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Control of Maritime Traffic in the Canary Islands

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ABSTRACT

In the present article, we present the Paper corresponding to the research project, "Infrastructure for the Control of Maritime Traffic in the Canary Islands: Island of El Hierro, A Pilot Project".

We will analyse the existing means in the Canary Islands, we will make a forecast of the material and method necessary to pick up the signals from vessels transiting the Island waters, their consequent retransmission to a Control Centre away from the place or places where receptors and their corresponding antennas are installed, and the system we deem best for presenting the information.

1. Introduction

We have attempted to demonstrate the efficacy of the automatic transmission of data using the TDMA technique (Transmission/Reception of data using the multiple access by time division technique), in order to implant it in all the vessels and aircrafts that transit our geographic surrounding, with coverage in the Canarian Archipelago and adjacent oceanic and flight space.

This Ship-Shore-Ship data exchange will be possible in VHF, for which it would be necessary to install a certain number of antennae or make use of the existing network of antennas and radiolinks, given that, once the information has been captured, it could be sent to a Traffic Control Centre. These identification systems would allow to detect any given anomaly in the pre-established course of a vessel, in such a way that if it is not confirmed by the methods established for habitual communications, it could be understood that said situation has been provoked and not desired, for example, a high-jack, and, in turn, it would be necessary to respond accordingly.

By means of real observations, we have tested, with the aid of a mobile receptor, the need for installing antennas to guarantee the total coverage of our shores, including shadow zones. All of this has led us to propose an optimum antenna location map. Although it would be desirable to fulfil this fieldwork in all of the other islands, the budgetary limitations have impeded us from carrying it through. Nevertheless, we have intended with this project to demonstrate the viability of the system and put forth a proposal to our Autonomous Government of the Canary Islands (Spain) for its application.

This system, apart from seeking safety in navigation, can also be of use in commercial ambits, where it can be used for providing the ship owner with immediate data regarding the journey: state of the cargo, voyage, fuel, breakdowns, etc., which would result in a better exploitation of the company. We have installed equipments on shore and onboard a vessel to demonstrate the effectiveness of the system.

We will explain the difficulties that have arisen during the execution of the present Project, the strategies employed for the collection of data of the target vessels, and the factors that influence the functioning of the system we are proposing. We wish to highlight that the results attained, as will be seen, are easily applicable to any other coast, given that, the complex relief of the Island has served as the best test bench for the system at hand, which, if it has worked with efficacy in El Hierro, will do so with less difficulty in areas with less complex and more shelved shores.

2. The current state of identification and location of vessels in the Canary Islands

According to the Spanish National Society of Maritime Salvage and Safety: The Rescue Coordination Centres (RCC), are the

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Centres in charge of coordinating the execution of operations regarding search, rescue, salvage, and the fight against pollution in their assigned geographical sphere. The Rescue Coordination Centres existing in Bilbao, Gijon, Santander, A Coruña, Vigo, Huelva, Cadiz, Algeciras, Cartagena, Valencia, Tarragona, Barcelona, Palma de Mallorca, Las Palmas de Gran Canaria and Santa Cruz de Tenerife, fulfil in addition, tracking tasks of vessel traffic in their approaches to and exits from the ports where they are located. Therefore, in the specific case of just the Canary Islands, the ships controlled are only those navigating in the nearby areas of the two Capital ports, lacking the means to obtain information concerning the ships located in the rest of the Archipelago waters. When we talk about these *nearby areas*, we are referring to the waters covered by the range of the radars located in Montaña de La Altura (Santa Cruz de Tenerife), and La Isleta (Las Palmas de Gran Canaria). Given that the radar range is slightly superior to the visual one, the only vessels detected are those in the Channel Tenerife-Agaete and in a sector of around 35 miles south of Puerto de La Luz.

We should clarify that what is detected is a radar echo, having to recur to the communication via VHF in order to interrogate the ship with the aim of obtaining its identity and other useful data, hence, depending on the willingness of the watch officer to respond or not to the petitioned information, especially when it is situated at beyond 12 miles, limit of our territorial waters.

Each one of the AIS equipments have been recently installed in each one of the Regional RCCs, providing an important help for the controllers.

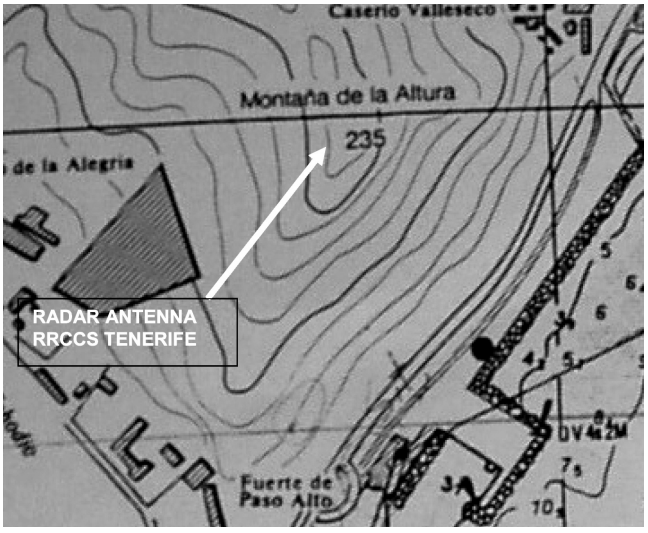
2.1. Equipment of the Tenerife RRCCS for location and identification:

— Radar: Approximate range: 34 miles; Orientation: E.
— Direction finder VHF.
— Identification Systems: AIS and interrogation via VHFRT.

Figure 1: VHF VHF-DF Direction finder (Antenna on cliff).

Source: Authors.

Figure 2. Tenerife's RRCC Radar Antenna. Located on the mountain of "La Altura" at 235 mts. altitude and communicated by radiolink with the control room.

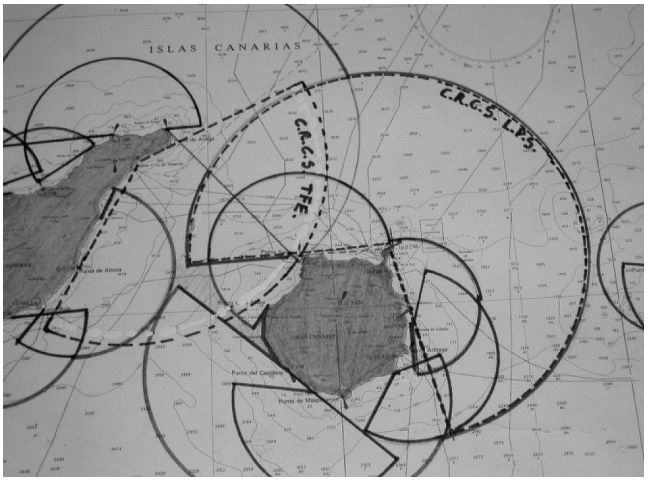


Source: Authors

2.2. Equipment of the RRCC of Las Palmas:

— Radar: Approximate range: 35 miles; Orientation: S
—VHF Direction finder
—Identification Systems: AIS and question via VHF-RT.

Figure 3: Zones with radar coverage of the RRCCs of Las Palmas and Santa Cruz de Tenerife (indicated by a dotted blue line). The antenna of Tenerife controls the Channel Tenerife-Agaete. The antenna of Las Palmas controls a minimum radius of around 35 miles around La Isleta from Pta.Sarrdina to Pta. Melenara.



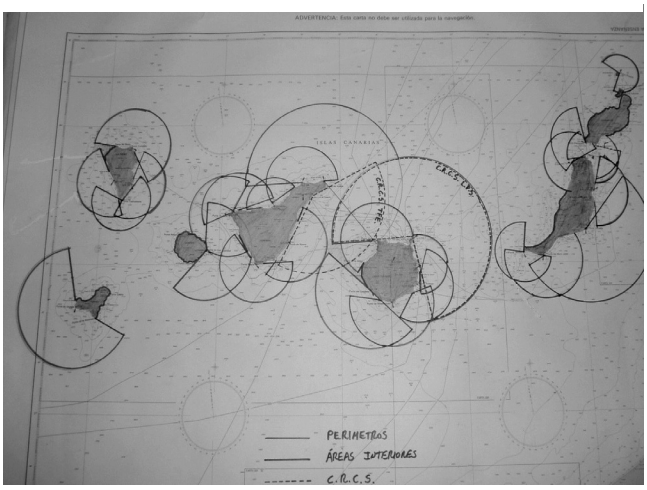
Source: Authors.

2.3. The current state of the identification and location of vessels on the island of El Hierro

The radio-electronic means of location and identification of vessels on the island of El Hierro are practically inexistent, limiting themselves to visual means carried out by the platform inspectors of the ports of La Estaca and La Restinga.

It is important to note the presence of the vessel belonging to the National Society of Rescue "Salvamar El Hierro" with

Figure 4: Lighthouses of the Canary Islands.



Source: Authors

base port in La Restinga, which will only be able to detect crafts during their sporadic exits from the ports.

3. Concrete aims of the project and their interest

We intend to test the effectiveness of the new system of vessel identification (Automatic Identification System – AIS), in the Canarian Archipelago which, as we know, has its implantation period between July 1st 2002 and July 1st 2008, and which intends to be a fundamental tool in navigation safety as it enables vessels or onshore stations to automatically "identify" all the vessels found in its surroundings, providing each station with valuable navigation safety information, such as the identification number of the vessel, type, position, course, speed, navigation status, dimensions, cargo, etc., ending, with this system, the uncertainty that has always existed at sea when interrogating another vessel.

We will install a receiver with its corresponding VHF antenna on the Island of el Hierro, we will pick up the information from the vessels close to the coast of the Island of El Hierro and, more specifically, the information transmitted by the Training Ship "Escuela Náutica Tenerife", which will make its way to El Hierro to fulfil the present work of research. We will send signals to a Control Centre located in the Town Council of the Island, to demonstrate the possibility of retransmitting the data from the receiver to any other desired place. We will extend the application of the system to small to urist and recreational boats, such as our apprentice sailing vessel, in order to test its effectiveness in areas close to the coast, attempting to detect the dark or no-coverage zones for recommending the installation of receivers in specific places as a guarantee of signal reception from vessels at all times.

The interest of this project lies in guaranteeing the location and identification of vessels and aircrafts navigating the coasts of El Hierro - this project being applicable to the rest of the Canary Islands -, and furthermore, in acquiring permanent information of their situation and navigation conditions, which will be advantageous for the safety of human life and the protection of the environment in our Islands.

4. Hypotheses, methodology and work scheme

Relying on two data transponder equipments, we will install one on board the vessel "Escuela Náutica Tenerife" (property of the University of La Laguna), and the other we will use as an onshore portable, focusing this pilot project on the Island of El Hierro, as it is the most exterior one bordering the Atlantic Ocean on its western end where there are no reference stations close-by.

We will pick up the signals and resend them via radiolink to a control station situated in the Island Council of El Hierro. We intend with this to demonstrate the possibility of implanting this system in the Canary Islands, as a means of centralizing all the information regarding the vessels and aircrafts transiting our Islands.

We will test ranges, interruptions in the transmission/reception, causes of the losses in remote and close-by targets, dysfunctions due to obstacles in the relief and meteorological phenomena, etc. We will study the ideal situation of the necessary receivers in different points of the Island. For this purpose, we require a sufficiently thorough format for data gathering, which will allow us to extract from it the necessary information to formulate a reliable hypothesis.

With the data of true ranges taken from the site of the ground equipment, we will extrapolate the conclusions arrived at to other geographic zones of the Island. With the previous data, we will initially study the theoretically ideal onshore location of the antennae. In order to test the former, we will situate the T/S "Escuela Náutica Tenerife" in different locations far from the coast and very close to it, behind headlands and capes, under cliffs, in different states of oceanic and atmospheric situations.

As former work to this project we count on the conclusions obtained in the one entitled, "location and identification of vessels and aircrafts in the canarian archipelago: a new proposal", with ending date January 2005, and in which the necessary observations were carried out, until the number of samples was considered to be abundantly significant leading to the instalment of the mobile station in different points of the island of Tenerife and a few others of the Canarian Archipelago. The system was tested at different altitudes and distances from the coast and the application of whose conclusions to the present project we will expose further on.

The identifying data of both stations are the following:
Boat Station:
Equipment: Furuno UAIS FA-100
Name: Escuela Náutica Tenerife
Call Sign: EA4450
Number of digital selective calling / MMSI:224090420
Height Of Antenna: 2.25 mts.
Ground Station:
Equipment: Furuno UAIS FA-100
Name: LAB COM
Call Sign: EON
Number of digital selective calling / MMSI:002241017
Experimental location on the island of El Hierro
In Geographic Coordinates:

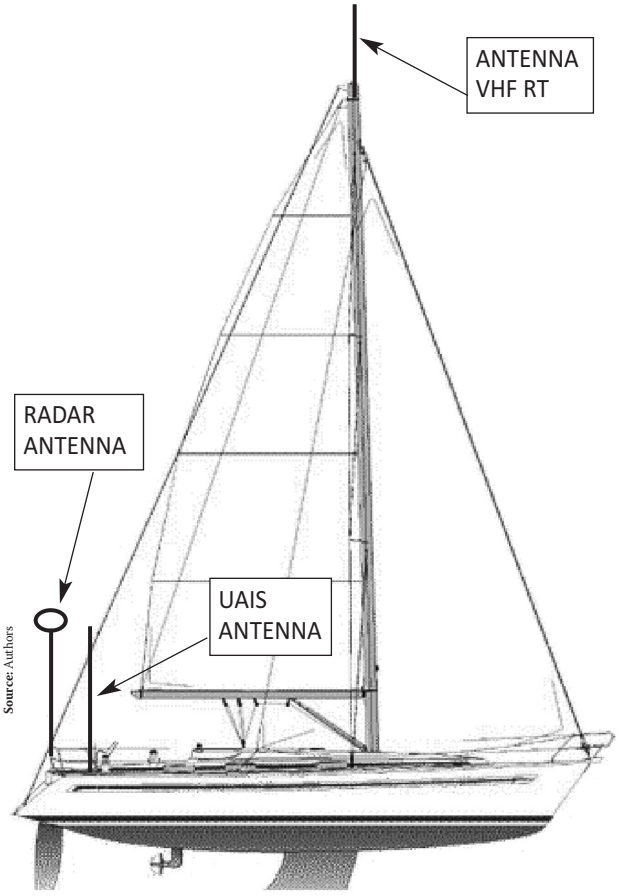
l= 27 48,2700 N L= 17 54,4835 W
H =545 mts. Above Average Sea Level
Datum: Pico De Las Nieves
In U.T.M Coordinates:
28 R 0213310
3079110
Z=545
Datum: WGS 84
Blind Sector: From 192º to 016º

4.1. Data taking

With the mobile ground station, we will pick up the signals and send them to a control station located in the Island Council of El Hierro. For this, we will have to experiment with different systems to determine the most appropriate technique.

5. Installations, instruments and available techniques

Figure 5: Bavaria Yacht 42 FEET YEAR: 1999.



Source: Authors.

Basic Equipment
Navigation
Radiotelephone MF/HF, Echosounding, VHF RT, VHF DSC, 2 NAVTEX, Radar, GPS Plotter, AIS, SART, EPIRB406, INMARSAT NINI M.

Figure 6: Navigation Equipment: Radar, GPS Plotter, UAIS.

Source: Authors

2 VHF Radiotelephones for voice communication between onshore personnel and observers on board the vessel.

1 Portable GPS for the location of the observers onshore with the aim of comparing locations.

— 1 Compass with chronometer for orientation.
— 1 binocular to test the theoretically foreseen visual ranges.
— 2 Charts of the Islands of La Gomera and El Hierro (Scale 1:50.000).
— Military Geographical Service Map of the Island of El Hierro (Scale 1:50.000)

1 AIS Transceiver (Ground Station Equipment).

6. Data taking

During this experimental phase, observations were carried out both from the "Velero Escuela Tenerife" in navigations around the southern coast of the island of Tenerife and the island of El Hierro. Observations were also taken with the ground equipment initially installed in the Communications laboratory of the *Centro Superior de Náutica y Estudios de Mar* (Institute for Maritime and Nautical Studies), and consequently, from the Island of El Hierro, where the land station was transferred to.

Below is an example of the formats used for data gathering, which we will proceed to explain in detail.

Let us take the general form in sections, explaining each one of them:

DATE: **GEO POSITION: l=** **/ L=** **NO.:**
OWN SHIP STATIC DATA: NAME MMSI CAL L SIGN: TYPE:
ANTENNAS HaisO: HradarO: HvhfO: HbridgeO:
TARGET STATIC DATA: NAME MMSI CALL SIGN: TYPE:
ANTENNAS (EST):HaisT: HradarT: HvhfT: HbridgeT:

OWN SHIP DYNAMIC DATA	FIRST OBSERVATION	LAST OBSERVATION
TIME		
COG/SOG		
COW/SOW		
REMARKS (WEATHER, ROLL, PITCH, ETC.)		

AIS TARGET DATA TIME BEARING/RANGE CPA/TCPA COG/SOG REMARKS	FIRST OBSERVATION	LAST OBSERVATION
RAD/ARPA TARGET DATA TIME BEARING/RANGE CPA/TCPA COW/SOW COG/SOG REMARKS	FIRST OBSERVATION	LAST OBSERVATION
VISUAL TARGET DATA TIME BEARING DAY/NIGHT VSIBILITY (FAIR/REG/POOR) VISUAL TYPE REMARKS	FIRST OBSERVATION	LAST OBSERVATION
VHF COMMUNICATION TIME POSSIBLE (YES/NO) QUALITY (FAIR/REG/POOR)	FIRST OBSERVATION	LAST OBSERVATION
OBSTRUCTIONS (YES/NO) TYPE REMARKS	FIRST OBSERVATION	LAST OBSERVATION
A.-AIS THEORETICAL MAXIMUM RANGE:		ROLLING
B.-RADAR THEORETICAL MAXIMUN RANGE:		ROLLING
C.-VISUAL MAXIMUN RANGE:		ROLLING
D.-VHF THEORETICAL MAXIMUN RANGE:		ROLLING

A.– $R = 2.2048\ (HaisO)^{½} + 2.2048\ (HaisT)^{½}$

B.– $R = 2.2048\ (HradarO)^{½} + 2.2048\ (radarT)^{½}$

C.– $R = 2.08\ (HvisO)^{½} + 2.08\ (HvisT)^{½}$

D.– $R = 2.2048\ (HvhfO)^{½} + 2.2048\ (HvhfT)^{½}$

Where R = Range; For example: HaisT = Target AIS antenna Height; HvisO = Own Ship Estimated bridge Height; HradarT = medium Height of Target vessel.

GENERAL QUESTIONS:

— WAS RADAR OBSERVATION POSSIBLE AT THE FIRST AIS OBSERVATION TIME?

— ARE THERE BUILDINGS OR BIG WALLS NEAR OWN SHIP OR TARGETS?

GENERAL REMARKS:

— VHF COMMUNICATION DATA ONLY WHEN FEASIBLE

— OBSTRUCTION TYPES BETWEEN OWN SHIP AND TARGETS: PIER /CAPE/INLET/REEF ETC.

6.1. Vessel/own station

DATE: **GEO POSITION: l=** **/ L=** **NO.:**
OWN SHIP STATIC DATA: NAME MMSI CAL L SIGN: TYPE:
ANTENNAS HaisO: HradarO: HvhfO: HbridgeO:

TARGET STATIC DATA: NAME MMSI CALL SIGN: TYPE:

ANTENNAS (EST): HaisT: HradarT: HvhfT: HbridgeT:

OWN SHIP DYNAMIC DATA TIME COG/SOG COW/SOW REMARKS (WEATHER, ROLL, PITCH, ETC.)	FIRST OBSERVATION	LAST OBSERVATION

In this section we take down the static and dynamic data of the vessel or the onshore station from which the observations are fulfilled. In the same manner, we take down the useful static data of the target vessel. The meaning of the abbreviations used in this section and those below is the following:

DATE: **FECHA**
GEO POSITION: l= **/ L=Situation: latitude /Longitude**
NO.:
OWN SHIP STATIC DATA: NAME
MMSI Number of digital selective calling
CAL L SIGN: Distinctive or Indicative of call
TYPE: Type of vessel (Tank, passenger, Sail, High Speed, etc.)
ANTENNAS HaisO Antennas Height of AIS antenna (own vessel)
HradarO: Height of RADAR antenna (own vessel)
HvhfO: Height of RT VHF antenna (own vessel)
HbridgeO: Height of bridge (own vessel)

TARGET STATIC DATA: NAME MMSI CALL SIGN: TYPE:
ANTENNAS (EST):HaisT: Antennas Height AIS antenna (observed vessel)
HradarT: Average height RADAR eco (target vessel)
HvhfT: Height of RT VHF antenna (target vessel)
HbridgeT Height of bridge (target vessel)

OWN SHIP DYNAMIC DATA
TIME Time of observation
COG/SOG Course Over Ground/ Speed Over Ground
COW/SOW Course Over Surface/ Speed Over Surface
REMARKS (WEATHER, ROLL, PITCH, ETC.)
FIRST OBSERVATION Column corresponding to data from the 1st observation
LAST OBSERVATION Column corresponding to data from the last observation. We refer to the moment in which the data from the observed vessel are starting to get lost.

6.2. Ais vessel/station target data

AIS TARGET DATA
TIME Hora
BEARING/RANGE Demora / Distancia
CPA/TCPA Time to closest point of approach
COG/SOG Course and Speed over ground (effective)
REMARKS (were there to be any)

6.3. Radar/Arpa Vessel/Station Target Data

RAD/ARPA TARGET DATA
TIME Hora

BEARING/RANGE	Demora / Distancia
CPA/TCPA	Time to closest point of approach
COW/SOW	Course and Speed over ground (effective)
COG/SOG	Course and Speed over water (surface)
REMARKS	(were there to be any)

Note: it must be taken into account that the ARPA systems initially give us the course and speed data with respect to the surface.

6.4. Visual data of the target vessel

VISUAL TARGET DATA	
TIME	Hora
BEARING	Demora
DAY/NIGHT	Día / Noche
VSIBILITY (FAIR/ REG/POOR)	Visibilidad (Buena/Regular/Mala)
VISUAL TYPE	Type of vessel (appearance)
REMARKS	Observaciones

6.5. Communication by vhf radiotelephone

VHF COMMUNICATION	
TIME	Hora
POSSIBLE (YES/NO)	Comunicación Posible (Sí/No)
QUALITY (FAIR/ REG/POOR)	Calidad de la señal (buena/regular/Mala)

6.6. Obstructions

OBSTRUCTIONS	Obstáculos entre estaciones receptora y transmisora
(YES/NO)	(SÍ / NO)
TYPE	Tipo (Cliffs, capes, inlets reefs etc.)
REMARKS	Observaciones

6.7. Table of theoretical ranges

Table 1. calculations of the theoretical ranges dependent on the heights of the antennae and/or of the observers, with the vessel righted and heeling

A.-AIS THEORETICAL MAXIMUM RANGE:		ROLLING
B.-RADAR THEORETICAL MAXIMUN RANGE:		ROLLING
C.-VISUAL MAXIMUN RANGE:		ROLLING
D.-VHF THEORETICAL MAXIMUN RANGE:		ROLLING

Source: Authors

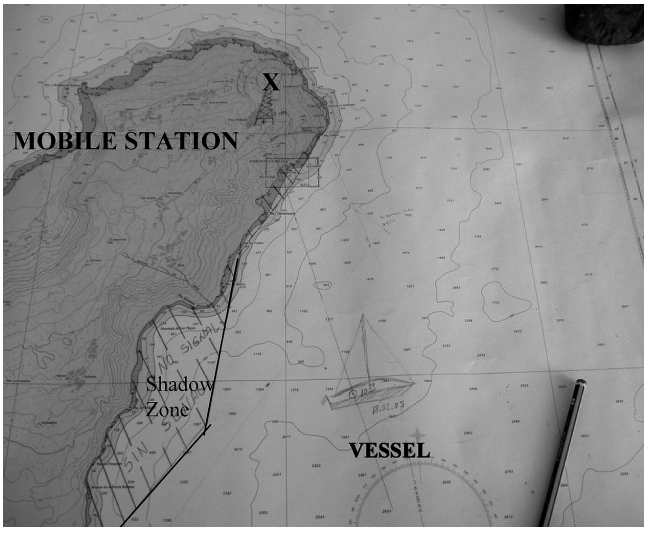
6.8. Observations taken from the portable station on the island of El Hierro.

58 observations were fulfilled onshore. The GPS and AIS antennas were transported in a cross-country vehicle and were installed on platforms designed to this effect in the following location.

6.8.1. Experimental location on the island of El Hierro in geographic coordinates:

l= 27 48,2700 N L= 17 54,4835 W
H =545 mts. Above Average Sea Level
Datum: Pico De Las Nieves
In U.T.M Coordinates:
28 R 0213310
3079110
Z=545
Datum: WGS 84
Theoretical Range: 51,47 Nautical Miles
Visible Sector: from **016º to 192º**
Blind Sector: from **192º to 016º**

Figure 7: Blind Sector.



Source: Authors

The main objective of these land observations was to attempt to receive signals from vessels found in the blind sector, that is, behind the coast and/or obstacles, or at a short angular distance of its limits. The Training Ship "Escuela Nautica Tenerife" was used for this purpose, navigating along the South, Southeast and Northeast coasts, from Puerto de La Restinga towards the northeast, navigating on occasions through the blind zone of Los Roques de Bonanza and La Restinga. Navigations were also carried out at different distances from the Coast, from and to Puerto de La Estaca.

At the same time, static related information to vessels was taken to analyse its correct introduction into the equipments.

7. Results

— All the vessels located within the theoretical visible sector and ranges, were satisfactorily observed with the AIS.
— Of the vessels observed, TWO were found outside the visible range.
— In situations of heavy rains and intense rainstorms, the dynamic data were received intermittently.

8. Conclusions

In an onshore station, such as the one installed, there is guarantee of receiving all the signals from transmitters found within the theoretical visible range and sector. This information leads us to a future determination of locations for antennas in order to implant the system at other points of the Island.

It has been demonstrated in practice that the ranges of the Automatic Identification Systems coincide and on occasions, surpass the foreseen theoretical ranges. The static data of the vessels are received in 100% of the cases.

The scarce angular sector outside the visual limits with which signals can be received, indicates that it is not necessary to overlap sectors between different antennas. This is one more data to determine the location of future antennas.

In specific occasions, the observed range of the system notably surpasses the theoretical range and, principally, that of the follow-up systems based on the RADAR technique.

The range of the system is limited by the visual range of antennas found behind land obstacles of great height. This range is always superior to that of the RADAR, whose echoes remain disguised behind land fixed features.

These results make the use of the system necessary in all types of vessels and onshore stations for traffic control and the fight against marine pollution.

In the case that the vessel initiates the navigation, fact which will be calculated by the internal GPS of the equipment, the information relative to the status of navigation should change automatically, without the need to introduce the information manually, proposing the transmission, by defect, of "machine navigation".

The following parameters should be blocked using an access code, as is the case with the identification number and signal call of the vessel:

— Position of the antenna (this data will only change in the unlikely case of a change in position of the same)

— Type of vessel. We propose adding to the new equipments a new function in which only the information relative to the nature of the cargo can be introduced without an access code.

We suggest endowing the equipments with a keyboard similar to that of a computer for a faster manual introduction of data.

It is advisable to make the connection of the equipments to screens with larger dimensions compulsory in order to carry a clearer and safer tracking of the vessels detected, allowing the superposition of the images with those of other systems, such as a radar and chart display.

The strong meteorological disturbances may difficult the adequate continuous tracking of the vessels, given that the dynamic data can be received intermittently.

The ground stations should be provided with remote antennas allowing the reception of signals from vessels that are hidden by large land obstacles. This coverage would be guaranteed in 100% of the cases were they to be located in headlands, coastal geodetic apexes or lighthouses with a height superior to 200 meters, guaranteeing a coverage superior to the 31 nautical miles (around 57 kilometres), for objects at sea level.

The tracking of aircrafts would be guaranteed with a lesser number of antennas, as there are less land obstacles.

The locations suggested for the installation of AIS antennas in the Island of El Hierro or its proximities, are the following:

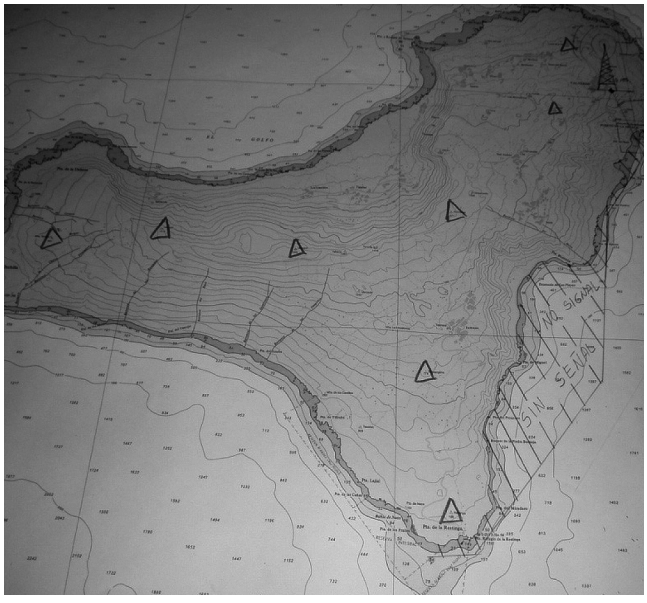
Table 2

Source: Authors

No.	Denomination Place	Coordinates	Range (Miles)*
1	MONTAÑA TENACA	l: 27 43,70 N L: 18 08,00 W h: 615 mts	54,6
2	VENTEJEA (LOS HUMILADEROS)	l: 27 44,00 N L: 18 05,40 W h: 1.234 mts	77,4
3	MALPASO	l: 27 43,68 N L: 18 02,30 W h: 1.501 mts	85,4
4	TEMBARGENA (CERRAJA)	l: 27 41,23 N L: 17 59,40 W h: 774 mts	61,3
5	RESTINGA	l: 27 38,71 N L: 17 58,90 W h: 197 mts	30,9
6	ASOMADAS (LOS FRAILES)	l: 27 44,70 N L: 17 58,80 W h: 1.372 mts	81,7
7	VENTEJIS (LA PELOTA)	l: 27 47,60 N L: 17 56,08 W h: 1.138 mts	74,4
8	CUEVA DE LA PAJA	l: 27 49,65 N L: 17 55,50 W h: 539 mts	51,2

* Objects with height=0 mts., that is, at sea level. The range would be greater the higher the object to be detected.

Figure 8: Suggested AIS Antennas (Mercator Chart).

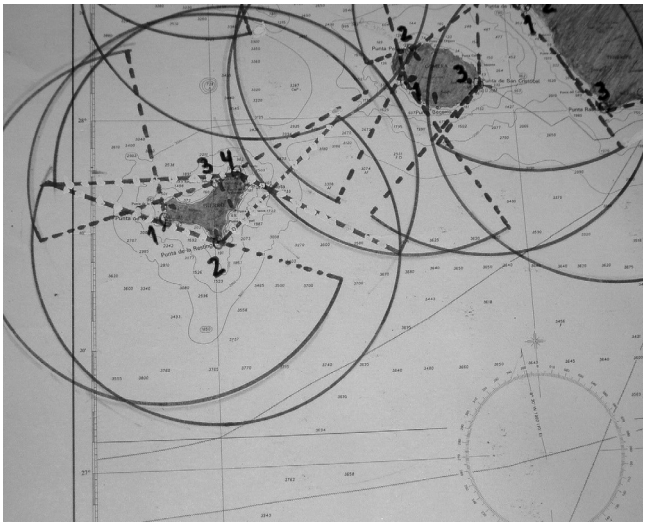


Source: Authors

The dependence of the system on the correct functioning of the satellite systems, together with the need to count on the collaboration of the transmitters as they have to keep their equipments functioning continuously, turn this system into a new navigation aid which, complemented with other systems, such as the radar (X band to detect SARTs), guarantee an effective tracking of vessels. This, together with the fact that dynamic data suffer from brief transmission/reception interruptions in situations of strong atmospheric disturbances due to rainstorms, reconfirms the need to contrast the data with those of other systems such as the Radar/Arpa.

In order to avoid these possible problems in the island of El Hierro, we suggest the location of four radar antennas, if possible in places of higher altitude (equal or above 200 metres), presenting small shadow zones, which do not affect tracking approaches to the island. It would be necessary to carry out a field study to determine the definitive location of the antennas. The antennas would be situated in the following places or their proximities:

Figure 9



Source: Authors

Table 3

No.	Denomination Place	Range (Miles)*	Shadow Zones
1	FARO DE ORCHILLA	31	SHORES FROM PTA. DE LA DEHESA TO PTA DE ORCHILLA
2	RESTINGA	31	ZONE OF LOS ROQUES DE BONANZA
3	SALMOR	31	EAST OF PTA. DEL NEGRO AND WEST OF PTA. DE LA SAL
4	PTA. NORTE	31	EAST OF PTA AMACAS AND WEST OF ROQUES DE SALMOR

* Objects with height=0 mts., that is, at sea level. The range would be greater the higher the object to be detected.

In this proposal a zone close to the Port of la Estaca would remain without coverage, at around 5 miles from the same. This problem would be resolved with the installation of a small port control radar with its antenna at a minimum sufficient height of 5 metres above sea level.

9. Final conclusion for the effective location and tracking of vessels and aircrafts in the island of El Hierro proposed for the rest of the archipelago

For tracking with coverage in the Island of El Hierro, it would be necessary to install the antennas/receivers suggested in the previous conclusions. These antennas would cause a minimum visual impact due to their reduced dimensions.

The signals received by the afore-mentioned antennas/receivers will have to be retransmitted to a Control Centre which will be provided globally and simultaneously with the static and dynamic data of the vessels and aircrafts transiting the waters of the Island from an average distance of 60 miles = 111 Km.

This system must be complemented with a series of low-level radar antennas to enable the confirmation of the dynamic data and of the effective presence of the echoes, in view of possible breakdowns or dysfunctions of the AIS system.

10. Proposal for the location of antennas in the Canary Islands

Following, we propose a model of ideal minimum network of AIS/RADAR antennas for the Canarian Archipelago. Logically, it would be necessary to carry through a field study, to confirm the hypothesis. The premises that have been taken into account have been:

— Height Of Antennas: 200 mts. Approx. RANGE: 31 Miles.
— Shadow Zones: small, do not affect tracking in approaches to the Island, only in coastal shores.
— Places: approximate, preferably in lighthouse proximities to make use of energy access and sources.

Figure 10

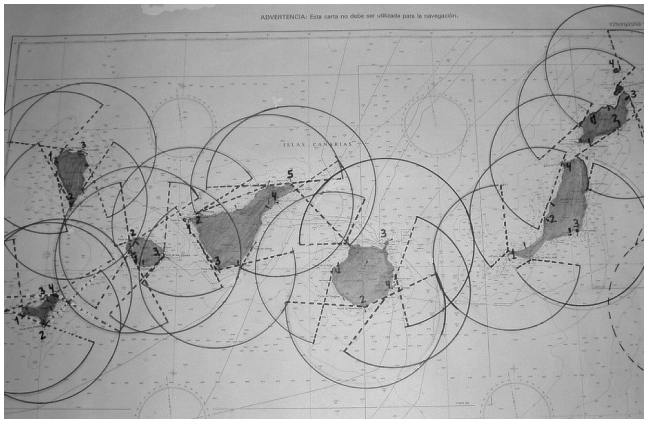


Table 4

	No.	Place	In Lighthouse
1	1	PTA. GAVIOTA	NO
2	2	ARRECIFE	NO
3	3	MOJON BLANCO	NO
4	4	ALEGRANZA	NO (Rise over the lighthouse)
5	1	JANDIA	YES
6	2	PTA. GUADALUPE	NO

7	3	LA ENTALLADA	YES
8	4	TOSTON	YES
9	1	PTA. DE LA ALDEA	NO
10	2	MASPALOMAS	YES
11	3	LA ISLETA	YES
12	4	ARINAGA	YES
13	1	PTA. TENO	YES
14	2	BUENAVISTA	YES
15	3	PTA. RASCA	YES
16	4	SANTA CRUZ DE TENERIFE	IN RRCC RADAR
17	5	PTA. ANAGA	YES
18	1	PTA. CALERA	NO
19	2	PTA. PELIGRO	NO
20	3	SAN CRISTÓBAL	YES
21	1	PTA. GORDA	NO
22	2	FUENCALIENTE	YES
23	3	PTA. CUMPLIDA	YES
24	1	ORCHILLA	YES
25	2	RESTINGA	NO
26	3	PTA. SALMOR	NO
27	4	PTA. NORTE	NO

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