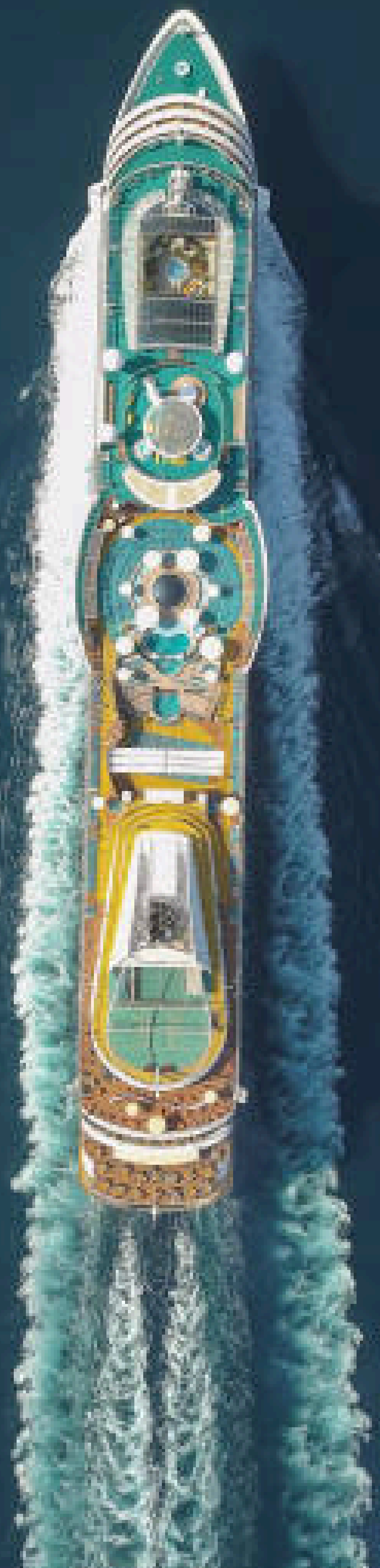
R30.1 : IMPLEMENT A TRANSMISSION SYSTEM

Interception and exploitation of AIS signals



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Summary

Glossary :

AIS (Automatic Identification System) : A global system for the automatic exchange of standardized messages between ships using radio signal transceivers and specific receivers.

VHF (Very High Frequency) : A range of radio frequencies from 30 MHz to 300 MHz, used for maritime communication. AIS frequencies (161.975 MHz and 162.025 MHz) are within this band. VHF communication offers optimal transmission range for exchanges between ships and coastal stations.

NMEA 0183 (**National Marine & Electronics Association)** : Standardized communication protocols that enable different marine devices to exchange data seamlessly.

SDR (Software-Defined Radio): A radio communication system where traditional hardware components (such as mixers, amplifiers, and modulators) are replaced by software, allowing flexible and programmable signal processing.

Introduction :

In our time marine traffic experienced an increase of 325% since 1970. Due to that it was important to determine standards and rules to decrease the risk of accidents on the sea.

To solve that problem public AIS signals are emitted by ships and help in many ways other sailors. An AIS signal provides real-time data on a vessel's identity, position, speed, course, heading, and other navigational information. All of those informations are standardized by the NMEA 0183 protocol

Since ships data is public (observable on https://www.marinetraffic.com), our project is to receive AIS Signals Furthermore, Seine is located in Paris and we are next to it .

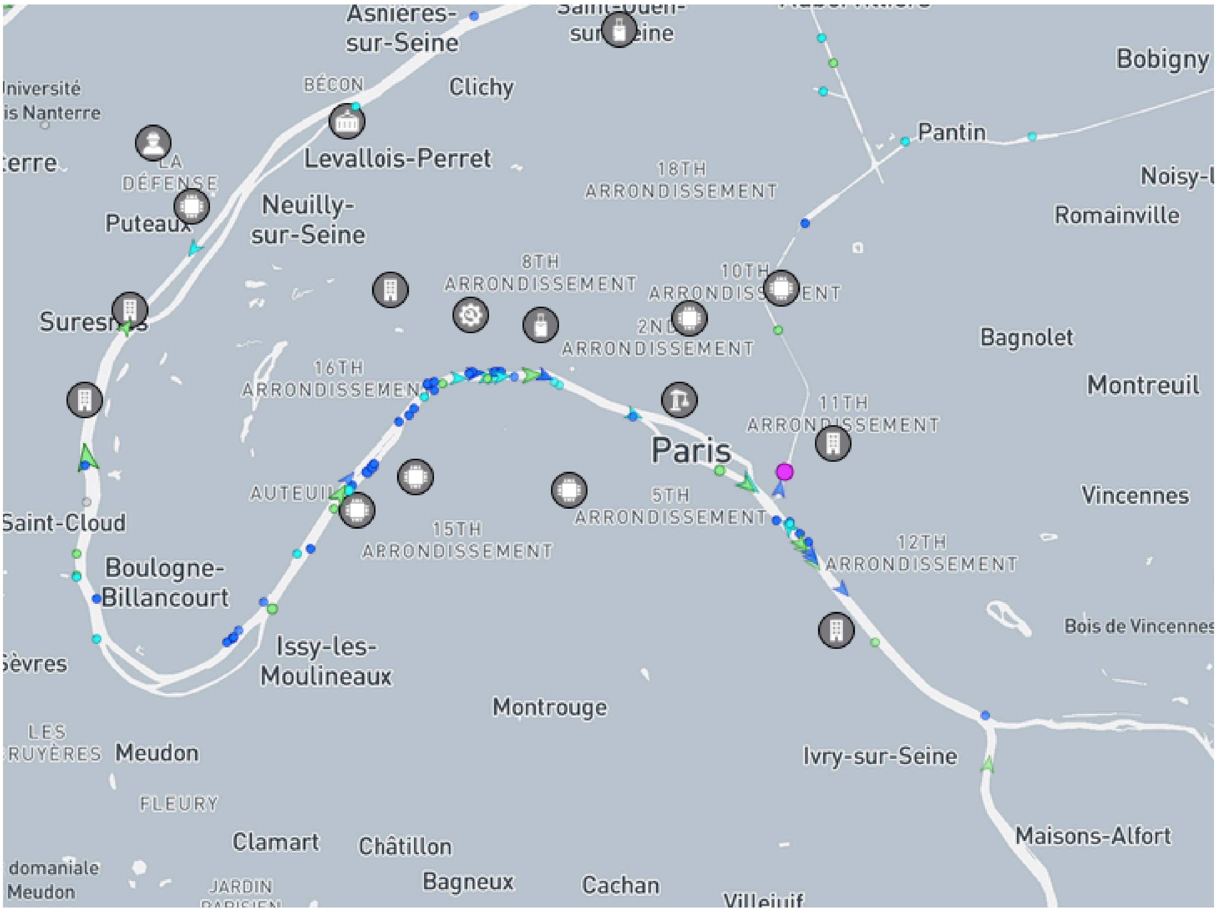


Figure 1: Screenshot of the map available on marine traffic

Equipement :

ADALM-PLUTO: SDR receiver and transmitter allowing the reception, transmission, and processing of radio signals from 70 MHz to 6 GHz (Our SDR has been specially unlocked).

GNU Radio: Open-source framework for designing, simulating, and running radio signal processing chains.

Research process :

While searching for solutions we manage to learned that :

- AIS SIGNALS are following NMEA 0183 standards
- AIS signals are VHF signals transmitted on 161.975 MHz and 162.025 MHz
- AIS signals use GMSK modulation at 9,600 baud, with 168 or 440-bit packets, and a 24-bit preamble. The frames are HDLC type, encoded in NRZI, and last only 30 ms. The connection to the computer is typically via serial communication (USB or traditional),

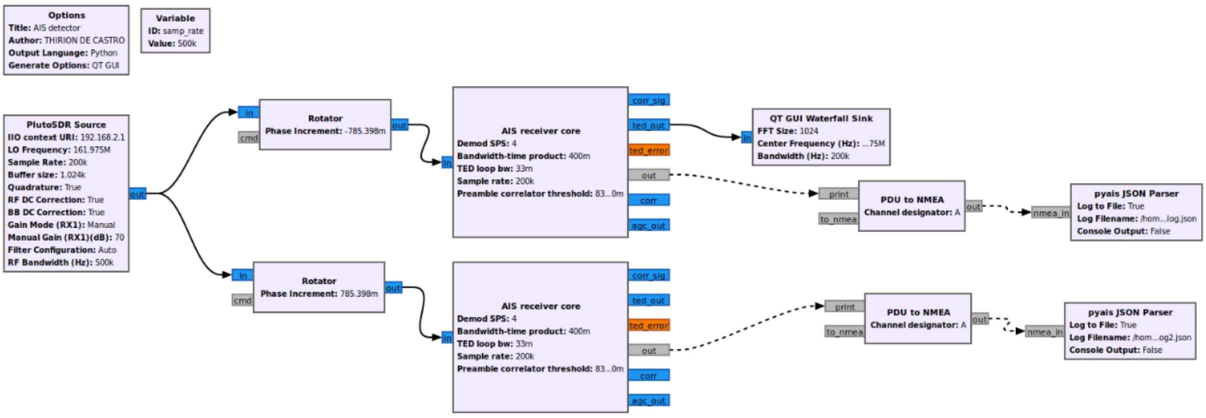
Conception process :

Setting up our model is quite simple: connect the ADALM Pluto to the PC, and then the signal is processed by GNU Radio.

But major issues come with that software indeed during our tests they were overflow flow problems and signal demodulation wasn't great. We managed to get Bytes but it disrespects NMEA 0183 format.

To help us we open ourselves to the GNU Radio community and we found out that it was necessary to install AIS blocks (https://github.com/bkerler/gr-ais/tree/maint-3.10)

At the end we got that Flowgraph :



PlutoSDR Source: Captures AIS signals at 161.975 MHz or 162.025 MHz with flexible frequency and gain settings.

Rotator (Frequency Correction): Compensates for signal drift to ensure proper frequency synchronization.

AIS Receiver Core: Demodulates AIS signals, corrects errors, and extracts NMEA messages.

QT GUI Waterfall Sink: Visualizes the signal spectrum in real-time for quality monitoring.

PDU to NMEA: Converts AIS packets into NMEA-readable frames.

PyAIS JSON Parser: Extracts AIS data and stores it as JSON files for analysis or web interfaces.

At the end we manage to get those messages :

- !AIVDM,1,1,,A,BDLA5?8JUTcd,053
- !AIVDM,1,1,,A,Cr@ji53OHgnFTQH:8k,23C

We believe that those messages are incomplete and we still miss a few pieces of them but the fact is that we managed to receive AIS messages.

Conclusion

This project demonstrates the successful reception and processing of AIS signals using the ADALM-PLUTO SDR and GNU Radio framework. However, we encountered challenges with signal demodulation, resulting in incomplete AIS messages. These issues could be resolved with a better antenna for improved signal quality. Despite these limitations, the project holds significant potential for further development.

With enhanced hardware and fine-tuning of the processing chain, the system could evolve into a real-time radar solution for maritime traffic monitoring, which could be commercialized. The ability to track and analyze AIS data in real-time opens up opportunities for various applications in maritime safety and navigation.