GMDSS modernization and introduction to digital information to support SAR and MSI

NAVDAT: Navigational Data

Captain Jean-Charles CORNILLOU – Technical adviser for maritime safety – Cerema/REM/DPN

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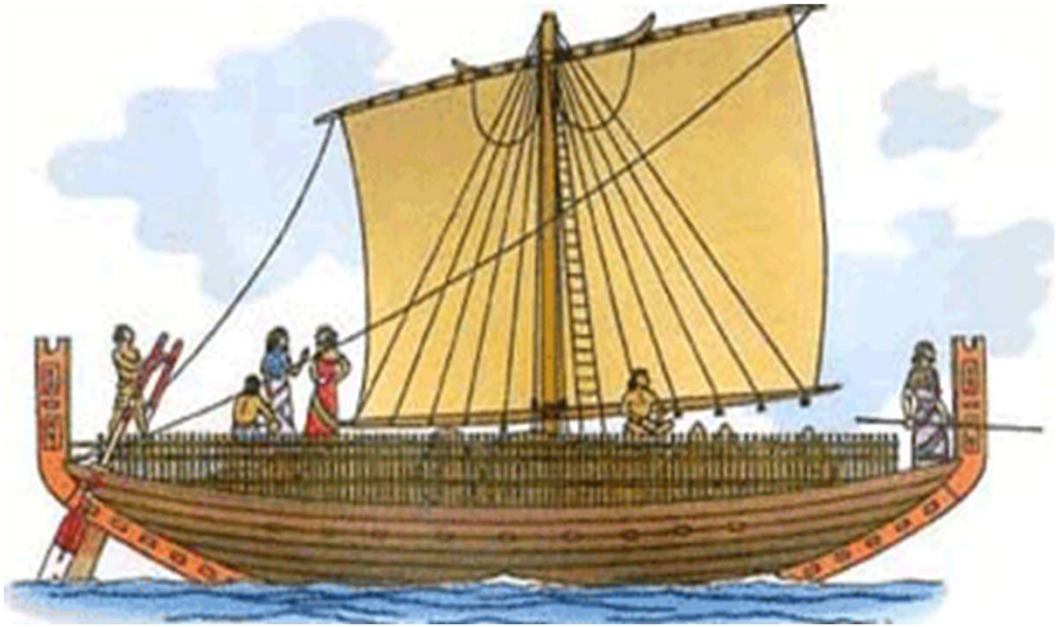
BACKGROUND
- 2000 …and long time before



At that time, shipping was **a real autonomous means of transport** for the crew was totally isolated from land and has to rely on its own resources and capacity to face the danger of navigation!

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BACKGROUND

1900


Guglielmo Marconi, a founding father of radio.

Marconi Wireless Telegraph Company

The night of 14th to 15th April 1912

One of the fisrts SOS transmitted in radiotelegraphy on 500 kHz

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BACKGROUND

2022

Nowadays, in case of any problem the last safety measure at sea is still

SAR

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BACKGROUND

The international convention on maritime SAR

adopted in Hamburg in April 1979 (SAR 79)

Resolution 6 of SAR 79 proposed to develop a global maritime distress and safety system (GMDSS)

GMDSS was prepared at ITU in order to be used by all ships… and IMO adopted on 9th June 1997 MSC/Circ. 803 participation of non-SOLAS ships in the GMDSS

(Note that MSC/Circ. 803/Rev.1 was adopted by MSC 105 IN April 2022)

GMDSS entered into force on 1st February 1999 for all SOLAS ships

BACKGROUND

Modernization of GMDSS

In June 2009, MSC 86 agreed to include, in the work programme of the COMSAR Sub-Committee a subitem on « **Scoping exercise to establish the need for a review of the elements and procedures of the GMDSS** ». The MSC requested the Secretariat to liaise with ITU with a view to utilizing the resources of the Joint **IMO/ITU Experts Group** in the cause of this exercise.

In April 2022, the MSC 105 adopted amendments to SOLAS chapters II-1, III, IV and V, and the appendix (Certificates); the 1988 SOLAS Protocol; the 1994 and 2000 HSC Codes; the 1983 and 2008 SPS Codes and the 1979, 1989 and 2009 MODU Codes, and … the associated draft MSC resolutions & circulars for their adoption … as reviewed and proposed by the **IMO/ITU EG**.

Nevertheless, the GMDSS functional requirements do not change. These functional requirements are adapted to any format of communication (telex, voice or data) and any radiocommunication system (terrestrial or satellite).

New SOLAS IV/4 functional requirements

1 Every ship, while at sea, shall be capable

.1 performing the GMDSS function as follows:

Distress

- .1 transmitting ship-to-shore distress alerts by at least two separate and independent means, each using a different radiocommunication service ;
- .2 receiving shore-to-ship distress alert relays ;
- .3 transmitting and receiving ship-to-ship distress alerts ;

SAR

- .4 transmitting and receiving search and rescue coordinating communications ;
- .5 transmitting and receiving on-scene communications ;
- .6 transmitting and, as required by regulation V/19.2.3.2, receiving signals for locating ;

MSI

- .7 receiving MSI ;

urgency and safety

- .8 transmitting and receiving urgency and safety radiocommunications; and

bridge-to-bridge

- .9 of transmitting and receiving bridge-to-bridge communications

.2 transmitting and receiving general radiocommunications subject to regulation 15.8 .

BACKGROUND

Modernization of GMDSS & e-navigation

The way forward now, and in line with the IMO strategic implementation plan on e-navigation, is to introduce **digital communications** supporting **S-100 format files**.

The gap-analysis of e-navigation identified the need to present information in **graphical format**.

For info: Actually HF facsimile is the only system now available to provide graphical information with weather and ice charts.
This is not a component of GMDSS but there are approximately 30 HF facsimile stations in service globally.

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BACKGROUND

Modernization of GMDSS & e-navigation: introduction of NAVDAT

The ITU has prepared for a long time different technical recommendations for Digital Radio Mondiale (DRM) with applications in the maritime sector such as NAVDAT, digital HF or VDES. In particular:

- In **November 2011**, Recommendation ITU-R-M 2010, NAVDAT 500 kHz and
- In **February 2014**, Recommendation ITU-R M.2058, NAVDAT HF
- In **November 2018**, Report ITU-R M.2443, NAVDAT Guidelines

In November 2019, WRC 19 confirmed the use of all frequency bands for NAVDAT: 500 kHz, 4226 kHz, 6, 8, 12, 16, 18/19, 22 & 25/26 MHz

In **January 2020**, presentation at NCSR 7 by **China & France** of test measurements of NAVDAT system under real conditions… and full support of NCSR to include NAVDAT as a new output for GMDSS!

In **May 2021**, the MSC 103 agreed to include in its post-biennial agenda an output on **"Development of performance standards for a digital navigational data system (NAVDAT)"**.

i.e. development of performance standards for NAVDAT receiver and NAVDAT manual
(how to broadcast info on NAVDAT and how to receive info by NAVDAT)

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BACKGROUND

Why using terrestrial system and not satellite?

1. GMDSS is based on the use of maritime mobile service (terrestrial) and mobile satellite service.

In particular for the broadcast of MSI two major areas have been defined (Res.MSC.468(101)): **coastal warning areas** and **NAV/METAREAs**

Coastal warning areas can be covered by terrestrial systems (NAVTEX or NAVDAT) up to **200 NM**.

Coastal warning areas concentrate heavy traffic and more danger and need naturally to be provided with more MSI than in the deep sea.

There is a possibility **to balance the flow of information** between coastal warning area and NAV/METAREAS with the different communication systems.

In short: Broadcast the appropriate information in the appropriate area, at the appropriate time and with the appropriate communication system.

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BACKGROUND

Why using terrestrial system and not satellite?

2. Terrestrial system are directly controlled by coastal States… and can be operated in cooperation with others coastal States.

Coastal States do not depend from a private company to broadcast MSI or SAR information with terrestrial system.

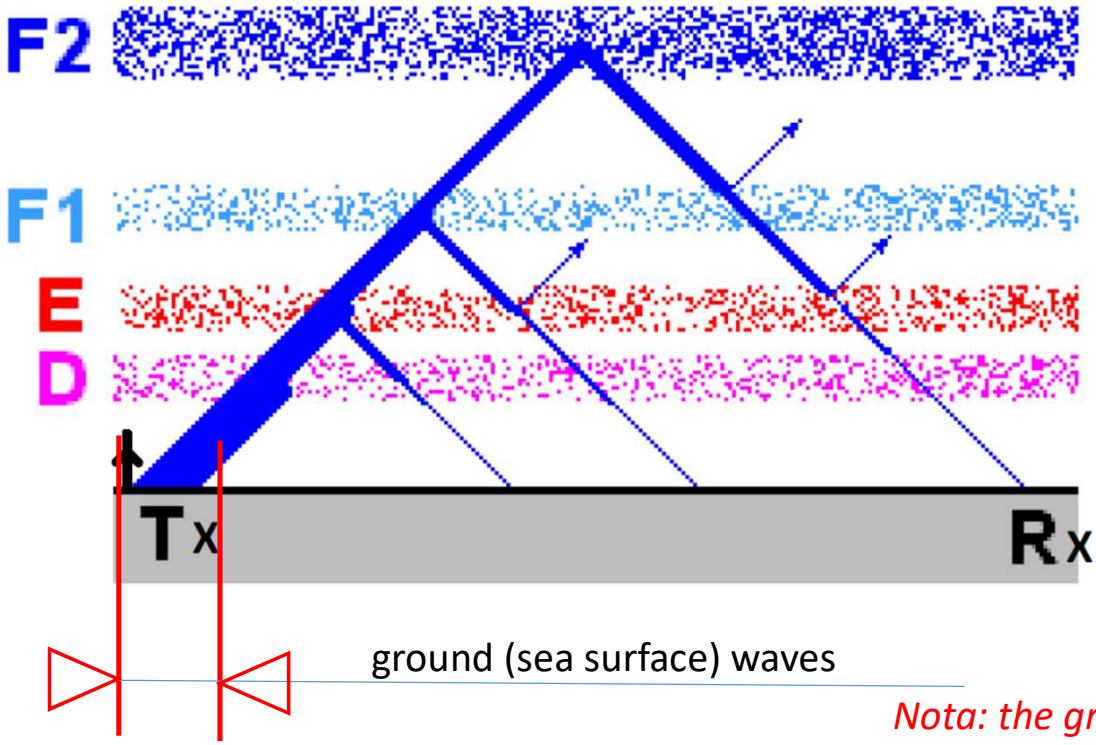
3. If the infrastructure of a coast radio station can be expensive, **the broadcast of information from a coast radio station is free of charge.**

4. In the event of failure of normal transmission facilities, an alternative means of transmission should be utilized. (See section 3.7 of Res. MSC.468(101).

In case of failure of terrestrial service we can secure a minimum MSI by satellite.
And in case of failure of satellite service we can secure a minimum of MSI in the coastal warning area with terrestrial service.

BACKGROUND

The different radio propagations in HF



sky waves

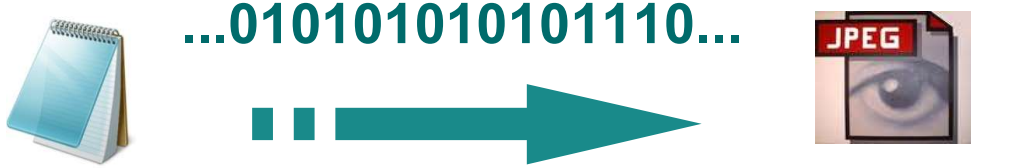
international NAVDAT service on 500 kHz or 4 226 kHz

Nota: the ground wave is used in GMDSS to define coverage area

BACKGROUND
The NAVDAT digital modulation

- Digital Modulation allows more important flow
- 15 to 25 kbit/s in a 10 kHz channel (more than 300 times the NAVTEX transmission)
- Faster transmission time per message
- Transmission files not limited to the texts but also:

- Drawings
- Graphs
- Pictures
- Data… including S-124
  or any S-100 format



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BACKGROUND

Comparison between NAVTEX and NAVDAT flow

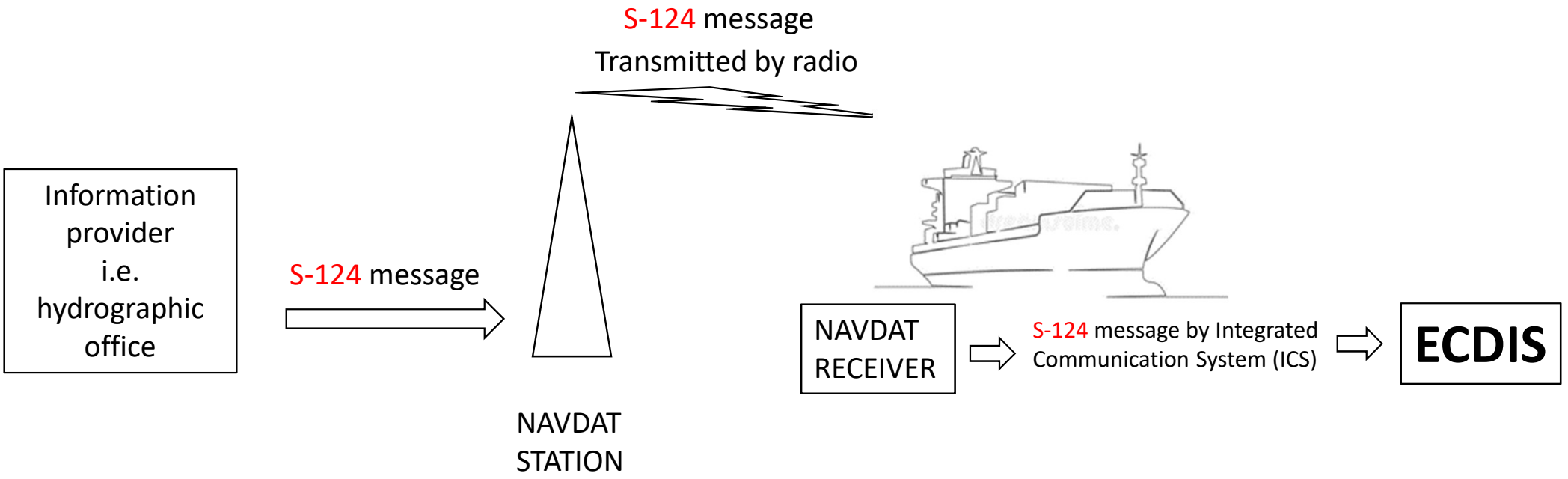
(if we may compare 2 different technology)

For a 10 mn NAVTEX slot at 50 bits/s
the maximun volume transmitted is
30 kbits or **3,75 kB** … but **in telex only**.

For a 10 mn NAVDAT slot at an average flow of 20 kbits/s
the maximun volume transmitted is
12 000 kbits or **1 500 kB** … and **in different data format!**

BACKGROUND

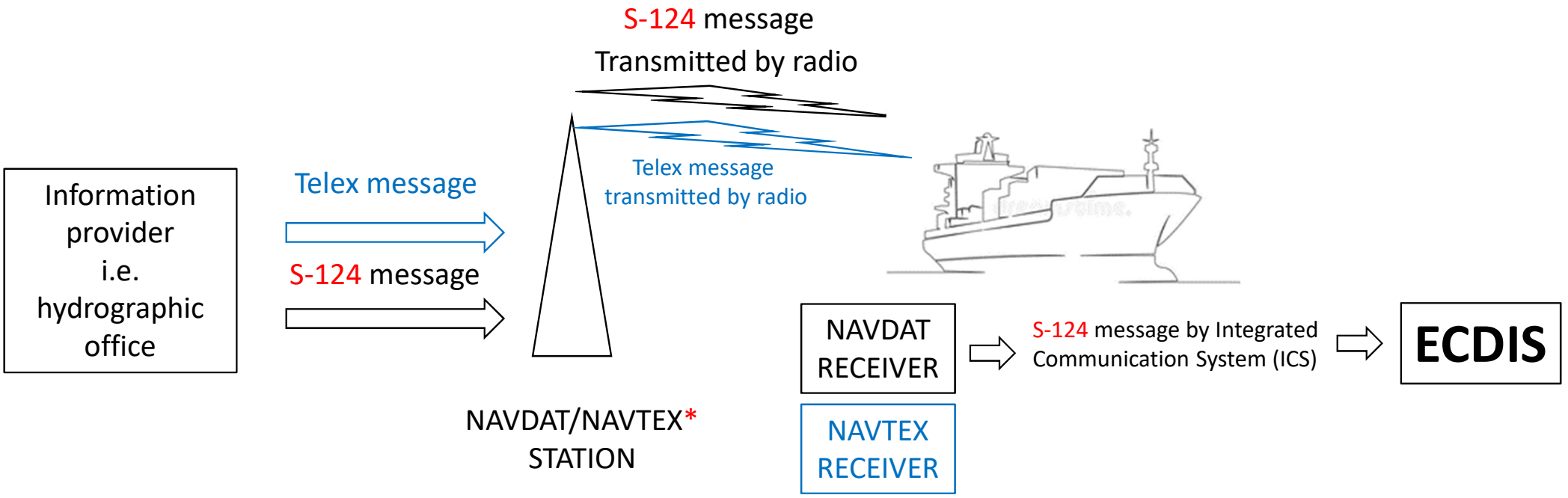
The interest of digital information



BACKGROUND

The interest of NAVDAT station

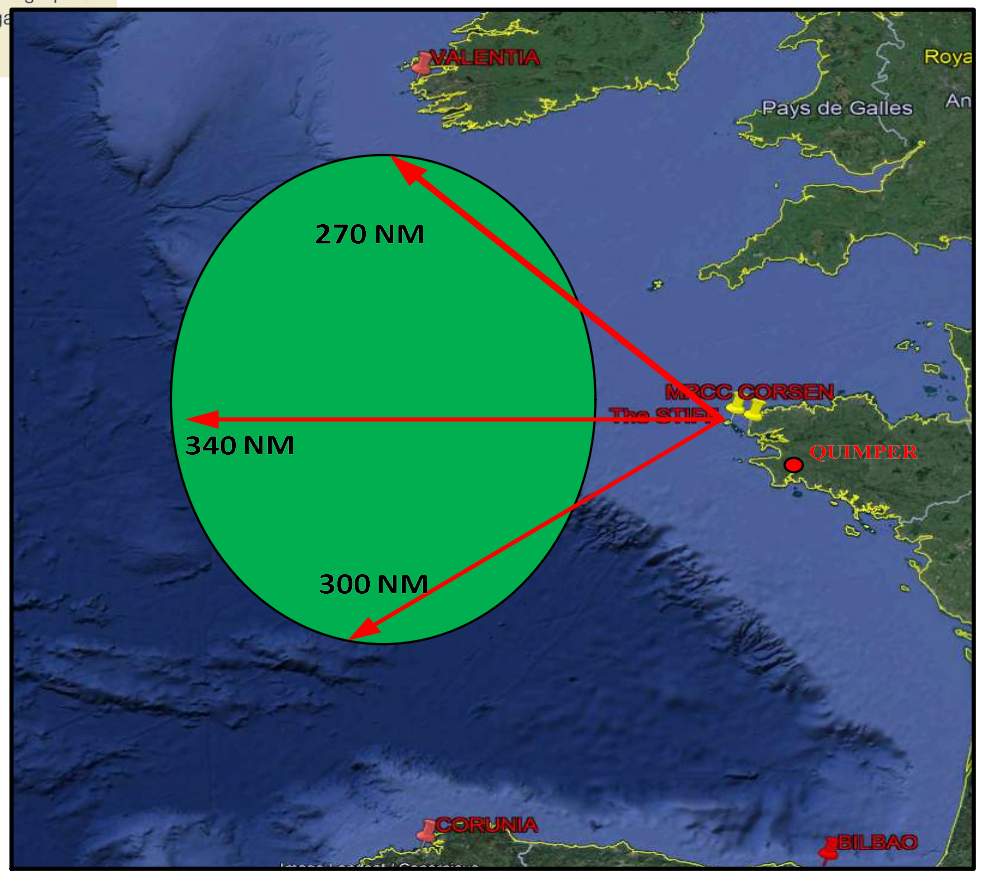
And the necessity to renew NAVTEX stations with a new technology!



**there are already NAVTEX tranceiver ready to NAVDAT*

TEST MEASUREMENTS OF NAVDAT SYSTEM

In France – Ushant island
NAVDAT 4 MHz test



In China – Shanghai
NAVDAT 500 kHz test

TEST MEASUREMENTS OF NAVDAT SYSTEM

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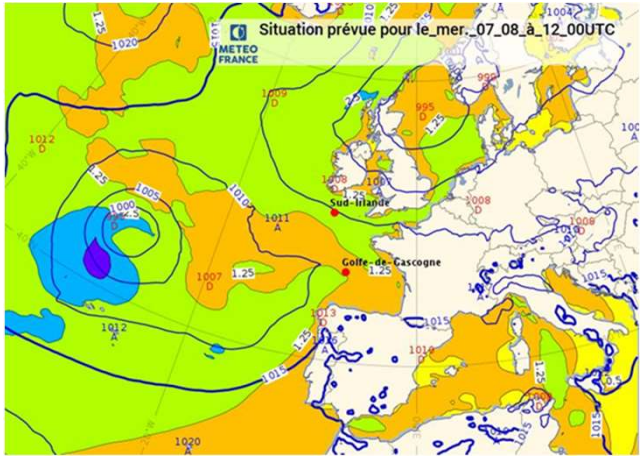
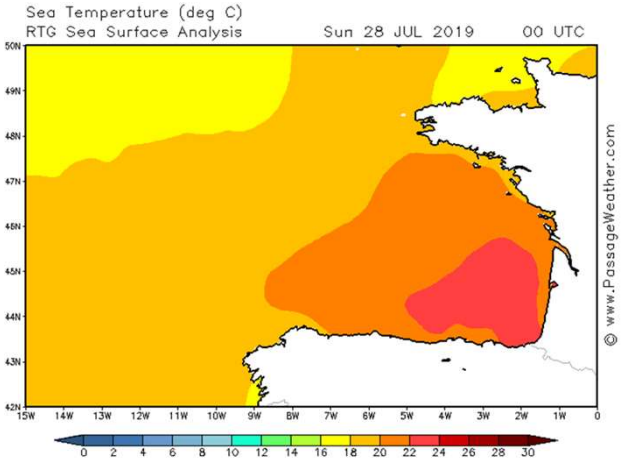
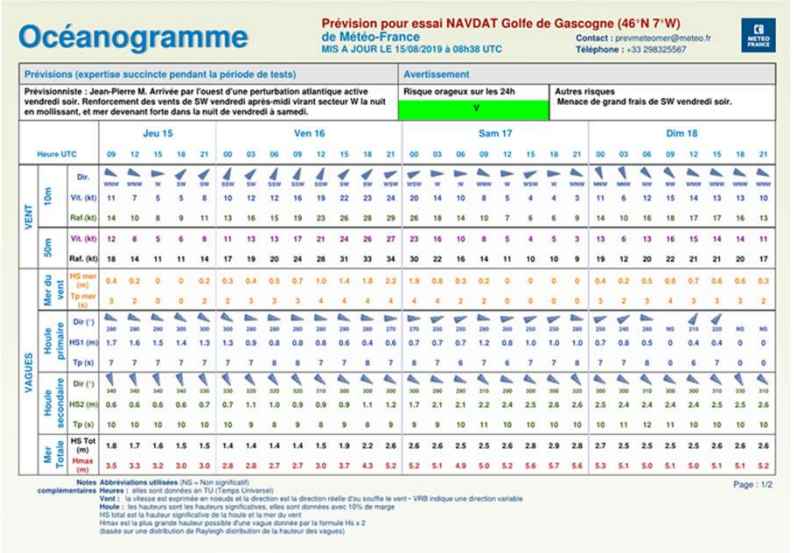
Examples of decoded files transmitted



isobaric weather chart
(Météo France)



temperature chart
(Météo France)



Océanogramme

Prévision pour essai NAVDAT Golfe de Gascogne (46°N 7°W)
de Météo-France
MIS A JOUR LE 15/08/2019 à 08h38 UTC

Contact : prevmeteomer@meteo.fr
Téléphone : +33 298325567

Prévisions (expertise succincte pendant la période de tests)

Prévisionniste : Jean-Pierre M. Arrivée par l'ouest d'une perturbation atlantique active vendredi soir. Renforcement des vents de SW vendredi après-midi virant secteur W la nuit en mollissant, et mer devenant forte dans la nuit de vendredi à samedi.

Avertissement

Risque orageux sur les 24h : V

Autres risques : Menace de grand frais de SW vendredi soir.

Heure UTC | Jeu 15 | Ven 16 | Sam 17 | Dim 18

VENT 10m — Dir., Vit. (kt), Raf.(kt)
VENT 50m — Vit. (kt), Raf. (kt)
VAGUES Mer du vent — HS mer (m), Tp mer (s)
VAGUES Houle primaire — Dir (°), HS1 (m), Tp (s)
VAGUES Houle secondaire — Dir (°), HS2 (m), Tp (s)
VAGUES Mer Totale — HS Tot (m), Hmax (m)

Notes complémentaires
Abréviations utilisées (NS = Non significatif)
Heures : elles sont données en TU (Temps Universel)
Vent : la vitesse est exprimée en noeuds et la direction est la direction réelle d'où souffle le vent - VRB indique une direction variable
Houle : les hauteurs sont les hauteurs significatives, elles sont données avec 10% de marge
HS total est la hauteur significative de la houle et la mer du vent
Hmax est la plus grande hauteur possible d'une vague donnée par la formule Hs x 2
(basée sur une distribution de Rayleigh distribution de la hauteur des vagues)

Page : 1/2

data and forecast in Biscay Bay
(Météo France)

TEST MEASUREMENTS OF NAVDAT SYSTEM

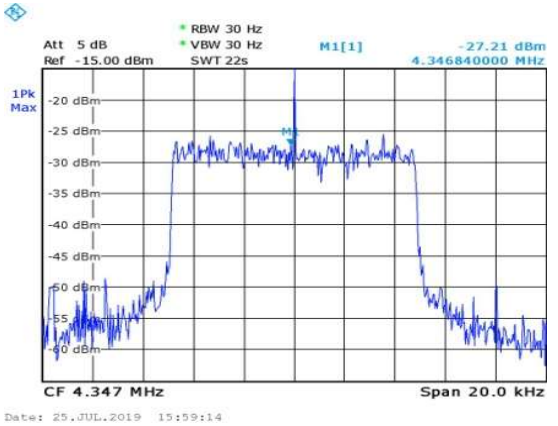
Test measurements of NAVDAT system in HF (4347 kHz)

From Ushant island (France)

Shore-side component

HF transmitter

HF biconical vertical antenna



spectral occupency

output RF wattmeter

The antenna used is a broadband biconical vertical antenna providing a gain of 3 dB. The RF radiated power for the experiment was thus 500 W rms.

TEST MEASUREMENTS OF NAVDAT SYSTEM

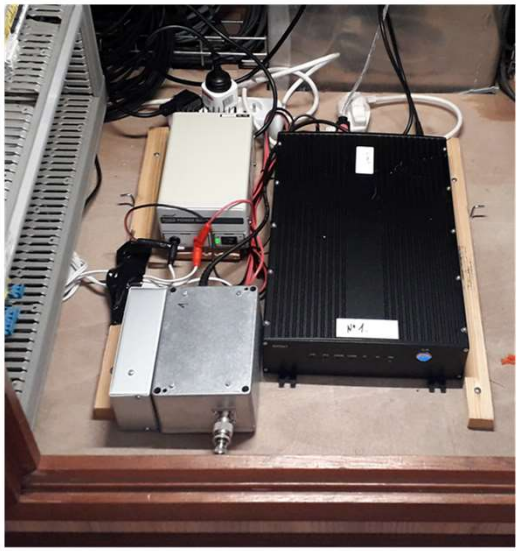
Test measurements of NAVDAT system in HF (4347 kHz)

From Ushant island (France)

Maritime component

f/v BARA LODENN

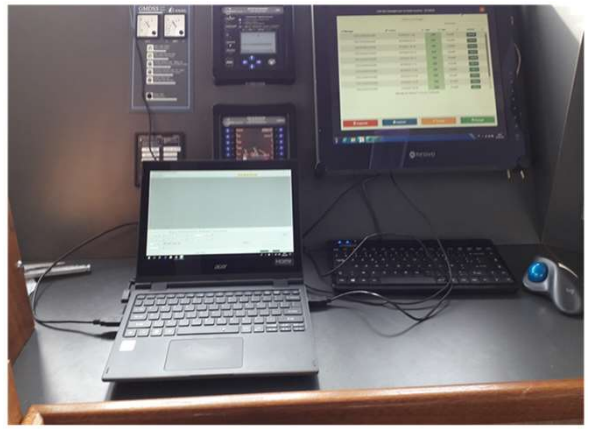
f/v BARA BREIZ



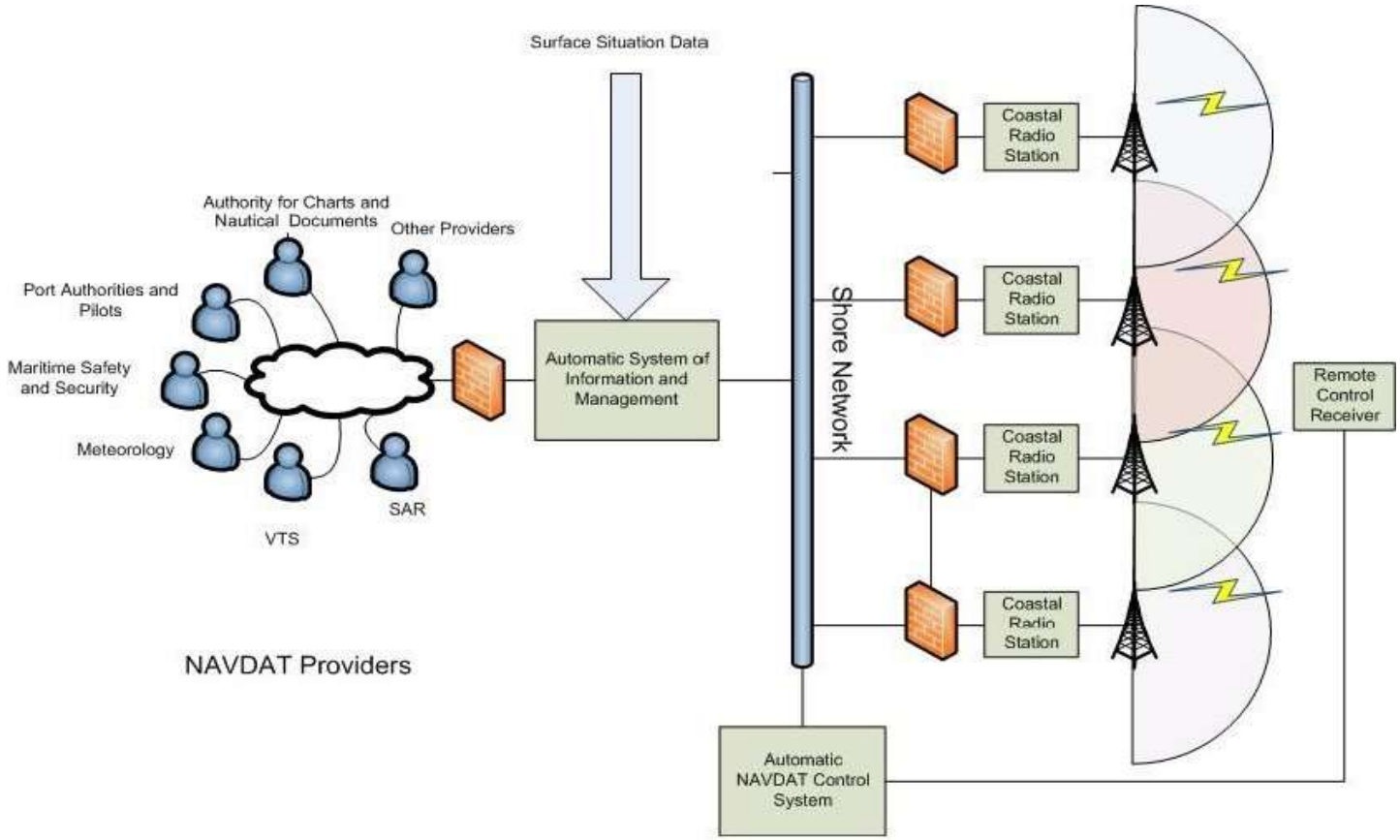
Receiver / demodulator

Provisional equipment included :

- 1 Active receiving vertical antenna
- 1 Receiver / demodulator
- 1 Laptop as controller and message storage
- 1 Power supply



THE NAVDAT ACHITECTURE



The NAVDAT system architecture is similar to the NAVTEX system architecture

THE NAVDAT BROADCASTING MODES

Broadcasting NAVDAT files can be done by:

.1 general broadcast (to all ships);

.2 selective broadcast (to ships located in a specific area, or for groups of ships according to the ship's position, MMSI or group identification); and

.3 dedicated message (according to ship's MMSI).

There are possibilities of **encrypting** sensitive files in the **three modes** of broadcasting.

In that respect there are different possibilities to use NAVDAT, not only in GMDSS (SAR and MSI) but also for national security messages, fishing information (regulations, special map of fishing areas, quota information), pilot services, tug services, port support services or VTS…

THE NAVDAT BROADCASTING MODES (FOLLOWING)

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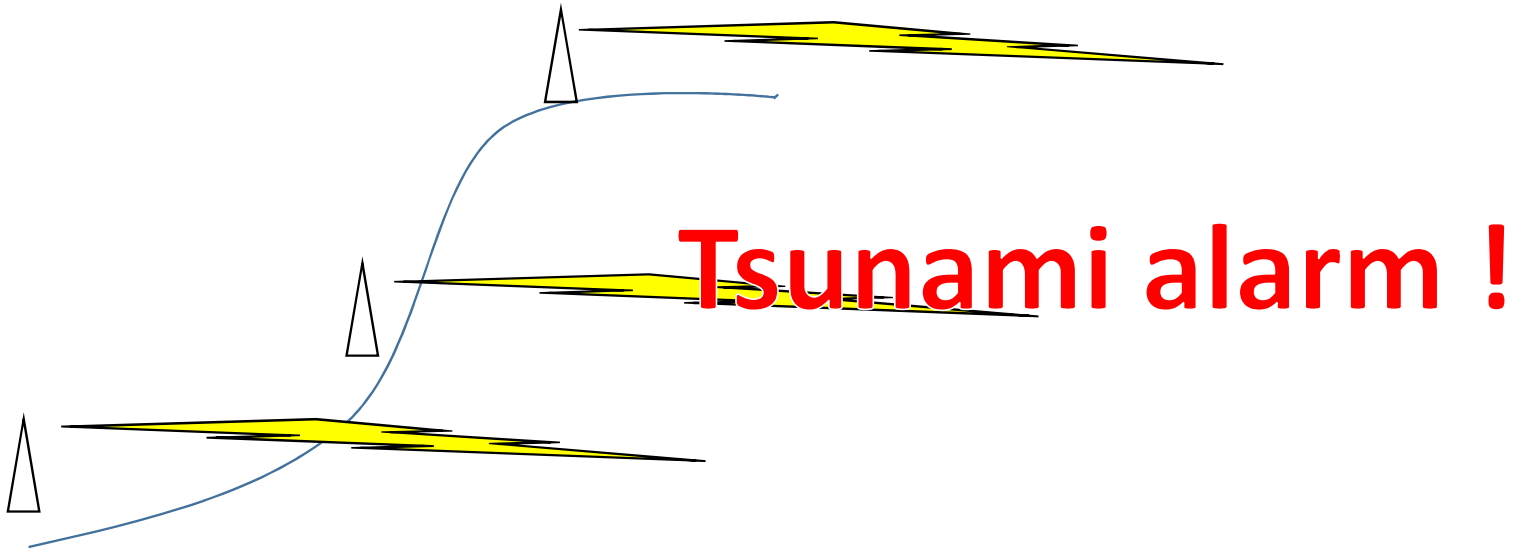
SFN mode (Single Frequency Network)

The NAVDAT system offers the possibility of operating in SFN mode. This network uses several transmitters operating on the same frequency and broadcasting the same information at the same time. This simplifies the distribution of the time slots, increases the effectiveness of the broadcast which can be longer and limits the potential interference.

Example:

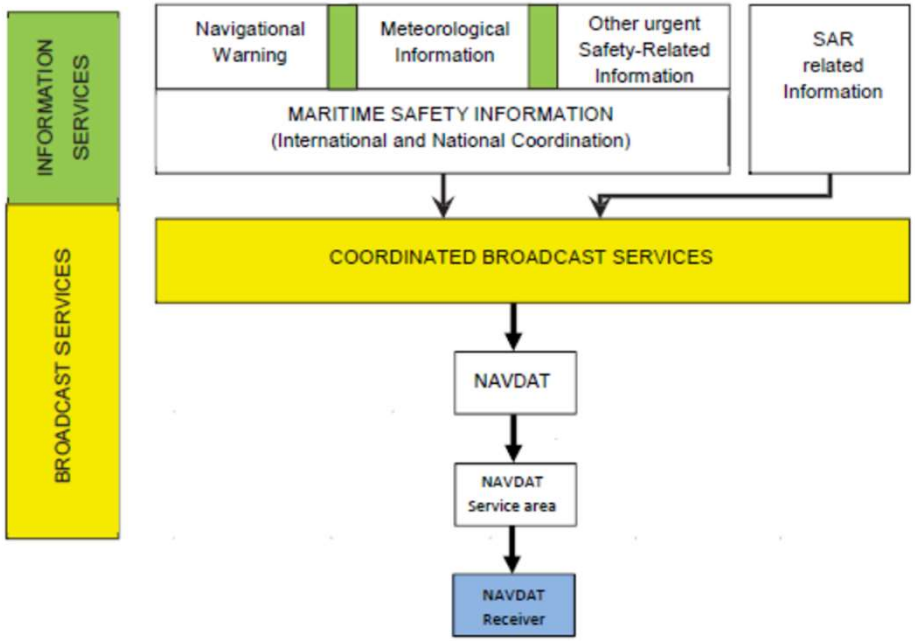


THE NAVDAT IN THE GMDSS

How the WWNWS and the WWMIWS might consider a conceptual way to implement NAVDAT?

Propose to study the **draft NAVDAT manual**. This draft has been prepared by an informal and international group of experts in conjunction with the latest work on ITU-R M. recommendations on NAVDAT.

Basic concept of the NAVDAT system:



THE NAVDAT IN THE GMDSS

International Hydrographic Organization

draft NAVDAT manual content

Foreword
1 General information
2 NAVDAT service
3 General features of the NAVDAT system
4 Planning NAVDAT services
5 NAVDAT message technical coding
6 Message numbering
7 Message format
8 Language and broadcast options
9 Information control
10 Message content
11 Message priorities and broadcast procedures in the International NAVDAT service
12 Responsibilities of a NAVDAT Coordinator
13 Mutual interference between NAVDAT coast stations
14 Notification of NAVDAT services

NAVTEX manual content

Foreword
1 General information
2 NAVTEX service
3 General features of the NAVTEX system
4 Planning NAVTEX services
5 NAVTEX message technical characters
6 Message identity
7 Message format
8 Language and national broadcast options
9 Information control
10 Message content
11 Message priorities and broadcast procedures in the International NAVTEX service
12 Responsibilities of a NAVTEX Coordinator
13 Best practice for those using the service
14 Mutual interference between NAVTEX stations
15 Notification of NAVTEX services

THE NAVDAT IN THE GMDSS

draft NAVDAT manual content

Annex 1 - IMO NAVDAT Coordinating Panel terms of reference

Annex 2 - NAVDAT system

Annex 3 - draft MSC resolution on performance standards for the reception of maritime safety information and search and rescue related information by MF and HF digital navigational data system (NAVDAT)

Annex 4 - Resolution MSC.509(105), new Annex 5 Criteria for use when providing a NAVDAT service

Annex 5 - NAVDAT ship receiver description

Annex 6 - Frequencies for NAVDAT HF system allocated by ITU

Annex 7 - Procedure for amending the NAVDAT Manual

NAVDAT manual content

Annex 1 - IMO NAVTEX Coordinating Panel terms of reference

Annex 2 – Rec.ITU-R M 540-2 Operational and technical characteristics for an automated direct-printing telegraph system for promulgation of navigational and meteorological warnings and urgent information to ships

Annex 3 - Resolution MSC.148(77) adopted on 3 June 2003 Adoption of the revised performance standards for narrow-band direct-printing telegraph equipment for the reception of navigational and meteorological warnings and urgent information to ships (NAVTEX)

Annex 4 - Resolution A.801(19), as amended, annex 4 Criteria for use when providing a NAVTEX service

Annex 5 - Procedure for amending the NAVTEX Manual

THE NAVDAT IN THE GMDSS

Section 4 Planning NAVDAT services

The two basic areas which must be defined when establishing a NAVDAT coast station are the **NAVDAT coverage area** and the **NAVDAT service area**. Each station will provide all the information for a particular NAVDAT service area. The boundaries of the NAVDAT service area must be wholly contained within the coverage area, and must not overlap with adjacent NAVDAT service areas.

Exactely like the NAVTEX service !

THE NAVDAT IN THE GMDSS

Section 5 NAVDAT message technical coding

NAVDAT messages include instructions to the NAVDAT receiver for processing MSI and SAR related information which consists of a coding for the following data:

1) Coast station identification code (ID)

This information will be displayed in plain text on the screen of the NAVDAT receiver with the following data:

- The header I and D (the encoding will be in 8-bit ASCII)
- The area: today there are 21 areas (I (01) to XXI (21))… coding will be done in binary on 8 bits, i.e. a maximum of **31** areas.
- The numbering of the station (For station broadcasting on several frequencies several numberings will be assigned to it).

station number allocated for a frequency will be coded on 8 bits (maximum of **255** stations by area).

Total of **32 bits** will thus be used for the identification of each pair station / frequency

2) Subject message coding (SC)

Information is grouped by subject in the NAVDAT broadcast and each subject group is allocated a subject message code from 1 to **63**.

The subject message code is used by the receiver to identify the different classes of messages.

THE NAVDAT IN THE GMDSS

Section 5 NAVDAT message technical coding (following)

NAVDAT transmission time slots in a NAVAREA/METAREA

Time slot: the 24 hours are divided into 72 slots of 20 minutes each according to the grid below.

0		1h			2h			3h			4h			5h			6h			7h			8h			9h			10h			11h			12h		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
		13h			14h			15h			16h			17h			18h			19h			20h			21h			22h			23h			24h		
37	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**6.0**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**

To compare the volume of data transmitted if we may compare NAVTEX and NAVDAT:

For a 20 mn NAVTEX transmission at 50 bits/s the maximun data volume transmitted is **7.5 kB**

For a 20 mn NAVDAT slot at an average flow of 20 kbits/s the maximun data volume transmitted is **3 MB**

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THE NAVDAT IN THE GMDSS

Section 6 Message numbering

All files coming from the different MSI or SAR related information providers are concentrated on a **NAVDAT server** which formats, calculates the broadcasting times and assigns a **message number** (which represents the list order of broadcasting).

The message number is solely allocated as a component of the NAVDAT message and should not be confused with (and bears no correlation to), the series identity and consecutive number of the Coastal warning contained in the message.

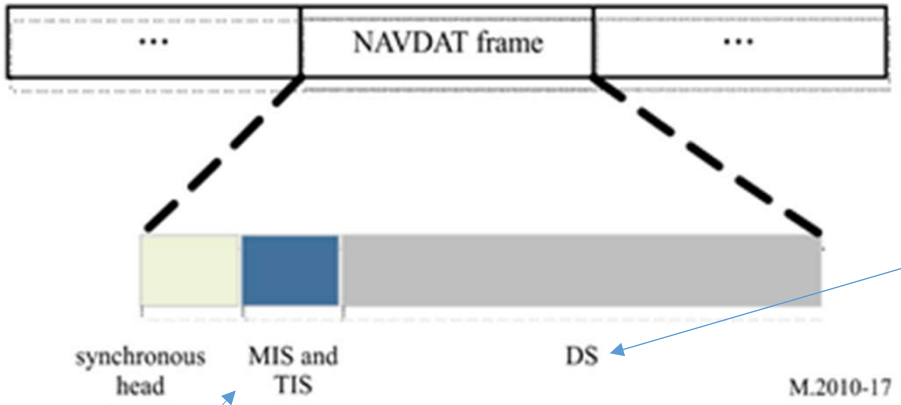
When a message is received for the first time by a **NAVDAT receiver**, the message is recorded and stored in the memory for 72 hours. This ensures that subsequent transmissions of the same message are not repeated in the display, unless they are re-received over 72 hours later.

THE NAVDAT IN THE GMDSS

Section 7 Message format

NAVDAT messages must be composed in accordance with the guidelines contained in the latest edition of the Joint IMO/IHO/WMO Manual on Maritime Safety Information and IHO Publication [S-53][S-100]. The digital format of all messages can be adapted to text, data or graphical information and entered into the NAVDAT frame structure.

The NAVDAT frame structure



the Data Stream (DS) contains the broadcast messages, with their allocated message numbers given by the information provider

Reserved for the synchronization of the receiver

the modulation information stream (MIS) part gives information about the spectrum occupancy, the type of transmitter information stream (TIS) and data stream (DS) modulation

the TIS part gives information about the error encoding of DS, coast station identification code (ID), broadcast mode, mode of robustness and subject message codes

BROADCAST OF DIGITAL FILES ON NAVDAT

International Hydrographic Organization

The propagation channel depends on the propagation mode and the frequency used. Report ITU-R BS.2144 which describes the broadcast Digital Radio Mondiale (DRM) with an Orthogonal frequency division multiplexing (OFDM) modulation defines **4 categories of basic transmission modes** that can be used for our analysis as describe in the following table:

Mode	Robustness	Typical propagation condition	Usable frequency band
A	Surface wave channels with minor fading	Surface Wave	MF (500 kHz)
B	Time and frequency selective channel with longer delay spread	Sky Wave	MF and HF
C	As B but with higher Doppler spread	Sky Wave	only HF long range
D	As B but with severe delay and Doppler spread	Sky Wave	only HF long range

For all robustness mode (A to D):

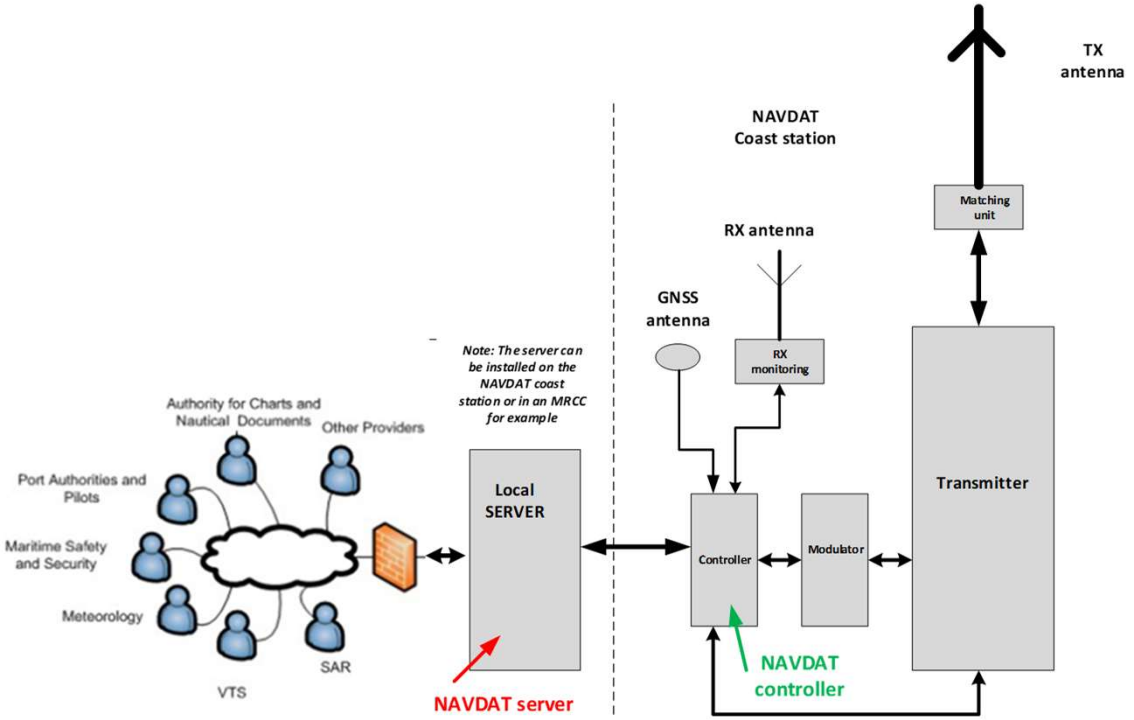
3 different modulations scheme (4, 16 or 64 QAM) can be used with code rate of 0.5 or 0.75.

(QAM: Quadrature Amplitude Modulation)

BROADCAST OF DIGITAL FILES ON NAVDAT

International Hydrographic Organization

The NAVDAT Broadcast chain



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BROADCAST OF DIGITAL FILES ON NAVDAT

Principle of operation

Each authorized information provider can access the NAVDAT server with a specific authenticated address.

Each file prepared by the information provider will have a heading giving the title of the document as well as the identification number of this document.

When connecting to the NAVDAT server, a window will open allowing the information provider to upload the file (or files) and configure the broadcast (periodicity and order of priority).

After validation by the information provider, the file will be entered in the NAVDAT server's log list and a message number will be assigned to each file transmitted. At the same time a confirmation copy of the validated log is sent to the provider at the origin of the message.

For each file the NAVDAT server will calculate the broadcasting time in relation to the size of the file and the selected parameters. It will verify that all the files submitted by the information provider can be broadcast inside the 20-minute slot. Otherwise, the last ROUTINE message(s) will be transferred to other slots and will inform the information provider of this situation.

NAVDAT SHIP RECEIVER

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The NAVDAT ship receiver should receive the main MF channel (500 kHz) and the main HF channel (4 226 kHz) simultaneously.

It should also be possible to receive, via a scanning function, at least one (or more) another frequency allocated to NAVDAT at international, national or regional level (in MF or HF maritime bands).

The NAVDAT ship receiver may decode the main MF channel (500 kHz) and the main HF channel (4 226 kHz) simultaneously.

The receiver can be a stand-alone equipment with an integrated display and interface to other external equipment or a black box type equipment.

To ensure proper operation of the receiver scan function, the transmitters of active NAVDAT coast stations will broadcast, before the NAVDAT frames, a pure carrier extended by an identification of the station and a blank, all repeated 3 times for a total duration of 3 seconds. This will allow the receiver to detect the transmission and tune in to the frequency, measure its SNR, identify the NAVDAT coast station and its NAVAREA/METAREA where it is located.

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Any question?

Anyway, I recommend to study the draft NAVDAT manual for further details.

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