



Universidade do Minho
Escola de Engenharia



UMINHO
cmems
CENTER FOR MICROELECTROMECHANICAL SYSTEMS

Master's in Industrial Electronics and Computers Engineering

University of Minho

5S Drifter

Sensoring System for Surface Sea Streams

Integrative Project in Industrial Electronics and Computers

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Acronyms

UART Universal asynchronous receiver/transmitter

LTE Long-Term Evolution

ADC Analog to Digital Converter

IMU Inertial Measurement Unit

PCB Printed Circuit Board

CMEMS Center for Microeletromachanical Systems

STM32

DMA Direct Access Memory

IoT Internet of Things

GPS

JSON

DB Data Base

SST Sea Surface Temperature

HRSST High Resolution Sea Surface Temperature

ITC Inter Thread Comunication

CS Channel Select

Chapter 1

Project Plan

This chapter will briefly talk about the 5S Drifter project motivations as well their function as a product developed by the Minho's University under supervision by the professors Luis Gonçalves and Sérgio Lopes.

1.1 Introduction

Under the course unity of Integrative Project in Industrial Electronics and Computers the students must apply for professors projects in order to integrate under their respective laboratories and start to understand the pace demanded on the Master's final paper.

This project, given by the professor Luis Gonçalves and Sergio Lopes under the CMEMS laboratory, has the main purpose to create a drifter for data acquisition. As a multi-themed project, this report will explore multiple areas, as the PCB design for hardware and firmware manufacture, software design under the idea to optimize the execution allowing for better performance. The main goal is to have the final product afloat at the end of the semester.

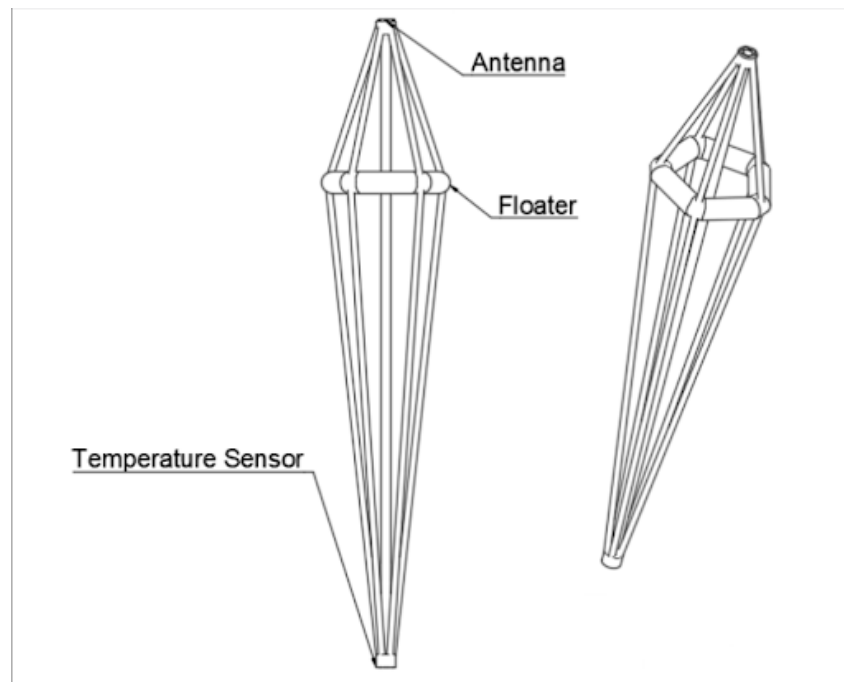


Figure 1.1: Draft Floater



1.1.1 Problem Statement

The ocean is one of the man the greatest mystery even before the written history. Humanity made the world ours over the water, from the Portuguese greatest discoveries, braving the raging ocean to the newest oil tanker demanding ever newer technology in order to tame the sea for safer and smoother sailing.

Nowadays, scientists believe only 20% to 26% of the ocean is discovered with the actual technology which means that humanity know as much about our so grate sky as our own seas. 5S ocean drifter is equipment made to acquire data from superficial sea streams and expand the oceanographic knowledge about it.

Better knowledge of the ocean lead to further development in diverse areas. Granting safety, security and efficiency.

5S, an acronym for Sensing System for Surface Sea Streams is a low-cost, low-power solution to acquire said data with the focus to last autonomously for the longest time possible. The drifter has to attain its GPS coordinates in order to track its current and average velocity, alongside with the water temperature and an accelerometer information to gather information about the wave intensity. All this data will be stored locally and transmitted by a protocol, yet to be defined, with a JSON format in order to be received by a database that already is implemented.

Oceanograpy

The current in study will be the IPC (Iberian Poleward Current), a well documented by the Advanced Very High Resolution Radiometer (AVHRR) over the last two decades, is a narrow (25-40km) flow of water that follows the continent slope due to topography and/or water density commonly referred as a "slope-trapped tongue". Iberian as is "slope-trapped" at the continent going roughly near Portugal going along up to the bay of Biscay and Poleward, meaning that the current flows North. Being at their strongest in the winter, and weaker at the summer peak, the current is known to be significantly warmer and carrying more salinity due to the Mediterranean influence, over the Eastern North Atlantic Central Water (ENACW).

Transport

It isn't uncommon to see transport accidents being reported, and even worse, for it to be a gigantic problem. Some of these accidents are caused by poor mapping of sea conditions, tankers spilling oil, fishing vessels capsizing, leading to financial problems and even loss of life. Even when there are no accidents, poor knowledge of tides results in higher energy consumption when routes are set against the currents.

A solution would be to create optimized shipping routes, minimizing accidents and improving energy efficiency while traversing the waves. Oil tankers could follow currents with lower fuel consumption. Fishing routes could become more efficient, as their target species may swim with the tides based on temperature and speed. This would ease the workload, making the activity less reactive and more predictable, aligning expected catch rates with reduced time and energy consumption.

A well-known example of a hazardous area is the Nazaré Canyon, where its unique shape creates enormous waves. Avoiding these waters is crucial for safer navigation.

Ecology

The IPC has an important part in their ecosystem, as it transports plankton transport, larval drift, and nutrient dynamics along the coast, essential components for the living fauna and flora.

Other way to see the importance of IPC looking after the ecology is the placement of wave energy converters, a growing field under the energy generation, is one of the main problems the technology faces. A good positioning improves the efficiency and reduces the costs of construction and maintenance.

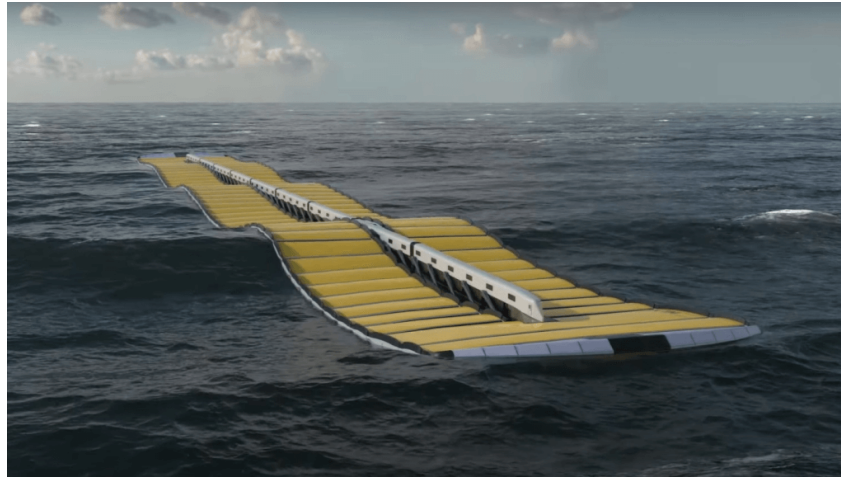


Figure 1.2: The Design of a Wave Energy Converter to Electricity

Nowadays, the field of renewable energy overseas is a hot topic, as the designs keep on changing and improving. As an example, the company Ocean Winds builds offshore wind farms over the world. Recently the company created the project WindFloat in Portugal as initiative to harvest the offshore winds in areas with depth greater than 40 meters, being around a few kilometers.

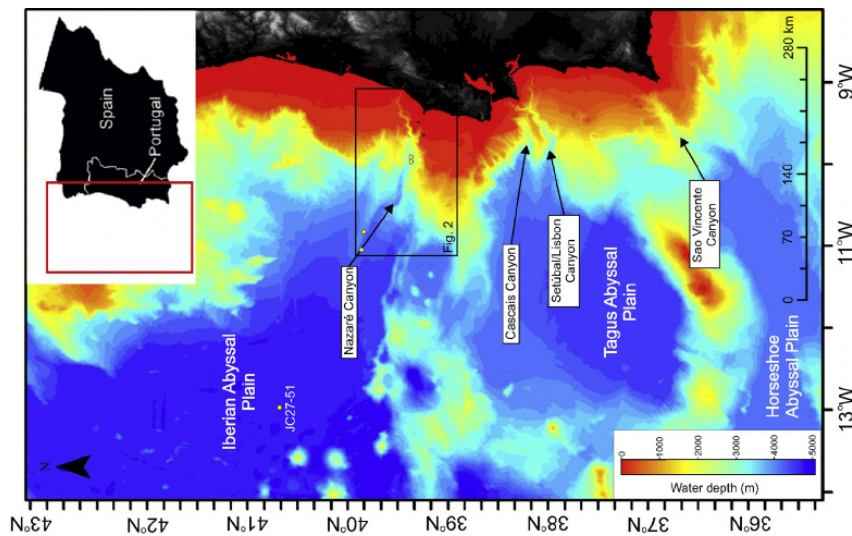


Figure 1.3: Depth Map of Portugal's Coast

Safety

As time passes one the important jobs of oceanography is the study of sediments of rocky structures at shore and their deposition. Data useful to determine the shore mineral composition and predict erosion areas or even weaker or stronger soil helping to plan coastal vulnerability and resilience.

The coast is a focus human attractor, being for sports, leisure, living and Industrial oportunities, and being so, good information around it prevent harm, and creates a safer environment.



1.1.2 Problem Statement Analysis

As a first step into solving this project, an initial construction of the demands is requested. Here will be presented, following the waterfall approach and UML standards, the solutions to the individual problems presented by the project.

As stated, the floater has a series of data to acquire, format, and send in order to be considered concluded. The system will be divided in smaller and simpler packages to solve each point then it will be assembled as a final product.

Equipment Objectives

The system, in order to accomplish said targets, must set the following topics

- Data acquisition
 - Power Source Level
In order to alert a low batteries.
 - Wave intensity
Measuring the force exercised by the water in the drifter
 - Position
Track the movement of the water.
 - Temperature
Measures the temperature directly.
- Wireless data transference
As the floaters has no physical connections with the shore.
- Local data storage
In case of lack of external communication.
- Autonomy
The longer it survives, the more data it will gather.
- Resistant and buoyant shell
The physical parts that support the system.

Chapter 2

Analysis

In order to accomplish said objectives listed on the problem Statement Analysis, it is first needed to enlist the embedded system components, this will help to choose a STM32 model as well the modules for this task without any over and under dimensions.

- Microcontroller
The STM32 CPU that will control the Embedded System.
- GNSS
A module to acquire the world position in latitude and longitude.
- Mobile Communication
The module with the ability to communicate wirelessly with MongoDB
- Power Source
The set of batteries the system will relay on for energy. It is stipulated that the system must have the autonomy of at least 30 days.
- SD Card Slot
Local long term memory in case of field transmission.
- Sensors:
 - IMU
System physical acceleration and angle data.
 - Temperature Sensor
Water Temperature data.
 - Power Source Level Sensor
Voltage reading data.

As for the outer shell there are a few things to have in attention.

- The Antenna to floater distance, once the water interferes with the antenna signal.
- The float size, that needs to support all the weight and float, respecting the first topic.
- The drifter ballast, that will be the drifter core, located between the floater and the temperature sensor tip. It should be heavy so the drifter points up, but it shouldn't exceed the second topic demand
- The Floater volume, as it has to balance the hole electronics and shell weight.

This creates a first view of the system as a block diagram. Indicating the physical connection between each component. This won't define the 5S architecture, but it will serve as an initial guide to build on.

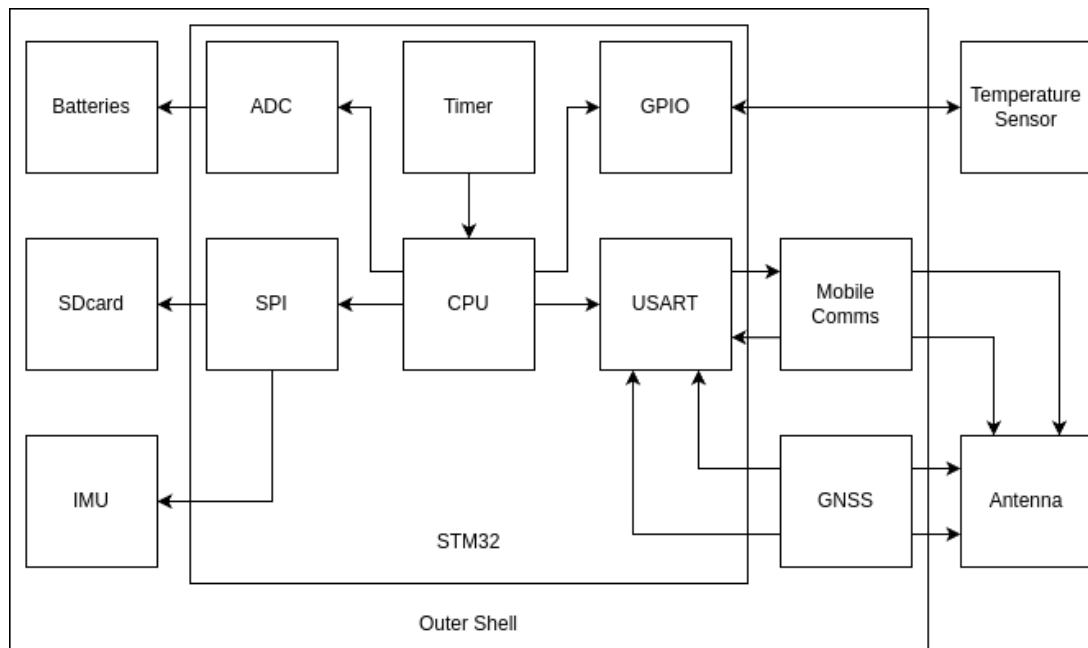


Figure 2.1: Block Diagram Initial Draft

The floater draft shows the initial concept of a drifter, as it has the above water antenna, a floater to counterbalance the buoy weight, and the temperature sensor. According to the blocked diagram.

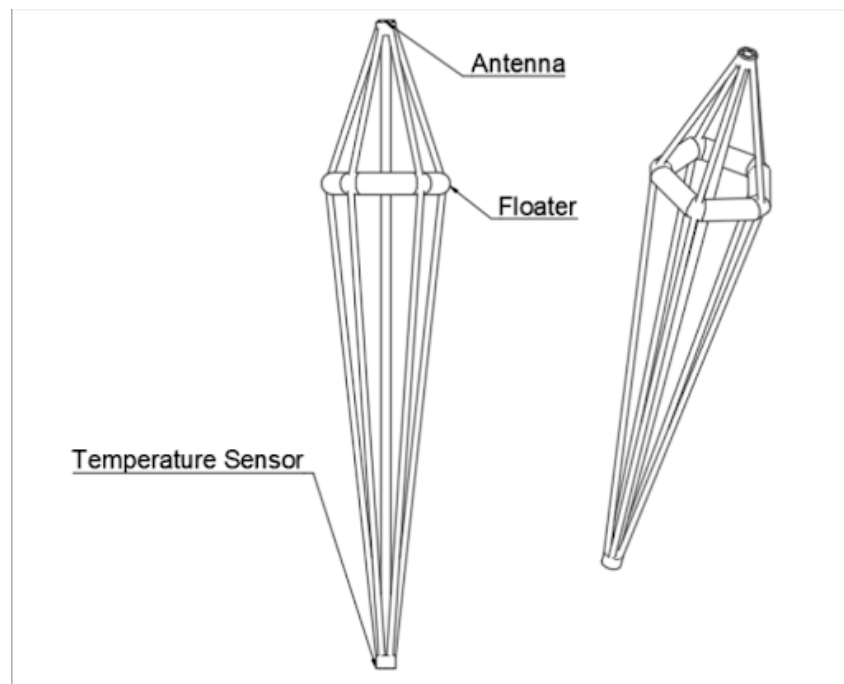


Figure 2.2: Floater Architecture Initial Draft



2.1 Requirements and Constraints

2.1.1 Requirements

- Search and selection of hardware components.
- Software design.
- PCB design.
- 5S outer shell 3D design.
- Actual product realization.
- Laboratory tests.

2.1.2 Constraints

- Limited Team
- The project must be presented for evaluation within deadline.
- The project has to be validated at the ocean.
- The pretended autonomy has to be of a month at minimum.

2.2 State of the art

Nowadays, there are a series of reasons in which drifters are used. Usually, government departments, companies and universities with relations to oceanography, use drifter alike to research the local coast for the following reasons.

- Border Control
- Climate Modeling
- Traffic management
- Aquaculture management
- Public oceanographic research
- Marine spatial planning
- Defense and security

5S drifter aims for **Climate Modeling**, **Public oceanographic** or even **Traffic management** research as this project main objective. As the data for this project can be used, as stated in the [Introduction](#), to model the environment in order to better the quality of said topics.

2.2.1 Copernicus Example

The Copernicus Marine Service, component of Copernicus Programme of the European Union, has developed the SVP-BRST, a drifter for temperature and depth measurement. Based on the SSP-B design, the updated version implements a HRSST in addition to the regular SST sensor, gathering the position with GNSS and transmitting the data using Iridium.

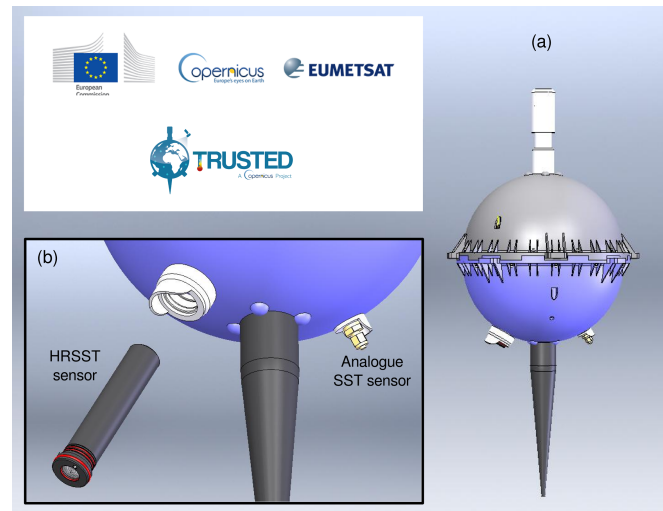


Figure 2.3: SVP-BRST Design

The image shows the SVP-BRST model. The (a) image shows the whole model with the antenna the buoyant part and the weight to point the buoy up. As for the (b) image, it shows the sensor's placement.

2.2.2 CMEMS Examples

The CMEMS lab at the University of Minho combines expertise in microsystems engineering with environmental research to develop innovative ocean monitoring technologies. One of its key areas involves the design and deployment of autonomous drifters to collect real-time data on sea surface conditions and currents.

SONDA

The project proposes a complementary system for atmospheric and oceanic monitoring using configurable probes launched by high-altitude balloons. These probes can measure environmental parameters from the stratosphere to the deep sea. After reaching the seafloor and collecting data (including acoustic imaging), the probe resurfaces and transmits the data via satellite. It then drifts until its material degrades. The system offers a low-cost, high-payload solution with limited positional accuracy.

NextSea

A new approach of monitoring coastal and estuarine relevant variables is presented. MEMS (Micro Electromechanical Systems), lab-on-chip and microelectronics are used to miniaturize and optimize main oceanic sampling. Beyond typical CTD (Conductivity, Temperature and Depth), other oceanic variables are also monitored. The system also samples type of phytoplankton and its concentration, pH, currents direction and intensity and turbidity.



2.3 System Architecture

Once studied what the system needs to follow, it is now needed to formulate a solution. Here it will be used UML diagrams to convey the solution in question, without real specifications once this proposal works as a validation and organization to the problem as a formal language.

Block Diagram

As previously stated, a block diagram is a formal representation of the system components and their connection. This one, shows how the peripherals communicate with the microcontroller STM32 as it considers connections with components outside the shell. Initially, as a first analysis the communication protocol isn't yet defined. However, it will be used to narrow it down.

The diagram shows the STM32 minimum peripherals: ADC, TIMER, GPIO, I2C / SPI, USART. However, as it describes the hardware, it doesn't give a good notion on the system software.

Some points to be considered are:

- The temperature sensor communicates using the GPIO, as waterproof sensors, usually, use a driver with specific communication protocols.
- Mobile Comms is the protocol that will be used to send information to the database. Yet to be chosen.
- GNSS and Mobile Comms for now communicate to the same Antenna, However it probably will use different antennas as different protocols require different frequencies to be used.
- The communication to the SDcard, uses SPI with STM32 below 64 pins. As it doesn't include SDMMC supporting FatFS.
- The batteries power the whole system. Even if not shown.
- Depending on the implementation, the timer block will be the Sysclock, as the RTOS may use by default.

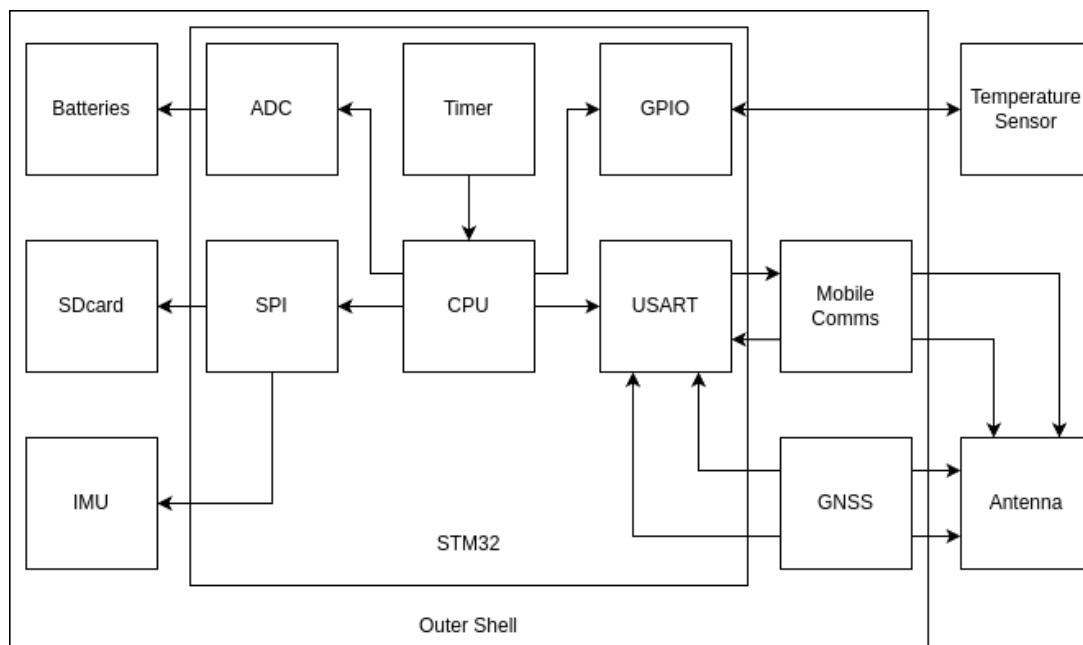


Figure 2.4: Block Diagram

Use Case

Now, for a software illustration, UML offers a user case, a diagram that exemplifies the system interactions and stimuli.

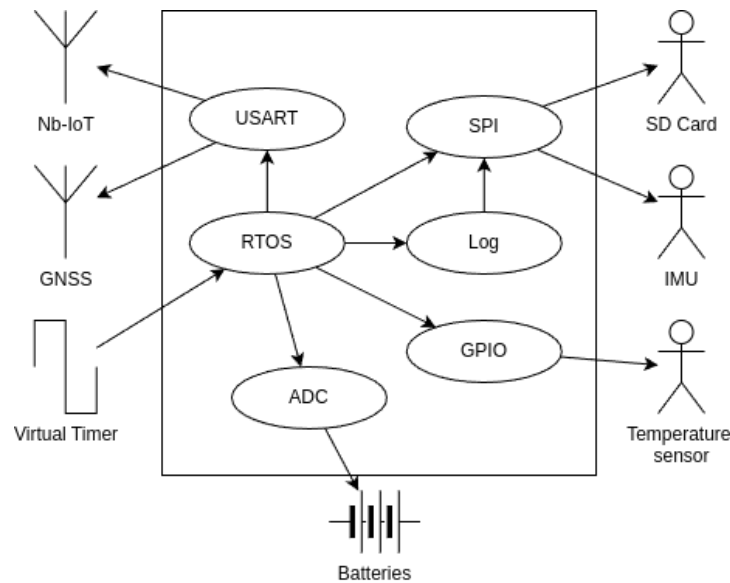


Figure 2.5: Use Case Diagram

Now it is introduced to one main component that will be explored further, an RTOS. As it is stimulated by the timer, it will activate the peripherals in a organized form, allowing a fast and efficient use of energy. Other component is the Log, a virtual memory that will store temporary the information, only storing locally, once per cycle, reducing the SDcard entries.

Sequence Diagram

Once the software and hardware are planed, now a time related diagram will show the blocks interactions as time passes.

First task sequence, a generic "Data Acquisition Task" shows the general behavior of a task focused to manage the sensors.

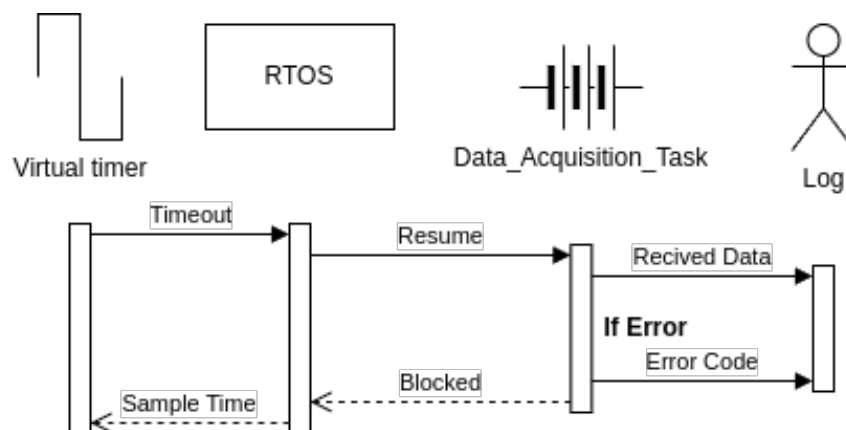


Figure 2.6: Sequence Diagram of Sensor Task

Next, the second task sequence, there will be 2 tasks with the behavior to get the GNSS

[illegible]

Figure 2.7: Sequence Diagram for Sending and Archive Task

Once this problem requires a list of tasks to be executed, using a OS will allow a better project organization and performance with little to no impact in power consumption, even helping to manage the low power mode. However, the implementation will suffer, as the codification as verification grows, so this topic may become an additional information by the end of the project.

The division in Threads demands a separation in Priority levels, as the OS scheduler takes in consideration once both tasks are ready for execution.

Setting a task priority it must take in vision the resources the task will use, the time it will take to execute said behavior and the actual importance in matching it time constraints. In order to manage this level of complexity, the RTOS offers a set of tools for tasks control that will be used for its synchronization and communication.

- High Priority Threads
Tasks that will handle the outer communication as GNSS and the internet integration will take the higher priority once, as will be handled by a peripheral, its execution will be faster, only using the USART interface for AC transmission.
- Normal Priority Threads
The only task here will be the one that has enough importance to be prioritized over the sensors but as the transmission begins it should release the processor for the outer communication.
- Low Priority Threads
Tasks that only has to measure the sensors having no problem to be removed from the CPU execution once their execution is, in their majority, asynchronous.

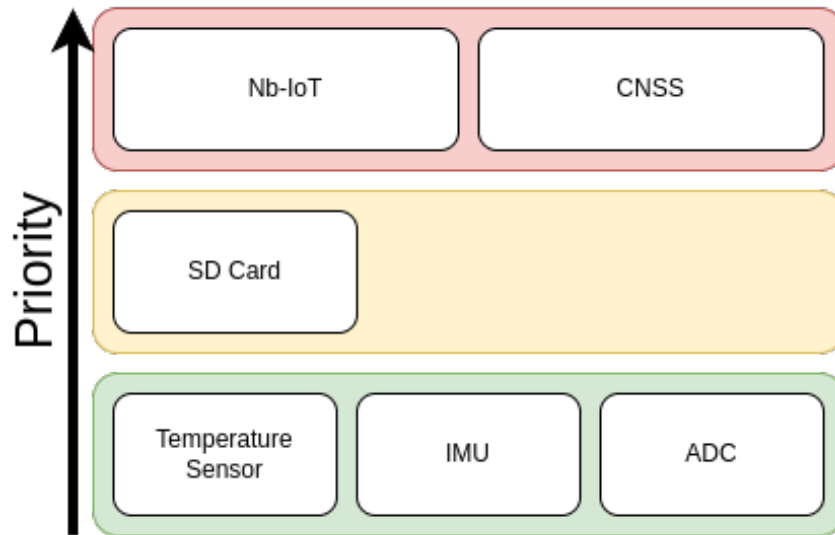


Figure 2.8: Thread Priority Stack

Other important perspective, is to emulate the task behavior with the priorities in action. Showing a repetition of X times a group of data acquisition tasks, then ending with the second task sequence. X yet to be defined as it first depends on the sample time.

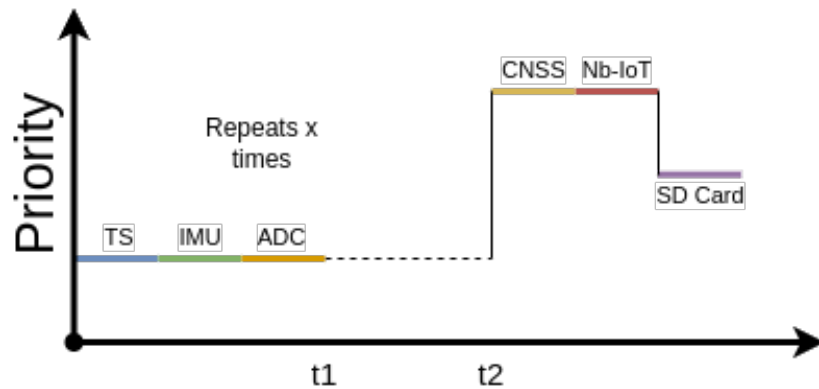


Figure 2.9: Thread Temporal Graph

Here up to t_1 the system executes tasks, storing data, then entering low power mode until the next sample. Then, at the end of the last repetition, at t_2 , starting the second task sequence. Then after the SDcard task behavior ends, as so do the cycle.

Memory Abstraction (Log)

The final diagrams, are a exception to UML diagrams, As it only builds a data structure and a simple interface to interact with it. Here the idea is to allow memory to be accessible while written by the system, optimizing the RTOS ITCs options.

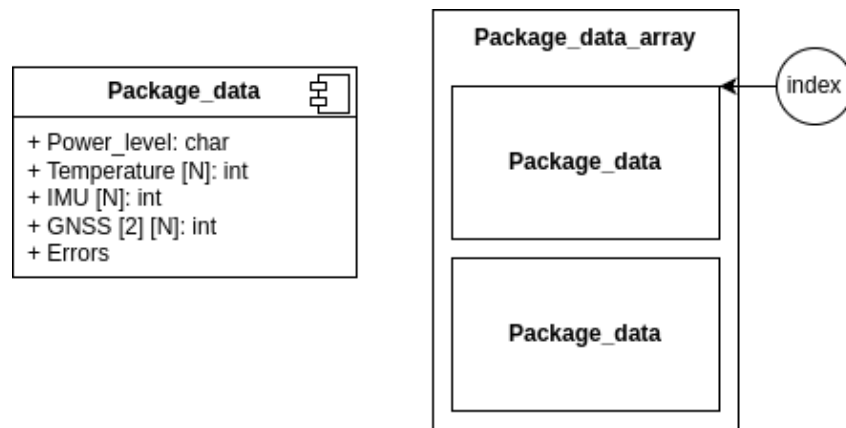


Figure 2.10: Package data structure

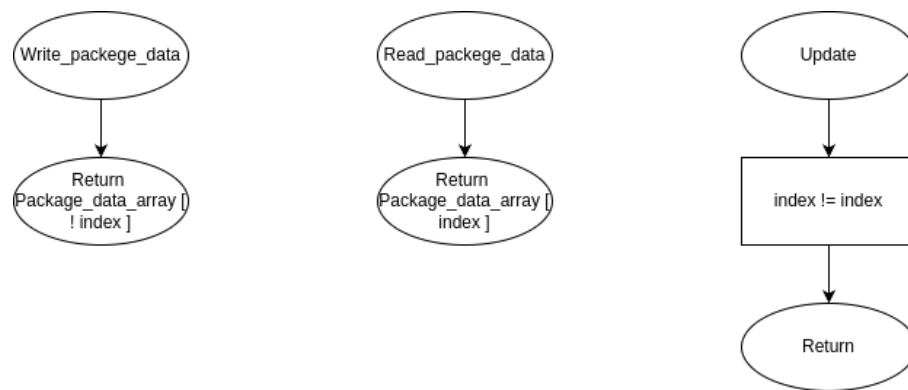


Figure 2.11: Memory Flowchart

Chapter 3

Design

Now, once planed "What" is the system, it is needed to plan the "How" the system will be build in the implementation phase. Here is explained the components and the reason for it. As well for the instructions on the system construction and realization.

3.1 Analysis Review

Taking in account the limited personal and time, some of what is specified in Analysis has the scope reduced as to accomplish according to the requirements and constraints. Using as inspiration the Copernicus SVP-BRST and the CMEMS labs previous experience, the 5S can/ and will recall for used technology for easier design process.

The project then will be divided in three main parts; The Software, Hardware and the outer shell. Then, lately, it will be shown the pieces of software used to accomplish this project.

3.2 Software

As for software there will be two possible approaches for the problem, as the use of a RTOS as stated on the Analysis, may require more time than it is worth. However, the use of a RTOS, allow for a better control off timings and the Low Power mode. Either way, as the implementation of both alternatives may differ, the overall design will remain the same.

This section will first decide the protocol available, abstractions, then the possibility of using a RTOS

3.2.1 Communication protocol

The selection of a network protocol is a complicated process as it interests with several factors that imply directly on the data to be acquired. To list the ones with more influence.

- Distance
- Bit-Rate
- Signal Availability (SIM card and protocol local integration)
- Price per package
- Integrated GNSS Hardware
- Low Power



There are several protocols to choose from, so first it is needed to categorize the system needs and filter the list.

The first filter will be the distance. The IPC extends for kilometers along the shore, however signal along the shore can be mostly guaranteed as the service providers are mostly equally distributed. The real distinct characteristic is the reach offshore going inside the ocean. This category of protocol is a WWAN (Wireless Wide Area Network)

Some available protocols are; 2G(GS), 3G(UMTS), 4G(LTE), 5G, NB-IoT, Lora, Iridium

As the distance increases, the effective bit-rate tends to lower, due to protocols overhead and errors, so is expected a lower than usual bit-rate.

The protocol availability will depend on the service provider. This one is another set of varieties itself, however it can be divided as local and global service providers.

Services like SIMBASE, a global provider, are available for the lab to use, however it will offer coverage for a specific set of protocols in Portugal (coast). This one uses the local network interface, so the coverage of each protocol depends on the local provider range of signal.

Portugal	2G	3G	4G	5G	LTE-M	NB-IoT
Meo	V	V	V	–	–	–
Nos	V	V	–	–	–	–
Vodafone	V	–	V	V	V	–

Table 3.1: Protocol per provider table

Doing a local search, the Vodafone service provider, differs from the others, as also offers NB-IoT protocol if accorded directly.

By these factors, it is reducible to LTE and NB-IoT protocols. The price is inclined to the LTE protocol, as is already available on lab, but the NB-IoT is more centered around the Low Power. There are several boards that include both protocols with GNSS integrated so it also ain't a defining criterion.

As Low Power is a main concern on this project, the NB-Iot is the chosen protocol, however the 4G is a strong alternative, in case of a substitution.

3.2.2 Abstraction

As the implementation require multiple communication protocols between components, the development will require a layer of abstraction named wrappers. Protocols like OneWire, SPI and AT commands can and should be a higher level function, even with HAL assistance.

AT commands can be simplified to simpler functions without the necessity to write down the command. As HAL handles the UART transmission by taking an array, it is possible to use a sprintf to format the command using function parameters. Then it can be received the module answer and writing it on an array given when the function is called.

As for the SPI, here the intention is to simplify the multiple registers needed to configure the system components like the IMU. A simple Get Function that sends a pre-defined signal, activating the right CS and making the communication easier.

The OneWire, as not covered by the HAL, can be the hardest one, as it would be needed to be written from scratch. However, there is already libraries specific for the module in use, simplifying the process to program on this phase.



3.2.3 RTOS

3.2.4 RTOS alternative

3.3 Hardware

This section elaborate on the system physical components, their connections and the reasons they were chosen. It is important to remember that the main objective, even if it is not specified on the topic, is the Low Power functionalities. So the ability to consume less power is a favoring point.

3.3.1 Autonomy

Autonomy is the main point to look for as the system is designed, as the higher autonomy, the longer 5S can stay adrift without maintenance.

As for the autonomy there are two main factors to consider, the batteries and the board consumption. To do it, so it is first need to set a consumption goal and the autonomy is good enough if the power needed is lower or equal then the goal.

Although the renewable energy is out of the scope of this project, the components suggested for future improvements will be shown at the end as a possible future feature.

As a restriction, the minimum amount of time in ocean is 1 month(720 hours), this will help us define the consumption goal.

Board Consumption

Remembering the Analysis list of components, there are several components that consume power in the system. And the sum of them will be used to choose the battery capacity.

The main power sinks in the systems will be the Microcontroller and the Communication Shield. As a head-start, choosing these two components will help. There are several options for both, however it must be selected according to the settled rules. The microcontroller has to be an STM32, containing the necessary peripherals, and the module have NB-IoT (And LTE just in case), both with Low Power functionalities.

According to the microcontroller rules, there are still several boards with the minimum resources to accomplish the goal, even if it is selected the L0 models, designed for Low Power. As this first prototype, it was selected a STM32H7, as it is available, that has an elevated power consumption, however it allows for a better system modulation. As the HAL is used, the transference for a future STML0 board model, with the necessary resources is mostly effortless.

Feature	STM32H7 $\mu\text{A}/\text{MHz}$	STM32L0 $\mu\text{A}/\text{MHz}$
Run Current @ 3.3V	~600	~87
Sleep/Stop Mode	~2.5	~0.5
Standby Mode	~0.25	~0.2
Supply Voltage	1.62V to 3.6V	1.65V to 3.6V

Table 3.2: Typical power consumption values for STM32H7 vs STM32L0.

Initial, the prototype will consume, on average as it will mostly stay on sleep mode , 2.5 $\mu\text{A}/\text{MHz}$, and lately 0.5 $\mu\text{A}/\text{MHz}$.

As for he GNSS/NB-Iot or LTE module, there is several modules that fit the design rules. The list of module available are SIM 7000,7020,7080,7600, Quectel BG77, Quectel BG95a and EVKITST87M01-1.



Module	Sleep Mode (μA)	Idle Mode (mA)	Peak Current (mA)
SIM7020	20	N/A	2,000
SIM7080G	600	10	N/A
SIM7000E	1,000	11	167
SIM7600	2,800	18	896
Quectel BG77	530	1	559.980
Quectel BG95-M3	3,840	24	357
EVKITST87M01-1	N/A	N/A	N/A

Table 3.3: Current Consumption of Modules (in μA)

Module	2G	3G	4G LTE	NB-IoT	GPS
SIM7020	No	No	No	Yes	No
SIM7080G	No	No	No	Yes	No
SIM7000E	Yes	No	Yes	Yes	Yes
SIM7600	Yes	Yes	CAT4	No	Yes
Quectel BG77	No	No	No	Yes	Yes
Quectel BG95-M3	Yes	No	LTE-M/NB-IoT	Yes	Yes
EVKITST87M01-1	No	No	No	Yes	No

Table 3.4: Supported Protocols by Module

In conclusion, the Module to choose is the SIM7000E, as it has the better average consume and has both protocols at disposal.

The following items were chosen by the laboratory availability.

IMU 9DOF GY-85 - ITG3205 + ADXL345 + HMC5883L

The **GY-85** is a compact Inertial Measurement Unit (IMU) that integrates three key motion sensors, offering 9 degrees of freedom (9DOF). It combines the following components:

- **ITG-3205**: a 3-axis gyroscope for measuring angular velocity,
- **ADXL345**: a 3-axis accelerometer for detecting linear acceleration,
- **HMC5883L**: a 3-axis magnetometer for sensing magnetic fields and orientation.
- **Amperage consume**: 23uA while turned on.

Together, these sensors provide comprehensive motion and orientation data, making the GY-85 suitable for applications in robotics, drones, wearable devices, and general motion tracking systems. The module communicates using the I2C protocol, enabling easy integration with microcontrollers and embedded systems.

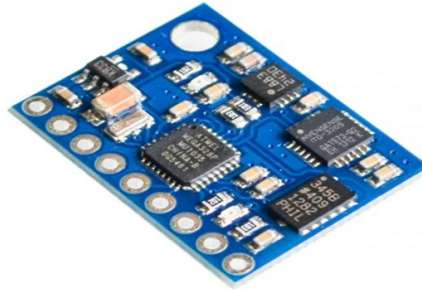


Figure 3.1: 9DOF GY-85 - ITG3205 + ADXL345 + HMC5883L

SIM7000E Arduino NB-IoT/LTE/GPRS/GPS Expansion Shield

The **SIM7000E Expansion Shield** is a versatile communication module designed for use with Arduino boards. It integrates the **SIM7000E** cellular module, enabling support for multiple communication technologies, including:

- **NB-IoT (Narrowband IoT)** for low-power, wide-area communication,
- **LTE Cat-M1** for efficient, low-latency data transmission,
- **GPRS/EDGE** as a fallback for 2G networks,
- **GPS** for accurate positioning and navigation.
- **Amperage consume** of 1 mA as it requests for data transference.

The shield is ideal for IoT applications requiring reliable connectivity and geolocation, such as asset tracking, environmental monitoring, smart agriculture, and remote sensing. It interfaces easily with Arduino via UART, making it accessible for both prototyping and deployment in embedded systems.

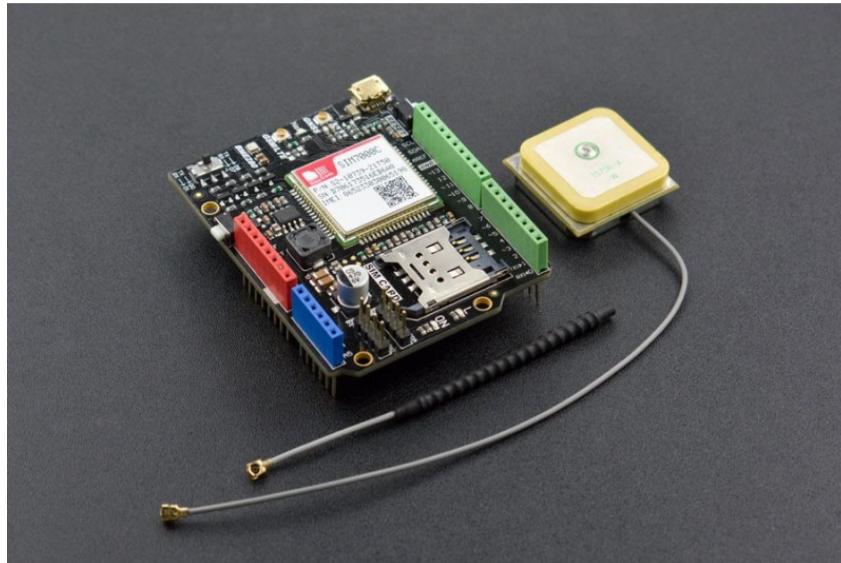


Figure 3.2: SIM7000E

Waterproof Temperature Sensor (DS18B20)

The **DS18B20** is a digital temperature sensor known for its accuracy, reliability, and ease of use. Encapsulated in a waterproof stainless steel probe, this version of the sensor is ideal for use in wet or outdoor environments.

Key features include:

- **Temperature range:** -55°C to $+125^{\circ}\text{C}$,
- **Accuracy:** $\pm 0.5^{\circ}\text{C}$ in the -10°C to $+85^{\circ}\text{C}$ range,
- **Digital output** via the **1-Wire** protocol, allowing multiple sensors to share a single data line,
- **Waterproof design** for robust operation in harsh environments.
- **Amperage consume** of 1mA per conversion.

The DS18B20 is commonly used in applications such as HVAC systems, weather stations, industrial temperature monitoring, and smart farming. Its simple interface and compatibility with microcontrollers like Arduino and STM32 make it a popular choice for both hobbyist and professional projects.



Figure 3.3: DS18B20

Micro SDHC Card INF01016

The size of the SD card, will depend on the amount of data to be stored.

$$StorageSize = (PackageSize(bytes) * TimeOnline(H)) / Sampleperiod(H)$$

Speculating that 5S will produce around 200 bytes each 10 minutes over 4 months it is possible to reach the value of

$$StorageSize = (200 * 4 * 30 * 24) / (10/60) = 3.4Gbytes$$



Figure 3.4: Cartão micro SD

Micro SDHC Card Reader Module and Battery Holder

As the last components, there's will be used some support modules and battery support to hold the electronics in place.



Figure 3.5: Battery Holder

Possible Solar Energy

As an additional topic, here will be briefly explored the option of renewable energy, for future exploration.

The module AEM10941 and the solar panel SM111K06L are good recommendations. Is advisable to follow the datasheet as the module requires specific configuration and circuits to work properly.

Batteries

Using the formula $BatteryCapacity = Amperage * Time$, it can be determinate the Amperage consumption limit. As Batteries capacity has a discrete value available on market, it is possible to make a table as graph the results for better visualization.

Using the 3,7V batteries available by the laboratory, the following table can be constructed.

Cell Capacity (mAH)	Max Amperage(mA)	price(€)
800	1,11	4,95
2000	2,77	3,40
2200	3,05	3,90
2500	3,47	4,40
2600	3,61	4,60
3200	4.44	5,40
3350	4.65	9,40

Table 3.5: Batteries Capacitis, prices and time relation.

However, 1 month is a short amount of time when the IPC cycle take almost one third of the year. Then, using more batteries, 5S will accomplish to acquire date of a full cycle. As the equation for the Amperage consumption is linear, multiplying the amount of time by four implies four times the capacity meaning the system will



Figure 3.6: LI-ION 18650 3,7V 2000MAH

3.3.2 System Pinout

Here will be displayed the systems pinout. (Yet to be decided)



Name	Pinout	uC Pin
Temperature Sensor	VDD	3.3V
IMU	VDD	3.3V
UART AT	3,05	3,90
UART DEBUG	3,47	4,40
ADC	3,61	4,60
SD card	VDD	3.3V

Table 3.6: Batteries Capacities, prices and time relation.

3.4 Shell

2.5 dB Antenna should be at least 15 cm form water

3.4.1 Conclusion

Diagram

The hardware configurations, as indicated on the datasheet should follow the leading steps.

As for the UART communication, the list of commands are listed on the datasheet. As for better flow, here are listed the commands used along the project and their functionalities.

3.5 Tools and COTS

3.5.1 Tools

Inkscape

A free and open-source vector graphics editor used for creating and editing SVG-based diagrams, schematics, and illustrations. Useful for generating custom graphics, PCB artwork, and documentation visuals.

draw.io

A web-based diagramming tool for creating flowcharts, system architectures, block diagrams, and wiring schematics. Supports real-time collaboration and integrates with cloud services like Google Drive and GitHub.

STM32 CUBEmx

A configuration and code generation tool for STM32 microcontrollers. Simplifies peripheral setup, clock tree configuration, and generates initialization C code for use with IDEs like STM32CubeIDE or Keil.



Fusion360

A professional-grade 3D CAD, CAM, and CAE tool from Autodesk. Used for mechanical design, simulation, and 3D modeling, making it ideal for designing enclosures, mounts, and mechanical parts.

L^AT_EX

A high-quality typesetting system used for technical and scientific documentation. Ideal for creating well-formatted reports, theses, datasheets, and documentation with complex mathematical content

Minicom

Minicom is a text-based serial communication program for Unix-like systems. It allows you to connect to serial devices (like routers, microcontrollers, or modems) via a serial port (e.g., /dev/ttyACM0). It's commonly used for debugging, configuration, and monitoring of hardware over UART.

3.5.2 COTS

All COTS are specified on the [Board Consumption](#) chapter.

Chapter 4

Implementation

4.1 Hardware and Shell

4.1.1 Project Sections

4.1.2 Task Behavior

4.2 Software

4.2.1 Mobile Communication

4.2.2 AT commands

Field	Value	Meaning	Parameter Description
Run Status	1	GNSS engine is running	Indicates whether the GNSS sub
Fix Status	(empty)	No valid fix yet	Shows if a location fix is acquire
UTC	(empty)	No time fix yet	Coordinated Universal Time (Y
Latitude	39.500002	Your current latitude	North/South position in decimal
Longitude	-8.000000	Your current longitude	East/West position in decimal c
Altitude	-54.560	Meters	Height above mean sea level
Speed	(empty)	Not available yet	Speed over ground in km/h
Course	(empty)	Not available yet	Direction of movement in degree
Fix Mode	1	Autonomous fix (probably 2D/3D)	1 = Autonomous, 2 = DGPS, 3
HDOP, PDOP, VDOP	0.1, 0.1, 0.0	Position accuracy factors	Horizontal, Position, and Vertic

Table 4.1: Detailed Breakdown of +CGNSINF Response Fields

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separar funções do IMU e GNSS para não atrapalhar um ao outro.

4.2.3 DataBase Communication

Mongo db
JASON

Chapter 5

Conclusion

5.1 Future improvements

5.2 Special Greatings

At last it's important to add the support from the CMEMS labs personal as well of the professor Tiago Matos for his support with hardware

5.3 Bibliografy

The secondary ageostrophic circulation in the Iberian Poleward Current along the Cantabrian Sea (Bay of Biscay) Atmospheric modes influence on Iberian Poleward Current variability