Degree thesis

"AIS (*Automatic Identification System*) receiver via module RTL-SDR"

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Introduction and Presentation Content

I. Introduction to the technical aspects of AIS.

II. Statement of the problem to be solved.

III. Proposed solution. Block diagram.

IV. Design and construction of the prototype.

V. Tests performed.

VI. Conclusion and future work.

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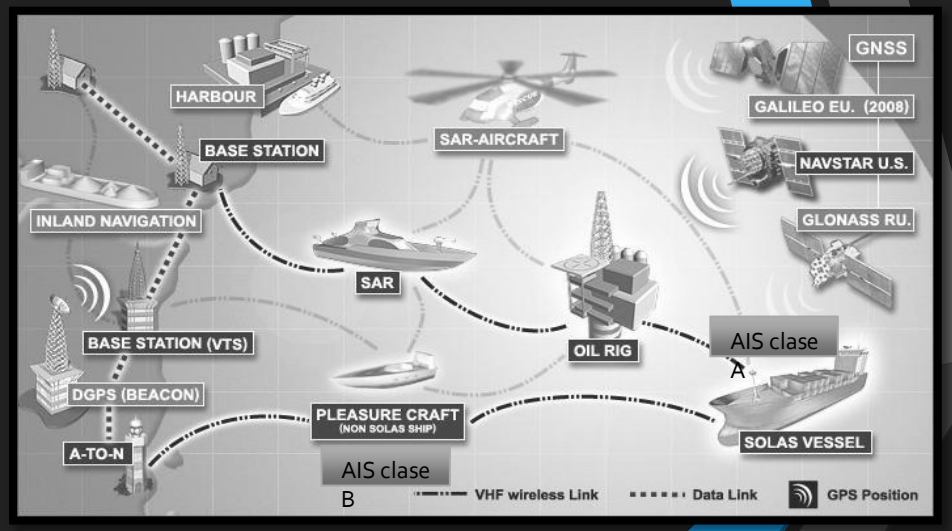
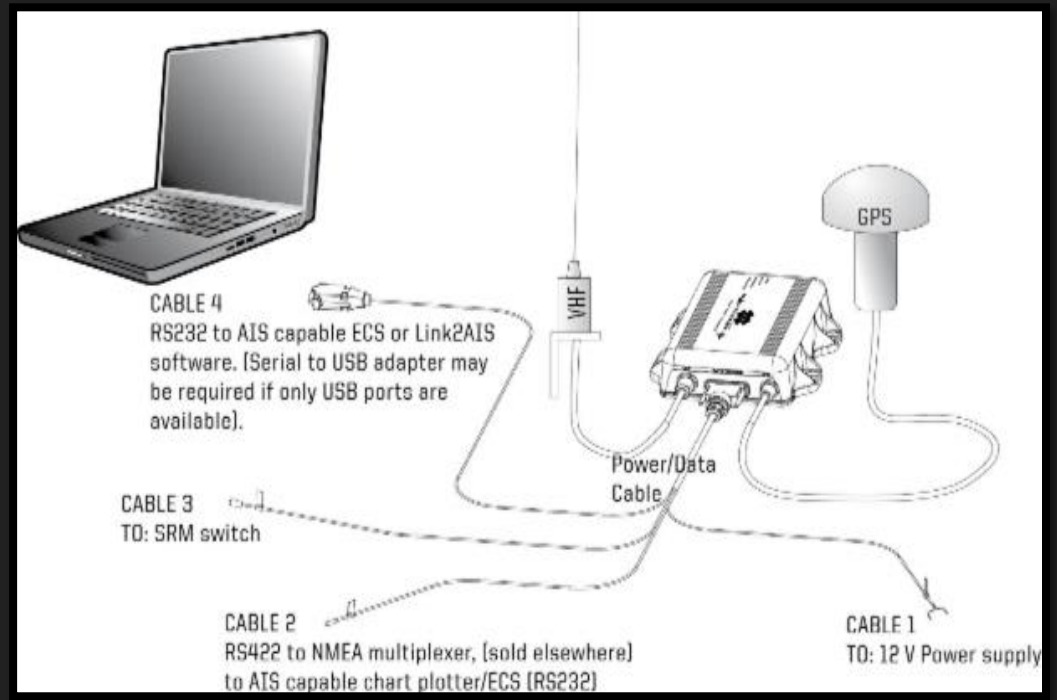
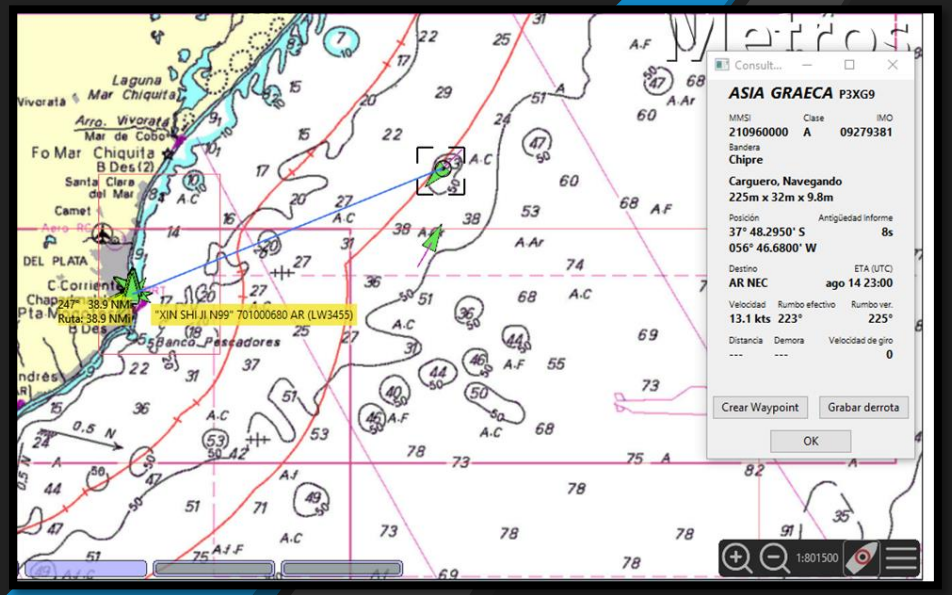
AIS (*Automatic Identification System*)

- Telecommunications technology that combines GPS, VHF to allow the exchange of relevant information between different marine entities.
- Used in: Ships of different sizes, base stations, aids to navigation (AtoNs), search and rescue transponders (SAR).







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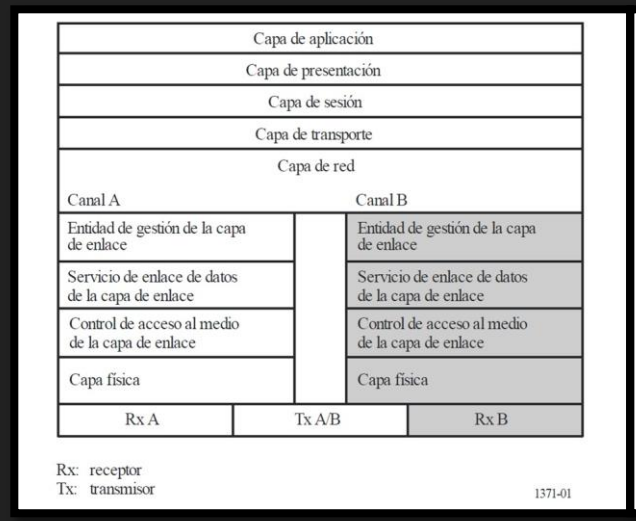
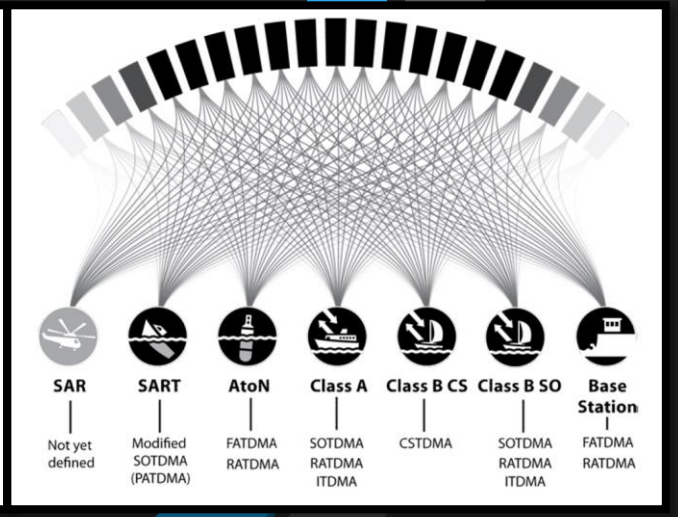
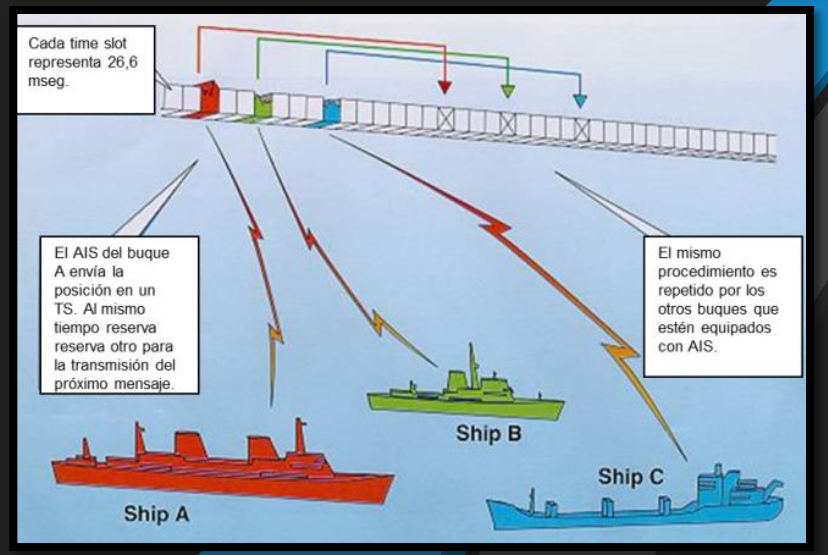
AIS Technical Specifications

- **Physical layer:**
  - Transmission on two VHF channels:
    - **AIS 1: 161,975 MHz**
    - **AIS 2: 162,025 MHz**
  - AB channel: 25 kHz.
  - NRZI coding.
- **Media access layer:** TDMA with 2,250 slots per channel (4,500 reports/min).
- **Link layer**: HDLC (adapted) with CRC-16 checksum.
- **Bitrate:** 9600 bps.
- **Interface:** NMEA-0183.
- **Message types:** 27.







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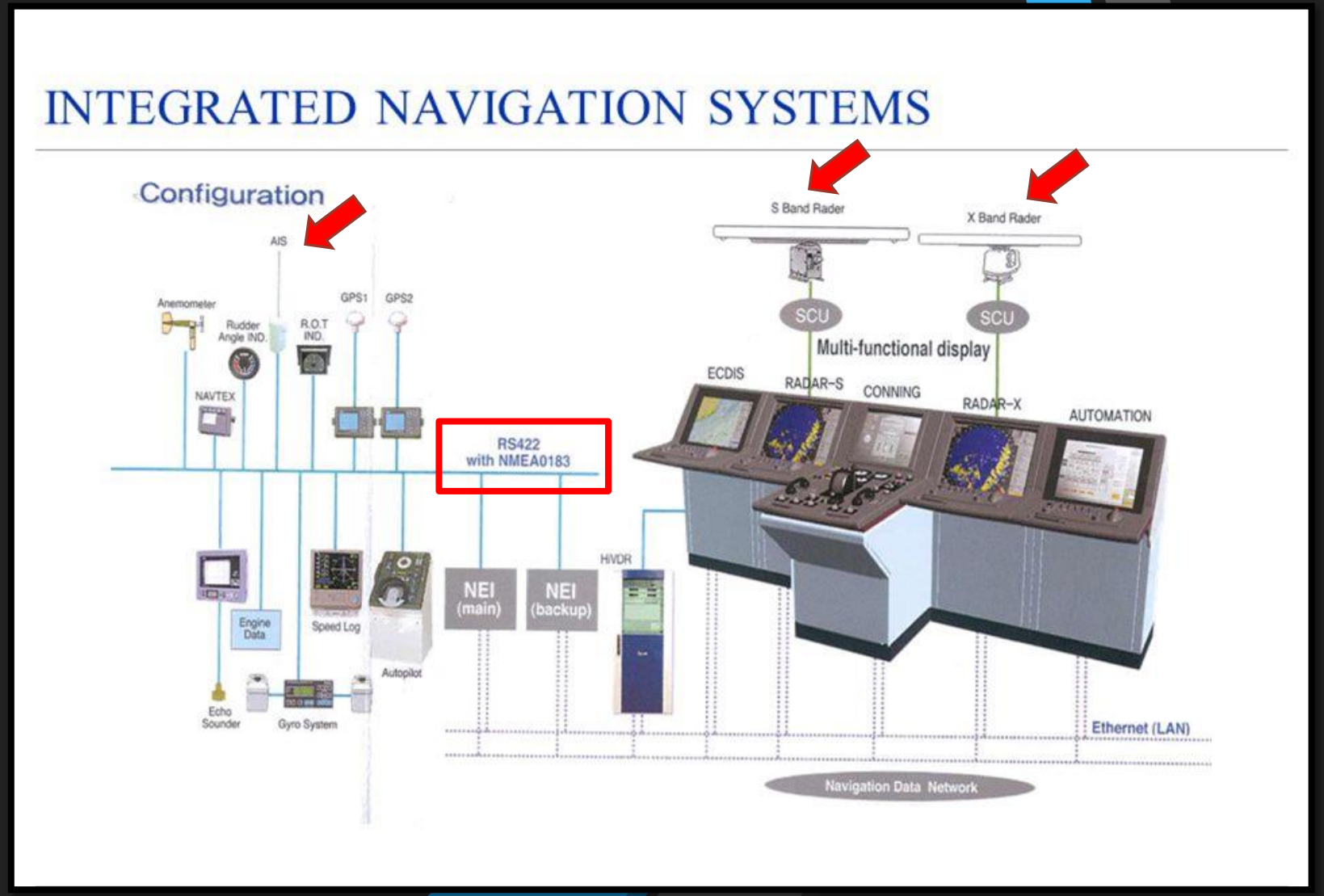
Problem to Solve

- Integrated Navigation Systems.
- Interconnection of **radars** to various sensors and navigation aid systems: GPS, **AIS**, gyro, LOG, etc.



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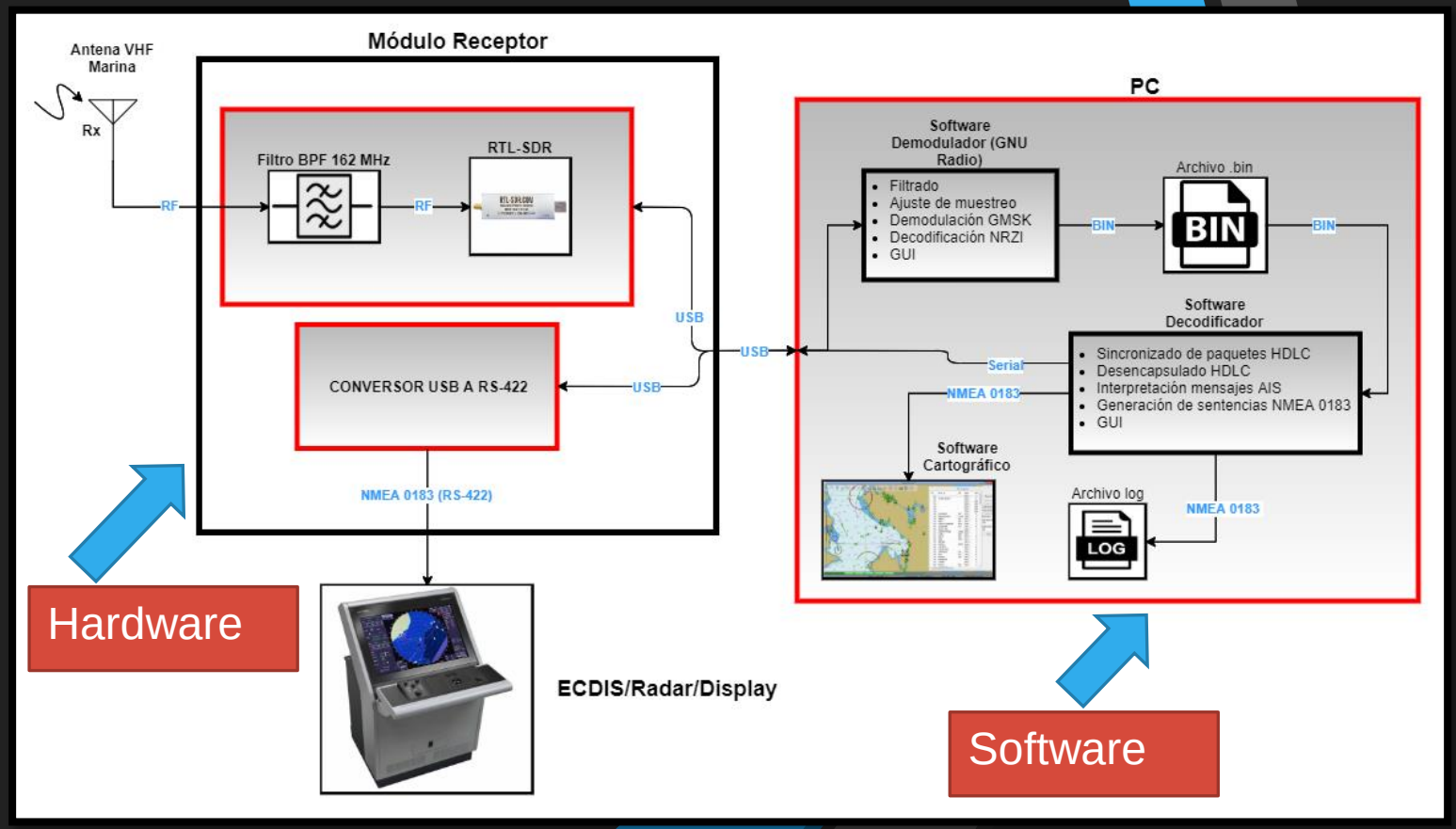
Proposed System: Solution

- **Low cost AIS Receiver System.**
- Based on RTL-SDR (software defined radio) receiver.
- Use of free and open source software.
- Easy-to-install hardware and graphical user interface (GUI) software for system control and monitoring.
- Representation of AIS contacts on PC and on radar/ECDIS/Multifunction display, etc.



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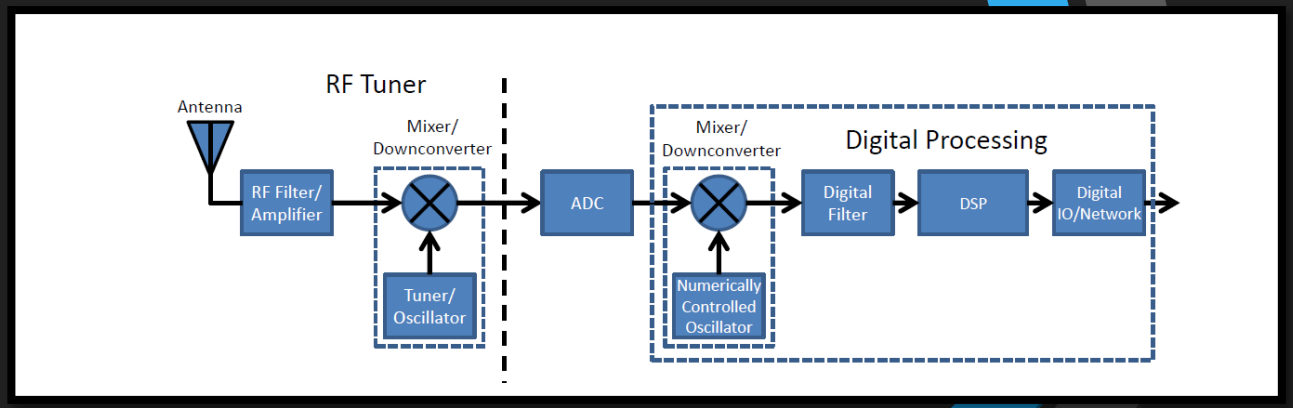
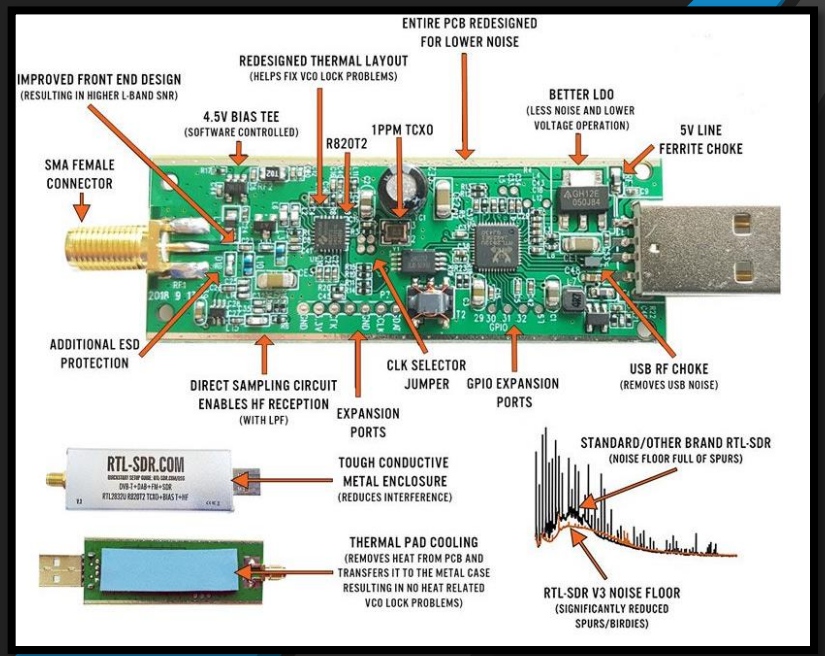
Receiver Module: RTL-SDR

- **Software Define Radio:** Transmission system with all/some of the physical layer functions implemented in software.
- Versatility: With the same hardware, different receivers can be built just by modifying the system software.
- **RTL-SDR:** cheap SDR receiver based on RTL2832U chipset and R820T2 tuner.
- Specifications:
  - Maximun simple rate: 3.2 Msps
  - Tunning bandwidth: 24 – 1766 MHz
  - ADC resolution: 8 bits
  - Channel bandwidth: 2.5 MHz (stable)
  - Maximun noise figure: 4.5 dB
  - Maximun input power: +10 dBm





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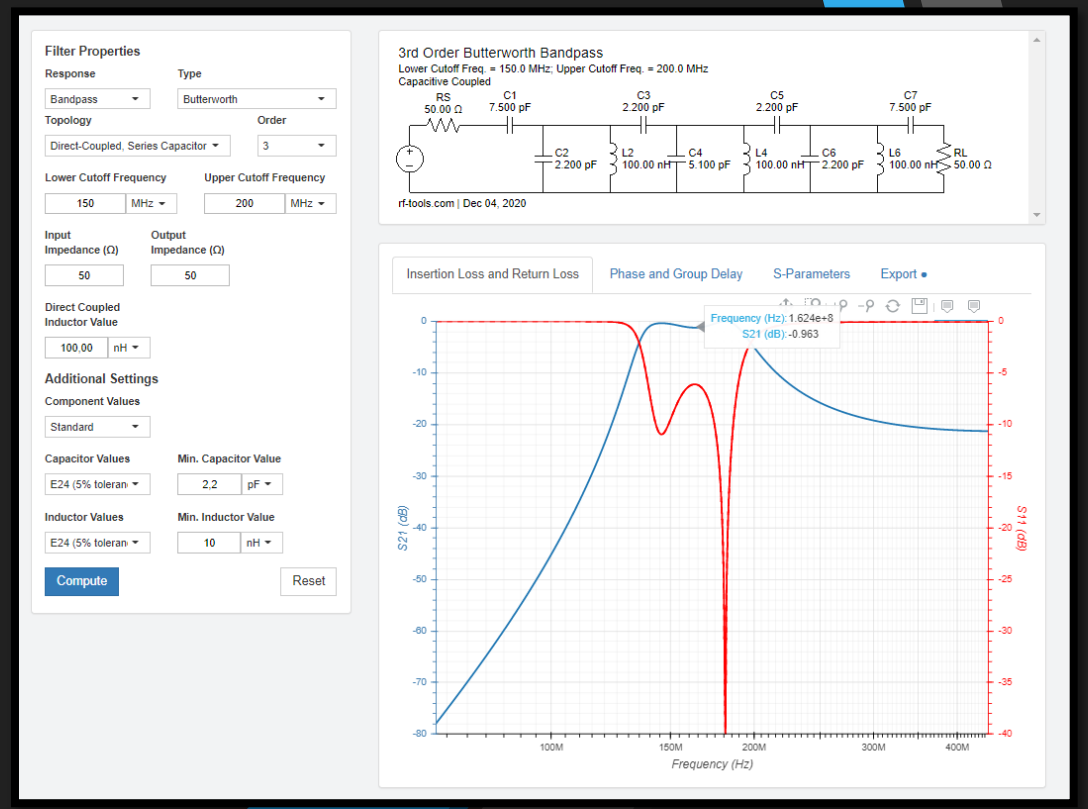
Receiver Module: *Front-End RF Filter*

- **Purpose:**
  - Reduce power spectral density due to the large reception AB range.
  - Attenuate signal power to the sides of the band of interest (162 MHz).
  - Reduce noise floor level.
- **Specifications:**
  - Passive band-pass filter based on a 3rd order Butterworth template.
  - Design center frequency: 162 MHz
  - Bandwidth: 50 MHz.
  - Protection against atmospheric discharges: anti-parallel diodes and gas discharge tube (proposed).
- Adaptation of design values to comercial values of components



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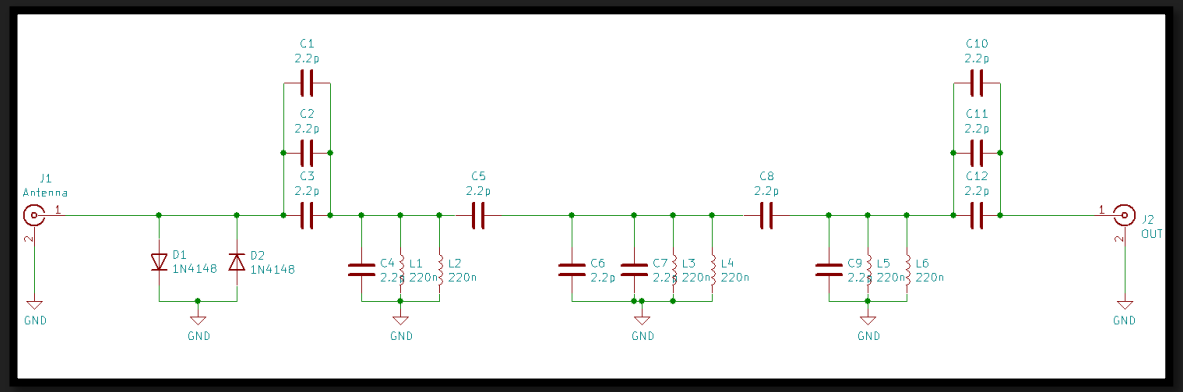
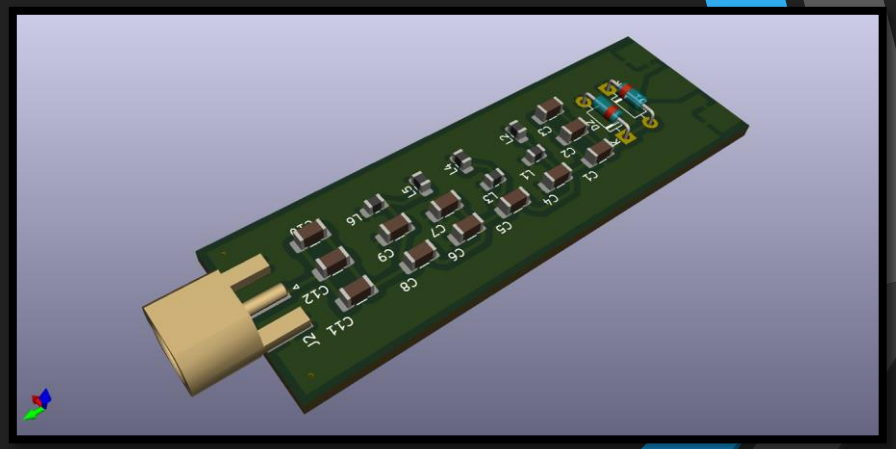
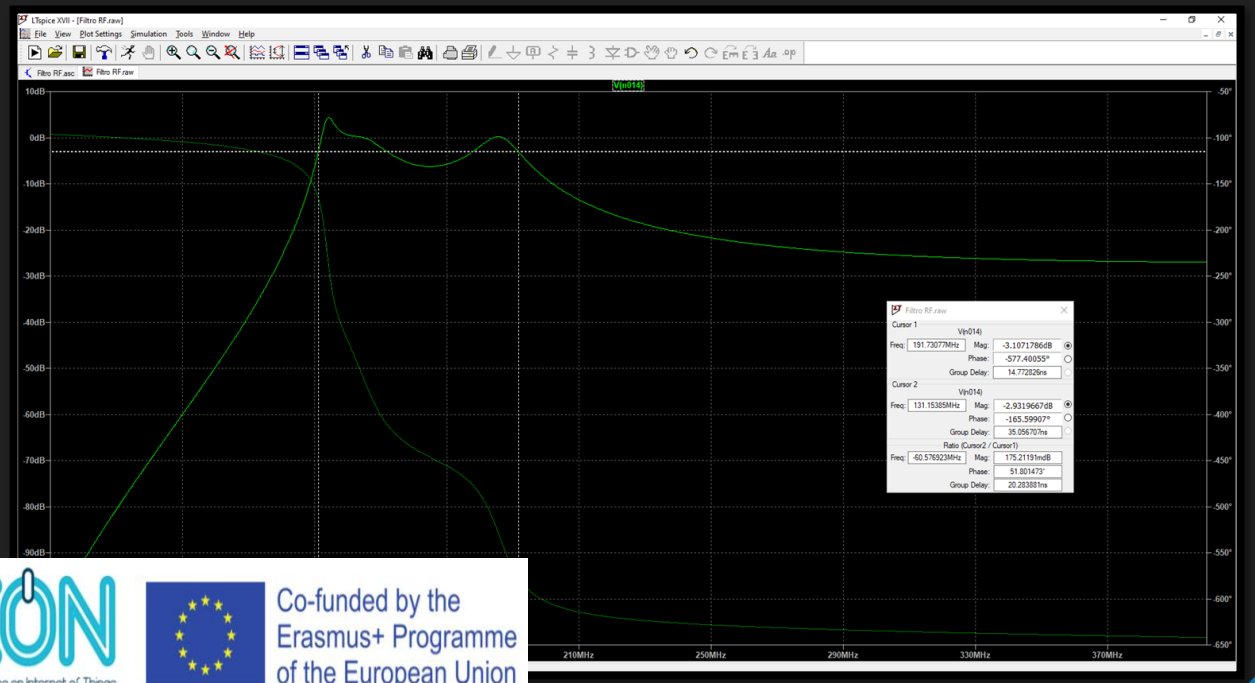
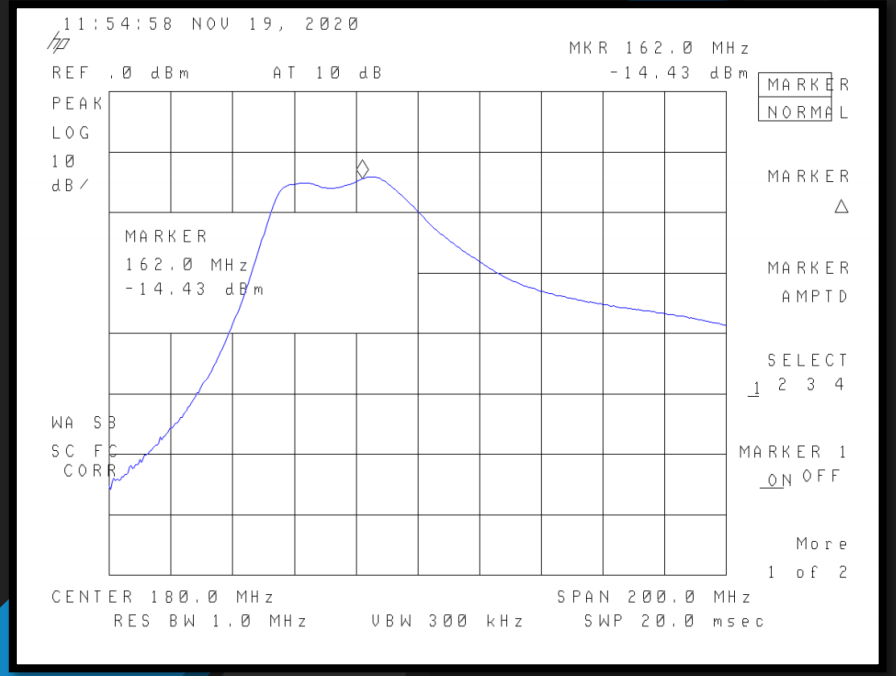
Simulation, Construction and Real Performance









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Receiver Module: USB to RS422 Converter

- **Purpose:**
  - Convert to the serial digital communication standard used in marine electronics devices.
  - View contacts generated by the receiving system in a system with the ability to plot AIS targets (eg: Radar, ECDIS, multifunction display, etc).

- **Specifications:**
  - Based on CH340G USB-UART converter.
  - Communication bus isolation using 6N135 optocoupler.
  - Galvanic isolation of power supply in RS422 driver by means of DC/DC converter isolator module B0505s.

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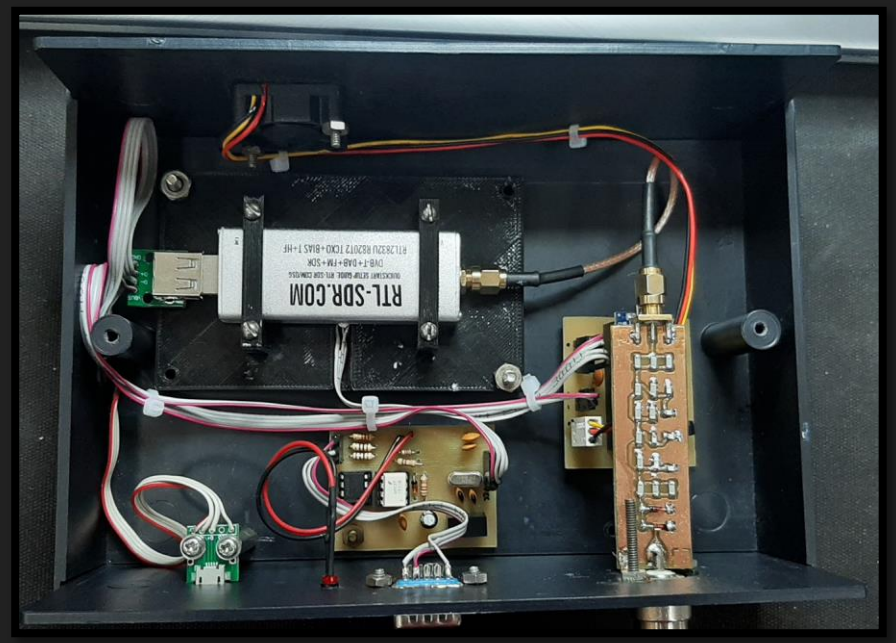
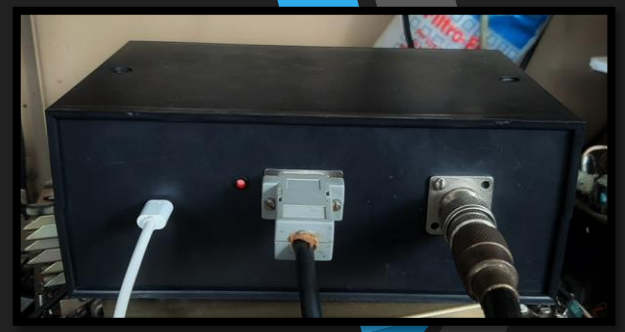
Cabinet Construction and Hardware Final Assembly

- **Purpose:**
  - Unification and organization of modules.
  - Improve portability and user experience.
- **Specifications:**
  - Integration of the converter module to the receiver cabinet.
  - 3D printed support (PLA) for RTL-SDR.
  - Unification of USB ports and fan power through HUB (HS8836A).
  - "N" type RF connector for VHF antenna.
  - DB9 connector for RS-422 interface.
  - Fan with temperature control.
  - Led Indicator of power on/data transmission.





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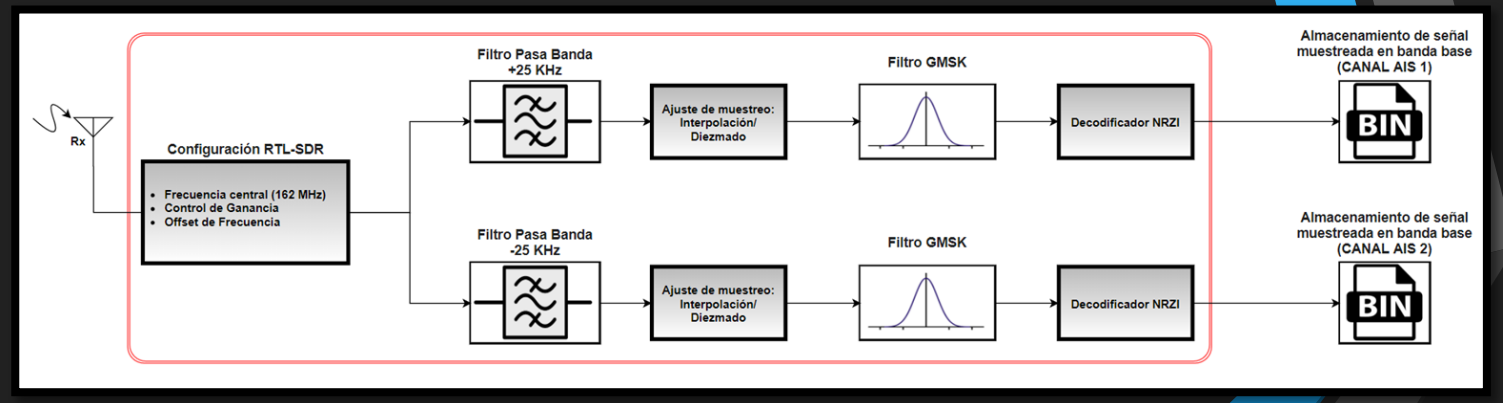
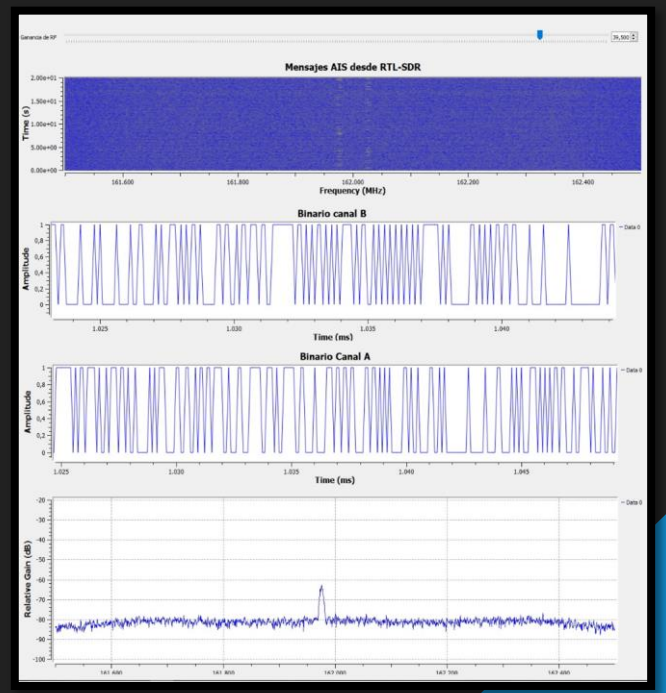
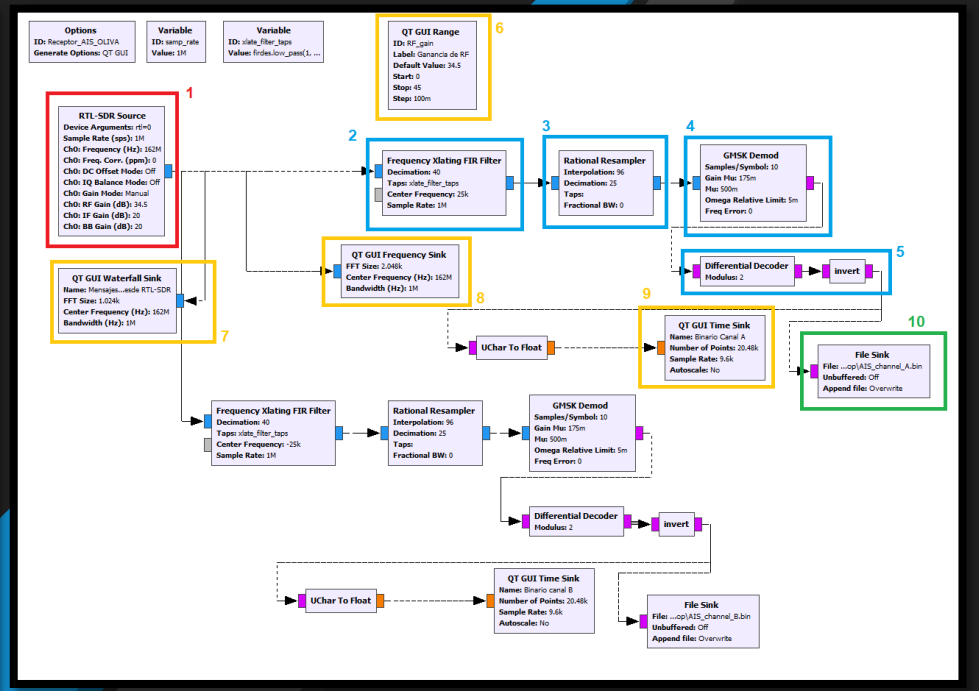
Software Package: Demodulator Software

- Configuration of RTL-SDR parameters for AIS reception on both channels.
- Programmed on GNU Radio platform.
- Sampling rate setting.
- GMSK filter and NRZI decoding.
- Binary stream stored in .bin files.
- Graphic interface: FFT input, bit output, gain control for performance tuning..







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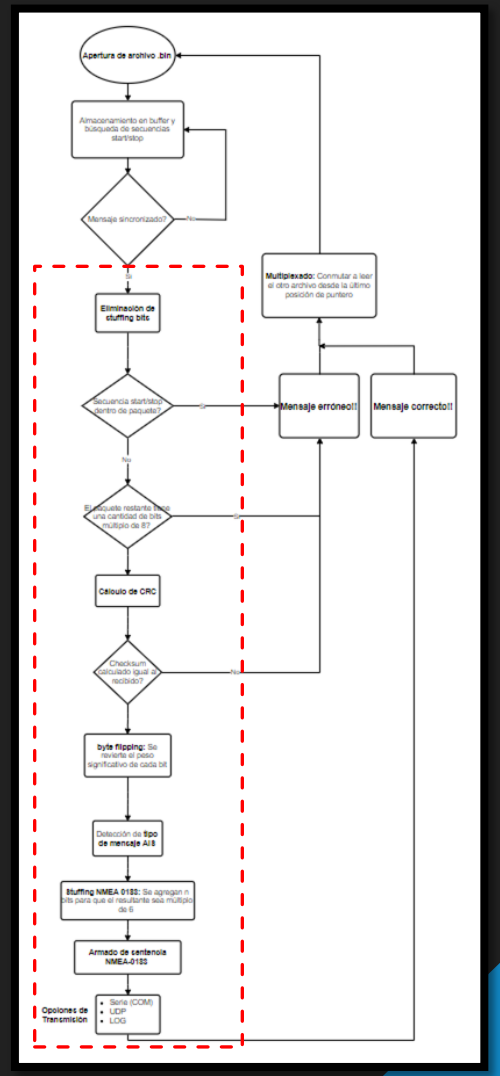
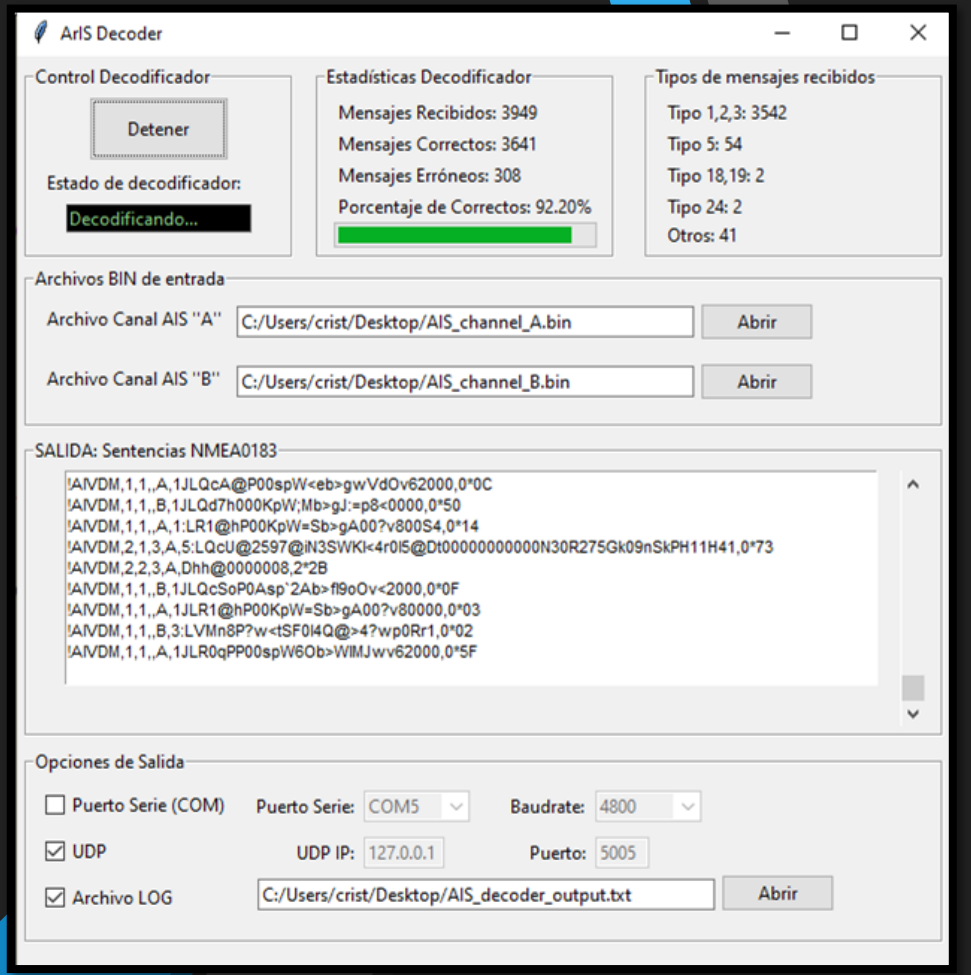
Software Package: Decoder Software

- Access .bin files in real time.
- Synchronization and decapsulation of HDLC packets.
- Channel multiplexing without message loss.
- Error detection.
- Assembly of NMEA-0183 sentences.
- Transmission of sentences by various means: Serial, local host UDP, remote UDP, log file.
- Graphical User Interface (GUI).
- Automatic execution of demodulator software via batch file.





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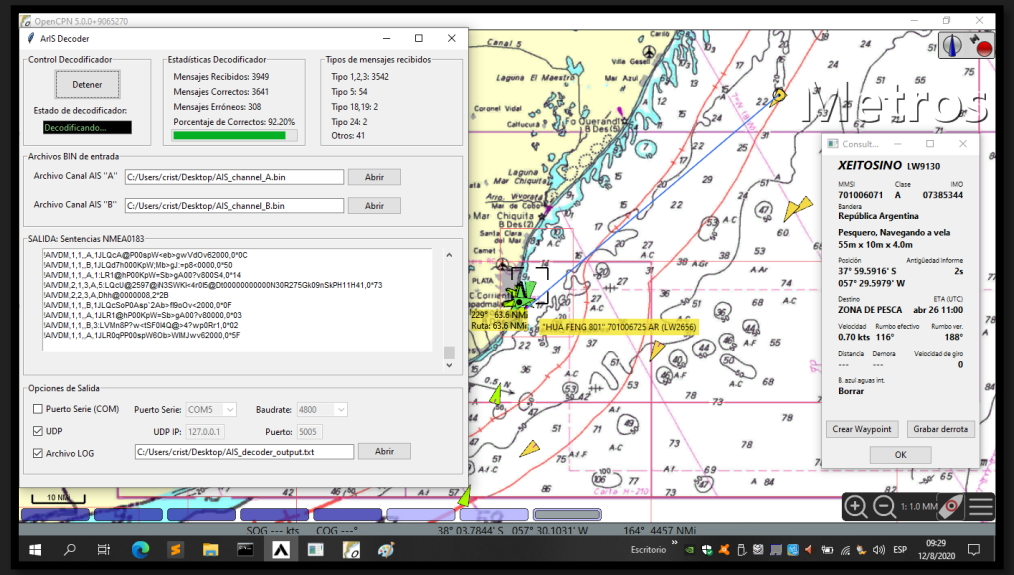
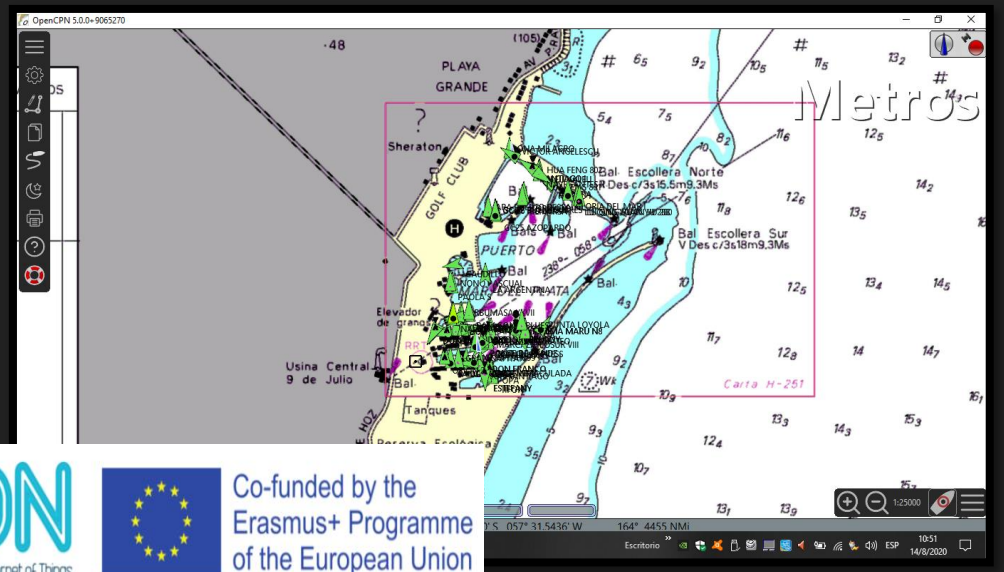
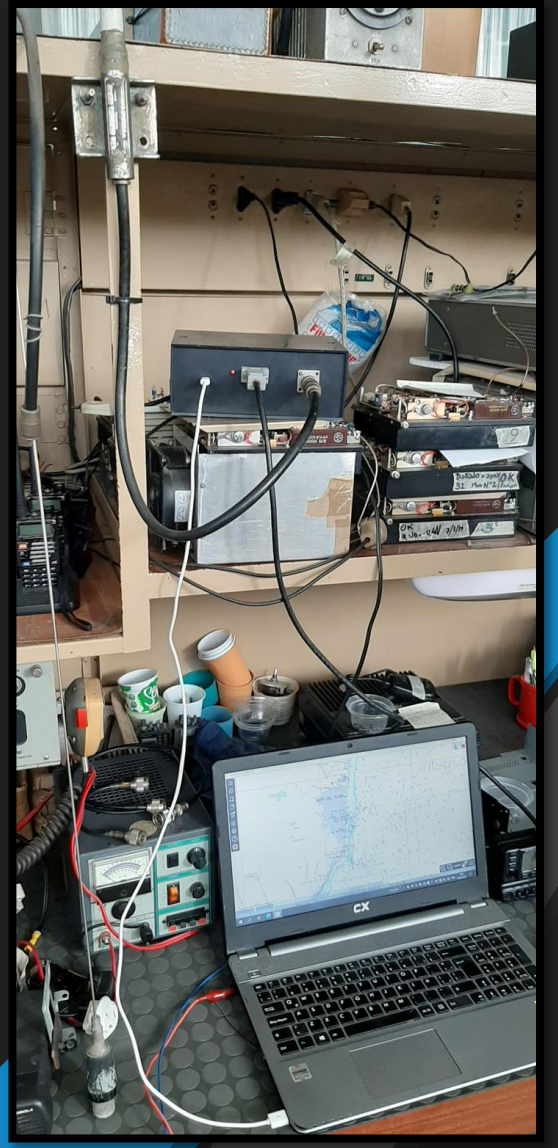
Lab Tests







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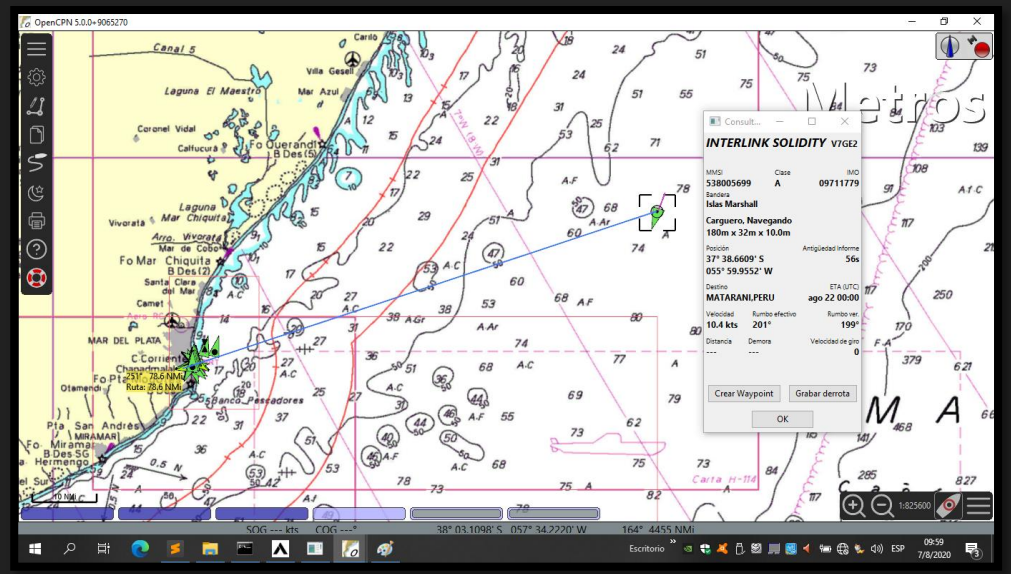

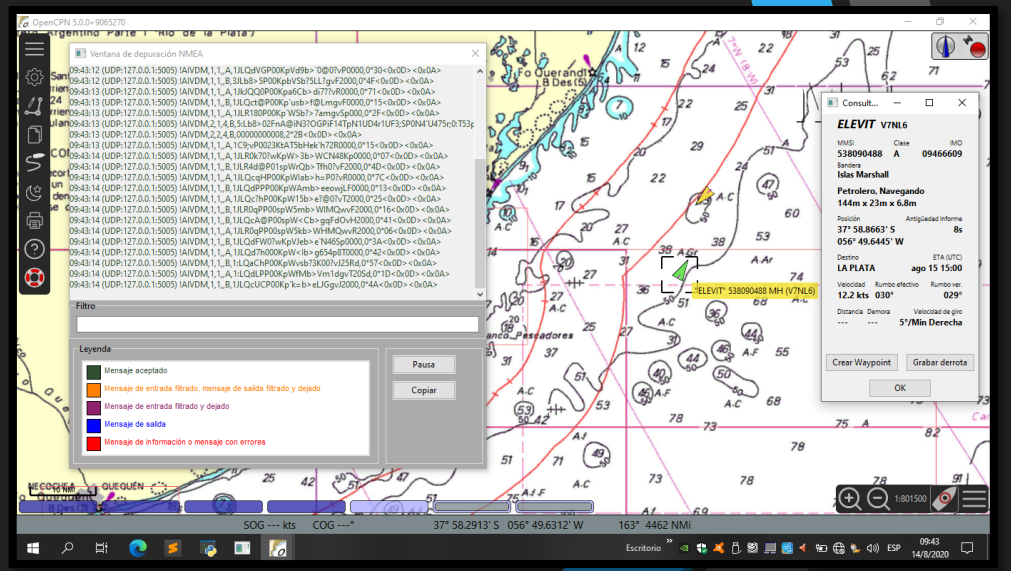

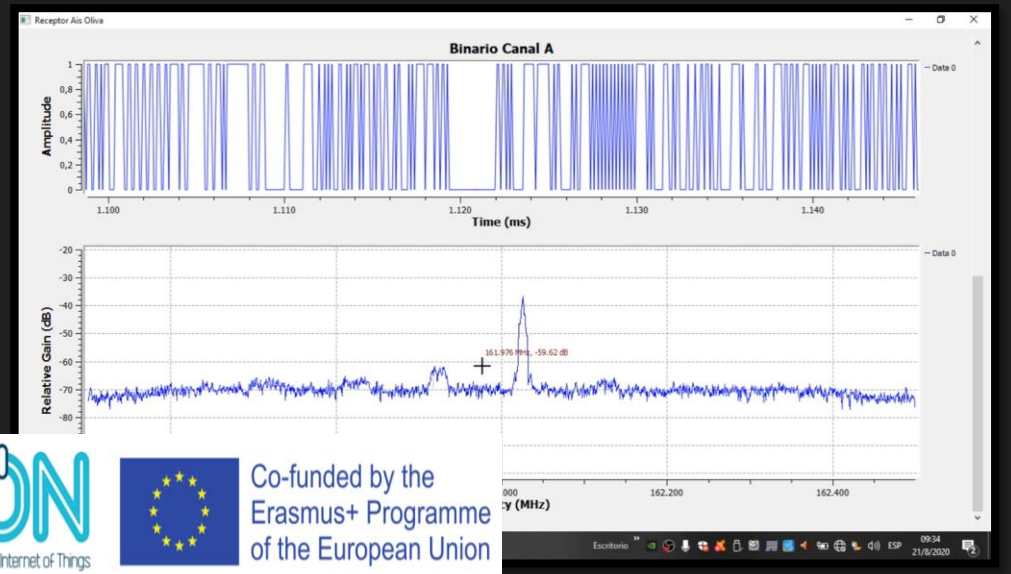

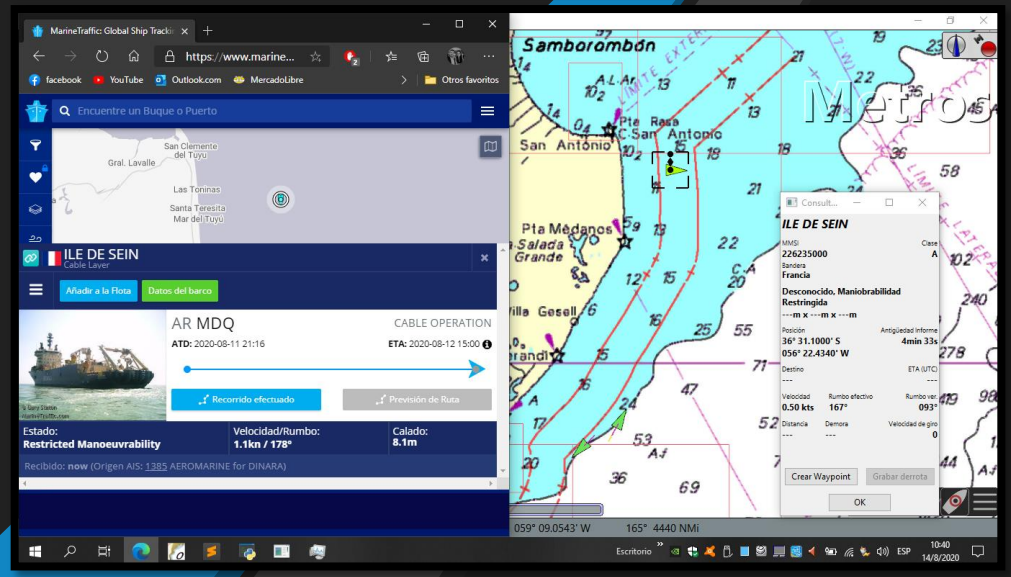

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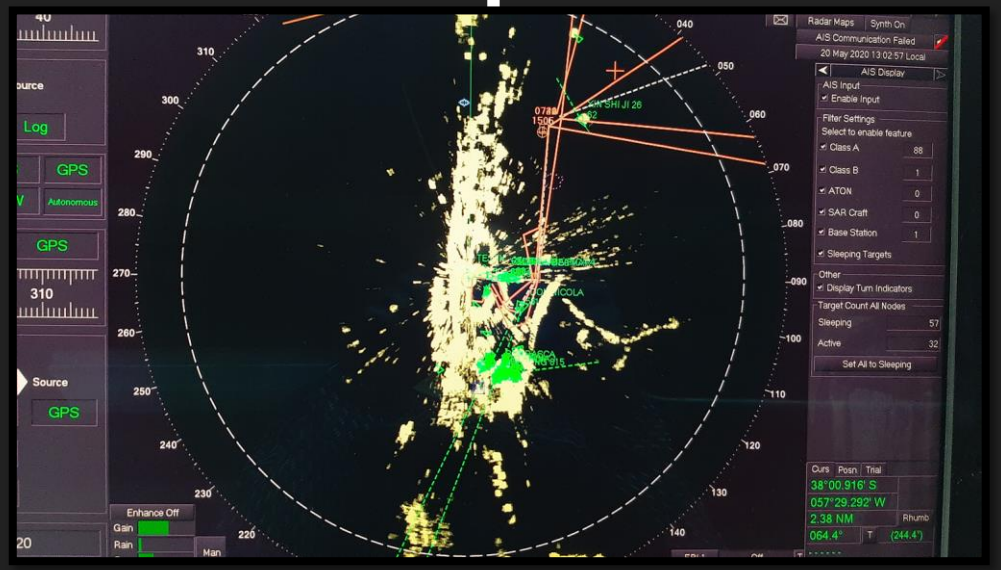
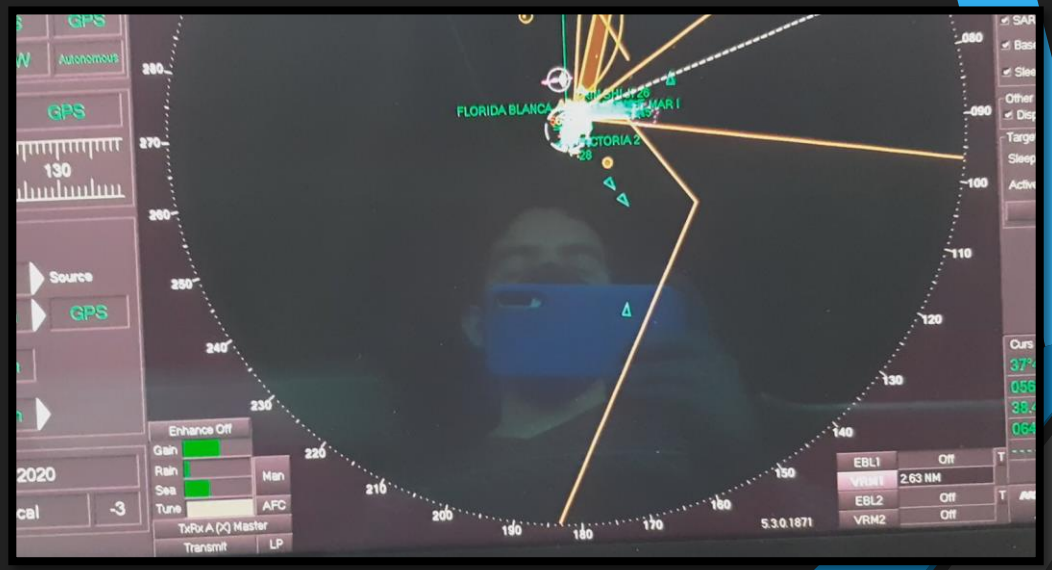
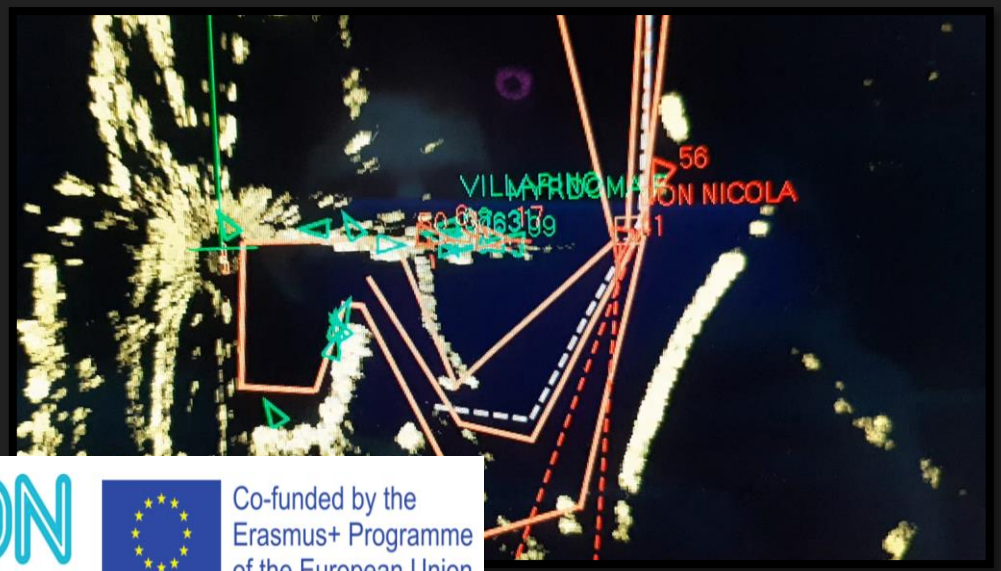
Tests on operational enviroment







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Conclusions and Future Work

- **Conclusions**
  - Prototype of correct functional performance and low cost.
  - Demonstration of the potential of free software and software-defined radio.
  - Project scalable and improveable in the future.
  - Optimal results taking into account the limitations produced by the pandemic.
  - Tests with good results both in the laboratory and on board.
- **Future work**
  - Replacement of PC by a portable system (microcontroller, Raspberry Pi, etc).
  - Prototype with marketing standards.
  - Improved filter and incorporation of LNA.
  - Software debugging and integration.
  - Transceiver system development.

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End of the presentation

Thanks for listening!

Questions?

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