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Demonstrative Method Between Theoretical Concepts and Their Application to the Real Environment: Internal Communications

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ABSTRACT: This paper provides a demonstrative method between theoretical and practical concept for understanding NMEA lines. This research arises from a teaching innovation project called "NMEA Protocol: from theory to practice in internal communications" whose objective is to analyze and give visibility to radio engineering students, in a practical, simple and real way, complex concepts present in internal communications on board. These allow the transmission; reception and processing of information shared by the radio and navigation teams of a wheelhouse. The challenge will be met using easily accessible electronic devices both for their low cost and for their availability on the market. The results indicate that it is possible to demonstrate to the student complex theoretical concepts explained in class, in part has aroused the interest of them to innovate and experiment on their own and in a particular way, making them partners of their own formation.

1 INTRODUCTION

Throughout the history of humanity, technology has played an essential role in the development of society, since largely progress is based on the invention of procedures that solve more or less complex problems for their practical implementation to everyday reality. The speed is such with that presently there arise new skills or technologies that sometimes it is to us difficult to assimilate that the most daily processes of our life and work work thanks to others much more complex that they are not visible to simple sight.

The sector concerned, the maritime sector, in recent years has seen how many of its electronic navigation and communications equipment have gone from working as independent units to doing it together, that is, to send their own information to some and to receive from others, so that all share useful data by improving the electronic navigation and communications system.

This innovation project aims to make visible to the radio-engineering learner the internal communications that take place in a continuous way on a wheelhouse between the different equipment using electronic devices that are easily accessible both for their low cost and for their availability on the market. In this way, in addition to demonstrating to the student complex theoretical concepts explained in class, it is intended to arouse the interest of the students to innovate and experiment on their own and in a particular way, making them partners of their own formation.

There is a practice of receiving the 87B and 88B channels [9] of the Maritime Mobile Service VHF band that have been assigned to the automatic identification system or AIS[7], to subsequently extract the information contained therein in NMEA[13,14,14] format and its subsequent use in a ECDIS[6] or information and visualization of ENC. In addition, the same practice allows the creation of "false" information that the same ECDIS system will represent without detecting its origin or truthfulness.

During the presentation of the practice, it is desirable to include certain technical explanations about the devices used in it and even about others that may be employed for the same purpose, since it is possible to achieve the same result with some flexibility as will be seen later.

2 STANDARD NMEA0183

In order to understand the information shared by equipment such as GPS, AIS, ECDIS, etc. in a more or less unknown way, it is necessary to know the standard NMEA 0183. So it is recommended to read the standard IEC 61162-1[20] and IEC 61162-2[21] where the electrical characteristics are specified, type of wiring, connection, and composition of statements that each computer is able to share.

Obtaining the valid information intended to be shared will be obtained in practice by using a transceiver VHF marine that has been intentionally removed from the amplifier or final power step, thus avoiding the possibility of accidentally disturbing the radio spectrum since we are very close to the coast and a maritime traffic control center. This proximity will allow you to receive AIS information on time.

The information we will extract from the VHF marine will be in the form of an audio signal, as we will use a disused VHF receiver designed for radiotelephony and not for receiving digital data. However, knowing the operation of this equipment it is possible to adapt it for our practice in a more or less simple way.

Once the audio signal is obtained, it is necessary to extract the digital information contained in it by using Shareware or Freeware software and a personal computer. The information the software will provide will now be in NMEA sentence form and will contain:

- Static data (name, caller sign, MMSI [8], etc.),
- Dynamics (position, speed, course, navigation status, etc.),
- And those relating to the voyage (length, sleeve, draught, port of destination, etc.) of the ship that transmitted them,
- Of the information of stations based on land and of the digital aids to navigation or AtoN, etc.

All the information obtained in real time is now possible to represent it on a navigation software or ENC, thus providing a panoramic view of the ships around us. At this point, it is important to understand that what is represented comes from radio signals over which we have not had any control, that is, what has been received has been interpreted and therefore if the information received has been misrepresented at source the system will not detect it and give it as valid.

The practice thus proposed would work perfectly as a basic demonstrator of an ECDIS system, but the main objective proposed is to share digital signal frames in NMEA format to all navigation equipment requiring it on a wheelhouse.

To be able to share internally all the information previously received in the form of NMEA sentences, USB converters to RS422 or RS485[16] will be used, allowing several computers to access the same information, that is, to have access to an internal communication system that is beyond the reach and manipulation of the equipment operator. The purpose of using converters is to show radio-engineering students the way digital information is shared on a wheelhouse.

3 MATERIALS USED IN PRACTICE

3.1 *Skanti radiotelephone VHF3000*

For reception in the channels 87B and 88B in VHF assigned to the AIS system we will use a model Skanti transceiver VHF3000, capable of receiving in the channels of maritime communications assigned to the maritime mobile service. It should be said that the Ministry of Transport and Sustainable Mobility no longer approve this equipment for installation on board, but for our purpose, it is perfectly valid.

Figure 1. Skanti radiotelephone VHF3000

Knowing the basic design of this type of receiver, its block diagram, and having the scheme of the actual equipment, it is possible to locate the exact point where it is feasible to extract the demodulated or detected signal that interests us for practice. As a relatively modern piece of equipment, it makes use of integrated circuits that perform several functions in a single element. In our case and studying the electronic diagram, we can observe that the received radio frequency signal is treated in its entirety in the integrated circuit KA3361 [12], conceived almost as a complete receiver. The datasheet of the KA3361 reports the elements that compose it at the internal level, including oscillator, mixer, FI amplifier, square discriminator and filter, that is, it is the soul of the receiver and therefore the signal that we are interested in can be found in the number 9 of the said integrated circuit. This pin is called "Recovered audio" as we can see in its datasheet.

Knowing also that our marine transceiver has been designed to detect the modes of emission [9] F3E and/or G3E. Moreover, that the modulation employed by AIS transceivers in a variant thereof. It is perfectly feasible to conclude that the information included in the frequencies received will be present in the audio signal obtained from track 9 of the circuit KA3361.

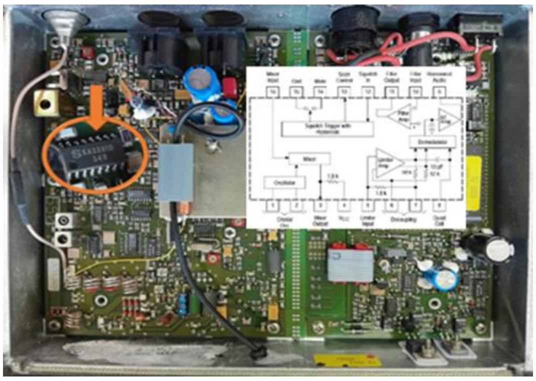


Figure 2 Pinout KA3361

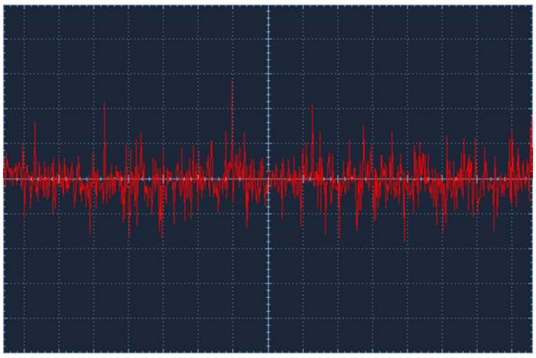


Figure 3. Signal present on pin 9 of KA3361

3.2 *Software Shareware ShipPlotter*

To be able to extract the information we need from the transmissions received in real time it is necessary to use some software capable of analyzing the audio signal previously obtained and transform its frequency variations into "0" and "1" logical.

Figure 4. Software shareware ShipPlotter

We have opted for the testing software ShipPlotter [5] for this arduous work. The function therefore is to analyze the audio signal that arrives, the detection of the frequency changes present in it, the transformation of these into binary states and the grouping of the "0" and "1" into frames that comply with the NMEA0183 standard. In addition, the program also allows the dissemination of digitized information through different communication ports to other devices.

In our practice, we will opt for a serial port as output for dissemination of the NMEA information obtained as well.

For a better understanding of the information ShipPlotter sends to other devices, it is convenient and advisable to know how AIS information sentences are structured, so reading ITU-R M.1371 [10] is recommended.

3.3 *USB to Serial Converter*

The great versatility of USB ports has led the vast majority of PC manufacturers to choose to include these to the detriment of other traditional ones as RS-232[16] was until a few years ago in its 9-pin and 25-pin versions. For our practice, and because marine electronics mainly employ NMEA 0183 series connections compatible with the RS-422 and RS-485 standard, we will employ a USB converter capable of emulating the 422 and 485 standards. This allows you to send previously obtained information sentences using ShipPlotter software to another PC emulating an ECDIS, as performed on a wheelhouse.

In practice, two USB to SERIAL converters will be used. The model chosen for this end bases on the integrated circuit PL2303[18] capably of turning the digital information of a port USB into digital information compatible with the standard RS-422 extensively used in the marine electronics.

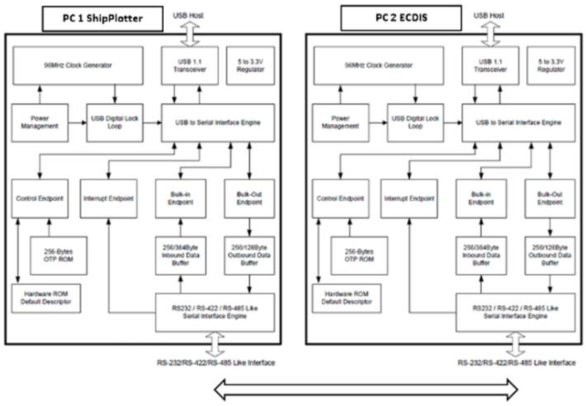


Figure 5. USB to Serial Converter

The device, once installed on the PC, will transform the occupied USB port into another serial port RS-422/485 with differential outputs Tx +, Tx-, Rx + and Rx-

Figure 6. USB converter

The use of two identical converter devices will allow two PCs to be connected as intended by practice, one of which can be understood to act as transmitter or talker and the other as receiver or listener in the same way as marine equipment.

3.4 *Software Shareware OpenCPN*

For representing of visual form, the received and decoded information one will make use of the free software OpenCPN [17]. Designed as a navigation planner capable of displaying nautical charts on which the information that said software reads through different routes of entry overlaps, whether TCP, UDP GPSD, SIGNAL K or serial network connections as in our case.

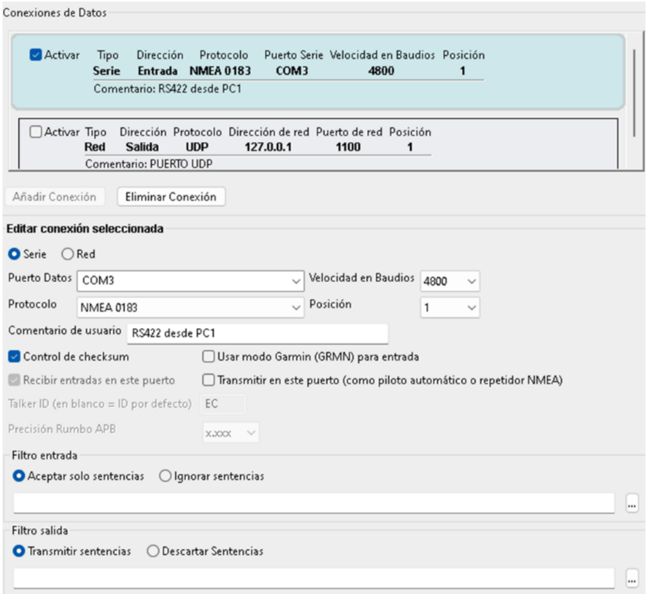


Figure 7. Software shareware OpenCPN

The same software that acts as receiver or listener, allows monitoring the NMEA sentences that reach you through the different serial ports, to represent the information of them on a nautical chart for interpretation by the pilot.

The same NMEA debug window allows the radio-engineering student to observe some of the 26 different types of messages that are transmitted according to the ITU-R M.1371.

For example, an NMEA debug screen has been captured on the listener or PC 2 with OpenCPN installed, where information from the talker computer or PC 1 with ShipPlotter installed is observed.

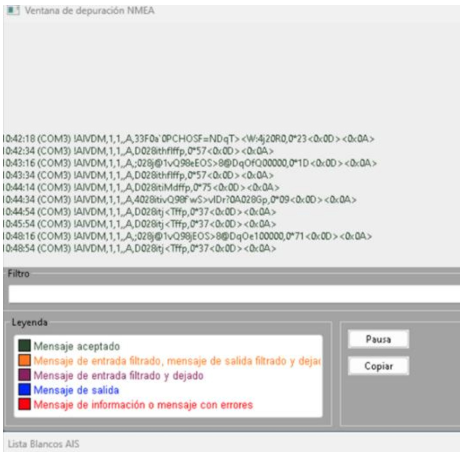
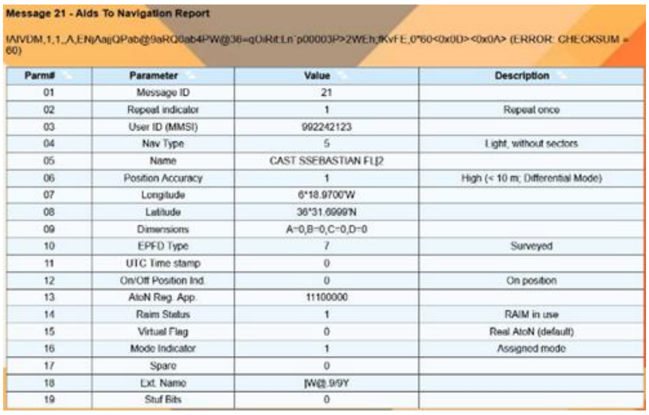


Figure 8. NMEA debug screen

Although it is difficult to read and understand an AIS-type NMEA sentence in plain view. The utility allows the student to copy one of them and extract their information on one of the many free websites that do so, in addition to being able to employ specific software that marine equipment manufacturers provide, as is the case with Actisense NMEA Reader [1]. As an example, we have chosen to copy one of the many sentences received and after decoding it, we observe the different parameters that make it up and that fit the aforementioned ITU-R M.1371.



Message 21 - Aids To Navigation Report

!AIVDM,1,1,,A,ENjAajjQPab@9aRQ0ab4PW@36=qOiRiLn'p00003P>2WEh;fKvFE,0*60<0x0D><0x0A> (ERROR: CHECKSUM = 60)

Parm#	Parameter	Value	Description
01	Message ID	21	
02	Repeat indicator	1	Repeat once
03	User ID (MMSI)	992242123	
04	Nav Type	5	Light, without sectors
05	Name	CAST SSEBASTIAN FL[2	
06	Position Accuracy	1	High (< 10 m; Differential Mode)
07	Longitude	6°18.9700'W	
08	Latitude	36°31.6999'N	
09	Dimensions	A=0,B=0,C=0,D=0	
10	EPFD Type	7	Surveyed
11	UTC Time stamp	0	
12	On/Off Position Ind.	0	On position
13	AtoN Reg. App.	11100000	
14	Raim Status	1	RAIM in use
15	Virtual Flag	0	Real AtoN (default)
16	Mode Indicator	1	Assigned mode
17	Spare	0	
18	Ext. Name	]W@.9/9Y	
19	Stuf Bits	0	

Figure 9. NMEA sentence

Reading at a glance, we can know that the sentence corresponds to an AIS type message from an external station (AIVDM). With a total number of 1 single sentences (AIVDM, 1) transmitted to include the information, that the sentences in question is the first of a total of 1 (AIVDM, 1, 1) and finally that was received in the channel AIS A (AIVDM, 1, 1, A). The rest of the data included are much more complicated to read in plain sight, as unlike the usual NMEA sentences that employ ASCII[2] encoding, the ones used in the AIS system employ a 6-bit binary encoding due to the large data content they must include. This is why it is necessary and convenient to use the specific software mentioned above. This particular NMEA plot or sentences corresponds to a programmed position report from the Sailing Aid (AtoN) Castillo de San Sebastian with MMSI 992242123 and placed in the nautical chart at 36º 31.6999 'N and 6º 18.9700' W. etc.

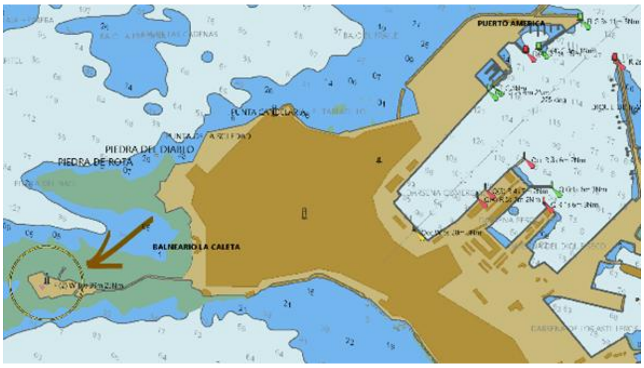


Figure 10. AtoN Castillo de San Sebastian

3.5 *Promax oscilloscope OD-606[19]*

Although it is possible to obtain good results without any electronic instrumentation, it is very convenient to use the oscilloscope to visualize the signals shared by the talker team with the listener. In this way, it is easier for the radio learner to observe in situ;

- The immunity against noise that they have on digital information the use of different connection standards,
- The tensions present in the data lines of each of them,
- The logic they employ etc.

However, always taking into account that in marine electronics differential transmission predominates in relation to NMEA information, which they will deal with in their professional lives if they engage in the world of repairs and maintenance.

In the course of the practice, talker and listener were first connected by parallel cables independent of type 24AWG[4] and the presence of a small interference signal at both high and low levels of the NMEA signal was clearly observed by intentionally turning on and off a second portable VHF marine receiver.

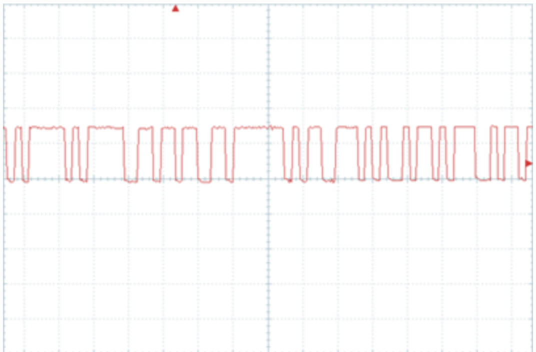


Figure 11. Noise on NMEA signal

Later it was used in the UTP braided cable connection of type IEC11801 [3] consisting of four pairs braided without screen and with a length of approximately 10 m.

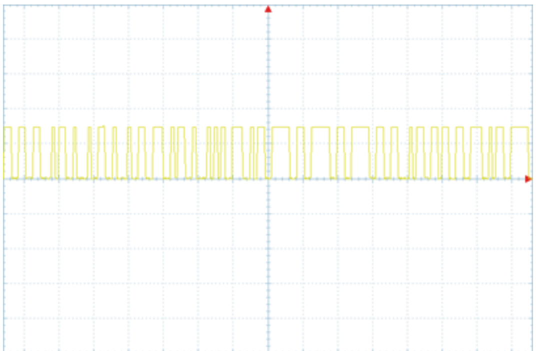


Figure 12. Clear NMEA signal

Only 1 pair was used in the connection, and the same signal could be clearly observed without appreciable interference, even repeating the process of turning the second receiver on and off as in the previous case.

During the development of the practice was also proceeded to visualize the same NMEA information at the output of a port RS232 that is, using another standard. This second observation in the oscilloscope helps to understand the pupil that even existing the same information in a port RS232, this one presents levels of particular tensions of the same one and that they do not have why to be an equivalent to that of other standards used in the marine electronics, comprising the incompatibility between them.

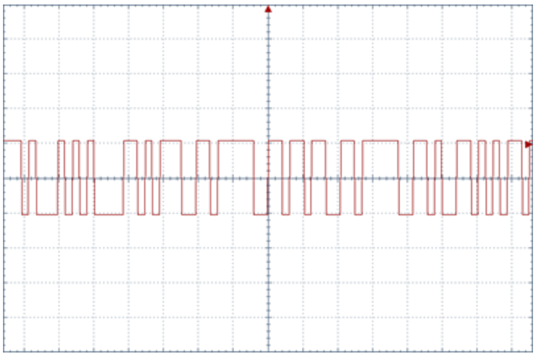


Figure 13. Level signal RS232

This way helps to understanding the concepts, graphs and values explained in classes in a very theoretical way and that sometimes lead to be assimilated by radio engineering students as true acts of faith, when their practical demonstration is simple.

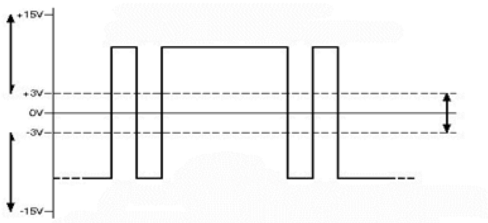


Figure 14. Voltage on RS232

4 ASSEMBLING THE PRACTICE

Transforming one or two personal computers into an ECDIS system, where we can see in real time the fleet that sails near our coast, it is undoubtedly the most eye-catching thing in practice. Although finally the students will be shown that they can obtain the same final result without needing several of the elements used in the laboratory, in order to awaken their interest in self-learning as they can carry it out alone and at home as curiosity.

Figure 15. Assembling the practice

First, in the laboratory we will use a VHF transceiver conditioning for our purpose, two USB converters to RS422 or RS485 and two PCs with the necessary software.

Our adapted VHF receiver will be responsible for capturing signals transmitted from ships, base stations, radio stations etc. and providing them to the first PC in audio form.

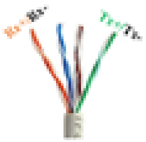
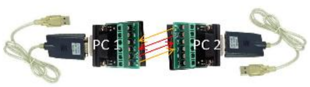
This first PC will act as a talker, once it treats the signal using the software provided for this purpose and converts it to NMEA digital signal, as it will send it abroad using the USB converter to RS422/RS485 configured in transmitter mode.

The second USB converter to RS422/RS485 configured as receiver will be responsible for receiving NMEA information from the first, to feed data to the second PC. This second PC will act as a listener; by using the information, it receives from the talker for a certain use, which in our case is to represent it on a digital nautical chart or ENC as ECDIS.

As soon as we install ShipPlotter software on the first PC along with USB converter drivers to RS422/485 in transmitter mode. We will continue installing OpenCPN on the second PC along with the drivers of the USB to RS422/485 converter in receiver mode. Moreover, will only subtract making the necessary physical connections on the converters and turning on our marine VHF receiver on one of the AIS channels.

The physical connections required are as described below:

Table 1. Physical connections

Data Connection	
USB to RS422/RS485 Transmitter/Talker PC1 DECODER	USB to RS422/RS485 Receptor/Listener PC2 ECDIS
Tx+	Rx+
Tx-	Rx-
Rx+	Tx+
Rx-	Tx-
Related for two-way communication	
	
Audio connection	
TRANSCEPTOR Skanti VHF3000 Dedicated Audio Output	PC1 DECODER Microphone Input
	

At this point only the VHF needs to be turned on in any of the AIS channels (87B or 88B), and the SQL or SQUELCH function can be used to silence the annoying audio of the speaker, since what you will hear will be unpleasant pulses of noise. We will be able to make use of this function thanks to the fact that in the adaptation of the transceiver VHF we take the audio exit straight from the proper integrated circuit detector KA3361. Therefore, it will only affect to the audio of the loudspeaker of the team and not to the dedicated exit that the PC1 uses decoder or talker.

We will connect the dedicated audio output from the transceiver, and to which we weld on its end a Jack 3.5 mono connector, to the microphone input of the PC1 or talker.

We will patiently wait a few seconds. If near our receiver there are AIS transmissions, we will be able to observe how information about the static data appears on the ENC of the PC2 or listener, dynamic and crossing of the ships around us, of the stations based on land and of course of the aids to the navigation.

Here are some interesting screenshots showing the good results of the practice.

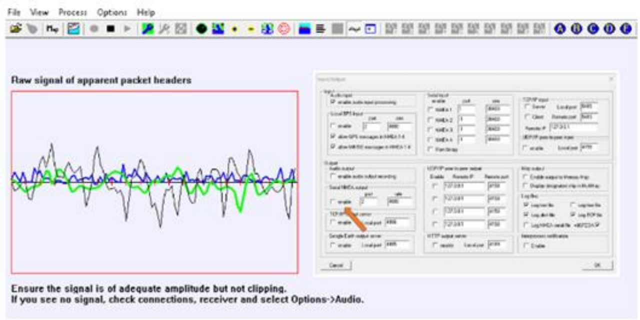


Figure16. Screenshots

We see how the audio signal injected into the talker is analyzed and decoded, transmitting it to listener via port 2 to 4800 baud, but no longer as audio but as signal converted to NMEA protocol.

The talker port 2 in turn connects with the listener port 3 at the same speed of 4800 baud, because if both ports do not work at the same speed they cannot be "understood." The information received by this port is interpreted as incoming information using the protocol NMEA0183 and will be used according to the function programmed in the listener.

We see in the image that OpenCPN also allows using the port as an information repeater to other listener.

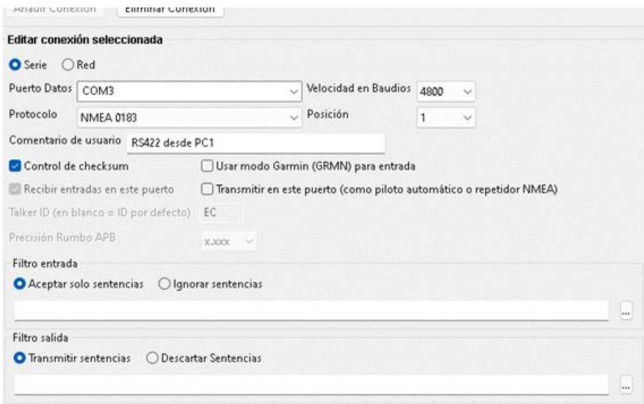


Figure 17. Port configuration on OpenCPN.

The NMEA information that is received (and transmitted) in the listener can be monitored in real time thanks to a debug window. This utility allows extracting certain sentences, or all of them, for further study and understanding and even for archiving in a file that may later be used for other purposes.

Information sentence can be represented in different ways, one of them being a radar screen simulation, but always remembering that it is simulation and not a real radar, because the principle of operation of a real radar is completely different.

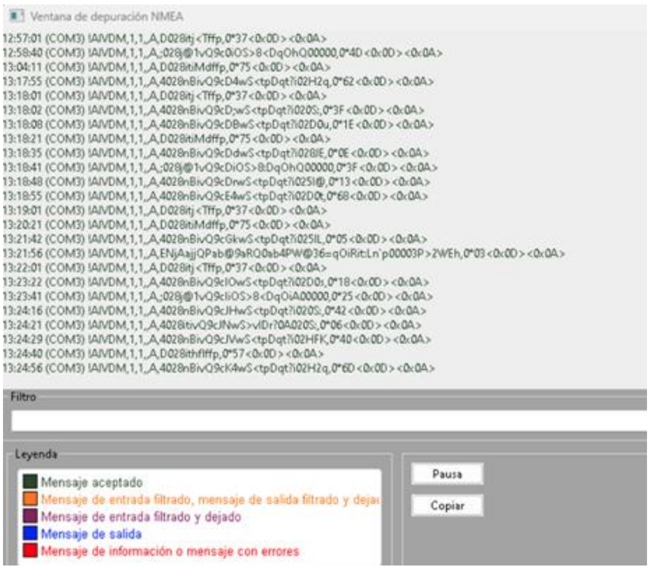


Figure 18. Sentences monitored by OpenCPN.

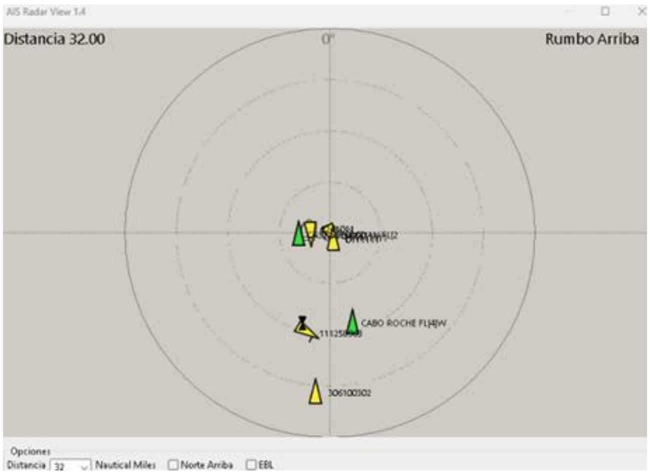


Figure 19. Radar screen simulation

The same information is mainly represented on an ENC where they will be observed, ship, base stations, etc., which transmit AIS information.

As these are repetitive transmissions, the representation on a chart also allows showing the defeats maintained by the ships in route, as well as static data etc. that ultimately provides very useful visual information to the pilots and centers of marine traffic coastal

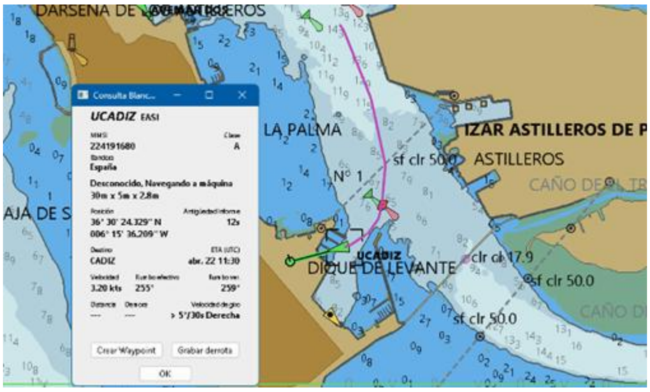


Figure 20. Representation on a Chart

We will show below several screenshots, carried out in different days and hours, you can observe the situation of maritime traffic in the bay of Cadiz at each of those moments

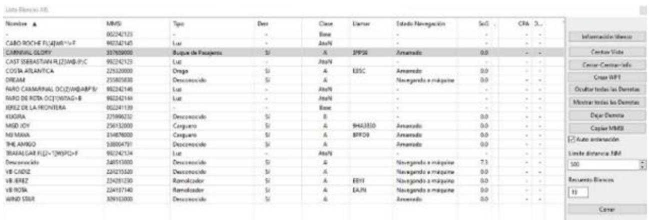


Figure 21. AIS target list.

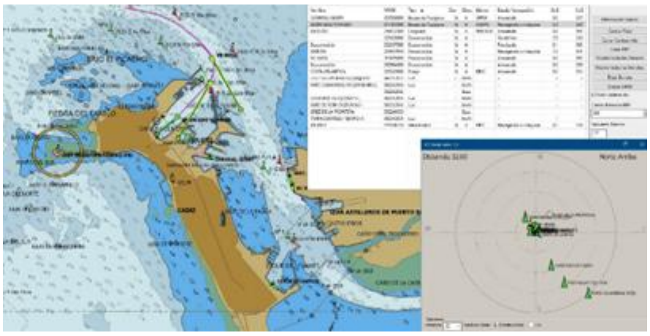


Figure 22. AIS target list, Chart and RADAR simulation screen

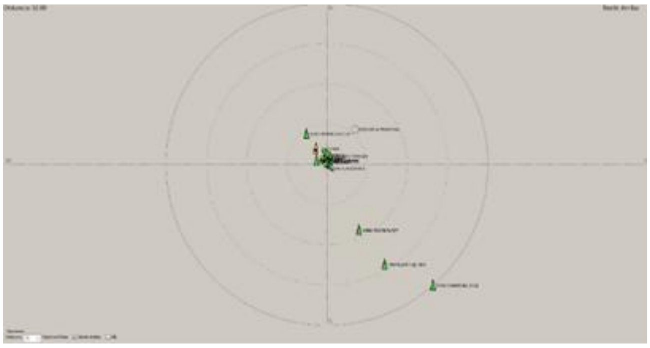


Figure 23. RADAR simulation screen

Figure 24. AIS target information, Chart and NMEA sentence

Figure 27. AIS target information, Chart and trail

5 CONCLUSION

The proposed practices on the exchange of information in internal communications can be used as a demonstrative alternative to understand their theory. This idea makes it possible to deduce how computers share information within an integrated navigation system.

The practice developed can be seen as the preamble to successive more explanatory and profound practices. Where a wide variety of devices will be provided.

Therefore, the students, by giving visualization to the theory by the implementation of these practices, have been able to pave the way for understanding.

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