	ľ
1		15	GND	1		15	Crimp Conta	act										1	
EM	Conn - J5	16	SPI1_SPCK			16	Crimp Conta	28	BS 3G 210 T	Black	35mm	Crimp Conta	1			1	1 SPI_SPCK		
Daughter	Harwin	17	SPI1_MOSI	Plugin +	M80 -	17	Crimp Conta	28	BS 3G 210 T	Blue	35mm	Crimp Conta	2	тво	Pluglo		2 SPI_MOSI		ADCS
Board	M80-	18	SPI1_MISO	Jackscrews	8883405	18	Crimp Conta	28	BS 3G 210 T	Brown	35mm	Crimp Conta	3		i lugini	3	3 SPI_MISO	- 1	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
	8513442	19	GND			19	Crimp Conta	act						-				-	
		20	GPIO0/D8			20	Crimp Conta	act						-				-	
		21	GPI01/D9			21	Crimp Conta	act						-				-	
		22	GPI02/D10			22	Crimp Conta	act				l		-			+	-	
		24	GND			23	Crimp Conta	act											
1		25	GPIO4/D0			25	Crimp Conta	act						1				-	
1		26	GPIO5/D1			26	Crimp Conta	act											
1		27	GPIO6/D2			27	Crimp Conta	act						1				1	
		28	GPIO7/D3			28	Crimp Conta	act										1	
		29	GND			29	Crimp Conta	act											
		30	GPIO8/D4			30	Crimp Conta	act											
		31	GPIO9/D5			31	Crimp Conta	act						-				-	
		32	GPIO10/D6			32	Crimp Conta	act						-				-	
		33	GPI011/D7			33	Crimp Conta	act						-				-	
		34	+3V3_SENSE			34	Crimp Conta	act	1			1					1		

Figure 29. Documentation for the harness H5

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		E B	_														Edition: 1	Date	: XX-XX-XX
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CNG	es Jan	S 4					DOCUI	MENTA	TION OF	WIRE(S)	) / HARN	ESS(ES)					Ionospheric	and	
		2															Gamma-ra	у	
l l	nivFarth	S 🔼															Observation	ns	ico
		U 😡															Satellite		
	AUTOR	Juan VALVE	RDE																
	SECTION	Electronics	System Engini	nering								DESCRIPTION:		-	HARN	IESSES			
	DATE	: 24/07/2019											LABEL	Туре	Fr	om		Го	
													H6	Wires	U3		U4		
	DIAGRAM																		
	FF	ROM							HAR	NESS							٦	ю	
				Fixation		Connector			w	ire			Connector		Fixation			-	1
Coupler /				· indefen											- Macron				Coupler /
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Colo	r Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
		1	VbatCH+			1	Crimp Conta	28	BS 3G 210 Ty	Black	TBD	Crimp Conta	1			1	VbatCH+		
		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 Contac	t				Crimp Conta	6			6	L	4	
		7		-		7	Crimp Contac	rt				Crimp Conta	7			7	4		
		8	DTXD			8	Crimp Conta	28	BS 3G 210 Ty	Grey	TBD	Crimp Conta	8			8	RX1D		
	11	9	DRXD			9	Crimp Conta	28	BS 3G 210 Ty	Violet	TBD	Crimp Conta	9			9	TX1D	- 11	
		10	5V_1	Plugin +	M80-	10	Crimp Conta	28	BS 3G 210 Ty	Pink	TBD	Crimp Conta	10	M80-	Plugin +	10	5V_1		
U3	M80-	11	5V_2	Jackscrews	4612005	11	Crimp Conta	28	BS 3G 210 Ty	Orange	TBD	Crimp Conta	11	4612005	Jackscrews	11	5V_2	M80-	U4
	5012005	12	3,3V_1			12	Crimp Conta	28	BS 3G 210 Ty	Yellow	TBD	Crimp Conta	12			12	3,3V_1	5012005	
		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	DTBD	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	IGPIO25			24	ICrimp Conta	28	IBS 3G 210 TV	Grev	ITRD	Crimp Conta	24			20	IPPS		

Figure 30. Documentation for the harness H6

	چ Jaw /Earth		-				DOCU	MENTA	TION OF	WIRE(S)	/ HARN	ESS(ES)					Réf.: XXX Edition: 1 Révision: 1 Ionospheric Gamma-ra Observatio Satellite	C-YY-NN Date 0 Date 0 and 19 ns	: XX-XX-XX : XX-XX-XX
	AUTOR	Juan VALVE	RDE																
	SECTION	Electronics	System Engin	nering							1	DESCRIPTION:			HAR	NESSES			
	DATE	17/05/2019											LABEL	Туре	Fi	rom		Го	
													H7	Wires	Reaction W	heel	ADCS Board		
	DIAGRAM	:																	
	FR	ом							HAR	NESS							7	го	
		1	1	Fixation		Connector			w	ire			Connector		Fixation				
Coupler / Subsystem	Reference	Pin	Label		#Part	Pin	#Part Din	#0.WG	#Part	Color	Length	#Part Pin	Dir	#Part		Pin	Label	Reference	Coupler /
	nererence	1	PGND		in arc						35mm	Crimp Conta	1			1	GND	liciterence	
		2	PGND								35mm	Crimp Conta	2	2		2	GND	1	
		3	V Bat								35mm	Crimp Conta	3	3		3	VBATT PRO	5	
		4	V Bat								35mm	Crimp Conta	4	มี		4	VBATT PRO	5	
		5	DGND								35mm	Crimp Conta	5	5		5	GND	1	
	CubeWheel	6	3V3								35mm	Crimp Conta	6			6	.+3.3V	1	
Reaction	connector	7	UART_TX	Elucad.							35mm	Crimp Conta	7	SFSD1-07-30	Divete	7	UART_TX	1	1000
Wheel	Constan	8	UART_RX	Fixed							35mm	Crimp Conta	8	G-03.00-55	Plugin	8	UART_RX	13	ADUS
	JUILLEC	9	Enable								35mm	Crimp Conta	9	•		9	Enable		
	11111	10	I2C_SCL								35mm	Crimp Conta	10	2		10	SCL		
		11	I2C_SDA								35mm	Crimp Conta	11			11	SDA		
		12	DGND								35mm	Crimp Conta	12	2		12	GND		
		13	CANH								35mm	Crimp Conta	13	3		13		_	
		14	CANL								35mm	Crimp Conta	14	L		14			

Figure 31. Documentation for the harness H7

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	AUTOR	: Juan VALVE	RDE																
	SECTION	: Electronics	System Engi	innering								DESCRIPTION:			HAR	NESSES			
	DATE	: 17/05/2019							-				LABEL	Туре	Fr	rom		Го	
	DIACRAM								4				H8	Wires	Solar Panel	s	EPS Power B	Board	
	DIAGRAM	1							HAF	MECC	_								
	FR	OM		Fixation		Connector	_		- Non	INE55 Uira	_		Connector		Eixation			го	
Subsystem	Reference	Pin	Label	-	#Part	Pin	#Part Pin	#AWG	#Part	t Col	or Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
Solar Panels	J1	1	SDA		M80-	1	Crimp Conta	28	BS 3G 210 T	Black	TBD	Crimp Conta	1	M80-		1	SDA	J1	EPS
SP_Xsat+	M80-	2	3v3		4610642	2	Crimp Conta	28	BS 3G 210 T	Blue	TBD	Crimp Conta	2	4610642		2	3v3	M80-	Alimentation
	5300642	3	SCL	Plugin +	fine Parts	3	Crimp Conta	28	BS 3G 210 T	Brown	TBD	Crimp Conta	3	(in the second	Plugin +	3	SCL	5300642	Board
	0	4	GND	Jackscrews	100	4	Crimp Conta	28	BS 3G 210 T	Red	TBD	Crimp Conta	4	100	Jackscrews	4	GND	0	
	10.41	5	GND	4		5	Crimp Conta	28	BS 3G 210 T	White	TBD	Crimp Conta	5	4		5	GND	- 1944	
		6	V_SP			6	Crimp Conta	28	BS 3G 210 Ty	Grey	TBD	Crimp Conta	6			6	V_SP	<u> </u>	
																_			
	FF	IOM		Eivation	<u> </u>	Connector			HAR	INESS		<b></b>	Compactor		Eivation			го	
Subsystem	Peference	Pin	Label	- Induon	#Part	Pin	#Part Pin	#AWG	#Part	t Col	orlength	#Part Pin	Pin	#Part	Tixation	Pin	label	Peference	Subsystem
Solar Panels	J1	1	SDA		M80-	1	Crimp Conta	28	BS 3G 210 T	v Black	TBD	Crimp Conta	1	M80-		1	SDA	J8	EPS
SP_Xsat+	M80-	2	3v3	-	4610642	2	Crimp Conta	28	BS 3G 210 T	vBlue	TBD	Crimp Conta	2	4610642		2	3v3	M80-	Alimentation
	5300642	3	SCL	Plugin +	finance of	3	Crimp Conta	28	BS 3G 210 Tr	Brown	TBD	Crimp Conta	3	(in the second	Plugin +	3	SCL	5300642	Board
	0	4	GND	Jackscrews	The second	4	Crimp Conta	28	BS 3G 210 T	Red	TBD	Crimp Conta	4	The second	Jackscrews	4	GND	0210	
	- 1911	5	GND			5	Crimp Conta	28	BS 3G 210 T	White	TBD	Crimp Conta	5			5	GND	- 1911	
		6	V_SP			6	Crimp Conta	28	BS 3G 210 T	Grey	TBD	Crimp Conta	6			6	V_SP		
L								<u> </u>											
	FF	IOM		Eivation		Connector			HAR	INESS Viro		<b></b>	Connector		Eivation			го	
Subsystem	Reference	Pin	Label	Fixation	#Part	Pin	#Part Pin	#AWG	#Part	t Col	or Length	#Part Pin	Pin	#Par	Fixation	Pin	Label	Reference	Subsystem
Solar Panels	J2	1	SDA	1	M80-	1	Crimp Conta	28	BS 3G 210 T	vBlack	TBD	Crimp Conta	1	M80-		1	SDA	J9	EPS
SP_Xsat+	M80-	2	3v3	i i	4610642	2	Crimp Conta	28	BS 3G 210 T	Blue	TBD	Crimp Conta	2	4610642		2	3v3	M80-	Alimentation
	5300642	3	SCL	Plugin +	(in the second	3	Crimp Conta	28	BS 3G 210 Tr	Brown	TBD	Crimp Conta	3	(in the	Plugin +	3	SCL	5300642	Board
	0	4	GND	Jackscrews		4	Crimp Conta	28	BS 3G 210 T	Red	TBD	Crimp Conta	4		Jackscrews	4	GND	0	
	-17411	5	GND			5	Crimp Conta	28	BS 3G 210 T	White	TBD	Crimp Conta	5			5	GND	- 17401	
		6	V_SP			6	Crimp Conta	28	BS 3G 210 T	Grey	TBD	Crimp Conta	6			6	V_SP		
					_			<u> </u>											
	FR	ROM		<b>Firsting</b>					HAR	INESS		<b></b>			-			го	
Subsystem	Peference	Rin	label	Fixation	#Part	Connector	#Part Pin	#AWG	#Par	/ire	lor Length	#Part Pin	Connector	#Par	Fixation	Rin	label	Peference	Subsystem
Solar Panels	J2	1	SDA		M80-	1	Crimp Conta	28	BS 3G 210 T	Black	TBD	Crimp Conta	1	M80-		1	SDA	J10	EPS
SP_Xsat+	M80-	2	3v3	-	4610642	2	Crimp Conta	28	BS 3G 210 T	vBlue	TBD	Crimp Conta	2	4610642		2	3v3	M80-	Alimentation
	5300642	3	SCL	Plugin +	(in the second	3	Crimp Conta	28	BS 3G 210 T	Brown	TBD	Crimp Conta	3	and a	Plugin +	3	SCL	5300642	Board
	0	4	GND	Jackscrews		4	Crimp Conta	28	BS 3G 210 Tr	Red	TBD	Crimp Conta	4		Jackscrews	4	GND	0	
	- 1411	5	GND			5	Crimp Conta	28	BS 3G 210 T	White	TBD	Crimp Conta	5			5	GND	- 1910	
		6	V SP			6	Crimp Conta	28	BS 3G 210 T	Grev	TBD	Crimp Conta	6			6	V SP		

Figure 32. Documentation for the harness H8

<b>Uni</b>	یمەر vEarth						DOCUI	MENTA	FION OF	WIRE(S)	/ HARNI	ESS(ES)					Réf.: XXX Edition: 1 Révision: 1 Ionospheric Gamma-ray Observatior Satellite	-YY-NN Date 0 Date and /	: XX-XX-XX : XX-XX-XX
	AUTOR	· Juan VALVE	2DE																
	SECTION	: Electronics S	vstem Enging	hering							D	ESCRIPTION:			HARM	IESSES			
	DATE	17/05/2019	,										LABEL	Type	Fr	om	Т	o	
													Н9	Wires	Battery Boar	rd	EPS Power B	oard	
	DIAGRAM	:																	
	DATE: 17/05/2019 DIAGRAM: FROM system Reference Pin Label ery Board Con- 1 VBATT-LC								HAR	NESS							т	0	
				Fixation		Connector			w	ire			Connector		Fixation			. <u> </u>	
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
	Battery1	2	VBATT-LOAD		M80 -	2	Crimp Conta	28	BS 3G 210 Ty	Blue	60mm	Crimp Conta	2	M80 -		2	VBATT-LOAD		Board
		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		
	O Links O	6	3V3	PlugIn +		6	Crimp Conta	28	BS 3G 210 Ty	Grey	60mm	Crimp Conta	6		Plugin +	6	3V3	O Links O	
		7	SCL	Jackscrews		7	Crimp Conta	28	BS 3G 210 Ty	Violet	60mm	Crimp Conta	7		Jackscrews	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

	ivEarth						DOCUN	IENTAT	ION OF	WIRE(S)	/ HARN	ESS(ES)					Réf. : XXX Edition : 1 Révision : Ionospheric Gamma-ray Observation Satellite	-YY-NN Date 0 Date and IS	: XX-XX-XX : XX-XX-XX
	AUTOR:	Juan VALVER	DE																
	SECTION:	Electronics S	System Enginr	nering							I	DESCRIPTION:			HARM	NESSES			
	DATE:	17/05/2019											LABEL	Туре	Fr	om	1	Го	
													H10	Radio Freq.	GPSRM Boar	d	GPS Antenno	7	
	DIAGRAM:																		
	50								HAR	NESS							-		
	FR	UNI		Fixation		Connector			W	ire			Connector		Fixation			0	
Subsystem	Reference	Pin	Label		#Part	Pin	#Part Pin	#AWG	#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
GPSRM		1		Diverter		1		Tallysman			40mm		1		Divisio	1			GPS
Board		2		Piugin		2		Tallysman			40mm		2		Piugin	2			Antenna

#### Figure 34. Documentation for the harness H10

Uni	s Jaw vEarths	PARIS					DOCUN	1ENTAT	ION OF \	WIRE(S)	/ HARN	ESS(ES)					Réf. : XXX Edition : 1 Révision : 1 Ionospheric Gamma-ray Observation Satellite	-YY-NN Date 0 Date and s	: XX-XX-XX : XX-XX-XX
AUTOR: Juan VALVERDE																			
	SECTION:	Electronics S	System Enginn	ering							[	DESCRIPTION:		-	HARM	NESSES			
	DATE: 17/05/2019												LABEL	Type	From Rettery Record		10 Will Cwitches		-
	DIACRAM												HII	wires	Battery Boar	a	KIII-SWITCHE	5	
<u> </u>	DIAGRAIM:																		
	FRO	ОМ		Eivation		Connector		HARNESS					Connector		Eivation		то		
Subsystem	Peference	Din	Label	TIXALION	#Dart	Pin #Part Din		#AW/C #Part		Color Length		#Part Din	Din	#Dart	Tixation	Din	Label Reference		Subsystem
Battery		1		Solder +	#Fait	1	#Fait Fill	28	#Fait	Black	90mm	#Fait Fill	1	#Fait	Solder +	F 111	Common	Reference	Subsystem
Board	22032021	2	Chrat	Adhesive +	TBD	2		20	BS 3G 210 Ty	Blue	90mm		2		Adhesive +			2	Kill Swich1
board		2	Chigt	Heat Shrink		2		20	03 3G 210 Ty	blue	5011111		2		Heat Shrink	4	NC		
FROM				Eivation		Connector	HARNESS						Connector		Finalian		т		
Subsystem Peference Pin Label		Label	FIXALION	#Dourt	Connector				Color	Longth	#Dart Dia	Die	#Do et	Fixation	Die	Inhal	Deference	Subsusteen	
Battory	Kelerence	1		Solder +	HPdrt	1	#Part Pin	10	#Part	Plack	00mm	HPart Pin	21n	#Part	Solder +		Common	Reference	Subsystem
Board	22032021	2	Cherge	Adhesive +	TBD	2		20	DS 3G 210 Ty	Plue	90mm		2		Adhesive +			2	Kill Swich2
board		2	Chirg+	Heat Shrink		2		28	DS 3G 210 IV	Diue	90mm		2		Heat Shrink	4	INC		

Figure 35. Documentation for the harness H11

UnivEarthS							DOCUI	MENTA	TION OF 1	WIRE(S)	/ HARNE	ESS(ES)					Réf.: XXX Edition: 1 Révision: Ionospherio Gamma-ra Observation Satellite	-YY-NN Date 0 Date : and y ns	: XX-XX-XX : XX-XX-XX
	AUTOR: Juan VALVERDE																		
	SECTION: Electronics System Enginnering					DESCRIPTION:						HARNESSES							
	DATE	DATE: 17/05/2019											LABEL Type From			1	Го		
												H12	Wires	Remove bef	re flight EPS Battery Bo		Board		
	DIAGRAM	:																	
					HARNESS														
FROM			Fixation		Connector		Wire					Connector		Fixation		то			
Subsystem	Reference	Pin Label			#Part	Pin	Pin #Part Pin		#Part	Color	Length	#Part Pin	Pin	#Part		Pin	Label	Reference	Subsystem
Battery	RBF1 -MOLEX	1	VBATT-LOAD	Solder +		1		28	BS 3G 210 Ty	Black	40mm		1	Solder +		:	1 Common		
Board	22032021	2	VBATT-LOAD	Adhesive + Heat TBD Shrink Tubine	IBD	2		28	BS 3G 210 Ty	Blue	40mm		2		Adhesive + Heat Shrink Tubing		2 NC	1 1	RBF

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.

			LO LO	-												Réf. : XX			
- (		O	S	-											F	Révision :	:0	Date : Date :	XX-XX-XX
cnes Jams							DOCUMENTATION OF COUPLERS DESIGN												
															9	Gamma-ray			
	artn S	0-											Joservati Satellite	SAT					
	4	UTOR: Ju	an VALV	ERDE			DESCRIPT	ION: Do	cumentati	on that h	elps us to	o choose	the corre	ct		<b>Juc</b> enite	-	_	
	SE	CTION: E	lectronics	System E	Inginneri	ng		sigr	nals and e	lectrical p	ower to	design th	ne couple	rs					
		DATE: 17	7/05/2019	•															
	Sub	System		INTERCO			Sub S	ystem			Sub S	System		INTERCO			Sub	System	
TEL Board	l (connectio	on with EASIR	OC Board)	from: U1_TEL_to_OBC			DBC (connection with ADCS)			TEL Board	l (connectio	n with EASI	ROC Board)	from: U1_1	EL_to_OBC	c c	BC (connect	ion with	ADCS)
Reference	TEL	EASIROC	Pin	_to_TEL	Antenna	Pin	OBC	ADCS	Reference	Reference	TEL	EASIROC	Pin	_to_TEL	Antenna	Pin	OBC	ADCS	Reference
J1 -H1		VbatCH+ VbatCH-	1 2	VbatCH+ VbatCH-		1 2			J1 -H1	J1-H2		CS_A	2	CS_A		2		CS_A	J1-H2
			3			3			-			CS B	3	CS B		3		CS B	7
		1	5			5			1				5			5		0.0_0	
	<u> </u>	+	6			6			-				6			6			
			8			8			1				8			8			1
	<u> </u>		10			10			-				10			10			
			11			11			-				11			11			_
			12			12							12			12			
			14			14			-				14			14			
			16			16							16			16			
			17			17			-				17			17			_
			19			19			-				19			19			$\neg$
	ALL SCL	SCL-2	20	SCL-2		20	SCLTON	SCL-2					20			20	DTXD		_
	ALCORA	SDA-2	22	SDA-2		22	SDAHME	SDA-2	-				22			22	DRXD		_
			24			24	200100						24			24			_
			25			25 26			-			-	25			25	+5		_
			27			27						VCC_SYS	27	3.3V_1	3.3V_1	27	+3V3_H2		
			28			28			-		GND	GND	28	3.3V_2 GND_1	3.3V_2 GND_1	28	+3V3_H2 GND	GND	
			30			30					GND	GND	30	GND_2	GND_2	30	GND	GND	
			32			32					GND	GND	32	GND_3	GND_3	32	GND	GND	
			33			33 34							33			33		-	_
			35			35							35			35			_
		RDY_A	36	RDY_A		36		RDY_A					36			36			
			38			38			-				38			38			
		RDY B	39 40	RDY_B		39 40	-	RDY B				-	39 40			39 40			
	SDA	SDA-1	41	SDA-1	SDA-1	41	SDA		1				41			41			コ
	SCL	SCL-1	42	SCL-1	SCL-1	42	SCL						42			42			
	GPIC-RX	-	44			44	GPIO 22		-		Bat Bus	Bat Bus	44	BatBus 1		44	Raf Pro	VBATT	_
			46			45	GPIO 23	EN-ADCS			Bat Bus	Bat Bus	45	BatBus_2		45	Bacoos	VBATT	_
		+	47			47	+5_5₩1	al)	-				47			47			
		MOSI_SPI_/	4 49	OSI_SPI_ADO	S S	49	+5.5₩1	MOSI_SPI_	4				49			49			
	<u> </u>	RTS_SPLA	4 50 51	ISU_SPI_ADO	ля S	50 51	+31/3_\$1/1(	MISO_SPI_ RTS_SPI_AI			GPID-FX	-	50	+		50	GPIO 24 GPIO 25		-
		CS_SPI_ADC 52		CS_SPI_ADC	S	52		SCK_SPI_A	I_AD			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



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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