FIRST MARITIME BUSINESS TEXTBOOK SERIES



A handbook for maritime **NAVIGATION SYSTEMS**

A collective work by

First Maritime Marine Team

A Handbook for Maritime Navigation Systems

A collective work by First Maritime Marine team



Table of contents

FEW WORDS ABOUT LIGHTHOUSE TRAINING PROGRAM ..... B
What is LIGHTHOUSE training program? ..... B
The role of FIRST MARITIME in navigation systems industry in our region ..... B
Lighthouse's third publication, « A handbook for Maritime Navigation systems » ..... B

AN INTRODUCTION TO MARINE NAVIGATION SYSTEMS 2

A SHORT HISTORY OF NAVIGATION SYSTEMS & ITS FUTURE 4
FROM ANCIENT TIMES TO THE END OF THE 19th CENTURY 4
20TH CENTURY – 100 YEARS OF CHANGES IN NAVIGATION 8
NAVIGATION IN THE 21ST CENTURY 10
NAVIGATION SYSTEMS IN THE FUTURE 13

TYPES & SHORT DEFINITION OF NAVIGATION SYSTEMS 15
GYRO COMPASS 15
RADAR 15
MAGNETIC COMPASS 16
AUTO PILOT 17
ARPA (Automatic Radar Plotting Aid) 17
AUTOMATIC TRACKING AID 18
SPEED & DISTANCE LOG DEVICE 18
ECHO SOUNDER 19
ECDIS (ELECTRIC CHART DISPLAY INFORMATION SYSTEM) 19
AIS (AUTOMATIC IDENTIFICATION SYSTEM) 20
LONG RANGE TRACKING AND IDENTIFICATION (LRIT) SYSTEM 20
RUDDER ANGLE INDICATOR 21
VOYAGE DATA RECORDER 22
RATE OF TURN INDICATOR 23
GPS RECEIVER 23
SOUND RECEPTION SYSTEM 24
NAVIGATIONAL LIGHTS 24
SHIP WHISTLE 25
DAYLIGHT SIGNALING LAMP 26
PILOT CARD 26
VOYAGE PLAN 27
FORECASTLE BELL 27
MANEUVERING BOOKLET 28
BLACK BALL SHAPE 29

RECORD OF NAVIGATIONAL ACTIVITIES 30
RECORD OF MAINTENANCE OF NAVIGATIONAL EQUIPMENT 30
WHEELHOUSE POSTERS 30
TRANSMITTING HEADING DEVICE 31
BLACK DIAMOND SHAPE 31
SHIP FLAGS 32

DETAILED EXPLANATION ABOUT NAVICO PRODUCTS 33
NAVICO Brands 33
SIMRAD Commercial Under Magnifier 36
AIS (Automatic Identification system) 36
Introduction 36
History 37
Why we need AIS? 38
What information does AIS need? 38
AIS on vessels 38
AIS class A approach 38
AIS class B approach 39
AtoN (Aids to Navigation) 39
Beach stations 40
Types of buoyancy data 40
Information displayed 40
Reasons for AIS 41
How AIS works? 41
Comparison between radar & AIS information 42
Advantages of using a dedicated monitor for AIS 42
Selection & installation of AIS antenna 43
Device installation requirements 43
Antenna and VHF cable 43
GPS antenna 45
Cabling interface equipment 45
Power supply 45
System configuration 46
AIS safety 46
NAVICO Featured AIS products 46
AIS V5035 Class A Transceiver 47
V3100 SOTDMA Class B AIS 48
NAIS-500 Class B AIS 48
NSPL-500 Antenna Splitter 49
Autopilot 50
What are Boat Autopilot systems? 50
How Boat Autopilots Work? 50
Principle of operations 51
How Boat Autopilots Work? 52
Different Types of Boat Autopilot Systems 52
Above-Deck Tiller and Wheel Autopilots 53
Below-Deck Autopilots 53
Autopilot Advantages 53
Disadvantages of Autopilots 54

Table of contents

When an Autopilot Should Not Be Used 54
Tips for Safe Autopilot Use 54
NAVICO Featured Autopilot products 55
SIMRAD AP70 Mk2 Autopilot 56
Continuum Steering Technology 57
Thruster Integration & Rudder Feedback Support 57
SIMRAD A2004 Autopilot 58
Proven SIMRAD Interface 60
Continuum Steering Technology 60
Optically Bonded 4.1-inch Color Display 61
Thruster Integration & Rudder Feedback Support 61
Products Positioning 62
Feature Comparison 63
GPS (Global Positioning System) 64
Introduction 64
Development of GPS 64
How Does GPS Work? 65
The Space Segment 65
The Control Segment 66
The User Segment 66
GPS technical analysis 66
The Essence of Time 67
Coming Full Circle 68
Almanac Data 68
Errors of GPS 69
DGPS (Differential GPS) 69
How to Use Marine GPS for Boating? 70
Marine Navigation with GPS 71
Why You Need GPS on Your Boat 71
Other Uses for GPS on Boats 71
Anchor Alarm 71
Security System 71
Additional Features 72
NAVICO Featured GPS Products 72
GPS Displays 72
Compass and Antenna 73
SIMRAD P3007 & P2005 GPS Systems 73
P3007 & P2005 Key features 74
MX521B DGPS Smart Antenna with GLONASS 75
Product details 75
Key Features 76
SIMRAD HS80A GNSS Compass 76
Product details 76
Type Approvals 76
Supplementary Sensors 76
Interface 77
Key features 77
Sonar 78
Introduction 78
History 78
ASDIC 79
SONAR 81
US Navy Underwater Sound Laboratory 81

Materials and designs in the US and Japan 82
Later developments in transducers 83
Active sonar 83
Project Artemis 85
Transponder 85
Upward looking sonar 85
Passive sonar 85
Identifying sound sources 85
Noise limitations 86
Scattering 86
Countermeasures 88
Chirp Technology 88
Types of Chirp (Only Name) 88
Fishers 90
Echo Sounding 91
Technique 91
Fishfinder 92
Fathometer 92
General interpretation 92
Fish arches 93
General history in sporting and fishing 94
Commercial and naval units 94
What is a CHIRP Sonar? 95
How Does CHIRP Sonar Work? 95
Low, Medium & High CHIRP 95
Dual Channel Chirp 96
Transducers 96
NAVICO Featured Sonars, Sounders & Echosounders Products 96
S2009 Fish Finder 98
Integrated CHIRP Echosounder 98
9-inch Portrait Display 98
Networking & Expansion 98
Key Features 98
S2016 Fish Finder 99
16-inch Widescreen Display 99
Key Features 99
S3009 Navigation Echosounder 100
IMO Type Approved Echosounder 100
Simple, Modern Interface for Easy Operation 100
Single or Dual Transducer Capability 100
Highly Reliable Data with On-Screen Scrollback and SD storage 101
Sophisticated Alert Management 101
Supports 50 kHz and 200 kHz Transducers 101
High Resolution Display 101
Industry-Standard Connectivity 101
Key Features 101
Commercial Radar 102
Introduction 102
History 103
First experiments 103
Just before the World War 2 104
During World War 2 107
Applications 107
Principles 108

Table of contents

Radar Signal 108
Illumination 109
Reflection 109
Doppler effect 110
Limiting Factors 111
Beam path and range 111
Noise 112
Interference 113
Clutter 113
Jamming 114
Radar Signal Processing (Distance Measurement) 115
Transit time 115
Frequency Modulation 115
Pulse Compression 116
Radar Signal Processing (Speed Measurement) 117
Pulse-Doppler signal processing 117
Radar Signal Processing (Peripherals) 118
Reduction of interference effects 118
Plot and track extraction 118
Engineering 119
Antenna design 120
Parabolic reflector 120
Types of Scan 121
Slotted Waveguide 122
Phased Array 122
Frequency Bands 123
Modulators 126
Coolant 126
Regulations 126
Track Algorithm 127
Marine Radar 127
Collision avoidance 127
Navigation 127
Radar controls 127
X Band 128
S Band 128
NAVICO Featured Radar Products 128
HALO Dome Radars 129
HALO™ Open Array Radars 130
HD Digital Radar 130
Simrad HALO-6 Pulse Compression Radar 131
Product details 131
See Near and Far, Simultaneously 131
Safety, Weather, and Bird-Finder Radar 131
Ready in an Instant 131
Minimum product requirements 132
Key Features 132
Simrad HALO-4 Pulse Compression Radar 132
Key Features 132
Simrad HALO-3 Pulse Compression Radar 133
Key Features 133
HALO Radars Compact descriptions 133
HALO Pulse Compression Radars have: 134

Unique Product Features ... 138
Target Consumer Summary ... 138
Competitor Comparison ... 139
Simrad HALO-24 Dome Radar ... 140
VelocityTrack™ Doppler Technology Built-In ... 141
Key Features ... 142
Simrad HALO-20+ Radar ... 142
Key Features ... 143
Simrad HALO-20 Radar ... 143
Key Features ... 145
HD Digital Radar TXL-10S-4 ... 145
Key Features ... 146
R5000 X- and S-Band Radar ... 147
Key Features ... 147
IMO/Solas Requirements ... 147
Categories of Ships ... 148
Target Consumer summary ... 149
R3016 Radar Control Unit ... 150
16-inch Widescreen Radar Control Unit ... 150
Rugged Design with Flexible Mounting Options ... 150
Keypad Operation with Direct-Access Menu Keys ... 150
Networking & Expansion ... 151
HDMI Output for Display Mirroring/Clone Station ... 151
Main Features ... 151
Marine VHF Radio ... 151
Introduction ... 151
Background ... 152
Types of equipment ... 153
Voice-only ... 153
Digital Selective Calling ... 153
Automatic identification system ... 154
Text messaging ... 154
Regulation ... 154
What is TRA approved? ... 154
Oman TRA ... 154
Vision ... 155
Mission ... 155
Automatic Transmitter Identification System (marine) ... 155
Channels & Frequencies ... 155
Which VHF Radio Channels Can be Use? ... 155
Channel 16: ... 155
Channel 9: ... 156
Channels 68, 69, 71, 72 and 78A: ... 156
Channels 1, 7A, 8, 10, 11, 18A, 19A, 63, 77, 79A, 80A and 88A: ... 156
Channel 13: ... 156
Channels 24, 25, 26, 27, 28, 84, 85, 86 and 87: ... 156
Channel 22: ... 156
Channel 6: ... 156
Channels 1, 5, 12, 14, 20, 63, 65A, 66A, 73, 74 and 77: ... 156
Channel 70: ... 156
Some notes: ... 156
Operating procedure ... 157
Navico Featured VHF Products ... 158
RS100-B Simrad VHF and GPS-500 ... 158

Table of contents

Complete visibility with integrated AIS 159
A modular system to fit any boat 159
Key Features 160
RS40-B VHF Radio 160
See and Be Seen with Integrated AIS 161
Removable Fist Mic 161
Expandable with Wireless Handsets 161
Key Features 161
RS20S VHF Radio 162
An Easy-to-Use Radio for Any Vessel 162
Class D DSC Approved 162
Easy Access to All International Channels 162
Key Features 162
Target Consumer Summary 163
ECDIS (ELECTRIC CHART DISPLAY AND INFORMATION SYSTEM) 164
Introduction 164
Advantages of ECDIS over paper charts 165
Types of ECDIS charts 165
ECDIS covered under the following 165
ENC (Electronic Navigational Chart) Layers 165
Minimum Interface Requirement 165
ECDIS Compliance 166
Chart Updating 166
Voyage Recording 166
Alarms and/or Indication in ECDIS 166
Alarms 166
Alarms or Indication 166
Indication 167
Power Supply 167
Carriage Requirement 167
Limitations of ECDIS 167
IMO Performance Standards for ECDIS 168
ECDIS Training 168
Concept of ECDIS 168
NAVICO Featured AIS Products 169
Simrad ECDIS900 MK15 24” 4S 170
IMO Type Approval 170
All-in-One PC Solution 170
Easy to Use 171
Advanced Route Planning and Optimization 171
Precise Navigation Tools 171
Logbook 171
Key Features 172
Simrad ECDIS900 MK5A W/ M5027 172
Key Features 173
Gyro compass 173
Introduction 173
Operation 174
History 175
NAVICO Featured Gyro compass Products 176
Gyro Compass 177
GC85 Compact Gyro System MK2 178
GC80 Expanded Gyro System MK2 178
GC80 Compact Gyro System MK2 179

Bridge Instruments 180
Introduction 180
NAVICO Featured Bridge Instruments Products 180
I3005 & I3007 Instrument 180
Key Features 181
SAL R1A Easy Tank Speed Log 182
Acoustic Correlation 182
Easy Tank for Easy Installation 182
Connectivity 182
Key Features 182
Monitors 183
NAVICO Featured Monitors 183
M5000 Series Widescreen Marine Monitors 184
M5016, M5019, M5024 and M5027 184
HD/Full HD Widescreen 184
Flush-Mount Installation 184
All-Glass Look, Optically Bonded 185
Main Features 185
MFD (Multi-function display) / Chartplotters 186
NAVICO Featured MFDs / Chartplotters 186
Simrad NSS9-12-16 evo3s 186
Make the most of your vessel 187
SolarMAX IPS displays ensure clear views in any conditions 187
Built-in high performance echosounder 187
Fast and Simple networking connects a wide range of accessories 187
Wireless connectivity to your smartphone or tablet 187
Radar options 187
Key Features 187
Simrad NSS7-9-12-16 evo3 188
Make the most of the boat 188
Touchscreen plus keypad for intuitive and reliable control 188
Chartplotter with built-in GPS makes navigation easy 188
SolarMAX™ HD displays ensure clear views in any conditions 189
Built-in echosounder supports fishing and safer cruising 189
Simple networking connects you to a wide range of accessories 189
Wireless connectivity to your smartphone or tablet 189
Radar Options 189
Broadband 4G™ Radar for greater situational awareness 189
LOWRANCE Featured Products 190
Fish Finders / Chartplotters 190
HOOK REVEAL 190
Casual, weekend anglers 190
Key Features 191
Tech Specs 191
Display Size 191
ELITE FS 191
Avid Weekend Anglers 191
Key Features 191
Tech Specs 192
Display Size 192
HDS LIVE 192
Tournament & Serious Anglers 192
Key Features 192
Tech Specs 193

Table of contents

Display Size ... 193
C-MAP ... 194
DISCOVER ... 195
CORE FEATURES ... 195
FULL-FEATURED VECTOR CHARTS ... 195
HI-RES BATHYMETRY LAYER ... 196
CUSTOM DEPTH SHADING ... 196
EASY ROUTING ... 196
TIDES & CURRENTS ... 197
DETAILED MARINA PORT PLANS ... 197
Available Charts for the GULF Region ... 198
AFRICA & ARABIA SEA CONTINENTAL DISCOVER Chart ... 198
RED SEA TO THE GULF AND SEYCHELLES IS. REVEAL Chart ... 198
PERSIAN GULF – OMAN DISCOVER Chart ... 199

LANDSCAPE AND OPPORTUNITIES IN THE UAE/GCC BOAT MARKET ... 200
Market Dynamics (Market Size Estimates) ... 200
Maritime Market Drivers in the GCC ... 202
Oman Freezones ... 202
SOHAR Freezone ... 202
SALALAH Freezone ... 202
KHAZAEN Economic City ... 202
Al Duqm Port & Drydock ... 202
Oman National Vision ... 202
Mission ... 202
Qatar Freezones ... 203
Qatar National Vision 2030 ... 203
Qatar Free Zones are made up of two free zones ... 203
Ras Bufontas ... 203
Umm Al Houl ... 203
Dubai Industrial Strategy 2030 ... 203
Dubai Maritime City (DMC) ... 203
Dubai Canal ... 204
Waterfront development of residential properties ... 204
Restraints ... 204
Volatility in oil prices ... 204
Need for Standard Regulations for manufacture of boats in the GCC ... 204
VAT Implementation ... 204
Challenges ... 204
High costs involved in boat/yacht maintenance can be daunting ... 204
Lack of adequate berthing facilities across the GCC ... 204
Shortage of Repair and Maintenance facilities in the GCC/UAE ... 204
Conclusion ... 205

GLOSSARY ... 206

RESOURCES ... 228

Few words about LIGHTHOUSE training program

From its inception, First Maritime Company is committed to meet the highest professional standards. This hails from the strong belief that working habits and processes, based on mindful and demonstrated standards, generate corporate value and definitely help at reaching business targets.

What is LIGHTHOUSE training program?

The LIGHTHOUSE training program is a tool used by First Maritime staff members to enforce “stay on top” standard policy during their operations throughout their carrier path.

By delivering flexible and customized training packages, Lighthouse program is a multi-modal training platform ready to address training needs:

- By creating an online collaborative experience-based community through a permanent digital framework
- By supporting online training schemes including cloud shared space, social network groups, distance learning platforms
- By archiving and putting at disposal series of training contents and materials available online
- By making possible exchange of views and questions related to related business

The role of FIRST MARITIME in navigation systems industry in our region

As a dealer, the objective of FMGTC for the navigation systems market is to embody its vision throughout our region: be the go-to trustable supplier in the region with outstanding solutions in performance and safety, with a world class service and support team on hand to answer any enquiry.

Alongside FMGC is determined at making quality equipment available and affordable for more and more customers through smart portfolio and commercial policy. No need to say this has to meet specific regional needs and requirements.

That is the mission ahead of FMGTC to reach high satisfaction level for customers and stakeholders altogether. Let’s do it.

Lighthouse’s third publication, « A handbook for Maritime Navigation systems »

After « A nutshell explanation of the shipping art » published in 2020 and “What are polymers about” published in 2021, we are pleased today to introduce the third title of our specialized textbooks. Derived from the collection by First Maritime Commercial Marine Team of open-source specialized materials, this textbook, entitled « A handbook for Maritime Navigation systems », is an introduction to the sophisticated world of maritime communication systems’ business. As the dealer of Simrad, Lowrance, B&G, C-MAP in Oman, no doubt this effort will strengthen our understanding of customers ‘needs for navigation systems and facilitate our daily commercial operations.

As the third publication resulting from LIGHTHOUSE program activities, we wish it will not only benefit First Maritime staff members but also prove helpful to a larger audience among its business community environment.

Julien PELISSIER,

CEO of First Maritime Company

First Maritime Lighthouse program team

January 2022

An Introduction to Marine Navigation Systems

A navigation system is a computing system that aids in navigation. Navigation systems may be entirely on board the vehicle or vessel that the system is controlling (for example, on the ship's bridge) or located elsewhere, making use of radio or another signal transmission to control the vehicle or vessel. In some cases, a combination of these methods is used.

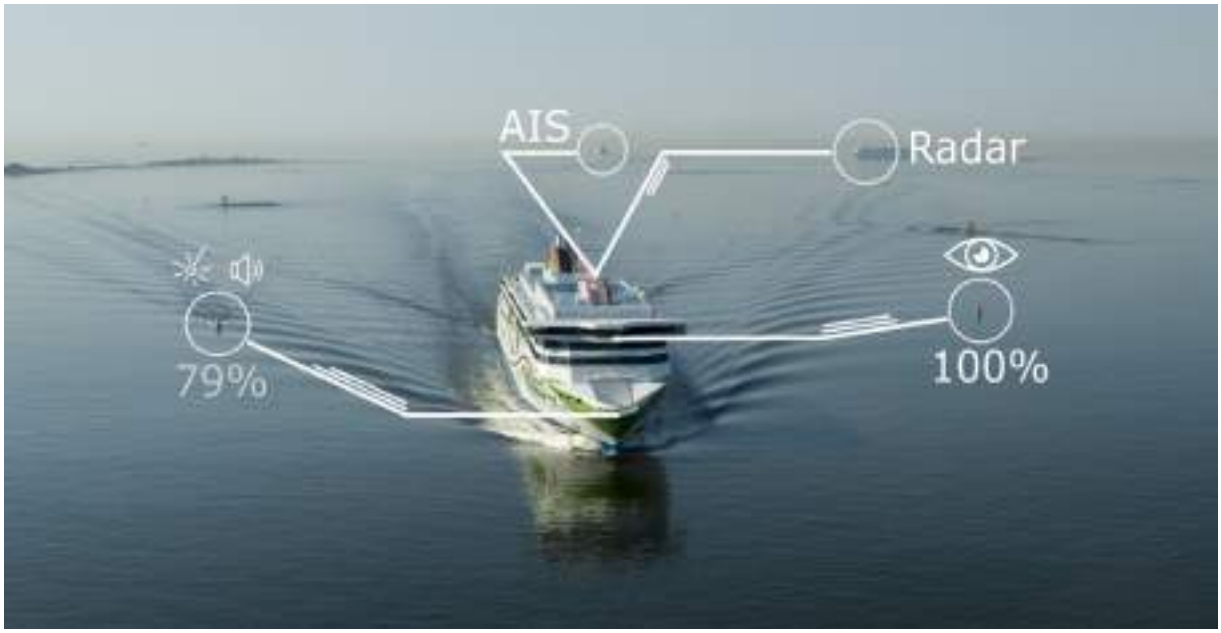


Fig 1) Merchant vessel’s example use of Navigation Systems

Navigation systems may be capable of one or more of:

- containing maps, which may be displayed in human-readable format via text or in a graphical format
- determining a vehicle or vessel's location via sensors, maps, or information from external sources
- providing suggested directions to a human in charge of a vehicle or vessel via text or speech
- providing directions directly to an autonomous vehicle such as a robotic probe or guided missile
- providing information on nearby vehicles or vessels, or other hazards or obstacles
- providing information on traffic conditions and suggesting alternative directions
- simultaneous localization and mapping

- acoustic positioning for underwater navigation



Fig 2) Simrad devices installed in a vessel

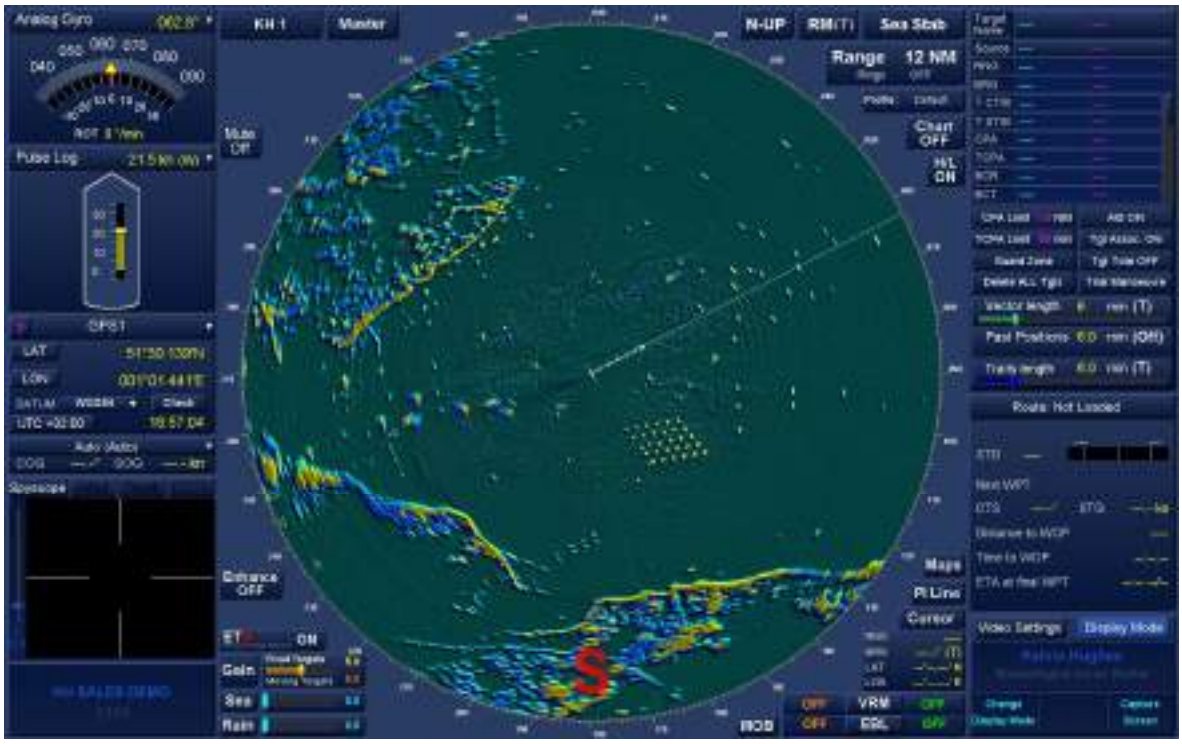


Fig 3) An example of Radar display

A Short History of Navigation Systems & Its Future

Marine navigation today mostly means:

- modern satellite systems, both the existing ones and those that will be launched in the nearest future;
- systems integrating pieces of a vessel's equipment: electronic navigational charts, speed and course gauges and tracking a vessel's movement, i.e., ECDIS equipment;
- communications systems, for example, the GMDSS (Global Maritime Distress and Safety System), which are used to alert vessels and coordinate search and rescue operations at sea;
- vessel traffic monitoring and control systems, such as the VTS, AIS, and LRIT. (Vessel traffic service, automatic identification system, Long-Range Identification and Tracking)

However, as is the case with every area of human activity, navigation would not have developed if we had not had knowledge about its history. Over the centuries, positioning methods were developed as technology progressed. Reflections on the development of navigation could be divided based on current positioning methods:

- analytical,
- comparative,
- terrestrial,
- astronomical,
- satellite-based, and
- inertial ones.

Nonetheless, the text below presents the development of positioning methods in chronological order.

FROM ANCIENT TIMES TO THE END OF THE 19th CENTURY

In ancient times sailors could only rely on their own senses, whereas what was beyond the horizon was "terra incognita", i.e., a world full of obstacles, dangers and mysteries. Both ancient and contemporary navigation can be defined as "a process of conducting a vehicle from one point to another in a safe and effective way in the appropriate physical and geographical environment". Thus, navigation marks started to be used as early as ancient times. Towers

that served as visual aids to navigation were erected along a flat shoreline. Standard lighthouses were also built, for example, in Piraeus, Ostia or near Ravenna.

The most famous one, Pharos of Alexandria was built about the year 280 B.C., was 160 meters high and probably had a light range of 50 km. It became a model for most other lighthouses**.**



Fig 3) Lighthouse on the Island of Pharos

These were the beginnings of the oldest type of marine navigation, i.e., terrestrial navigation. Until the end of the 19th century, terrestrial navigation was based on optical navigation systems. Depending on where particular marks and devices are located and how they are arranged,

navigation marks can be divided into:

- fixed navigation marks – these are structures or devices that are placed on land or on special platforms that are driven into the seabed; they are placed in very specific locations and they are usually equipped with the appropriate devices that ensure large visibility radius and reliable operation;
- floating navigation marks – these are special structures or devices that have been adapted so as to be positioned on the sea surface in locations with precisely defined geographic coordinates and anchored to the seabed. Among fixed navigation marks are, for example:
- lighthouses – these represent the most important and the most well-known type of fixed navigation aids; they have been used from the beginning of the history of sailing;
- beacons – these are wooden, steel or concrete structures that are either placed on shore or in shallow coastal waters;
- leading marks – it is an arrangement of two or more navigation marks that are located relative to one another at a given distance so that they determine a line or sector in the horizontal plane;

- piles or dolphins – these are structures made of piles which are driven into the seabed and tied or loosely connected above the water;
- poles – these are structurally the simplest navigation marks; among them are bars or rods which are driven into the seabed and which are sometimes also equipped with a top mark.



Fig 4) Examples of fixed navigation marks.

Among floating navigation marks are, for example:

- lightvessels – these were specially constructed vessels with a characteristic silhouette that made them distinguishable from other vessels; a lantern was usually mounted amidships at about 15 m a.s.l.; they are not used anymore due to high operating costs;
- buoys – these are metal or plastic structures which are geometrically shaped and anchored; they are used to mark fairways, navigational hazards and the boundaries of bodies of water;
- spar buoys – these are anchored spars that float upright in the water; they serve as substitute

navigation marks.



Fig 5) Examples of floating navigation marks.

The vessel positioning methods that are used in terrestrial navigation are mainly based on simple graphical structures that are employed in geodesy. These methods can be divided depending on:

- number of marks that are used;
- time interval between observations;
- type of position lines.
- Flags and fanions

Human beings have always been trying to synchronize their activity with the environment around them, and therefore, the traditional nautical units of measure used in navigation, such as a nautical mile and cable length, are to this day connected with mathematical modelling of the Earth. Ancient sailors used celestial bodies along with shoreline objects – they could determine geographic directions by observing the Sun and the North Star. However, astronavigation only started developing rapidly in the 17th century, which was an era of great geographical discoveries.

In 1631 Pierre Vernier invented an instrument that allowed one to take more precise measurements and obtain fractions of degrees of an angle, which is known as the vernier scale, and:

- in 1730 Thomas Godfrey constructed the first sextant;

- in 1764 the first chronometer was built; this instrument made it possible to precisely measure time;



Fig 6) Instruments used in astronavigation.

- 1837 saw a breakthrough in celestial navigation because this was when Thomas Sumner discovered the position line, which has provided a basis for modern astronavigation; the astronomical position line, i.e., the "parallel of equal altitude", was discovered by analogy with a classic lighthouse;
- in 1845 Marcq Saint-Hilaire described an altitude-based method of determining the astronomical position line.

20TH CENTURY – 100 YEARS OF CHANGES IN NAVIGATION

The age of changes in navigation began in 1934, when the Committee for the Scientific Study of Air Defense came up with an idea of creating a device that would be able to defend the UK from German air attack.

Reports from post offices indicated that there were disruptions

to telephone services, which compelled scientists to analyze this phenomenon. Therefore, the first experimental measurement apparatus was constructed in order to answer the question as to whether radio waves could be reflected by other objects.

A simple experiment was conducted on 26 February 1935. An aircraft that was flying through an electromagnetic field over an antenna emitting a radio wave at a frequency of 6 MHz (49 m) reflected this wave, which was displayed on the oscillator's screen. After this date, an era of radar navigation began; this era can be described in terms of over a dozen important dates, some of which are provided

below:

- March–May 1939 – antennas of ground-based radar stations had been installed along the coast of England;
- 1940 – RAF aircraft were equipped with the Gee system which supported the process of identifying air targets; it was a prototype of an on-board radar system;
- 1941 – a radar guidance system was developed for Royal Navy vessels;
- the 1960s and 1970s – all types of vessels were equipped en masse with navigation radars;
- 1984 – it became obligatory for vessels to be equipped with a radar and ARPA (Automatic Radar Plotting Aid) devices.

Radar-based navigation amounts to constructing graphical structures, which are also used in terrestrial navigation, where radar echo that has been correctly identified constitutes a navigation mark. The simplest example of how a vessel can determine its own position is as follows: one reads bearings to two selected and clearly identified targets (i.e., their echoes) from the radar screen, and then transfers these bearings onto a nautical chart and reads the vessel's position. What

is more, a navigation radar is also used to determine the elements of movement of another vessel that is being observed and it also supports the decision-making process regarding a change of one's movement parameters so as to avoid a collision. In the past this was done by constructing simple graphical structures on the radar screen, whereas today it is ARPA radars that are used for this purpose. These devices independently generate data about the movement of a vessel that is being observed and show what actions a navigator should take in order to avoid a collision.



Fig 7) Display units of RADAR – ARPA.

The Decca Navigator System, i.e., the first ground-based radio-navigation system, was another breakthrough invention of the first half of the 20th century. This system's advantages were demonstrated during the Normandy Landings.



Fig 8) Receivers for the Decca Navigator System.

After World War II ended, ground-based satellite systems began developing rapidly. Since there were many local positioning systems, which were incompatible, a large number of receivers often hindered rather than supported navigators' work. This is why the idea of integrated navigation systems

for one-man-bridge operation emerged.



Fig 9) Example: one man bridge system

Two main types of radio-navigation positioning methods can be identified:

- in the past, the values for position lines were read from the system's receiver and then plotted on a nautical chart that was specifically designed for that purpose; the navigational position was read from the chart;
- currently the modern receivers show the geographic coordinates of a vessel's position, which are transferred onto a nautical chart.

Today, navigation is mostly based on satellite systems. The era of "conquering" space for the purposes of positioning, as broadly understood, began in 1964, i.e., when the TRANSIT system was put into operation. It was also made available for civilian uses in 1967. Then in 1968, a Russian counterpart of this system, i.e., CYKADA, started to be used. In 1973 the GPS Navstar system was created [Specht 2007] and it was fully functional in 1995. The Russian GLONASS system began to be deployed in 1982 and it became fully operational in 1994.

NAVIGATION IN THE 21ST CENTURY

As Einstein said, limitations only exist in a human being's mind. Therefore, it is impossible to determine how each type of navigation will develop in the future. Today one can only point to those aspects of navigation that are progressing rapidly and changing this field of science. Currently, satellite systems are being further developed, not only for the purposes of navigation, but also with regard to any other human activity on the planet.

The European satellite system Galileo has started its operational deployment phase. Finally, this system consists of 30 satellites which are placed in three orbits.

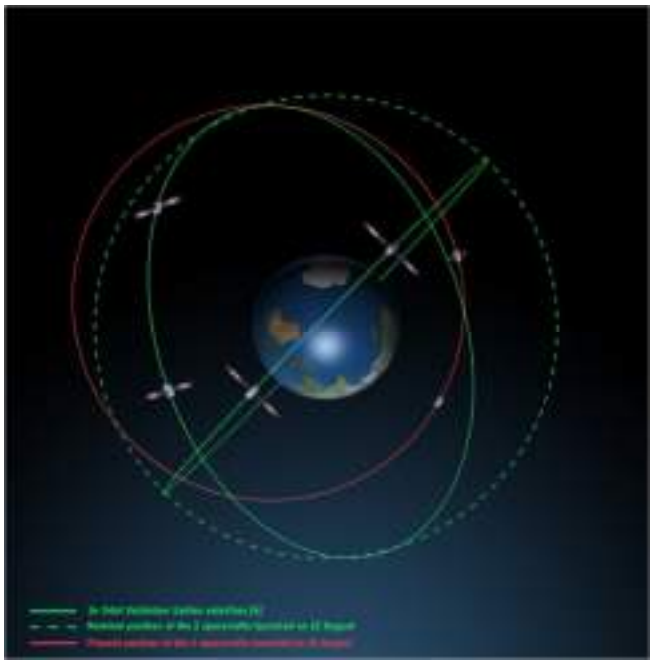


Fig 10) Galileo satellite orbits

Other countries, i.e., Japan and India, are also working on their own satellite systems.

This trend shows that the ability to determine the positions of particular objects by using different types of navigation on earth will depend on the technology that has been launched into space. Comparative navigation, which is a relatively new method, is constantly being developed. This approach deals with determining an object's position by comparing a dynamically registered image with an image of a given pattern. Among images that are registered in this way can be radar images, sonar images and aerial photographs which have been properly prepared for comparison with radar and sonar images or aerial photographs (maps) that are stored in computer memory.

These are the main positioning methods that are used in comparative navigation:

- analytical methods, which are based on classical minimum distance functions or similarity functions;
- artificial intelligence methods, i.e., artificial neural networks and other bio algorithms. From the beginning of its existence, navigation has been related to the model of the Earth's surface, i.e., a navigational chart. Such charts change rapidly, just like navigation itself. Currently, navigational charts are evolving into:
- electronic charts, on which a vessel's position is plotted dynamically;
- 3D nautical charts, which provide realistic representations of a given sea area as well as the vessel's position.

The figure below presents examples of contemporary electronic navigational charts.



Fig 11) Examples of electronic navigational charts

The vehicles that human beings use change as the environment around them changes. Current research studies show that the vehicles of the 21st century will move autonomously. The most well-known studies in this field are focused on constructing cars of the future and unmanned aerial vehicles (UAV), which are commonly known as drones. Moreover, autonomous underwater vehicles will appear at sea. Tethered underwater vehicles are commonly used today but they are evolving into devices that can move independently at sea. The main research problem in navigation is how an autonomous underwater vehicle will determine its own position since it is impossible to use classical positioning systems, for example, terrestrial or satellite-based systems, in the depths of the sea. It seems that the issue of a vehicle's capability to determine its own position in an automatic and autonomous way will be the main trend in the development of navigation in the 21st century. Navigation tools that are used on the Earth's surface will evolve towards autonomous systems, whereas space navigation, which will allow human beings to make interplanetary flights, should be based on navigation systems that will be placed in space.



Fig 12) GPS satellites.

NAVIGATION SYSTEMS IN THE FUTURE

Yet the changes of the last decade will be eclipsed by the transformation in the decades to come, which will accelerate as the shipping industry embraces greater digitalization and moves towards an era of smart and connected operations.

Marine portfolio has evolved from standalone single function products, through smart products with feature rich software, better user interface and integrated sensor data, to smart and connected products combining remote monitoring, control and optimization.

This vision reflects not just the advances in technology that can deliver data more widely and securely, but the influences on the industry, particularly from digital transformation and the need for sustainability.

The efficiency gains required to meet long term sustainability targets will require shipping to embrace vessel efficiency and voyage optimization on a completely new level and will place a stronger emphasis on connectivity to the wider transport and logistics supply chain.

It has also been recognized that the trend towards enhanced connectivity and greater use of networks creates a further challenges that must be considered.

In the last decade, the integration of more and more sensors into bridge systems has become the industry standard, but it has also created problems, principally how to avoid users being overwhelmed with information and data that could distract them from their mission.

One of the next challenges will be to move beyond simply pulling and sharing data with navigators to simplifying the presentation of information in more intelligent ways that drive human decision-making. This creates the opportunity to share the information load with shoreside systems that can process the information and present specialist teams with options that can support navigators onboard.

For some, this path leads inevitably to the era of autonomous or remote-controlled ships but such an outcome – in mainstream shipping at least – is far from a foregone conclusion. What is likely is that crew numbers will be progressively reduced as technology advances and that a globally connected bridge system can enjoy remote operational and maintenance support.

The critical lesson of the past is that things move faster than we expect and often develop in ways we can’t predict. Shipping needs to think about how to absorb and understand these disruptive influences, embrace new thinking and continue to push the boundaries. This means that the regulated bridge may stays at the heart of the vessel but how it integrates to the wider industry will change beyond all recognition.

As a ‘system of systems’, the vessel’s operational technology will in future be connected to port and terminal systems for monitoring and control and to shoreside vessel management for optimization and maintenance. Data services designed to promote optimization and efficiency will be seamlessly connected and the operator can share selected information with customers and partners.



Fig 13) Autonomous shipping

Types & Short Definition of Navigation Systems

Gone are the days when a ship navigation officer had to take help of unconventional ways to plan and navigate a voyage at sea. Today, a ship officer has myriad of marine navigation equipment which makes his life a lot simpler, thanks to the advancement in technology. Moreover, present-day seafarers are trained so as to know the functioning and operation of all modern-day navigational equipment that has made the journey at sea smoother and safer.

With modern day facilities and automation, a ship today has several advanced navigation equipment systems which give accurate data for the voyage.

Herein, there are 30 types of navigational equipment explained, both old and new, which are present on all merchant ships.

GYRO COMPASS

It is used for finding the right direction. Unlike magnetic compass, gyro compass is not hampered by an external magnetic field. It is used to find the correct North Position, which is also the earth's rotational axis to provide a stable directional source. Its repeater system must be present in the steering platform for emergency steering.



Fig 14) Gyro compass

RADAR

The seagoing vessels depend on S-band and X-band frequency radar system for navigation as it can detect targets and display the information on the screen such as the distance of the ship from land,

any floating objects (an island, rocks, iceberg etc.), other vessels, and obstacles to avoid a collision. It is a rotating antenna which discovers the surrounding area of the ship.



Fig 15) SIMRAD R3016 Radar Control Unit Display - 16" w/HALO-4 Radar Bundle

MAGNETIC COMPASS

The magnetic compass work in conjunction with the magnetic field of the earth and is the essential means of the direction indicating device. It is used to get a planned course for the voyage. This ship navigation equipment is usually fitted at the center line of the ship on the monkey island. A transmitting magnetic type compass is fitted so that the output can be displayed in the bridge panel.



Fig 16) Magnetic compass

AUTO PILOT

The ship bridge layout is filled with equipment and tools used for navigation. The autopilot is considered to be one of the most effective bridge navigational equipment as it assists the human operator in controlling the ship by keeping the steering in autopilot, which allows them to concentrate on broad aspects of the operation.

It is a combination of hydraulic, mechanical, and electrical system and is used to control the ship's steering system from a remote location (Navigation bridge).





Fig 17) Auto pilot

ARPA (Automatic Radar Plotting Aid)

Automatic Radar Plotting Aid displays the position of a ship and other vessels nearby. The radar displays the position of the ships in the vicinity and selects the course for the vessel by avoiding any kind of collision.

This bridge navigational equipment constantly monitors the ship's surrounding and automatically acquires the number of targets, in this case; ships, boats, stationary or floating objects etc., and plot their speeds and courses respectively. It also presents them as vectors on the display screen and constantly update the parameters with each turn of the antenna by calculating their nearest points of approach to own ship and also the time before this will occur.



Fig 18) Typical on-board Radar system

AUTOMATIC TRACKING AID

Just like ARPA, automatic tracking aid displays the information on tracked targets in graphic and numeric to generate a planned layout for a safer and collision-free course.

Usually, A large size target measuring 800 m or more in the circumference is considered as a landmass and not tracked. Echoes less than 800 m are deemed as targets to be tracked.

SPEED & DISTANCE LOG DEVICE

This bridge equipment on a ship is used to measure the speed and the distance travelled by a ship from a set point. By calculating the same, ETA of the ship is adjusted or given to the port authority and agent.



Fig 19) Speed & Distance Log Device

ECHO SOUNDER

There are many modern ship navigation tools present on ship and echo sounder is one of the instruments which has been in the play from almost 100 years now. It is used to measure the depth of the water below the ship's bottom using sound waves which work on the principle of transmission of sound waves and an audio pulse which will bounce off a reflecting layer, returning as an echo to the source.



Fig 20) SIMRAD S2016 Echosounder

ECDIS (ELECTRIC CHART DISPLAY INFORMATION SYSTEM)

ECDIS is a development in the navigational chart system used in naval vessels and ships. With the use of the electronic navigation equipment, it has become easier for a ship's navigating crew to pinpoint locations, and attaining directions are easier than before.



Fig 21) Ecdis system

AIS (AUTOMATIC IDENTIFICATION SYSTEM)

AIS is also among the types of a navigation system which helps to pinpoint the location and other navigational statistics of ships. AIS uses VHF radio channels as transmitters and receivers to send and receive messages between ships which endeavors to fulfil a lot of responsibilities.

As per the regulation enforced by The International Maritime Organization (IMO), all passengers' vessels and commercial ships over 299 Gross Tonnage (GT) sailing in the international to carry a Class A AIS transponder.



Fig 22) SIMRAD V5035 AIS-Transceiver Class A

LONG RANGE TRACKING AND IDENTIFICATION (LRIT) SYSTEM

LRIT is an international tracking and identification system incorporated by the IMO under its SOLAS convention to ensure a thorough tracking system for ships of 300 gross tons and above which are on international voyages across the world. This maritime equipment is fitted to improve the maritime domain awareness.

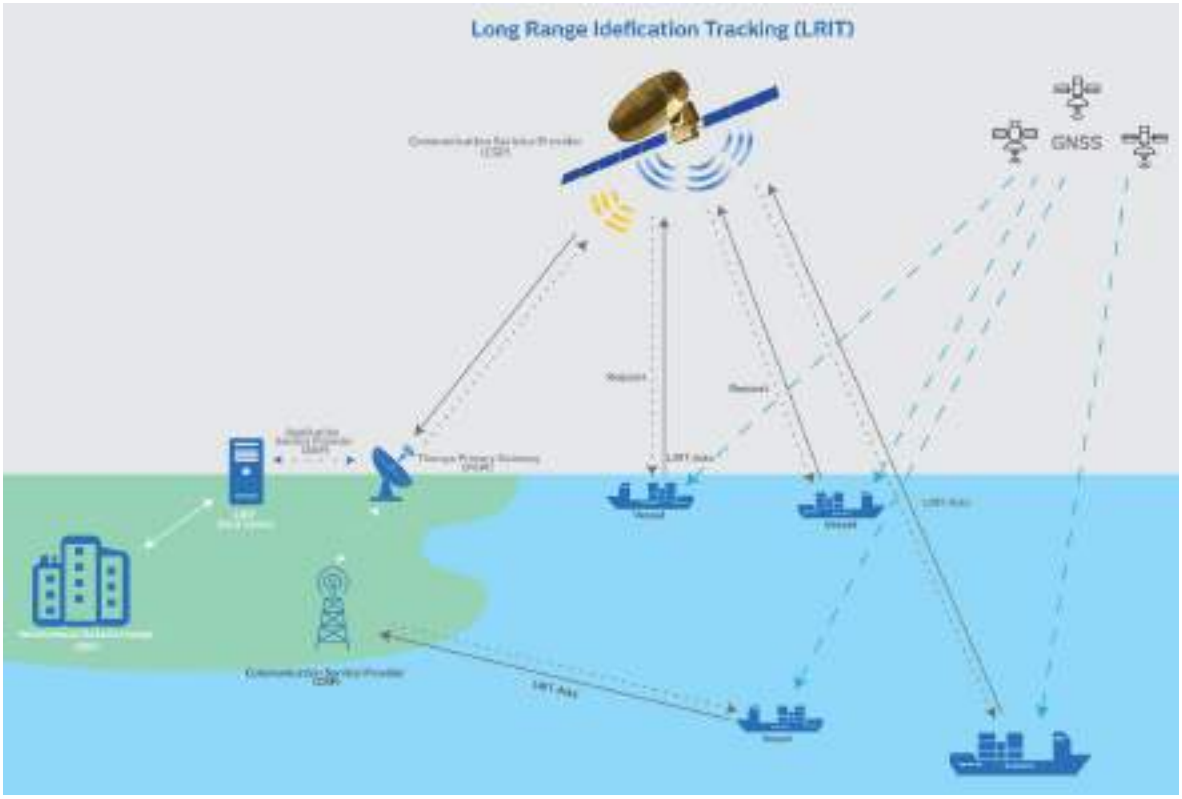


Fig 23) LRIT schematic

RUDDER ANGLE INDICATOR

Rudder angle indicator, as the name indicates, provides the angle of the rudder. The display is provided on the navigation bridge equipment console so that the ship navigation officer can control the rate of turn and rudder angle of the ship. The indication is also provided in the bridge wing and engine control room.



Fig 24) Simrad RI35 Rudder angle indicator



Fig 25) Rudder Angle indicator

VOYAGE DATA RECORDER

A VDR or voyage data recorder is a crucial instrument among the ship navigation equipment list which is installed on a ship to continuously record vital information related to the operation of a vessel. It contains a voice recording system for a period of at least the last 12 hours. This recording is recovered and made use of for investigation in events of accidents. The importance of VDR is similar to a “black box” installed on an airplane.

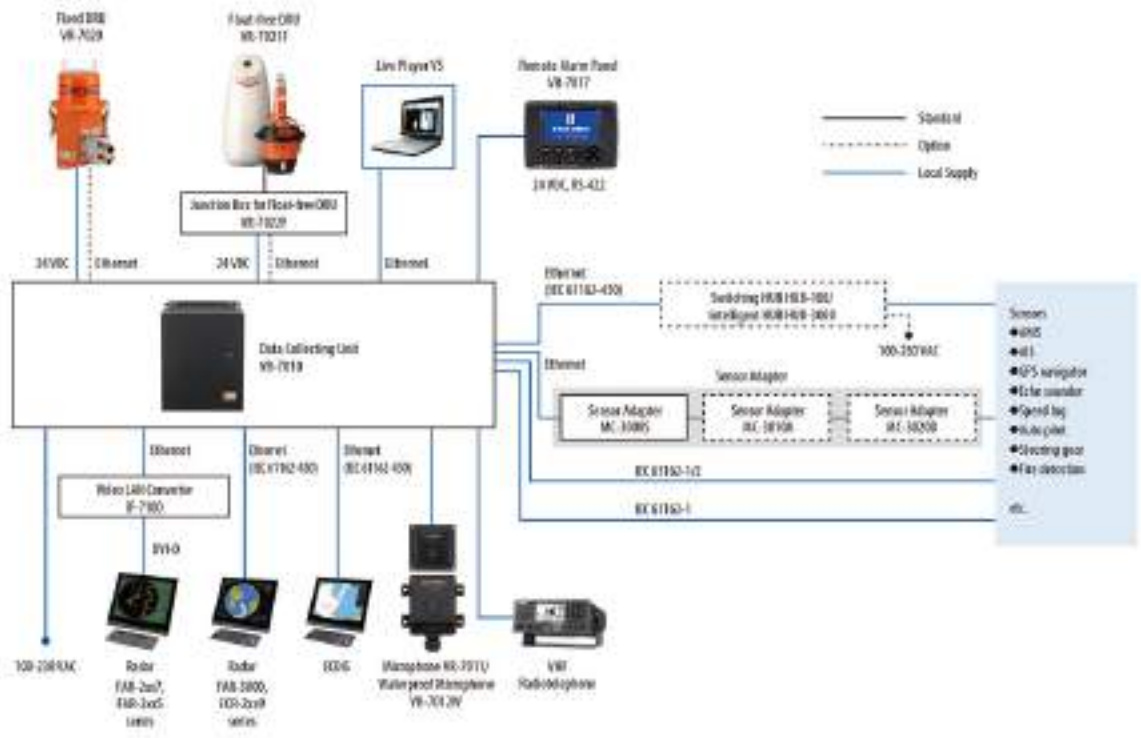




Fig 26) Voyage data recorder

RATE OF TURN INDICATOR

This navigational tool indicates how fast the ship is turning at a steady rate (useful during pilotage and maneuvering), normally shown as a number of degrees turned. The rate a ship is turning is measured in degrees per minute. This essential tool assists a coxswain in steering a course safely.



Fig 27) Rate of turn indicator

GPS RECEIVER

A Global Positioning System (GPS) receiver is a display system used to show the ship's location with the help of Global positioning satellite in the earth's orbit.

With the record of the ship's positions, the speed, course, and the time is taken to cover the distance between "two marked positions" can be calculated.



Fig 28) A waterproof marine GPS receiver

SOUND RECEPTION SYSTEM

This acoustic system is required for a ship with a fully enclosed type bridge. It enables the navigating officer inside the cabin to listen to the sound signals (such as fog or ship's horn) from other ships in the vicinity. This is fitted in ships bridge equipment console and helps the navigating officer to conduct the look-out duty as per the International Regulations for Preventing Collisions at Sea.



Fig 29) An example of sound reception system

NAVIGATIONAL LIGHTS

All boats – whether big or small are required to have night lights as a part of the navigation systems. This system was introduced in the year 1838 by the United States and then was followed by the United Kingdom in 1849. In the year 1889, the International Maritime Conference was established by the

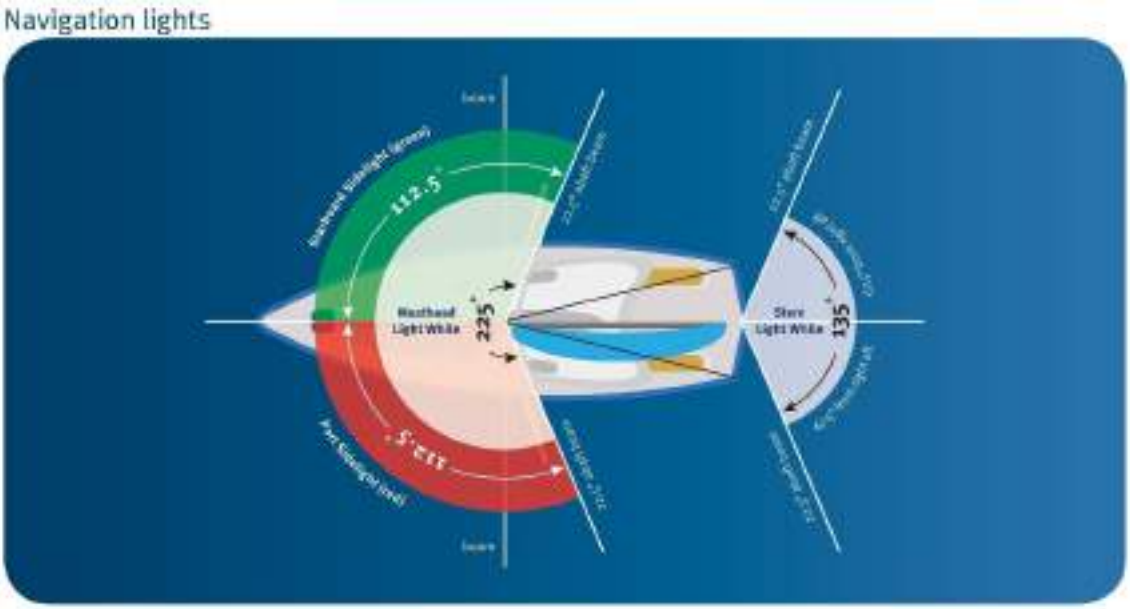


Fig 30) Navigational lights

United States to establish proper guidelines to prevent marine accidents. In the year 1897, these rules were officially adopted internationally. The navigation lights are one of the most critical navigation equipment needed for sailing in high seas as it enables self-vessel being clearly visible to other ships in the vicinity.



Fig 31) Navigational lights

SHIP WHISTLE

A ship's horn is known as a whistle and it is generally provided in duplicate. One is driven by air and the other is electrically operated. The whistle should be both manually and electrically operational from the bridge.

Among different instruments used in difficult navigation such as bad weather, fog, poor visibility, high traffic etc., the ship's whistle or horn helps in alerting the nearby vessels.

During an emergency, the horn is used to notify and alert the ship's crew and other vessels nearby.



Fig 32) Ship whistle

DAYLIGHT SIGNALING LAMP

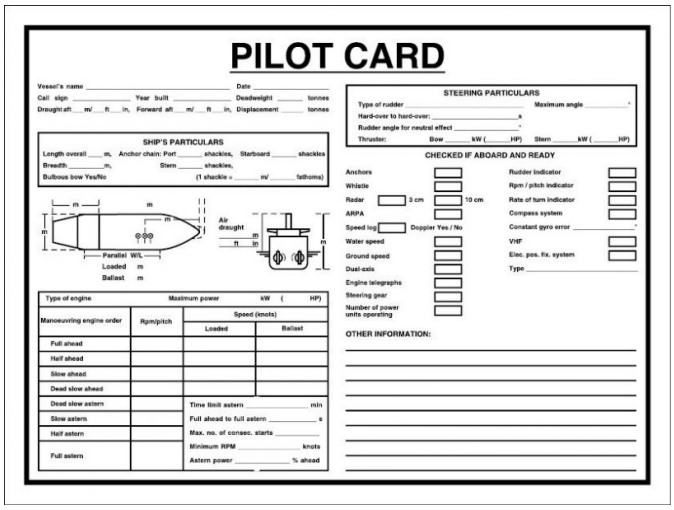
They are light-signaling devices used for emergency signaling in the day time (and can also be used during the night). Like other emergency ship instruments, the energy source for the lamp is not solely dependent on the ship's main power supply. Also, the lamp enclosure should be weather and seawater- proof material.



Fig 33) Daylight signaling lamp

PILOT CARD

It is an informative booklet provided to the ship's pilot. It consists of the dimension, draught, turning circle, maneuvering, propulsion equipment and other navigation tools and instruments list of the vessel for safe maneuvering.



PILOT CARD

Vessel's name _____ Date _____
Call sign _____ Year built _____ Deadweight _____ tonnes
Draught aft ___ m/___ ft ___ in, Forward aft ___ m/___ ft ___ in, Displacement _____ tonnes

SHIP'S PARTICULARS
Length overall ___ m, Anchor chain: Port _____ shackles, Starboard _____ shackles
Breadth _____ m, Stern _____ shackles,
Bulbous bow Yes/No (1 shackle = _____ m/_____ fathoms)

STEERING PARTICULARS
Type of rudder _____ Maximum angle _____ °
Hard-over to hard-over: _____ s
Rudder angle for neutral effect _____ °
Thruster: Bow _____ kW (_____HP) Stern _____ kW (_____HP)

CHECKED IF ABOARD AND READY

Anchors		Rudder indicator	
Whistle		Rpm / pitch indicator	
Radar	3 cm / 10 cm	Rate of turn indicator	
ARPA		Compass system	
Speed log	Doppler Yes / No	Constant gyro error	°
Water speed		VHF	
Ground speed		Elec. pos. fix. system	
Dual-axis		Type	
Engine telegraphs			
Steering gear			
Number of power units operating			

Parallel W/L
Loaded m
Ballast m
Air draught m / ft in

Type of engine Maximum power kW (HP)

Manoeuvring engine order	Rpm/pitch	Speed (knots) Loaded	Speed (knots) Ballast
Full ahead			
Half ahead			
Slow ahead			
Dead slow ahead			
Dead slow astern		Time limit astern _____ min	
Slow astern		Full ahead to full astern _____ s	
Half astern		Max. no. of consec. starts _____	
Full astern		Minimum RPM _____ knots	
		Astern power _____ % ahead	

OTHER INFORMATION:

Fig 34) Pilot card

VOYAGE PLAN

A voyage Plan must be present onboard for referring past voyage plans or planning a future voyage. Among the different aids to navigation carried on a ship, a voyage plan is a tool for the deck officer to ensure the safety of the ship from a commercial and legal perspective too. It is prepared by gathering different information such as weather, meteorological, ship's current and future cargo data, other navigational data etc.



Fig 35) Voyage plan

FORECASTLE BELL

It is used to mark the presence of the ship in fog or bad weather and sound the alarm in case of an emergency, along with the ship's main horn or whistle.



Fig 36) Forecastle bell

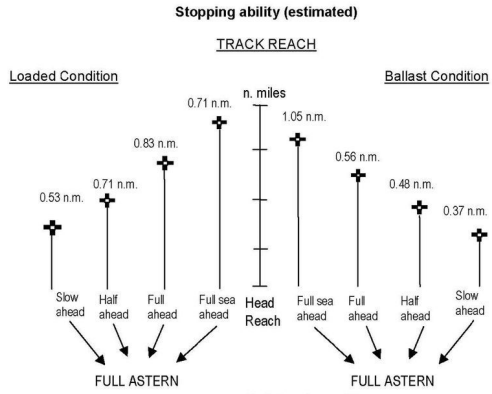


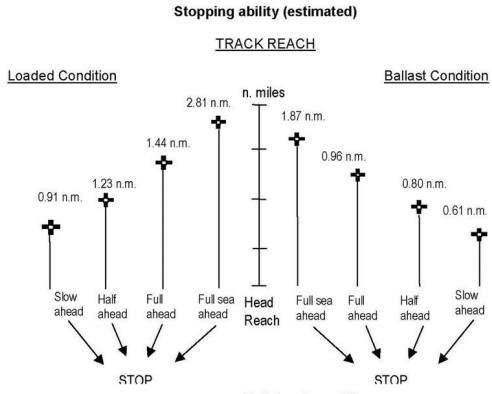
Fig 37) Forecastle bell

MANEUVERING BOOKLET

In this booklet, the performance of the propulsion plant and the ship during maneuvering in different weathers and situations is recorded for quick reference. The important contents of the maneuvering booklet are:

- Ships General description
- Maneuvering characteristics in deep water
- Stopping and speed control characteristics in deep water
- Maneuvering characteristics in shallow water
- Maneuvering characteristics in wind
- Maneuvering characteristics at low speed
- Additional information





Full Load condition

Full astern from:	Track Reach	Head Reach	Side Reach	Time required	Track reach deceleration factor
Full ahead (sea)	1.89 n.miles	1.87 n.miles	-0.04 n.miles	12m 02s	0.16 n.miles/min
Full ahead	0.88 n.miles	0.83 n.miles	-0.08 n.miles	8m 23s	0.10 n.miles/min
Half ahead	0.75 n.miles	0.71 n.miles	-0.07 n.miles	7m 11s	0.10 n.miles/min
Slow ahead	0.56 n.miles	0.53 n.miles	-0.03 n.miles	5m 22s	0.10 n.miles/min

Normal Ballast condition

Full astern from:	Track Reach	Head Reach	Side Reach	Time required	Track reach deceleration factor
Full ahead (sea)	1.06 n.miles	1.05 n.miles	-0.02 n.miles	6m 58s	0.15 n.miles/min
Full ahead	0.59 n.miles	0.56 n.miles	-0.05 n.miles	6m 10s	0.10 n.miles/min
Half ahead	0.51 n.miles	0.48 n.miles	-0.05 n.miles	5m 11s	0.10 n.miles/min
Slow ahead	0.39 n.miles	0.37 n.miles	-0.04 n.miles	3m 02s	0.13 n.miles/min

Full Load condition

Stop Engine from:	Track Reach	Head Reach	Side Reach	Time required	Track reach deceleration factor
Full ahead (sea)	2.94 n.miles	2.81 n.miles	0.53 n.miles	21m 26s	0.14 n.miles/min
Full ahead	1.90 n.miles	1.44 n.miles	0.74 n.miles	18m 27s	0.10 n.miles/min
Half ahead	1.63. n.miles	1.23 n.miles	0.64 n.miles	15m 48s	0.10 n.miles/min
Slow ahead	1.20 n.miles	0.91 n.miles	0.47 n.miles	11m 10s	0.11 n.miles/min

Normal Ballast condition

Stop Engine from	Track Reach	Head Reach	Side Reach	Time required	Track reach deceleration factor
Full ahead (sea)	1.96 n.miles	1.87 n.miles	0.36 n.miles	14m 22s	0.14 n.miles/min
Full ahead	1.26 n.miles	0.96 n.miles	0.50 n.miles	12m 25s	0.10 n.miles/min
Half ahead	1.05 n.miles	0.80 n.miles	0.41 n.miles	10m 16s	0.10 n.miles/min
Slow ahead	0.81 n.miles	0.61 n.miles	0.32 n.miles	7m 55s	0.10 n.miles/min

Fig 38) Maneuvering booklet

BLACK BALL SHAPE

It is a day time signaling shape used to determine the characteristics of the vessel with a different arrangement of ball shapes. For e.g. a vessel at anchor will show a black ball at the foremost end of the forecastle and a ship not under command shows two black balls in a vertical line on her highest mast.



Fig 39) Black ball shape

RECORD OF NAVIGATIONAL ACTIVITIES

All the navigational activities which are performed by the ship's officers and crew using different navigation equipment on the bridge must be recorded and kept on board for ready reference. This is mandatory and the most important log book.

RECORD OF MAINTENANCE OF NAVIGATIONAL EQUIPMENT

The hard copy of all the ship navigation system and equipment list must be present as records onboard ships for ready reference of port and regulatory authorities and must be signed by master and duty officers of the ship.

WHEELHOUSE POSTERS

Present in the Navigation bridge, it displays detailed information of maneuvering characteristics of the ship including turning circle, stopping and maneuvering characteristics of the vessel.

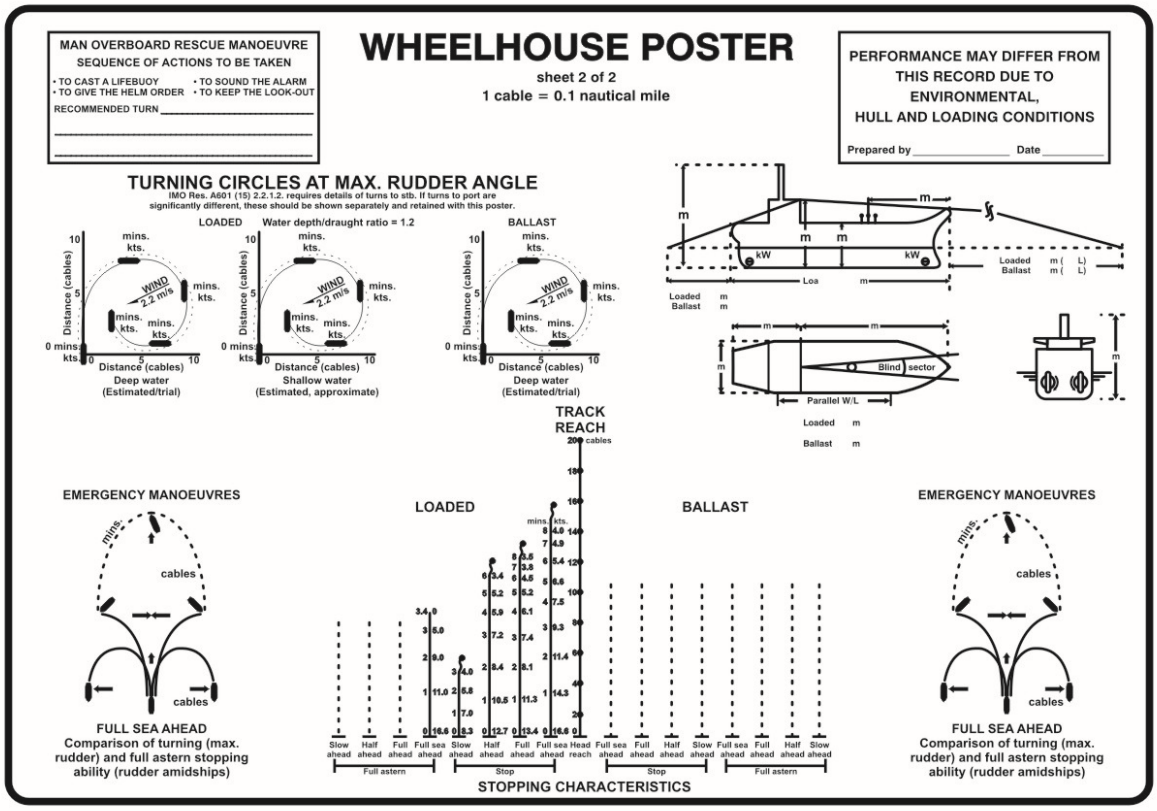
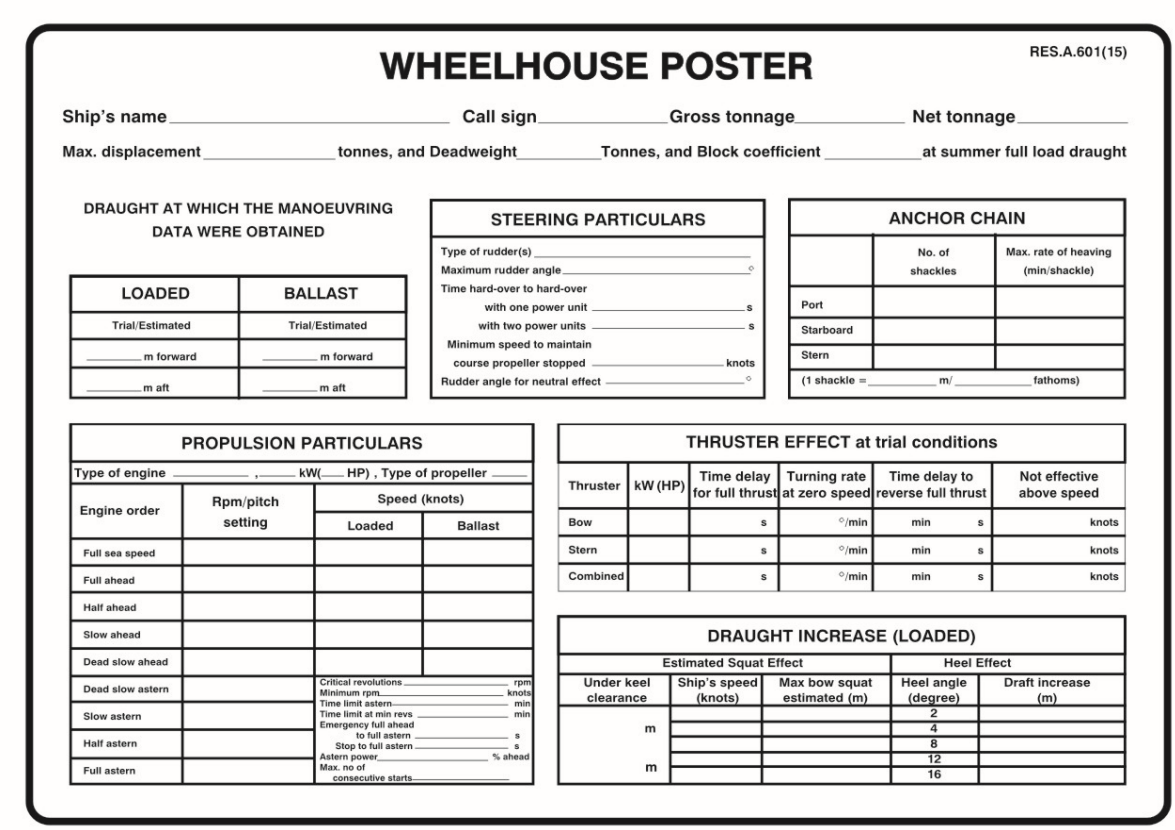


Fig 40) An example of wheelhouse posters



WHEELHOUSE POSTER

RES.A.601(15)

Ship's name _____ Call sign _____ Gross tonnage _____ Net tonnage _____

Max. displacement _____ tonnes, and Deadweight _____ Tonnes, and Block coefficient _____ at summer full load draught

DRAUGHT AT WHICH THE MANOEUVRING DATA WERE OBTAINED

LOADED	BALLAST
Trial/Estimated	Trial/Estimated
_____ m forward	_____ m forward
_____ m aft	_____ m aft

STEERING PARTICULARS

Type of rudder(s) _____
Maximum rudder angle _____ °
Time hard-over to hard-over
with one power unit _____ s
with two power units _____ s
Minimum speed to maintain
course propeller stopped _____ knots
Rudder angle for neutral effect _____ °

ANCHOR CHAIN

	No. of shackles	Max. rate of heaving (min/shackle)
Port		
Starboard		
Stern		

(1 shackle = _____ m/ _____ fathoms)

PROPULSION PARTICULARS

Type of engine _____ , _____ kW(____ HP) , Type of propeller _____

Engine order	Rpm/pitch setting	Speed (knots) Loaded	Speed (knots) Ballast
Full sea speed			
Full ahead			
Half ahead			
Slow ahead			
Dead slow ahead			
Dead slow astern			
Slow astern			
Half astern			
Full astern			

Critical revolutions _____ rpm
Minimum rpm _____ knots
Time limit astern _____ min
Time limit at min revs _____ min
Emergency full ahead to full astern _____ s
Stop to full astern _____ s
Astern power _____ % ahead
Max. no of consecutive starts _____

THRUSTER EFFECT at trial conditions

Thruster	kW (HP)	Time delay for full thrust	Turning rate at zero speed	Time delay to reverse full thrust	Not effective above speed
Bow		s	°/min	min s	knots
Stern		s	°/min	min s	knots
Combined		s	°/min	min s	knots

DRAUGHT INCREASE (LOADED)

Estimated Squat Effect			Heel Effect	
Under keel clearance	Ship's speed (knots)	Max bow squat estimated (m)	Heel angle (degree)	Draft increase (m)
m			2	
			4	
			8	
m			12	
			16	

Fig 41) An example of wheelhouse posters

TRANSMITTING HEADING DEVICE

Transmitting Heading Device or THD is an electronic device which is used to display the information of the vessel's true heading. The THDs compliance information is provided in chapter V of the SOLAS Convention.

BLACK DIAMOND SHAPE

When the ship is being towed or when a vessel is unable to maneuvers on itself, a black diamond shape is shown during the day time.

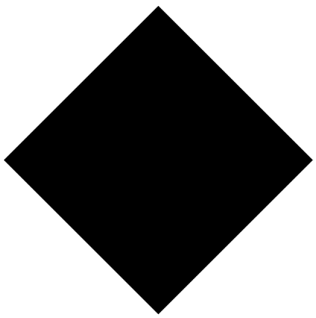


Fig 42) Black diamond shape

SHIP FLAGS

Various types of ship flags with different colors and signs are used to indicate a navigation ship's position. Signal flags are they are commonly known, have been used since the ancient times and are still used on all vessels.



Fig 43) Ship flags

Detailed Explanation About NAVICO Products

NAVICO is the leader in marine electronics and is currently the world's largest marine electronics company. NAVICO is the parent company to leading marine electronics brands: LOWRANCE, SIMRAD, B&G and C-MAP. NAVICO has approximately 1,500 employees globally and distribution in more than 100 countries. NAVICO partners with a talented, global supplier network to deliver quality products to its customers.

NAVICO Brands



SIMRAD
RECREATIONAL

SIMRAD Yachting’s range of products covers recreational vessels of all sizes, from small runabouts and sportfishing vessels up to luxury cruisers and superyachts. With a rich history spanning back to 1946, SIMRAD Yachting was born from the union of many distinguished pioneers in marine technology. Today SIMRAD Yachting offer a range of sophisticated auto steering, navigation and safety products with a commitment to deliver the most forward-thinking and practically-designed equipment on the market.

Detailed Explanation About NAVICO Products



SIMRAD
COMMERCIAL

The SIMRAD brand is a leader in electronics technology for commercial vessels. Over the past sixty years SIMRAD have developed systems for the benefit of commercial vessels. Today SIMRAD Commercial offer a range of sophisticated auto steering, navigation and safety products for vessels of all sizes, from small vessels on inland waterways to larger coastal commercial and passenger craft. SIMRAD Commercial continue to apply unrivalled experience to provide better system solutions and customer support for vessel owners around the world to maximize performance at sea by providing a complete range of navigation, performance and communications equipment.



LOWRANCE
FISHING

LOWRANCE has been a leader in marine electronics since it invented the first consumer sonar device in 1957 known as ‘The Little Green Box’. In the years since, LOWRANCE has never wavered from its purpose to push the envelope of innovative performance to help anglers find and catch more fish. LOWRANCE products are sold around the world serving the tournament fisherman, the seasoned pro, the avid weekend angler or the casual fisherman.



B&G

SAILING

B&G has been at the cutting edge of sailing innovation for 50 years. Our racing heritage gives us an unrivalled platform for developing new technology, which is put through its paces by the world's best, in the most challenging conditions. You'll find B&G powering Grand Prix victories and inspiring the adventures of cruising sailors around the world.



C-MAP

CARTOGRAPHY

Founded in 1985, C-MAP serves boaters worldwide, providing cartography products and services for all types of leisure boaters, from fishermen and sailing enthusiasts to powerboat owners. C-MAP worldwide cartography products and services include multiple formats for lakes, coasts and oceans. C-MAP products are compatible for different devices from all the leading brands.

SIMRAD Commercial Under Magnifier



Fig 44) Commercial Maritime vessels

In this textbook, the focus is on SIMRAD Commercial products. After a thorough explanation of each system, some of the system's featured products of the mentioned brand are brought and each one's features and benefits are discussed.

AIS (Automatic Identification system)

Introduction

System AIS Or Automatic Identification System A system that reports floating information and its position. Vessels equipped with this system automatically and dynamically share and update the position, speed, route and other floating information. AIS is a Complementary marine radar information And Used as a secondary method to prevent sea collisions. Position through GPS Receiving and transmitting between vessels by transceiver VHF will be done. AIS can help navigating officers to monitor and track the movement of vessels. The system is an international ship identification standard that allows the vessel to receive and transmit information from adjacent ships. It is basically a telecommunication system that automatically sends the position of the vessel and other data to other vessels and shore stations. It also transmits information related to vessel traffic management and navigation safety from coastal stations to vessels. It is an independent automated system for the exchange of navigation information between ships equipped with this device and coastal stations using separate messages in two specified sea channels.



Fig 45) AIS

System AIS was first introduced as a short-range system with a visibility of 10-20 miles between the transponder and the receiver. With the advancement of signal technology AIS Can be received by satellites equipped with low orbits. This can make the system global and track floating anywhere in the world.

History

It is not clear exactly when this device was made, but after the introduction GPS As a global coverage in the early 1990s, a combination of the system GPS With telecommunication technology VHF That was the system AIS Formed. In recent years, the use of AIS was developed as a system to prevent ship-to-ship collisions at low visibility and at night to assist radar. VHF Transmitted to be expanded. Finally in 2002 the use of the system AIS Class A On all passenger vessels and high merchant ships 300 GT By IMO Became mandatory. It was originally introduced as a short-range vessel detection and tracking system. But at the beginning of the 21st century, it became clear that the signal AIS Can be up to suffering 400 Km Received. In fact, this equipment and tracker and float to vessel became a float management system with global coverage.

Why we need AIS?

To create a favorable position for navigation, taking into account the limitations of visual vision, radar and telecommunications VHF and to avoid collisions regardless of the size of the boat, from IMO perspective AIS is a tool to prevent collisions when used in buoyancy mode (Ship-To-Ship mode) and it provides information on a vessel and its cargo to local authorities overseeing maritime trade. (Ship-To-Shore mode) and it helps officers involved in floating traffic management (Ship-To-Shore mode).

What information does AIS need?

- Unique insider float identification information
- GPS information to record and track the position of an insider
- VHF radio to send and receive AIS information signals

AIS on vessels

- ships with 300 or more gross tonnage, and all passenger ships regardless of size must have AIS class A.
- Vessels less than 300 gross tonnage can have AIS class B.
- Military and security vessels are now allowed to be tracked so their AIS transmitter are set to off.

AIS class A approach

- MMSI (maritime Mobile Service Identity) information
- Navigation status (anchor, etc.)
- True rotation rate, ground speed, position, path and heading
- Information is sent at sea with an interval of 10 seconds, in the anchor with an interval of 3 minutes.
- Additional information will be sent in 6 minutes.
- This type of AIS is installed on commercial vessels, just like as cargo ships and large passenger ships.
- Its transmitting power is 12.5 watts and it is higher than the class B, therefore, it can carry its information to more distant vessels.
- It obeys the SOTDMA protocol.
- This protocol stands for Self-Organizing Time Division Multiple Access.

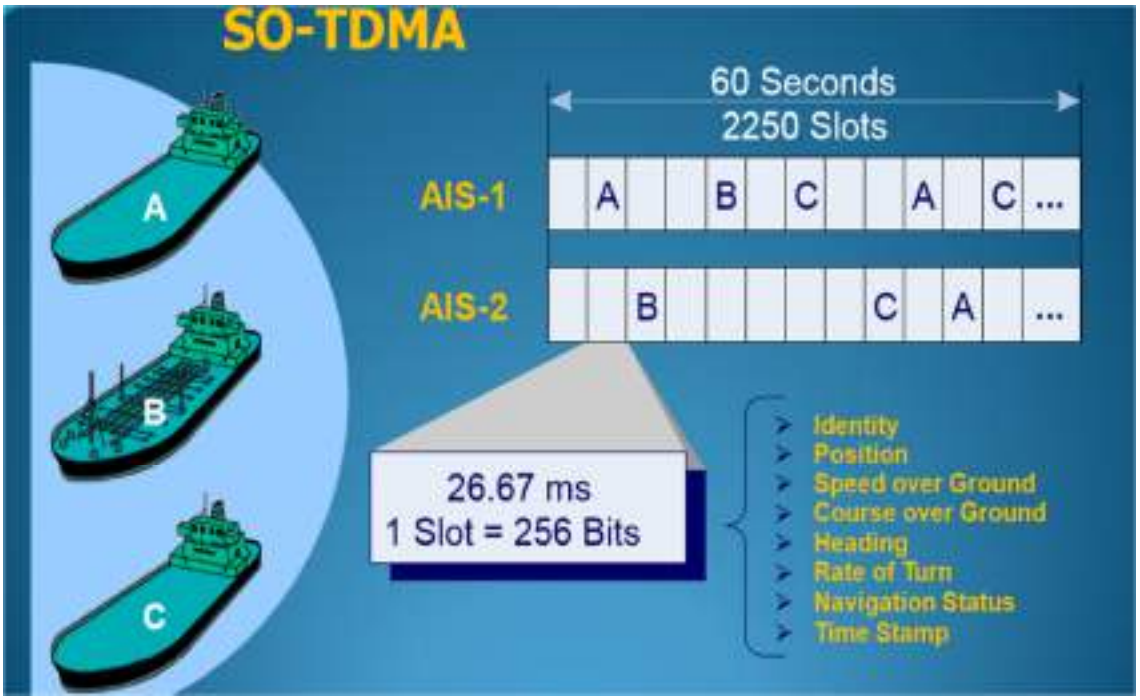


Fig 46) SO-TDMA

AIS class B approach

- MMSI (Maritime Mobile Service Identity) information
- True ground speed, position, path and heading
- This information is sent every 3 minutes when the ground speed is less than 2 knots. For speeds higher than 2knots, this information is sent every 30 seconds.
- Class B transceiver (transmitter and receiver) relative to Class A is cheaper due to its lower executive requirements.
- Additional information will be sent 6 minutes apart.
- It uses CSTDMA protocol.
- This protocol stands for Carrier Sense Time Division Multiple Access.
- Class B transceiver has less power (2 watts) compared to Class As and due its reporting rate is lower than the Class A.
- When the vessel is anchored, it sends the information every 6 minutes.
- Small floats use AIS class B which is nit under the laws of SOLAS.

AtoN (Aids to Navigation)

This type of transceiver is installed on buoys and other alarms for ships. And sends its location information to nearby ships.

Beach stations

AIS is used in these stations for displaying and controlling maritime or vessel traffic systems (VTS)

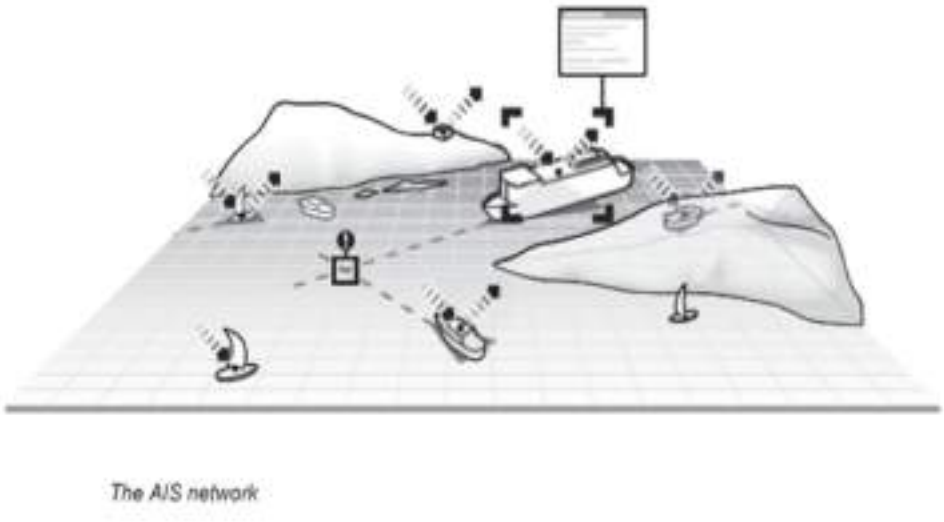


Fig 47) The AIS network

Types of buoyancy data

Information sent by the AIS is sent in to categories: static and dynamic

- Dynamic data: Velocity over ground (SOG), way on the ground (COG) and for these data GPS and automatic calculations are obtained
- Static data: It includes MMSI code, name, ID and size of the ship which must be sent via scheduled AIS

Information displayed

- MMAS (Both classes)
- Floating name (Both classes)
- Call sign (Both classes)
- Destination (Class A only)
- IMO number (Class A only)
- ETA Or the estimated time to reach the target (Class A only)
- Drinking (Class A only)
- Navigation status (In anchor-sailing, etc.) (Class A only)
- Dimensions (Both classes)
- Floating type (Both classes)
- Current date and time (UTC) (Both classes)
- Latitude / Longitude (both classes)
- SOG, COG (Both classes)

- Heading (for class A And if available for the class B)
- Rotation rate ROT (Rate of Turn) (Class only A)
- Exact position (both classes)
- Receiver DSC Installed (class only B)
- Seller number ID (class B only)

Reasons for AIS

- Avoid collisions
- More crew safety
- Improve buoyancy to buoyancy
- Provides your position relative to other vessels.
- Relative protection of boat capital
- Allows air and sea reconnaissance teams to identify your location (for search and rescue operations)
- Merchant fleet tracking

How AIS works?

The heart of this system is called a transfer protocol SOTDMA.

SOTDMA Abbreviation is (Self Organizing Time Division Multiple Access).

This protocol is what allows AIS to operate independently and continuously.

Each vessel, sends details of position, route, speed and specifications by telecommunication.

Any vessel within a radius of 37 km of the transmitter can receive and display this information.

It only takes a few milliseconds to transfer AIS data. Each ship can receive AIS information Update every few seconds.

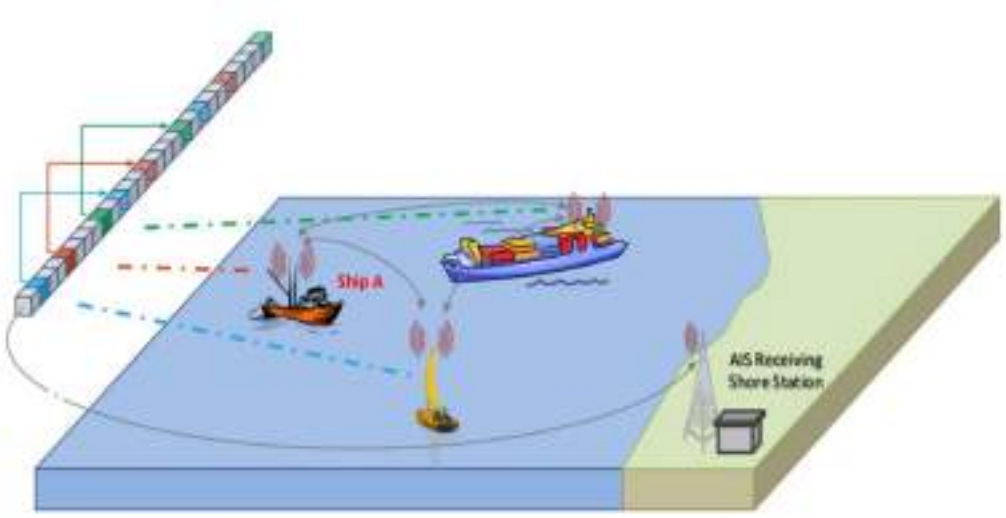


Fig 48) Visualization of an AIS system

Comparison between radar & AIS information

- Radar, definitely has advantages and it is vital in large vessels.
- AIS existence Makes all large vessels and many small vessels visible from a distance.
- Small floats will not be visible to radar next to large targets.
- When the target is close to land or behind islands, there is a better chance of being discovered by AIS than radar.
- AIS is Less affected by weather conditions.
- AIS electricity consumption is Lower.
- AIS Price is Less than radar.
- AIS is Equipped with buoys, Hydrographic information and water



Fig 49) Radar

Advantages of using a dedicated monitor for AIS

- All AIS information Can be Displayed without having to enter complex menus at high workloads.
- System Chart with AIS In high-traffic areas, can be difficult to identify targets.
- Some AIS monitors have the ability to filter out minor goals so that they can focus only on larger goals.
- Display power consumption is very low (about 3 watts)
- Install a dedicated AIS monitor is very simple.

Selection & installation of AIS antenna

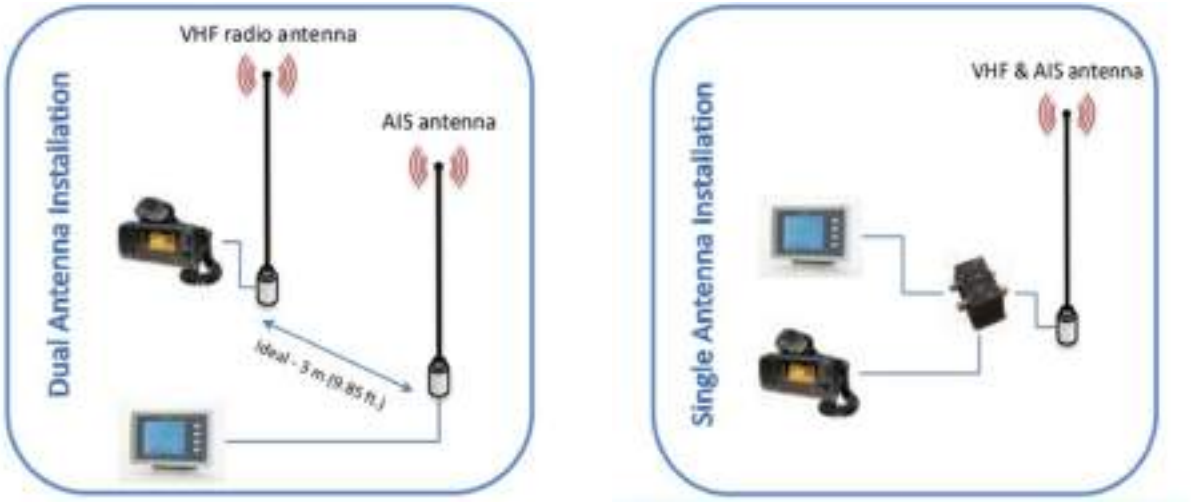


Fig 50) Installation guide

It can be made of two antennas; AIS, VHF or an integrated antenna.

- Install the antenna as high as possible. Ideally at least 2 to 3 meters above the water surface
- Do not install a radar antenna on the beam.
- It should not be integrated with other equipment antennas.
- The minimum ideal distance to the next antenna is 3 meters.
- Do not place the antenna in the shadow of the command bridge or body.

Device installation requirements

1. Antenna and VHF cable
2. GPS Antenna
3. Cabling equipment Interface
4. Power supplies
5. The main plug

Antenna and VHF cable

- AIS Operating frequency at the upper end of the VHF-FM band Is (162 MHz)
- VHF Standard marine Antennas do not perform optimally at this frequency.
- Suitable antennas should be used for optimal system performance.
- Possibility of integration with the GPS antenna.
- Must be at least 1/8 meter (6 feet) away from conductive objects.
- Must be at least 1/8 meter (6 feet) high or low from VHF antenna.

- Otherwise, it must be at least 1.9 meters (30 feet) horizontally apart.

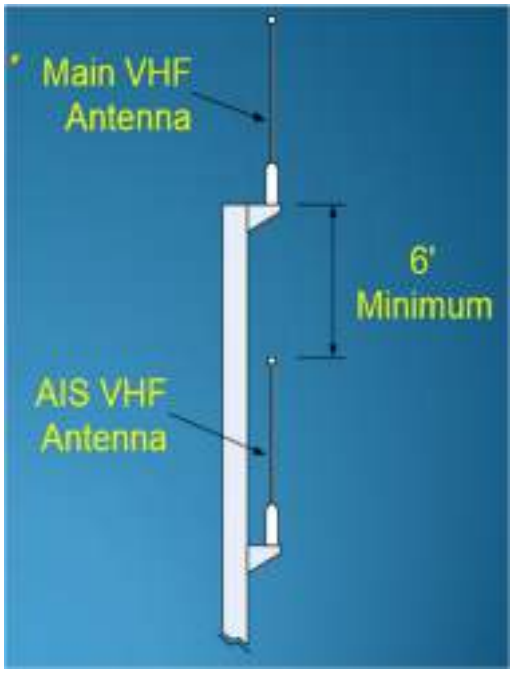


Fig 51) Antenna component

Safety standard Nav Circular 227 IMO Recommends that Use coaxial cable RG-214; it has a two-layer coating and good insulation.

- For comparison, the technical specifications of the four cable models are as follows:
- RG-58 @ 50 ft. 3.0 dB Loss 50% Loss
- RG-8 Mini @ 50 ft. 2.3 dB Loss 40% Loss
- RG-8 @ 50 ft. 1.2 dB Loss 20% Loss
- RG-214 @ 50 ft. 1.2 dB Loss 20% Loss

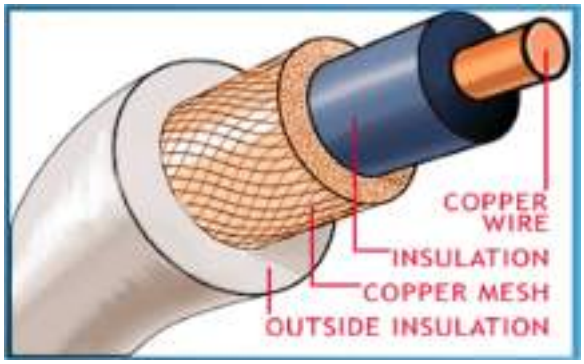


Fig 52) Coaxial cable RG-214

GPS antenna

Suggested installation location for the GPS antenna can be from 5 degrees above the horizon line to 90 degrees.



Fig 53) MX521B DGPS Smart Antenna with GLONASS

Cabling interface equipment

All connecting cables from equipment such as GPS, Gyro, speedometer and similar equipment to the interface NMEA 0183 Enters, must have two shields or two protective shields.

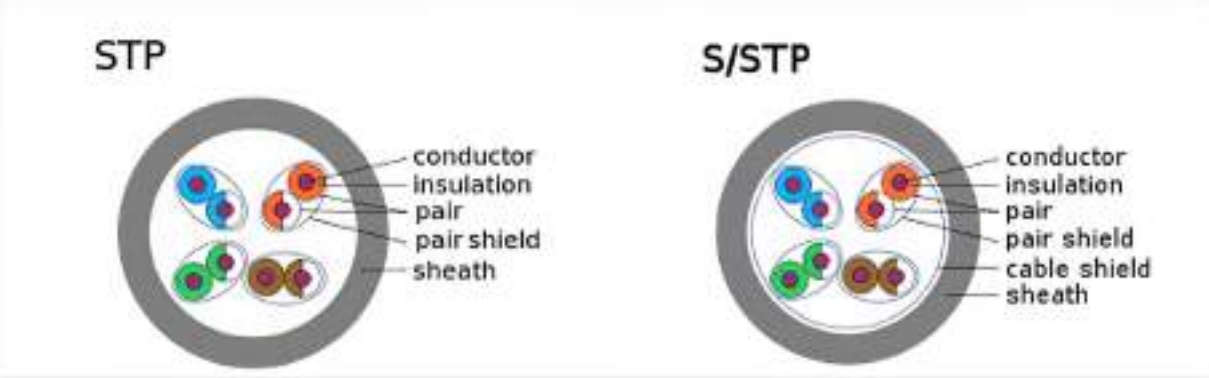


Fig 54) Cabling interface equipment

Power supply

For the AIS Class A system ‹IMO Recommends that the system must be connected to an emergency power supply. However, the emergency generator must be installed for all navigation and telecommunication equipment.

Also, the system should be one UPS Connected to maintain power for 45 seconds when switching from mains to emergency power.

For vessels equipped with the AIS Class B system, which is a subset, IMO is not recommended that the device connected to a battery.

- DC voltage drops <3%
- Class A units: 5A @ 24Vdc-10 AWG for 50 ft
- Class B units: 2A @ 12 Vdc-14 AWG for 25 ft

- American standard AWG (American Wire Gauge) For sizing conductors of non-ferrous wires Gauge is the same diameter 12 or 14 AWG For home wiring and 22 or 24 or 26 AWG Used for telephone wire. The larger the number, the smaller the wire diameter.

System configuration

At the time of the final system check, make sure that you have entered all the static information correctly into the device.

By a ship or station, confirm that all your floating information is being sent and received correctly.

This system is as efficient as the information provided, and keep in mind that AIS Is a navigation aid equipment.

AIS safety

- This device must be installed according to the manufacturer's instructions. Any problems in the installation can seriously affect the operation of the device. It is recommended that the installation and configuration of the system be done by people who are sufficiently trained.
- Never install the device in flammable environments such as the engine room or near fuel tanks.
- This device should not be installed in direct sunlight or under glass that could be exposed to the sun's heat.
- This product should not be installed in a place where it is exposed to rain or water. The installation room of the device should be free of moisture.
- Always keep in mind that military, fishing and recreational vessels may not be available to be AIS equipped.
- Accuracy of GPS system positioning function Based on factors such as the location of the antenna, the number of satellites used and the amount of information received from the satellites.
- The safe distance from the receiver-transmitter to the compass or gyro must be at least 0.3 meters.

NAVICO Featured AIS products

The Automatic Identification System (AIS) is an automatic tracking system that uses transponders on ships and is used by Vessel Traffic Services (VTS) to determine ship position. AIS information supplements marine radar, which continues to be the primary method of collision avoidance for water transport.

The IMO's Convention for SOLAS vessels requires AIS equipment to be fitted onboard ships with 300 or more gross tonnage, and all passenger ships regardless of size.

AIS V5035 Class A Transceiver

The SIMRAD V5035 is a fully featured Class-A AIS transponder system, IMO type approved for use aboard SOLAS vessels. As a standalone solution with integrated display and included GPS antenna, junction box, and pilot plug assembly, the V5035 cost-effectively delivers a complete solution requiring only a VHF antenna to be procured separately. The V5035 offers support for multiple external sensors and integration with SIMRAD navigation and charting systems, external GPS receivers, radar systems, voyage data recorders and other NMEA 0183®/2000® devices.



Fig 55) AIS V5035 Class A Transceiver

- IMO type approved Class-A AIS transponder
- Integrated 3.5-inch color LCD
- Rotary knob and keypad for easy operation
- Basic-coastline, radar, alphanumeric (text), and satellite display modes
- Includes NMEA 0183®/2000® junction box, GPS antenna, pilot plug assembly, cables and mounting hardware
- Multiple sensor input ports and bi-directional data ports
- Connects to SIMRAD GN70/MX610/MX612 navigation systems and E5000-series ECDIS

V3100 SOTDMA Class B AIS

The V3100 Class B AIS is designed to meet the needs of light commercial vessels and workboats operating in high-traffic areas. SOTDMA technology and increased transmission power enhance transmission frequency, reliability, and range compared to standard Class B AIS. This 'black-box' solution integrates with SIMRAD displays, and features industry-standard connectivity.



Fig 56) V3100 SOTDMA Class B AIS

- Enhanced performance compared to standard Class B AIS
- Transmit over greater distances with 5-Watt output power
- Transmit more frequent position updates with SOTDMA
- Greater transmission reliability in high-traffic areas
- Integrated 'black-box' solution
- NMEA 2000®, dual NMEA 0183®, and USB connectivity
- IP67 water-resistant housing
- Built-in SD card slot for AIS data logging

NAIS-500 Class B AIS

Reduce your risk of collision with this fully integrated, Class-B AIS transponder - essential for navigating today's busy shipping lanes and congested ports. Compact in size, lightweight, fully waterproof, with low power draw and featuring multiple connections, the NAIS 500 is ideal for networking with any NSS, NSO, or GO series chartplotter / multifunction display and SIMRAD RS VHF system.



Fig 57) NAIS-500 Class B AIS

- Class-B approved
- Send & receive
- Integrated solution
- Multiple networking connections
- Waterproof
- Lightweight
- Low power consumption
- Wide voltage range

NSPL-500 Antenna Splitter

Save the hassle of installing a costly second antenna and use your existing single antenna with VHF/AIS/FM, by enlisting the lightweight, compact NSPL 500 antenna splitter. When combined with the NAIS 500 AIS system, you can see and be seen on the water, whether tackling busy shipping lanes or crowded ports.



Fig 58) NSPL-500 Antenna Splitter

- FM connector for SonicHub™ 2 or any compatible stereo FM unit
- Lightweight Unit at 260 grams
- IPX7 standard
- Power consumption of less than 150 mA at 12 V DC
- Suitable for 12 or 24 V DC systems with a wide range of supported input voltages from 9.6 V to 31.2 V DC
- No insertion loss on AIS and VHF receive
- Low insertion loss on AIS and VHF transmit

Autopilot

What are Boat Autopilot systems?

An autopilot is a combination of electric or electronic navigation tools that steer a vessel without continual hands-on involvement. Autopilots allow short- or single-handed sailors and boaters to leave the helm to trim or rig sails, adjust lines, set anchor, eat without interruption, take short naps, or other activities while not at the helm.

Autopilots have been used on commercial, sail, and power vessels for over a century, in various forms, making navigation safer and more convenient. Mariners have called autopilots by nicknames, like “Iron Mike,” “Otto,” or “the silent crew.”

How Boat Autopilots Work?

Autopilots work much like cruise control on a vehicle, except that manual control of the tiller or steering wheel is not needed: After the vessel is steadied on a desired heading for a few seconds, an “Auto” button is pushed and the autopilot takes over. The computer remembers the heading and adjusts rudder position to keep the vessel on the selected course, even in high winds, strong currents, or over/under steering situations.

Autopilots generally consist of three main components: a course computer (also called a central processing unit) that contains a compass, a drive unit that applies force to move the rudder, and a control unit.

Control of ship movement started with use of celestial observation - earlier ship fearer stared with us of almanac, map, and sextant, to invention of electrically driven gyroscope and magnetic compass until 1911 when gyrocompass- autopilot system which uses control feedback was invented.

Principle of operations

The auto plot system work on control three term control law –proportional-integral-derivative (PID).

Simple autopilot system uses a SISO (single input single output) control system where the heading of the ship is measured by gyrocompass.

With introduction of control feedback system, the signal is fed back to the computer PID (auto- pilot), which follow commands of the software.

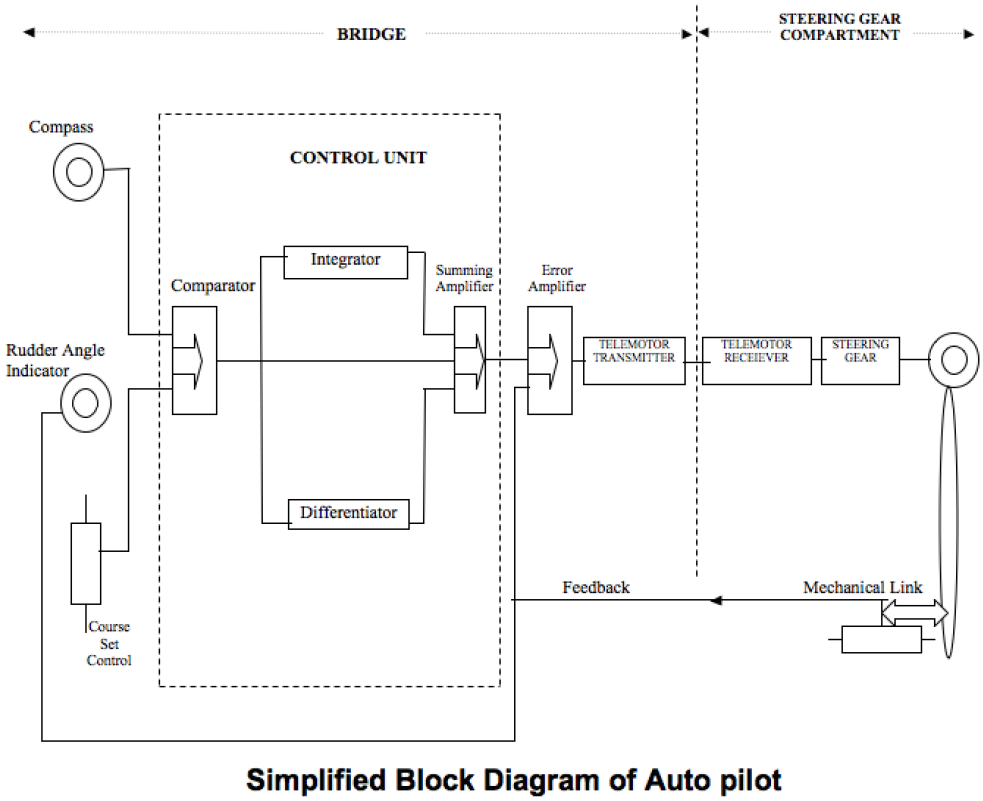


Fig 59) Simplified Block Diagram of Autopilot

Feedback system in auto plot system maintain the following:

- Position data
- Rate of data
- Accumulation of error data

The autopilot system is complex system divided into following components:

Inputs: Connected from different sensor to the controller

- Gyrocompass
- GPS
- Wind sensor
- Human input

Outputs: To move vessel around to desired position

- Main propulsion
- Tunnel thrusters
- Azimuth

Controller: Recommended for efficient autopilot control system

- Good output feedback
- Good wave notch filtering
- And good integral action for compensation of wave drifts. The input come from the pilot as a step command, the rudder is then rotated in the direction of the desired course. The amount of heading change is determined by the amplitude of the step command and heading and position of the pilot are determined by the judgement of the helmsman.
- The control of the heading and the position is done by the autopilot.
- It takes position information and calculates the heading and correction in real-time to make the vessel follow the predetermined course.

A good auto pilot can improve vessel profit margin by reducing number of ship personnel and fuel consumption. the drawback remains with leak associated the hydraulic system

How Boat Autopilots Work?

Autopilots work much like cruise control on a vehicle, except that manual control of the tiller or steering wheel is not needed: After the vessel is steadied on a desired heading for a few seconds, an “Auto” button is pushed and the autopilot takes over. The computer remembers the heading and adjusts rudder position to keep the vessel on the selected course, even in high winds, strong currents, or over/under steering situations.

Autopilots generally consist of three main components: a course computer (also called a central processing unit) that contains a compass, a drive unit that applies force to move the rudder, and a control unit.

Different Types of Boat Autopilot Systems

Autopilots come in a variety of arrangements, dictated by vessel length, displacement and steering type, including above-deck units and below-deck units, described below. An older type, a wind vane, transfers wind energy from a vertical air paddle to a trim tab or water paddle affixed to the rudder. Wind vanes have mostly disappeared, replaced by modern autopilots.

Above-Deck Tiller and Wheel Autopilots

Above-deck autopilots are common on smaller sailing and power vessels (generally 40 feet and under) with tillers or steering wheels. The equipment is easy to operate, inexpensive, uses simple electric connections, and is energy efficient. The variety of available small boat autopilots makes them affordable, even for the occasional boater.

Most tiller autopilots use an electric ram mounted between the tiller and a gunwale fitting to control the rudder. The computer sends a signal to the ram to move the tiller, which adjusts the rudder to stay on course. Depending on configuration, some units connect directly to the top of the rudder.

The other type of above-deck autopilot is used on boats with steering wheels. The autopilot connects directly to the boat's wheel drive with a belt or toothed gears to move the wheel, powered by a small motor.

Below-Deck Autopilots

Below-deck autopilots are best for sail and powerboats over 40 feet. They are more powerful, able to perform a wider range of functions, and provide better steering for long distance cruising, but also use more electricity and require exacting installation. The three below-deck autopilot components are described below:

- **Course Computer:** The autopilot possesses course headings and other data. The computer usually contains the most critical component, the fluxgate compass. Compass: The device that generates vessel headings, usually a fluxgate type. The fluxgate provides a stable, long-term directional reference and works with a rate gyro compass. Boaters should know how these compasses function:
- **Fluxgate Compass:** Uses electronics to generate course headings and communicates with the rate gyro compass. Fluxgate compass data can be interfaced with chart plotters, GPS, and radar.
- **Rate Gyro Compass:** Indicates angular change relative to a course heading over short periods, not direction. Used to control pitch-and-roll movement, the rate gyro provides fast, accurate data and corrects fluxgate compass errors. The magnetic compass, which uses the earth's magnetic pull to establish the north direction, serves as a reference for comparison to autopilot data.
- **Drive Unit:** The workhorse of an autopilot that moves the rudder by electricity or hydraulics. Drive units are one of three types, described below:
    - **Linear:** The most common type on sailboats which moves the rudder directly from the tiller arm or rudder using electricity.
    - **Rotary:** Used on chain and cable steering (wheeled) systems that may use sprockets ranging from 13 to 25 teeth.
    - **Hydraulic:** For boats with hydraulic steering systems. The drive unit must match the size of the existing hydraulic ram.
- **Control Unit:** The interface between the helmsman and autopilot, usually with an LED display on a control panel with knobs, joysticks, or buttons.

Autopilot Advantages

Autopilots provide several advantages to sailors and boaters:

- Save fuel by reducing cruising time, particularly on vessels with a GPS interface. Have an infinite attention span and do not tire. Helpful when sail or power boating with a short- or single-handed crew.
- For anglers, pre-programmed trolling patterns can make fishing more productive.
- Many models are "self-learning," meaning they remember helm positions needed to hold a course and prevent over/under steering.
- An autopilot's ability to hold a steady course without a helmsman has made them almost standard equipment on larger sail and powerboats.

Disadvantages of Autopilots

There are some disadvantages to autopilots:

If autopilot components need repair, recalibration, or replacement during a voyage, getting service, especially in foreign ports, may be difficult.

- Heavy weather can affect how quickly an autopilot responds with helm corrections and works harder at maintaining headings in adverse conditions, which can strain the electrical system.
- Water intrusion and corrosion in the computer, drive motor components and wired connections can cause an autopilot to fail or generate faulty data.
- Even for short periods, an unattended helm without an engaged autopilot can put the boat off course and create potentially dangerous or unsafe situations.
- The electric power needed to operate an autopilot during rough weather and heavy use can be high and sudden energy spikes can cause the unit to fail or generate faulty data.

When an Autopilot Should Not Be Used

In some conditions, navigating a vessel with an engaged autopilot can create potentially dangerous conditions. For example, if underway on waterways with heavy vessel traffic, known underwater hazards or shallow water or areas where crab pots are deployed are two situations when the helm should be manned. The autopilot should not be engaged while docking or maneuvering in close-quarters.

Tips for Safe Autopilot Use

- Brief all crewmembers on how to engage/disengage the autopilot.
- Constant awareness 360 degrees around a vessel is critical, even with an engaged autopilot.
- Should an autopilot fail or generate suspect data, immediately disengage the unit, check the magnetic compass and adjust as needed.
- Most autopilot hardware is waterproof, but should be cleaned after a voyage. Below-deck units should be mounted in a dry, well-ventilated area, as they generate considerable heat.
- The speed at which an autopilot makes course corrections can be a safety issue. Speed is gauged by the amount of heading change (in degrees) per second as the helm is moved.
- The drive unit should have a dedicated breaker connected directly to the vessel's main electric panel.
- To check autopilot heading accuracy, "swing the compass," which is slowly turning the boat in a circle while the computer makes corrections.

Marine autopilots utilize innovations in aviation and land transportation as add-on features or standard equipment, such as:

- One-touch buttons that allow course locking and/or GPS waypoint tracking.
- Rudder angle indicators that show where the rudder is pointed; the units can also indicate how fast the rudder reacts to helm commands.
- Radar and chartplotters that detect close-aboard obstructions or vessels. If a threat exists, an alarm sounds and the boat is automatically steered to a safe heading.
- Remote controls that allow adjustments away from the helm, with ranges up to 40 feet.
- Small, LED screen “repeaters” that relay course headings from the computer and mounted in bunk areas or the galley.
- Sensors indicating when a vessel is about to surf. The computer senses when the boat is at the bottom of a wave and steers to the next set of waves.
- Programs that follow underwater depth contours, especially useful to anglers.
- Small transmitters worn by the crew. If a crewmember goes overboard, the computer steers the vessel into a stall so the man overboard can be retrieved.

Installed and calibrated correctly and utilized as intended, autopilots of any size and type can enhance enjoyment, efficiency, and safety during a voyage.

NAVICO Featured Autopilot products

SIMRAD Autopilots are developed to provide commercial vessels with the highest standards of reliability and the functionality needed in a professional environment.

Commercial autopilots have evolved from simple course holding systems to adaptive computer systems that offer reduced fuel costs and optimal transit times, learning the characteristics of the vessel’s handling and minimize rudder movement and thus reducing drag on the vessel.



SIMRAD AP70 Mk2 Autopilot



Fig 60) SIMRAD AP70 Mk2 Autopilot

After six years in the market, time has come to adjust the SIMRAD Pro autopilot line-up. AP70 Mk2 will replace the workhorses AP70 and AP80 as our IMO/SOLAS autopilot controller. AP70 Mk2 reuses much of the well-reputed platform of its predecessors, with a new brilliant display and modernized software.

AP70 Mk2 is a dedicated autopilot controller designed to meet the needs of professional mariners aboard a variety of commercial vessels. AP70 Mk2 will include all the features of AP70 and AP80 and will be compatible with the same range of autopilot computers, remote controllers and interface to 3rdparty navigation equipment as its predecessors. Engineered for responsiveness, robustness and ease of use, the AP70Mk2 pairs a precision rotary control dial with dedicated buttons for instant access to steering modes, several custom-configurable Work modes and multiple rudder/thruster integration.



Fig 61) SIMRAD AP70 Mk2 Autopilot

- Suitable for all vessel sizes
- All common rudder drive signal types supported
- Certified for SOLAS vessels
- Multiple thrusters/rudders
- Configurable work modes and low/high speed modes
- Large, heavy-duty rotary control dial for precision steering
- Performance optimization through a wide range of settings and parameters
- Directly compatible as a replacement for AP70 and AP80in existing systems.
- No or little re-training of sales, installers or users familiar with AP70 and AP80

Continuum Steering Technology

Every SIMRAD steering innovation builds upon a legacy encompassing over sixty years of autopilot development, which continues to this day.

This legacy is exemplified by the Continuum algorithm: the software behind SIMRAD steering technology. Continuum steering distils years of research and on-water testing into a flexible software solution, capable of delivering reliable auto-steering performance tuned specifically to match a vessel's control characteristics.

With a comprehensive range of hardware and interface modules, SIMRAD autopilot solutions can be tailored to suit a wide range of commercial vessels and applications.



Fig 62) AP70 A2004 AP70 Mk2

Thruster Integration & Rudder Feedback Support

The AP70 Mk2 enables simultaneous autopilot control of up to 6 rudders and thrusters by adding optional AD80 or SD80 interface modules. The thrusters can be set to engage automatically below a user-defined speed threshold, and configured separately for normal and Work modes.

The AP70 Mk2 also supports specialized heavy-duty rudder feedback units designed for reliable operation aboard commercial vessels.



Fig 63) Thrusters, rudders & heavy-duty rudder feedback unit

Additional features:

- Compatible with SG05 Pro CAN-CAN autopilot computer
- Handshake signals with steering gear
- Pendulum ferry function
- Pulse speed log
- External Follow-Up control
- External mode control
- BNWAS signaling
- Multiple control stations
- Advanced command transfer function
- Configurable thruster control Automatic/Manual
- Advanced settings and tuning options

SIMRAD A2004 Autopilot



Fig 64) SIMRAD A2004 Autopilot

The a2004 autopilot system is designed to meet the needs of professional mariners aboard Workboats, Commercial Fishing Vessels, and Passenger Vessels.

It features a proven SIMRAD interface, presented on a wide-angle and zero-fog color display. Engineered for responsiveness and ease of use, the a2004 pairs a precision rotary control dial with dedicated buttons for instant access to steering modes, a custom-configurable Work mode, and automated turn patterns.

The SIMRAD a2004 replaces the renowned ap35 and ap60, and is perfect for vessels that don't require SOLAS Heading Control Systems (where a SIMRAD ap70 or ap80 would be more suitable).

Features:

- Proven SIMRAD interface designed for commercial marine applications
- Large, heavy-duty rotary control dial for precision steering
- Utilizing SIMRAD Contimuum Steering Technology -giving you the benefit of our 60 years of experience
- Optically bonded 4.1-inch color display with 170-degree viewing angle
- Thruster integration & heavy-duty rudder feedback support
- Configurable work mode and low/high speed modes
- Automated turn patterns for fuel-efficient, hands-free maneuvers
- No Drift steering holds course against wind and tide
- Flush or bracket mounting options
- Certified NMEA 2000® connectivity



Fig 65) SIMRAD A2004 Autopilot

Some features of the product:

a) Flush or bracket mounting options
b) Low profile to style match SIMRAD Standalone Radar & Sonar
c) Proven SIMRAD interface designed for commercial marine applications
d) Optically bonded 4.1-inch color display with 170°viewing angle
e) Large, heavy-duty rotary control dial for precision steering
f) Automated turn patterns for fuel-efficient, hands-free maneuvers
g) Configurable work mode and low/high speed modes

Proven SIMRAD Interface

The A2004 builds upon the proven user interface and keypad layout of the SIMRAD AP70 and AP80 professional autopilot controllers, and delivers consistency with the latest generation of SIMRAD radar, sonar, and ECDIS displays. A large aluminum rotary control dial enables quick but precise steering adjustments, while dedicated keys offer instant access to steering modes, a custom-configurable Work mode, and automated turn patterns. All built-in controls are designed for ease of use with wet or gloved hands, in commercial settings such as fishing vessels and workboats. The A2004 also supports a wide range of SIMRAD autopilot remotes and steering levers.



Fig 66) A large aluminum rotary control dial enables quick but precise steering

Continuum Steering Technology

Every SIMRAD steering innovation builds upon a legacy encompassing over sixty years of autopilot development, which continues to this day.

This legacy is exemplified by the Continuum algorithm: the software behind SIMRAD steering technology. Continuum steering distils years of research and on-water testing into a flexible software solution, capable of delivering reliable auto-steering performance tuned specifically to match a vessel's control characteristics.



Fig 67) Continuum Steering Technology trademark

With a comprehensive range of hardware and interface modules, SIMRAD autopilot solutions can be tailored to suit a wide range of commercial vessels and applications.

Optically Bonded 4.1-inch Color Display

To ensure optimal visibility in all conditions, the A2004's color LCD panel is optically bonded to its protective glass covering –eliminating the possibility of internal condensation.

TransflectiveLCD technology makes use of reflected sunlight to brighten rather than obscure the screen, delivering superior day-time visibility and lower power consumption compared to traditional backlit displays.

An ultra-wide 170 degree viewing angle means key autopilot information is clearly visible at a glance, from anywhere in sight of the display.



Fig 68) 4.1-inch color display

Thruster Integration & Rudder Feedback Support

The A2004 enables autopilot control of a single thruster via an optional AD80 or SD80 interface module. The thruster can be set to engage automatically below a user-defined speed threshold, and configured separately for normal and Work modes.

The A2004 also supports specialized heavy-duty rudder feedback units designed for reliable operation aboard commercial vessels.



Fig 69) Thrusters, rudders & heavy-duty rudder feedback unit

Products Positioning

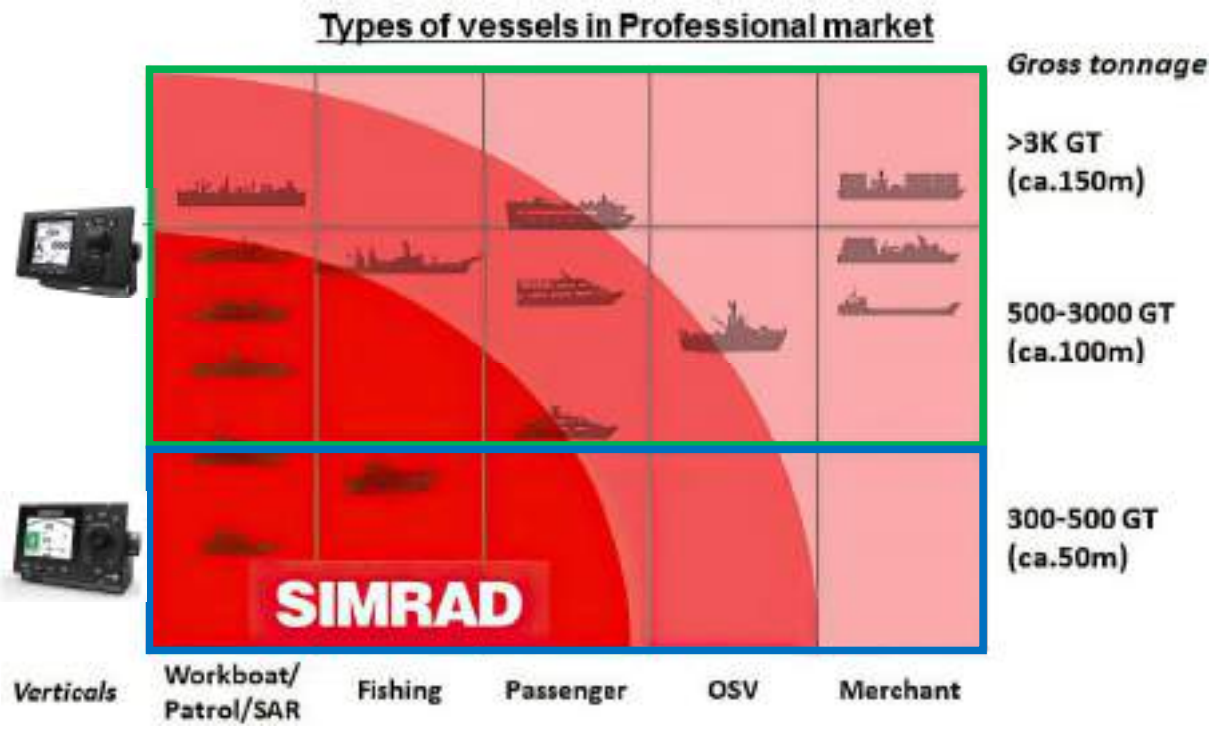


Fig 70) Products position in the marine market

	ComNav P4	**Raytheon Pilotstar NX**	**Furuno Navpilot 700**	**SIMRAD A2004**	**AP70 Mk2**
					
Screen	Color 5.7’’ 640x480	7’’ touch display	4.6” Mono 160x160 pixels	4.3” Mono 130 x 104 pixels	Color 5’’ TFT 480x480
HMI	Knob + 10Buttons	Knob + 4Buttons	Knob + 8Buttons	Knob + 14Buttons	Knob + 10 buttons
Footprint	214mm x 145mm	192mm x 192mm	220mm x 115mm	172mm x 114mm	230mm x 144mm
Mentionable Features	Automatic trim Multi-station Adjustable turn rate Work modes Non-IMO	Touch display IMO Trim mode Dual rudder	SafeHelm& Power Assist Non-IMO	Work Mode – Single Thruster Integration Non-IMO	6 rudders/thrusters Work profiles IMO All drive types

Table 1) Competitor comparison

Feature Comparison

- A2004
- AP70
- AP80
- AP70Mk2

Feature	A2004	AP70	AP80	AP70 Mk2
User definable steering profiles	3	6	6	6
Independent drive support	2	3	6	6
4.1” Color TFT Bonded TransflectiveLCD Display	x			
5” 16bit Color TFT bonded display		x	x	x
FU80/NF80/QS80support	x	x	x	x
S9/S35/JS10/R3000Xsupport	x	x	x	x
RF300/RF25/RF70/RF45Xsupport	x	x	x	x
RF14XUsupport (with AC80A, AC80S, AC85)		x	x	x
Wheelmark approved (depending on Autopilot Computer)		x	x	x

Table 2) Comparison between NAVICO devices itself

GPS (Global Positioning System)

Introduction

GPS, or Global Positioning Systems, are satellite-based navigation systems developed by the U.S. Department of Defense for military purposes—but they're familiar to most of us as the navigational system used by our phones and cars. Whether you're talking about the GPS on your phone, in your car, or a marine GPS for boats, all these units receive radio signals from multiple orbiting satellites to determine your position.

There are currently 30 active GPS satellites in orbit, plus some extras reserved as spares in case one or more satellites has mechanical difficulties or is damaged. By knowing the position of a minimum of four of these satellites, and calculating the time differences between the transmitted signals—which are moving through space at over 186,000 MPH—your GPS receiver can determine its exact position anywhere on earth.



Fig 71) GPS Satellites in the earth's orbits

Development of GPS

The USA developed NAVSTAR (GPS) to provide position fixing accuracy for the military. They launched a series of satellites through the 1970s and 1980s, refining the concept until the system was ready. The complete system comprises 24 satellites, with extras in reserve. This gives at least 4 in view from every position on the surface of the earth.

GPS was only initially used by the military, but it wasn't long until it was opened up for civilian use. As a direct result of gaining access, the aeronautical and maritime sectors both benefited from improved position fixing accuracy.

Civilian users were denied full positional accuracy with a feature called “Selective Availability”. Basically, it added intentional errors to GPS signals. Errors of up to 50m horizontally and 100m vertically were expected. The US military kept full accuracy with a “key”, allowing them to compensate for these errors. In 2000, all users regained full accuracy when Selective Availability was effectively deactivated.

How Does GPS Work?

The NAVSTAR system (the acronym for Navigation Satellite Timing and Ranging, the official U.S. Department of Defense name for GPS) consists of:

- a space segment (the satellites),
- a control segment (the ground stations), and
- a user segment (you and your GPS receiver

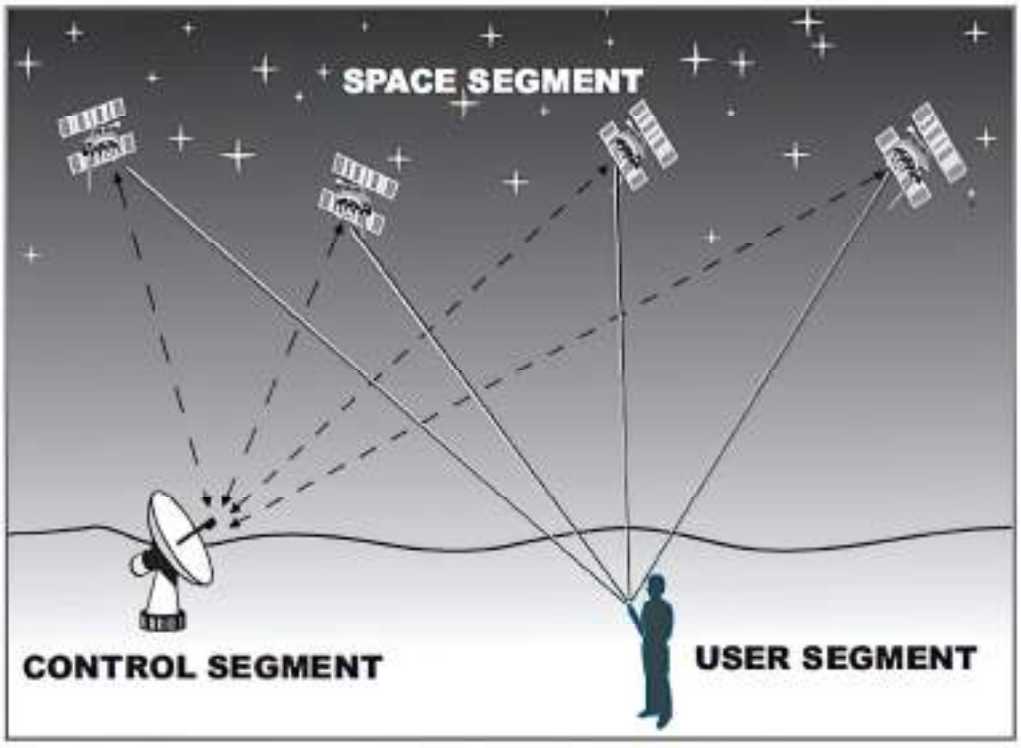


Fig 72) 3 Segments of GPS

The Space Segment

The space segment, which consists of at least 24 satellites (21 active plus 3 operating spares) is the heart of the system. The satellites are in what’s called a “high orbit” about 12,000 miles above the Earth’s surface. Operating at such a high altitude allows the signals to cover a greater area. The satellites are arranged in their orbits so a GPS receiver on earth can always receive from at least four of them at any given time.

The satellites are travelling at speeds of 7,000 miles an hour, which allows them to circle the earth once ever)’ 12 hours. They are powered by solar energy and are built to last about 10 years. If the solar energy fails (eclipses, etc.), they have backup batteries onboard to keep them running. They also have small rocket boosters to keep them flying in the correct path.

The first GPS satellites were launched into space in 1978. A full constellation of 24 satellites was achieved in 1994, completing the system. Money is in the U.S. Department of Defense budget to continue buying new satellites, sending them up to keep the system running for years to come.

Each satellite transmits low power radio signals on several frequencies (designated LI, L2, etc.). Civilian GPS receivers “listen” on the LI frequency of 1575.42 MHz in the UHF band. The signal travels “line of sight”, meaning it will pass through clouds, glass and plastic, but will not go through most solid objects such as buildings and mountains.

To give you some idea of where the LI signal is on the radio dial, your favorite FM radio station broadcasts on a frequency somewhere between 88 and 108 MHz (and sounds much better!). The satellite signals are also very low power signals, on the order of 20-50 watts. Your local FM radio station is around 100,000 watts. Imagine trying to listen to a 50-watt radio station transmitting from 12,000 miles away! That’s why it’s important to have a clear view of the sky when using your GPS.

LI contains two “pseudorandom” (a complex pattern of a digital code) signals, the Protected (P) code and the Course/Acquisition (C/A) code. Each satellite transmits a unique code, allowing the GPS receiver to identify the signals. “Anti-spoofing” refers to the scrambling of the P-code in order to prevent its unauthorized access. The P-code is also called the “P (Y)” or “Y” code.

The main purpose of these coded signals is to allow for calculating the travel time from the satellite to the GPS receiver on the Earth. This travel time is also called the Time of Arrival. The travel time multiplied by the speed of light equals the satellite range (distance from the satellite to the GPS receiver). The Navigation Message (the information the satellites transmit to a receiver) contains the satellite orbital and clock information and general system status messages and an ionospheric delay model. The satellite signals are timed using highly accurate atomic clocks.

The Control Segment

The “control” segment does what its name implies — its “controls” the GPS satellites by tracking them and then providing them with corrected orbital and clock (time) information. There are five control stations located around the world — four unmanned monitoring stations and one “master control station”. The four unmanned receiving stations constantly receive data from the satellites and then send that information to the master control station. The master control station “corrects” the satellite data and, together with two other antenna sites, sends (“uplinks”) the information to the GPS satellites.

The User Segment

The user segment simply consists of you and your GPS receiver. As mentioned previously, the user segment consists of boaters, pilots, hikers, hunters, the military and anyone else who wants to know where they are, where they have been or where they are going.

GPS technical analysis

Let’s first look at how the GPS receiver knows where the satellites are located in space. The GPS receiver picks up two kinds of coded information from the satellites. One type of information, called “almanac” data, contains the approximate positions (locations) of the satellites. This data is continuously transmitted and stored in the memory of the GPS receiver so it knows the orbits of the satellites and where each satellite is supposed to |be. The almanac data is periodically updated with new information as the satellites move around.

Any satellite can travel slightly out of orbit, so the ground monitor stations keep track of the satellite orbits, altitude, location, and speed. The ground stations send the orbital data to the master control station, which in turn sends corrected data up to the satellites. This corrected and exact position data

is called the “ephemeris” (pronounced: i-’fe-me-res) data, which is valid for about four to six hours, and is transmitted in the coded information to the GPS receiver.

So, having received the almanac and ephemeris data, the GPS receiver knows the position (location) of the satellites at all times.

The Essence of Time

Even though the GPS receiver knows the precise location of the satellites in space, it still needs to know how far away the satellites are (the distance) so it can determine its position on Earth. There is a simple formula that tells the receiver how far it is from each satellite:

Your distance from a given satellite object equals the velocity of the transmitted signal multiplied by the time it takes the signal to reach you (Velocity x Travel Time = Distance).

Remember as a kid how you could find out how far a thunderstorm was from you? When you saw a lightning flash you counted the number of seconds until you heard the thunder. The longer the count, the further away the storm was. GPS works on the same principle, called “Time of Arrival”.

Using the same basic formula to determine distance, the receiver already knows the velocity. It’s the speed of a radio wave — 186,000 miles per second (the speed of light), less any delay as the signal travels through the Earth atmosphere.

Now the GPS receiver needs to determine the time part of the formula. The answer lies in the coded signals the satellites transmit. The transmitted code is called “pseudo-random code” because it looks like a noise signal. When a satellite is generating the pseudo-random code, the GPS receiver is generating the same code and tries to match it up to the satellites code. The receiver then compares the two codes to determine how much it needs to delay (or shift) its code to match the satellite code. This delay time (shift) is multiplied by the speed of light to get the distance.

Your GPS receiver clock does not keep the time as precisely as the satellite clocks. Putting an atomic clock in your GPS receiver would make it much larger and far too expensive! So, each distance measurement needs to be corrected to account for the GPS receiver’s internal clock error. For this reason, the range measurement is referred to as a “pseudo-range”. To determine position using pseudo-range data, a minimum of four satellites must be tracked and the four fixes must be recomputed until the clock error disappears.

Coming Full Circle

Now that we have both satellite location and distance, the receiver can determine a position. Let's say we are 11,000 miles from one satellite. Our location would be somewhere on an imaginary' sphere that has the satellite in the center with a radius of 11,000 miles. Then let's say we are 12,000 miles from another satellite. The second sphere would intersect the first sphere to create a common circle. If we add a third satellite, at a distance of 13,000 miles, we now have two common points Even though there are two possible positions, they differ greatly in latitude/longitude position AND altitude. To determine which of the two common points is your actual position, you'll need to enter your approximate altitude into the GPS receiver. This will allow the receiver to calculate a two-dimensional position (latitude, longitude). However, by adding a fourth satellite, the receiver can determine your three-dimensional position (latitude, longitude, altitude). Let's say our distance from a fourth satellite is 10,000 miles. We now have a fourth sphere intersecting the first three spheres at one common point.

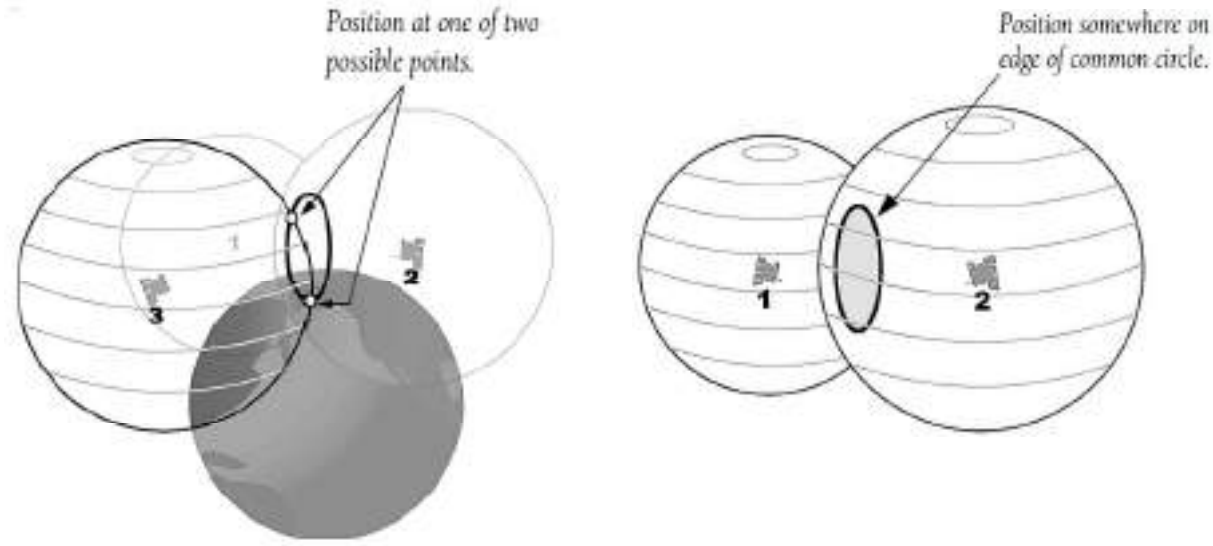


Fig 73) Illustration for GPS satellites shared areas

Almanac Data

The unit stores data about where the satellites are located at any given time. This data is called the almanac. Sometimes when the GPS unit is not turned on for a length of time, the almanac can get outdated or "cold".

When the GPS receiver is "cold", it could take longer to acquire satellites. A receiver is considered "warm" when the data has been collected from the satellites within the last four to six hours. When you're looking for a GPS unit to buy, you may see "cold" and "warm" acquisition time specifications. If the time it takes the GPS unit to lock on to the signals and calculate a position is important to you, be sure to check the acquisition times.

Once the GPS has locked onto enough satellites to calculate a position, you are ready to begin navigating! Most units will display a position page or a page showing your position on a map (map screen) that will assist you in your navigation.

Errors of GPS

1. **Ionospheric and Tropospheric delay:** Due to the radio waves radiated by the satellite when passing through the different layers of the ionosphere and troposphere, the velocity of the waves varies which affects the time difference measurement and the fix will not be accurate.
2. **Users clock error:** if the user clock is not perfectly synchronized with the satellite's clock, the range measurement will not be accurate and the range measurement along with the clock error is known as the pseudo range. This error can be eliminated within the receiver on board by obtaining the pseudo range from three satellites and is done automatically within the receiver.
3. **Satellite clock error:** This error is caused due to the error in the satellite's clock with respect to GPS time. This is monitored by. the ground-based segments and any errors in the satellite's clock forms part of the 30 second's navigational message.
4. **Geometric dilution of precision:** The geometry of the position of the satellite determines the angle of cut which in turns governs the quality of the position obtained. Wider the angular separation between the satellites, more accurate is the fix as the intersection will be almost at right angles.

   The lower the GDOP value higher the accuracy of the fix and this GDOP value is indicated on the display unit.
5. **Multipath error:** multi-path errors are caused by signals from the satellites not taking a direct path to the receiver. Maybe they bounce off a building or a cliff face before reaching the receiver. This results in the signal taking a longer time to reach the receiver than it would have taken had it traveled along the direct route. Again, this results in an erroneous distance being calculated. Multi-path errors are usually noticed by the receiver because it takes measurements from multiple satellites. It then discards measurements that are clearly the result of multi-path. In terms of marine GPS, these errors are not so common because there are not many structures at sea that result in multi-path errors.
6. **Deviation of the satellite from the predicted path:** The satellites are monitored and their paths are predicted by ground-based segment. However, between two consecutive monitoring of the same satellites, there may be minor drifts from their predicted paths resulting in small position inaccuracy.

DGPS (Differential GPS)

Differential GPS: the system is used to enhance the accuracy of the normal GPS system so that it can be used for survey, drilling, oceanography etc. Where higher accuracy of position fixing is required.

The DGPS reference station is situated at a fixed location and from this position the GPS receiver tracks all the satellite within its site, obtains data from them and computes the correction based on the position obtained from the GPS and its actual position. These corrections are then broadcast to GPS users to improve their positional accuracy.

The fundamental principle of DGPS is the comparison of fixed point, referred to as the reference station with position obtained from a GPS receiver at that point.

Since the reference station knows its exact location, it can determine the errors in the satellite signals. It does this by measuring the ranges to each satellite using the signals received and comparing these measured ranges to the actual ranges calculated from its known position. The difference between the measured and calculated range or each satellite in view becomes a “differential correction”. The differential corrections for each tracked satellite are formatted into a correction message and transmitted to DGPS receivers. These differential corrections are then applied to the GPS receiver’s calculations, removing many of the common errors and improving accuracy. The level of accuracy obtained is a function of the GPS receiver and the similarity of its “environment” to that of the reference station, especially its proximity to the station. The reference station receiver determines the error components and provides corrections to the GPS receiver in real time. Corrections can be transmitted over FM radio frequencies, by satellite, or by beacon transmitters maintained by the U.S. Coast Guard. Typical DGPS accuracy is 1-5 meters (about 3-16 feet).

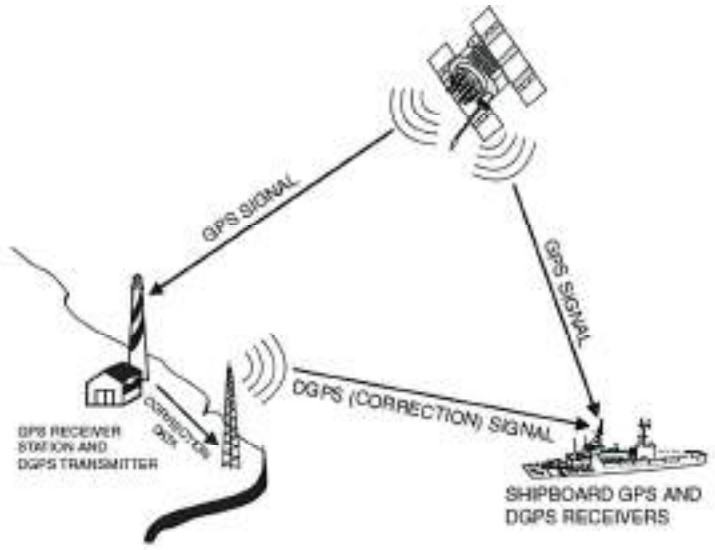


Fig 74) DGPS

How to Use Marine GPS for Boating?

The more satellite signals your GPS receivers, the more accurately it can calculate that position, and while accuracy depends on a number of factors ranging from atmospheric conditions to receiver quality, when many multiple satellites are in view a common GPS receiver can typically put your position within a 16-foot radius. High-end receivers with dual channels can get significantly more accurate.

- Once underway, your GPS continually updates your position and provides speed and directional information.
- GPS also allows you to save positions, which we commonly call “waypoints.” For boaters, this can be helpful to permanently record the location of a channel, a shoal, or a fishing hot-spot.
- You can also string a number of waypoints together to create a route, taking you from point “A” to point “Z”.

Originally boating GPS units displayed your position in latitude and longitude, and while that information can still be displayed, on most modern marine GPS people use a digital chart to see where they are—much like you can look at a street map showing your position on your cell phone. A GPS that can display charts is called a “chartplotter” or “GPS/chartplotter.” And in recent years digital

charts have become much more comprehensive in the areas they cover, have improved detail levels, and better accuracy. In fact, many modern chartplotters also allow you to improve the digital charts you look at in real-time as you operate your boat, by matching up your GPS position with depth soundings taken by your fishfinder.

Marine Navigation with GPS

Navigating with GPS is usually the most efficient, easiest way to navigate a boat, but far too many people use it as a graphical representation rather than a numeric one. You can display a digital chart on your GPS unit, and steer the boat in such a way that the boat icon at the center of the screen points in the correct general direction. But you'll steer much more accurately if you instead use a dedicated "steering screen" that gives you the numeric compass heading you want to follow, the course you're actually steering, and an arrow or indicator that tells you whether to steer to port or starboard to get back on the most direct course.

Why You Need GPS on Your Boat

Even boaters who never leave sight of land should have a GPS/chartplotter aboard, on just about any boat. You never know when you'll encounter fog, or a mechanical issue forces you to stay out late and navigate home in the darkness. And at times like those, you'll be quite relieved you have GPS aboard. Plus, today's units are so inexpensive (you can get a basic GPS/chartplotter for just a couple hundred dollars) that there's really no excuse not to have one.

Wait a minute—your phone already has GPS, so why get another one just for your boat? That's a good question, particularly because you can use a number of boating apps to more or less turn your phone into a mini-chartplotter. Cell phones, however, have a number of drawbacks:

- They aren't always hearty enough to escape damage when spray starts flying or they fall off the dash and onto a fiberglass deck;
- They aren't hard-mounted at the helm and few add-on mounts can take the vibration and impacts a running boat dish out;
- Their batteries may run out faster than expected; and many boaters travel outside of cell coverage areas on a regular basis.

So, while having a cell phone with a navigational app loaded up can come in handy and is a good back-up to have aboard, it should never be depended upon as your main navigational tool.

Other Uses for GPS on Boats

Anchor Alarm

A feature of GPS that's useful to boaters in particular is the ability to set an "anchor alarm." You can establish a geofence around your boat while it's at anchor, and if the anchor drags or the line comes loose and your boat goes through the geofence, your GPS will sound an alarm.

Security System

Some of today's systems also allow you to interface with your boat's GPS from afar, via an app on your cell phone, so it acts as a security system. You can set that geofence up around your boat, and if someone tries to steal it, you'll get a text alarm as soon as it moves out of position.

Additional Features

If your GPS is “networked” (wired to the other electronics aboard the boat) it can also fulfill a number of additional functions.

- It can let the autopilot know where to steer, overlay additional data (like boat radar) over the digital charts.
- Perhaps most importantly, give your VHF radio the boat’s position data. When your VHF receives position data you can use it for DSC (digital selective calling). Do so, and if you ever have to call the Coast guard, they will receive your exact position data via the radio transmission. This is a potentially life-saving feature, so be sure to take a closer look at VHF communications and DSC by reading How to Use a VHF Radio.

NAVICO Featured GPS Products

These products meet the needs of today's professional mariners with over twenty years of development behind them

GPS Displays

Superior color displays combining a GPS navigator and GPS compass in one solution along with easy touch control, position data accuracy, and reliability while enabling distribution of position, course, speed, time and navigation data to other bridge systems such as radar, ECDIS, and the autopilot.

SIMRAD GPS Displays offer a flexible installation by supporting a wide variety of I/O signal types, and a high clarity and contrast viewing distance with great data visibility.



Fig 75) P3007 Model

Compass and Antenna

Providing accurate and reliable data for safe navigation, our flexible IMO and non-IMO system configuration options make both new and retrofit installations into existing systems simple.



Fig 76) SIMRAD HS75

SIMRAD P3007 & P2005 GPS Systems

The SIMRAD® P2005 and P3007 GPS System Series offers a 5- or 7-inch superior color display with easy touch control, position data accuracy, and reliability while enabling distribution of position, course, speed, time and navigation data to other bridge systems such as radar, ECDIS, and the autopilot. Offering a flexible installation by supporting a wide variety of I/O signal types, and a high clarity and contrast viewing distance with great data visibility.



Fig 77) SIMRAD P2005



Fig 78) SIMRAD P3007

- The P3007 GPS System serves as a replacement for the MX612, MX610, and GN70 products. Both a GPS Navigator and GPS compass in one solution, each system works with a direct

antenna connection. These new GPS Systems are scalable with an MX Junction Box, MX610JB or MX612JB.

- The P2005 GPS system is geared towards workboats, the light professional segment, and other non-SOLAS vessels. The P2005 can be paired with a wide range of SIMRAD GPS antenna or GPS compasses. A Serial port expansion with optional junction box is also supported.
- The P3007 GPS system is IMO approved for SOLAS vessels and, when paired with high-precision antennas, the P3007 system can be configured for use as a DGPS, THD (Transmitting Heading Device). With an optional junction box, the system can be configured with up to 12 NMEA 0183 serial ports.
- Both display sizes include value features such as; routes & waypoints, trip log, position & heading page, auxiliary AIS plot, configurable digital data pages, GPS + GLONASS, and an optional external pot-meter dimming feature.
- Sensor data on analog input, serial ports, NMEA 2000, Ethernet (IEC61162-450), and a pulse speed log input are also included.

P3007 & P2005 Key features

- Easy to operate
- Touch display
- Intuitive familiar menu system
- Great viewing distance, clarity and contrast. Great data visibility
- Flexible installation options
- Ethernet/LWE (IEC61162-450)
- Replacement for MX612/MX610/GN70
- Works with direct antenna connection
- Scalable system with MX Junction box 610 or 612
- GPS Navigator and GPS Compass in one solution
- Routes and Waypoints
- Trip log
- Position page
- Heading page
- Auxiliary AIS plot
- Configurable digital data pages
- GPS + GLONASS
- External pot-meter dimming (optional)
- Sensor data on: Analog input, Serial ports, NMEA 2000,
- Ethernet (IEC61162-450), Pulse Speed log input

MX521B DGPS Smart Antenna with GLONASS

The MX521B is a precision D/GNSS (Global Navigation Satellite System) D/GPS positioning solution in a smart antenna.



Fig 77) MX521B DGPS Smart Antenna with GLONASS

Product details

The MX521B is an IMO compliant D/GNSS smart antenna for the Professional market. It provides enhanced position performance with GLONASS and GPS, and delivers position accuracy better than 1 meter in DGPS/DGNSS mode when using RTCM corrections. It also has the ability to select SBAS (WAAS, EGNOS, MTSAT) corrections from the CDU. Beacon Navigation authorities around the world have installed DGPS radio beacon networks that broadcast RTCM corrections. With the use of its built-in beacon demodulator, the MX521B uses these real-time DGPS corrections from compliant IALA Beacon base stations to deliver accurate, reliable positioning when antenna is within range of Beacon station. RAIM Receiver Autonomous Integrity Monitoring (RAIM) is a safety feature in the MX521B which continuously verifies the integrity of the GPS system to ascertain its accuracy and reliability. When satellite range error exceeds a pre-set limit, the CDU alerts the operator to take precautionary measures. Interface The MX521B features two independent NMEA compliant serial ports which are identical to MX421B-10 and MX521A DGPS smart antennas. The MX521B will connect directly with the new P3007 CDU.

Key Features

- IMO compliant GPS/DGPS sensor with GLONASS (SIMRAD CDU is required to comply as an IMO approved system)
- Enhanced position performance with GLONASS
- Flexibility for easy integration into NMEA 0183 interface
- RAIM (Receiver Autonomous Integrity Monitoring) enabled
- Meets Smart Beacon specifications for DGPS Smart Antenna
- Connects directly to MX Control and Display Unit
- Better than 1-meter DGPS Position accuracy
- Better than 3-meter GPS position accuracy
- Built-in DGPS source including SBAS (WAAS, EGNOS, MTSAT)
- D/GPS mode compatibility with MX Series CDU and P3007

SIMRAD HS80A GNSS Compass

The SIMRAD HS80A GNSS (Global Navigation Satellite System) compass is designed to provide reliable heading, ROT and position information to SIMRAD Autopilots and the MX Series of navigation and AIS transponder systems.



Fig 78) SIMRAD HS80A GNSS Compass

Product details

The SIMRAD HS80A GNSS compass is type-approved to the latest IMO regulations including RAIM (Receiver Autonomous Integrity Monitoring). The HS80A delivers heading accuracy of better than 0.5° and provide sub-meter DGPS positioning accuracy. This level of accuracy is achieved in the HS80A from SBAS.

Type Approvals

Both the HS80A has two IMO compliance certifications which is a big advantage for SIMRAD customers. A separate IMO compliant antenna is not required as the compasses meet both navigation and heading function approvals.

Supplementary Sensors

Integrated Gyro and tilt sensors deliver fast start-up times and provide heading updates during temporary loss of satellites.

Interface

The HS80A is supplied with NMEA 2000 as the standard interface, but can be used as a NMEA 0183 device with an optional cable.

Key features

- IMO Type-Approved as a primary positioning AND heading device when used with SIMRAD CDU
- Compatible with new MX610/MX612/GN70 CDU's
- Enhanced heading and positioning performance with GLONASS
- Pitch, roll and heave as standard output
- Heading accuracy Heading updates 1-20 HzDGPS Position accuracy (no SA) < 1.0m
- GPS Position accuracy (no SA) < 3.0m
- Fast start-up times
- Integrated DGPS source including WAAS, EGNOS
- Provision for external RTCM SC104 corrections
- More satellites tracking means better geometry
- NMEA 2000 interface

Sonar

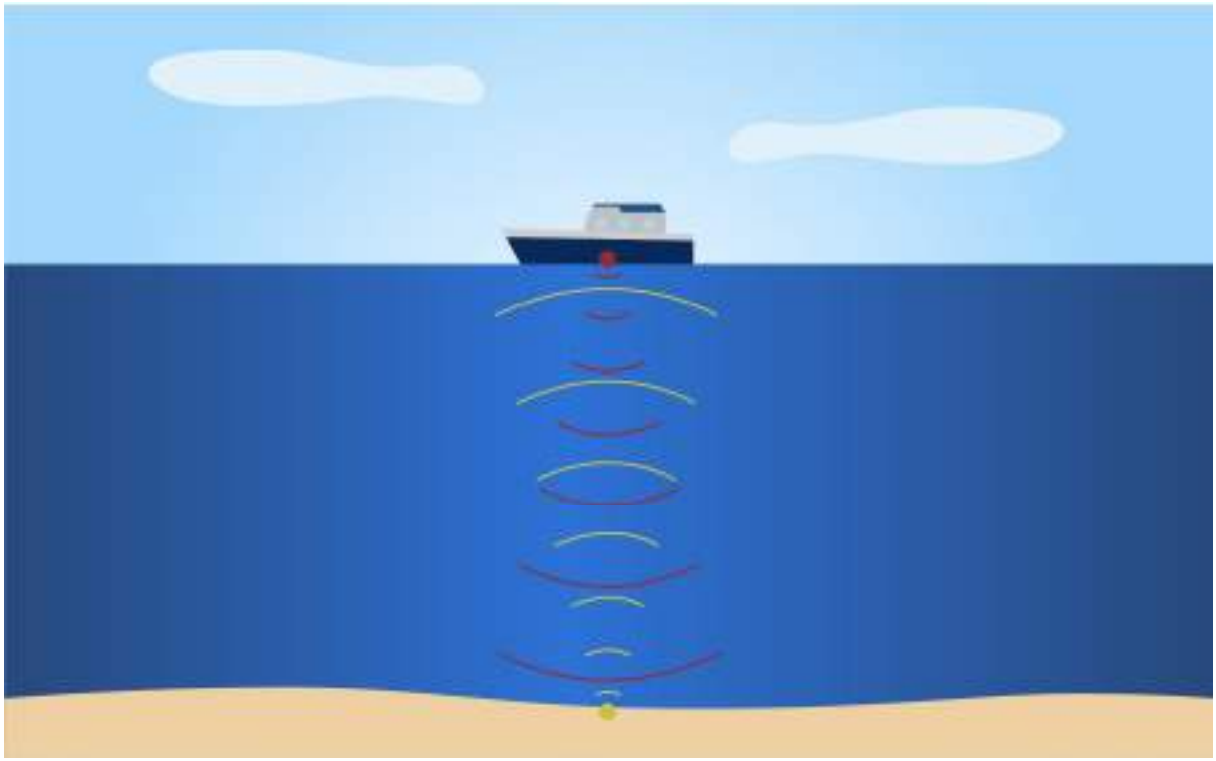


Fig 79) Sonar scheme

Introduction

Sonar (sound navigation and ranging) is a technique that uses sound propagation (usually underwater, as in submarine navigation) to navigate, measure distances (ranging), communicate with or detect objects on or under the surface of the water, such as other vessels. Two types of technology share the name "sonar": passive sonar is essentially listening for the sound made by vessels; active sonar is emitting pulses of sounds and listening for echoes. Sonar may be used as a means of acoustic location and of measurement of the echo characteristics of "targets" in the water. Acoustic location in air was used before the introduction of radar. Sonar may also be used for robot navigation, and SODAR (an upward-looking in-air sonar) is used for atmospheric investigations. The term sonar is also used for the equipment used to generate and receive the sound. The acoustic frequencies used in sonar systems vary from very low (infrasonic) to extremely high (ultrasonic). The study of underwater sound is known as underwater acoustics or hydroacoustics.

The first recorded use of the technique was by Leonardo da Vinci in 1490 who used a tube inserted into the water to detect vessels by ear. It was developed during World War I to counter the growing threat of submarine warfare, with an operational passive sonar system in use by 1918. Modern active sonar systems use an acoustic transducer to generate a sound wave which is reflected from target objects.

History

Although some animals (dolphins, bats, some shrews, and others) have used sound for communication and object detection for millions of years, use by humans in the water is initially recorded by Leonardo da Vinci in 1490: a tube inserted into the water was said to be used to detect vessels by placing an ear to the tube.

In the late 19th century, an underwater bell was used as an ancillary to lighthouses or lightships to provide warning of hazards.

The use of sound to "echo-locate" underwater in the same way as bats use sound for aerial navigation seems to have been prompted by the Titanic disaster of 1912. The world's first patent for an underwater echo-ranging device was filed at the British Patent Office by English meteorologist Lewis Fry Richardson a month after the sinking of Titanic, and a German physicist Alexander Behm obtained a patent for an echo sounder in 1913.

The Canadian engineer Reginald Fessenden, while working for the Submarine Signal Company in Boston, Massachusetts, built an experimental system beginning in 1912, a system later tested in Boston Harbor, and finally in 1914 from the U.S. Revenue Cutter Miami on the Grand Banks off Newfoundland. In that test, Fessenden demonstrated depth sounding, underwater communications (Morse code) and echo ranging (detecting an iceberg at a 2-mile (3.2 km) range). The "Fessenden oscillator", operated at about 500 Hz frequency, was unable to determine the bearing of the iceberg due to the 3-metre wavelength and the small dimension of the transducer's radiating face (less than 1⁄3 wavelength in diameter). The ten Montreal-built British H-class submarines launched in 1915 were equipped with Fessenden oscillators.

During World War I the need to detect submarines prompted more research into the use of sound. The British made early use of underwater listening devices called hydrophones, while the French physicist Paul Langevin, working with a Russian immigrant electrical engineer Constantin Chilowsky, worked on the development of active sound devices for detecting submarines in 1915. Although piezoelectric and magneto strictive transducers later superseded the electrostatic transducers they used, this work influenced future designs. Lightweight sound-sensitive plastic film and fiber optics have been used for hydrophones, while Terfenol-D and PMN (lead magnesium niobate) have been developed for projectors.

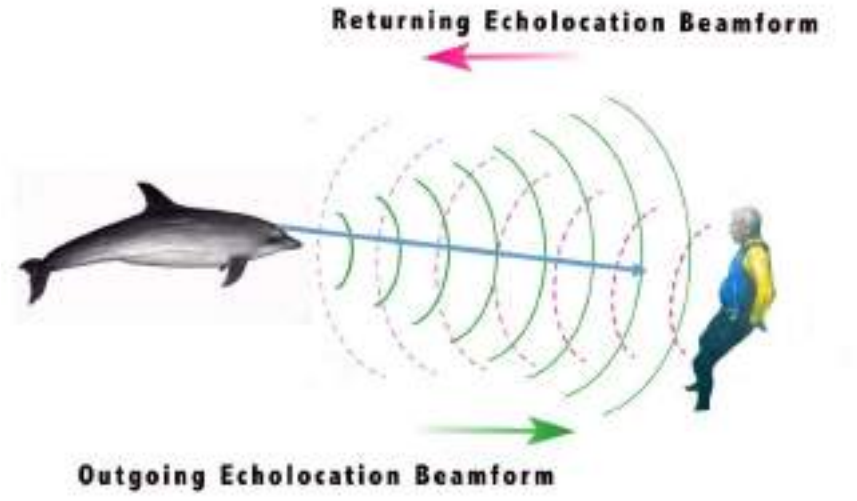


Fig 80) Dolphins using Sonar for their target detection

ASDIC

In 1916, under the British Board of Invention and Research, Canadian physicist Robert William Boyle took on the active sound detection project with A. B. Wood, producing a prototype for testing in mid-1917. This work for the Anti-Submarine Division of the British Naval Staff was undertaken in utmost secrecy, and used quartz piezoelectric crystals to produce the world's first practical underwater active

sound detection apparatus. To maintain secrecy, no mention of sound experimentation or quartz was made – the word used to describe the early work ("supersonics") was changed to "ASD"ics, and the quartz material to "ASD"ivite: "ASD" for "Anti-Submarine Division", hence the British acronym ASDIC. In 1939, in response to a question from the Oxford English Dictionary, the Admiralty made up the story that it stood for "Allied Submarine Detection Investigation Committee", and this is still widely believed, though no committee bearing this name has been found in the Admiralty archives.

By 1918, Britain and France had built prototype active systems. The British tested their ASDIC on HMS Antrim in 1920 and started production in 1922. The 6th Destroyer Flotilla had ASDIC-equipped vessels in 1923. An anti-submarine school HMS Osprey and a training flotilla of four vessels were established on Portland in 1924.

By the outbreak of World War II, the Royal Navy had five sets for different surface ship classes, and others for submarines, incorporated into a complete anti-submarine system. The effectiveness of early ASDIC was hampered by the use of the depth charge as an anti-submarine weapon. This required an attacking vessel to pass over a submerged contact before dropping charges over the stern, resulting in a loss of ASDIC contact in the moments leading up to attack. The hunter was effectively firing blind, during which time a submarine commander could take evasive action. This situation was remedied with new tactics and new weapons.

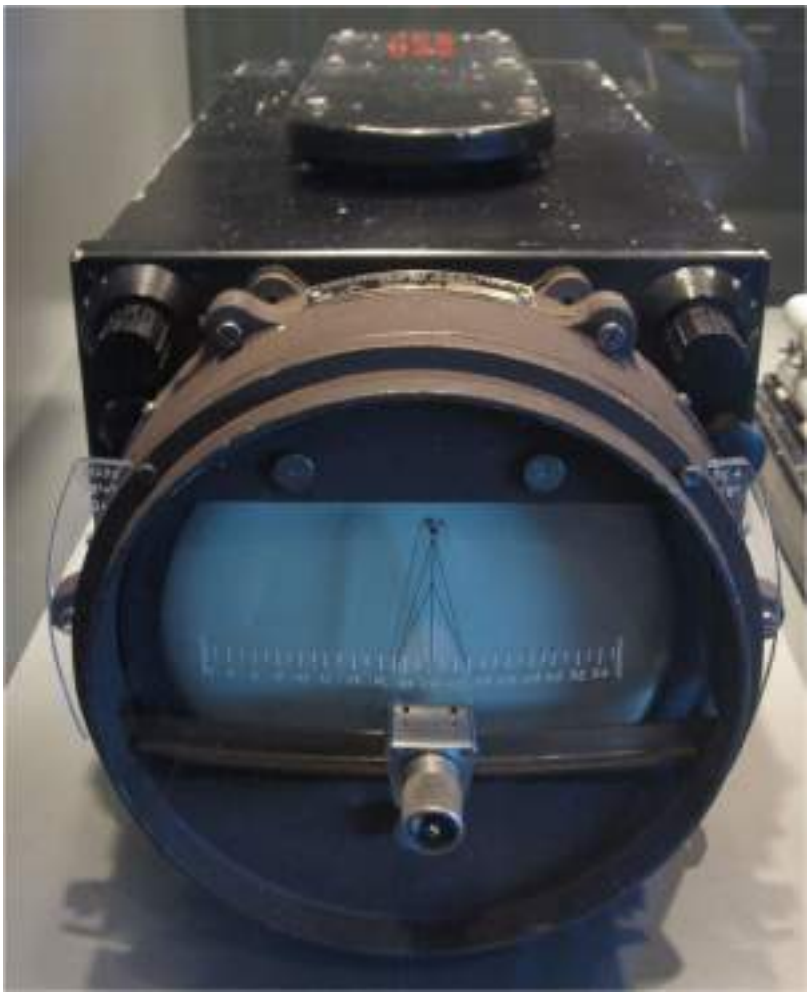


Fig 81) ASDIC display unit from around 1944

The tactical improvements developed by Frederic John Walker included the creeping attack. Two anti-submarine ships were needed for this (usually sloops or corvettes). The "directing ship" tracked

the target submarine on ASDIC from a position about 1500 to 2000 yards behind the submarine. The second ship, with her ASDIC turned off and running at 5 knots, started an attack from a position between the directing ship and the target. This attack was controlled by radio telephone from the directing ship, based on their ASDIC and the range (by rangefinder) and bearing of the attacking ship. As soon as the depth charges had been released, the attacking ship left the immediate area at full speed. The directing ship then entered the target area and also released a pattern of depth charges. The low speed of the approach meant the submarine could not predict when depth charges were going to be released. Any evasive action was detected by the directing ship and steering orders to the attacking ship given accordingly. The low speed of the attack had the advantage that the German acoustic torpedo was not effective against a warship travelling so slowly. A variation of the creeping attack was the "plaster" attack, in which three attacking ships working in a close line abreast were directed over the target by the directing ship.

The new weapons to deal with the ASDIC blind spot were "ahead-throwing weapons", such as Hedgehogs and later Squids, which projected warheads at a target ahead of the attacker and still in ASDIC contact. These allowed a single escort to make better aimed attacks on submarines. Developments during the war resulted in British ASDIC sets that used several different shapes of beam, continuously covering blind spots. Later, acoustic torpedoes were used.

Early in World War II (September 1940), British ASDIC technology was transferred for free to the United States. Research on ASDIC and underwater sound was expanded in the UK and in the US. Many new types of military sound detection were developed. These included sonobuoys, first developed by the British in 1944 under the codename High Tea, dipping/dunking sonar and mine-detection sonar. This work formed the basis for post-war developments related to countering the nuclear submarine.

SONAR

During the 1930s American engineers developed their own underwater sound-detection technology, and important discoveries were made, such as the existence of thermoclines and their effects on sound waves. Americans began to use the term SONAR for their systems, coined by Frederick Hunt to be the equivalent of RADAR.

US Navy Underwater Sound Laboratory

In 1917, the US Navy acquired J. Warren Horton's services for the first time. On leave from Bell Labs, he served the government as a technical expert, first at the experimental station at Nahant, Massachusetts, and later at US Naval Headquarters, in London, England. At Nahant he applied the newly developed vacuum tube, then associated with the formative stages of the field of applied science now known as electronics, to the detection of underwater signals. As a result, the carbon button microphone, which had been used in earlier detection equipment, was replaced by the precursor of the modern hydrophone. Also, during this period, he experimented with methods for towing detection. This was due to the increased sensitivity of his device. The principles are still used in modern towed sonar systems.

To meet the defense needs of Great Britain, he was sent to England to install in the Irish Sea bottom-mounted hydrophones connected to a shore listening post by submarine cable. While this equipment was being loaded on the cable-laying vessel, World War I ended and Horton returned home.

During World War II, he continued to develop sonar systems that could detect submarines, mines, and torpedoes. He published Fundamentals of Sonar in 1957 as chief research consultant at the US Navy Underwater Sound Laboratory. He held this position until 1959 when he became technical director, a position he held until mandatory retirement in 1963.

Materials and designs in the US and Japan

There was little progress in US sonar from 1915 to 1940. In 1940, US sonars typically consisted of a magneto strictive transducer and an array of nickel tubes connected to a 1-foot-diameter steel plate attached back-to-back to a Rochelle salt crystal in a spherical housing. This assembly penetrated the ship hull and was manually rotated to the desired angle. The piezoelectric Rochelle salt crystal had better parameters, but the magneto strictive unit was much more reliable. High losses to US merchant supply shipping early in World War II led to large scale high priority US research in the field, pursuing both improvements in magneto strictive transducer parameters and Rochelle salt reliability. Ammonium dihydrogen phosphate (ADP), a superior alternative, was found as a replacement for Rochelle salt; the first application was a replacement of the 24 kHz Rochelle-salt transducers. Within nine months, Rochelle salt was obsolete. The ADP manufacturing facility grew from few dozen personnel in early 1940 to several thousands in 1942.

One of the earliest applications of ADP crystals were hydrophones for acoustic mines; the crystals were specified for low-frequency cutoff at 5 Hz, withstanding mechanical shock for deployment from aircraft from 3,000 m (10,000 ft), and ability to survive neighboring mine explosions. One of key features of ADP reliability is its zero aging characteristics; the crystal keeps its parameters even over prolonged storage.

Another application was for acoustic homing torpedoes. Two pairs of directional hydrophones were mounted on the torpedo nose, in the horizontal and vertical plane; the difference signals from the pairs were used to steer the torpedo left-right and up-down. A countermeasure was developed: the targeted submarine discharged an effervescent chemical, and the torpedo went after the noisier fizzy decoy. The counter-countermeasure was a torpedo with active sonar – a transducer was added to the torpedo nose, and the microphones were listening for its reflected periodic tone bursts. The transducers comprised identical rectangular crystal plates arranged to diamond-shaped areas in staggered rows.

Passive Sonar arrays for submarines were developed from ADP crystals. Several crystal assemblies were arranged in a steel tube, vacuum-filled with castor oil, and sealed. The tubes then were mounted in parallel arrays.

The standard US Navy scanning sonar at the end of World War II operated at 18 kHz, using an array of ADP crystals. Desired longer range, however, required use of lower frequencies. The required dimensions were too big for ADP crystals, so in the early 1950s magneto strictive and barium titanate piezoelectric systems were developed, but these had problems achieving uniform impedance characteristics, and the beam pattern suffered. Barium titanate was then replaced with more stable lead zirconate titanate (PZT), and the frequency was lowered to 5 kHz. The US fleet used this material in the AN/SQS-23 sonar for several decades. The SQS-23 sonar first used magneto strictive nickel transducers, but these weighed several tons, and nickel was expensive and considered a critical material; piezoelectric transducers were therefore substituted. The sonar was a large array of 432 individual transducers. At first, the transducers were unreliable, showing mechanical and electrical failures and deteriorating soon after installation; they were also produced by several vendors, had different designs, and their characteristics were different enough to impair the array's performance. The policy to allow repair of individual transducers was then sacrificed, and "expendable modular design", sealed non-repairable modules, was chosen instead, eliminating the problem with seals and other extraneous mechanical parts.

The Imperial Japanese Navy at the onset of World War II used projectors based on quartz. These were big and heavy, especially if designed for lower frequencies; the one for Type 91 set, operating at 9 kHz, had a diameter of 30 inches (760 mm) and was driven by an oscillator with 5 kW power and 7 kV of output amplitude. The Type 93 projectors consisted of solid sandwiches of quartz, assembled into spherical cast iron bodies. The Type 93 sonars were later replaced with Type 3, which followed German design and used magneto strictive projectors; the projectors consisted of two

rectangular identical independent units in a cast iron rectangular body about 16 by 9 inches (410 mm × 230 mm). The exposed area was half the wavelength wide and three wavelengths high. The magneto strictive cores were made from 4 mm stampings of nickel, and later of an iron-aluminum alloy with aluminum content between 12.7% and 12.9%. The power was provided from a 2 kW at 3.8 kV, with polarization from a 20 V, 8 A DC source.

The passive hydrophones of the Imperial Japanese Navy were based on moving-coil design, Rochelle salt piezo transducers, and carbon microphones.

Later developments in transducers

Magneto strictive transducers were pursued after World War II as an alternative to piezoelectric ones. Nickel scroll-wound ring transducers were used for high-power low-frequency operations, with size up to 13 feet (4.0 m) in diameter, probably the largest individual sonar transducers ever. The advantage of metals is their high tensile strength and low input electrical impedance, but they have electrical losses and lower coupling coefficient than PZT, whose tensile strength can be increased by prestressing. Other materials were also tried; nonmetallic ferrites were promising for their low electrical conductivity resulting in low eddy current losses, Metglas offered high coupling coefficient, but they were inferior to PZT overall. In the 1970s, compounds of rare earths and iron were discovered with superior magneto mechanic properties, namely the Terfenol-D alloy. This made possible new designs, e.g., a hybrid magneto strictive-piezoelectric transducer. The most recent of these improved magneto strictive materials is Galfenol.

Other types of transducers include variable-reluctance (or moving-armature, or electromagnetic) transducers, where magnetic force acts on the surfaces of gaps, and moving coil (or electrodynamic) transducers, similar to conventional speakers; the latter are used in underwater sound calibration, due to their very low resonance frequencies and flat broadband characteristics above them.

Active sonar

Active sonar uses a sound transmitter (or projector) and a receiver. When the two are in the same place it is monostatic operation. When the transmitter and receiver are separated it is bistatic operation. When more transmitters (or more receivers) are used, again spatially separated, it is multistatic operation. Most sonars are used monostatically with the same array often being used for transmission and reception. Active sonobuoy fields may be operated multistatically.

Active sonar creates a pulse of sound, often called a "ping", and then listens for reflections (echo) of the pulse. This pulse of sound is generally created electronically using a sonar projector consisting of a signal generator, power amplifier and electro-acoustic transducer/array. A transducer is a device that can transmit and receive acoustic signals ("pings"). A beamformer is usually employed to concentrate the acoustic power into a beam, which may be swept to cover the required search angles. Generally, the electro-acoustic transducers are of the Tonpilz type and their design may be optimized to achieve maximum efficiency over the widest bandwidth, in order to optimize performance of the overall system. Occasionally, the acoustic pulse may be created by other means, e.g., chemically using explosives, airguns or plasma sound sources.

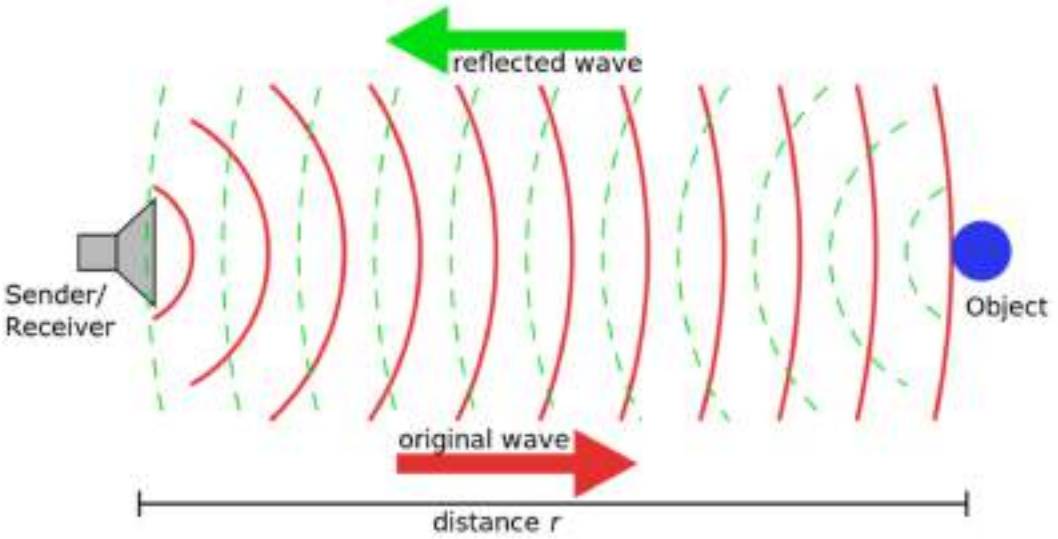


Fig 82) Principle of an active sonar

To measure the distance to an object, the time from transmission of a pulse to reception is measured and converted into a range using the known speed of sound. To measure the bearing, several hydrophones are used, and the set measures the relative arrival time to each, or with an array of hydrophones, by measuring the relative amplitude in beams formed through a process called beamforming. Use of an array reduces the spatial response so that to provide wide cover multibeam systems are used. The target signal (if present) together with noise is then passed through various forms of signal processing, which for simple sonars may be just energy measurement. It is then presented to some form of decision device that calls the output either the required signal or noise. This decision device may be an operator with headphones or a display, or in more sophisticated sonars this function may be carried out by software. Further processes may be carried out to classify the target and localize it, as well as measuring its velocity.

The pulse may be at constant frequency or a chirp of changing frequency (to allow pulse compression on reception). Simple sonars generally use the former with a filter wide enough to cover possible Doppler changes due to target movement, while more complex ones generally include the latter technique. Since digital processing became available pulse compression has usually been implemented using digital correlation techniques. Military sonars often have multiple beams to provide all-round cover while simple ones only cover a narrow arc, although the beam may be rotated, relatively slowly, by mechanical scanning.

Particularly when single frequency transmissions are used, the Doppler effect can be used to measure the radial speed of a target. The difference in frequency between the transmitted and received signal is measured and converted into a velocity. Since Doppler shifts can be introduced by either receiver or target motion, allowance has to be made for the radial speed of the searching platform.

One useful small sonar is similar in appearance to a waterproof flashlight. The head is pointed into the water, a button is pressed, and the device displays the distance to the target. Another variant is a "fishfinder" that shows a small display with shoals of fish. Some civilian sonars (which are not designed for stealth) approach active military sonars in capability, with three-dimensional displays of the area near the boat.

When active sonar is used to measure the distance from the transducer to the bottom, it is known as echo sounding. Similar methods may be used looking upward for wave measurement.

Active sonar is also used to measure distance through water between two sonar transducers or a combination of a hydrophone (underwater acoustic microphone) and projector (underwater acoustic

speaker). When a hydrophone/transducer receives a specific interrogation signal it responds by transmitting a specific reply signal. To measure distance, one transducer/projector transmits an interrogation signal and measures the time between this transmission and the receipt of the other transducer/hydrophone reply. The time difference, scaled by the speed of sound through water and divided by two, is the distance between the two platforms. This technique, when used with multiple transducers/hydrophones/projectors, can calculate the relative positions of static and moving objects in water.

In combat situations, an active pulse can be detected by an enemy and will reveal a submarine's position at twice the maximum distance that the submarine can itself detect a contact and give clues as to the submarine's identity based on the characteristics of the outgoing ping. For these reasons, active sonar is not frequently used by military submarines.

A very directional, but low-efficiency, type of sonar (used by fisheries, military, and for port security) makes use of a complex nonlinear feature of water known as non-linear sonar, the virtual transducer being known as a parametric array.

Project Artemis

Project Artemis was an experimental research and development project in the late 1950s to mid-1960s to examine acoustic propagation and signal processing for a low-frequency active sonar system that might be used for ocean surveillance. A secondary objective was examination of engineering problems of fixed active bottom systems. The receiving array was located on the slope of Plantagnet Bank off Bermuda. The active source array was deployed from the converted World War II tanker USNS Mission Capistrano. Elements of Artemis were used experimentally after the main experiment was terminated.

Transponder

This is an active sonar device that receives a specific stimulus and immediately (or with a delay) retransmits the received signal or a predetermined one. Transponders can be used to remotely activate or recover subsea equipment.

Upward looking sonar

An upward looking sonar (ULS) is a sonar device pointed upwards looking towards the surface of the sea. It is used for similar purposes as downward looking sonar, but has some unique applications such as measuring sea ice thickness, roughness and concentration, or measuring air entrainment from bubble plumes during rough seas. Often it is moored on the bottom of the ocean or floats on a taut line mooring at a constant depth of perhaps 100 m. They may also be used by submarines, AUVs, and floats such as the Argo float.

Passive sonar

Passive sonar listens without transmitting. It is often employed in military settings, although it is also used in science applications, e.g., detecting fish for presence/absence studies in various aquatic environments – see also passive acoustics and passive radar. In the very broadest usage, this term can encompass virtually any analytical technique involving remotely generated sound, though it is usually restricted to techniques applied in an aquatic environment.

Identifying sound sources

Passive sonar has a wide variety of techniques for identifying the source of a detected sound. For example, U.S. vessels usually operate 60 Hz alternating current power systems. If transformers or

generators are mounted without proper vibration insulation from the hull or become flooded, the 60 Hz sound from the windings can be emitted from the submarine or ship. This can help to identify its nationality, as all European submarines and nearly every other nation's submarine have 50 Hz power systems. Intermittent sound sources (such as a wrench being dropped), called "transients," may also be detectable to passive sonar. Until fairly recently, an experienced, trained operator identified signals, but now computers may do this.

Passive sonar systems may have large sonic databases, but the sonar operator usually finally classifies the signals manually. A computer system frequently uses these databases to identify classes of ships, actions (i.e., the speed of a ship, or the type of weapon released), and even particular ships.

Noise limitations

Passive sonar on vehicles is usually severely limited because of noise generated by the vehicle. For this reason, many submarines operate nuclear reactors that can be cooled without pumps, using silent convection, or fuel cells or batteries, which can also run silently. Vehicles' propellers are also designed and precisely machined to emit minimal noise. High-speed propellers often create tiny bubbles in the water, and this cavitation has a distinct sound.

The sonar hydrophones may be towed behind the ship or submarine in order to reduce the effect of noise generated by the watercraft itself. Towed units also combat the thermocline, as the unit may be towed above or below the thermocline.

The display of most passive sonars used to be a two-dimensional waterfall display. The horizontal direction of the display is bearing. The vertical is frequency, or sometimes time. Another display technique is to color-code frequency-time information for bearing. More recent displays are generated by the computers, and mimic radar-type plan position indicator displays.

Scattering

When active sonar is used, scattering occurs from small objects in the sea as well as from the bottom and surface. This can be a major source of interference. This acoustic scattering is analogous to the scattering of the light from a car's headlights in fog: a high-intensity pencil beam will penetrate the fog to some extent, but broader-beam headlights emit much light in unwanted directions, much of which is scattered back to the observer, overwhelming that reflected from the target ("white-out"). For analogous reasons active sonar needs to transmit in a narrow beam to minimize scattering.

The scattering of sonar from objects (mines, pipelines, zooplankton, geological features, fish etc.) is how active sonar detects them, but this ability can be masked by strong scattering from false targets, or 'clutter'. Where they occur (under breaking waves; in ship wakes; in gas emitted from seabed seeps and leaks etc.), gas bubbles are powerful sources of clutter, and can readily hide targets. TWIPS (Twin Inverted Pulse Sonar) is currently the only sonar that can overcome this clutter problem.

This is important as many recent conflicts have occurred in coastal waters, and the inability to detect whether mines are present or not present hazards and delays to military vessels, and also to aid convoys and merchant shipping trying to support the region long after the conflict has ceased.

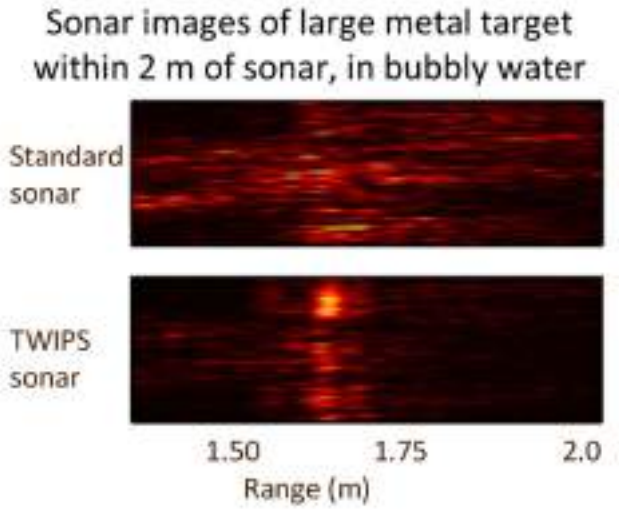


Fig 85) Comparison of Standard Sonar and TWIPS in finding a target in bubbly water.

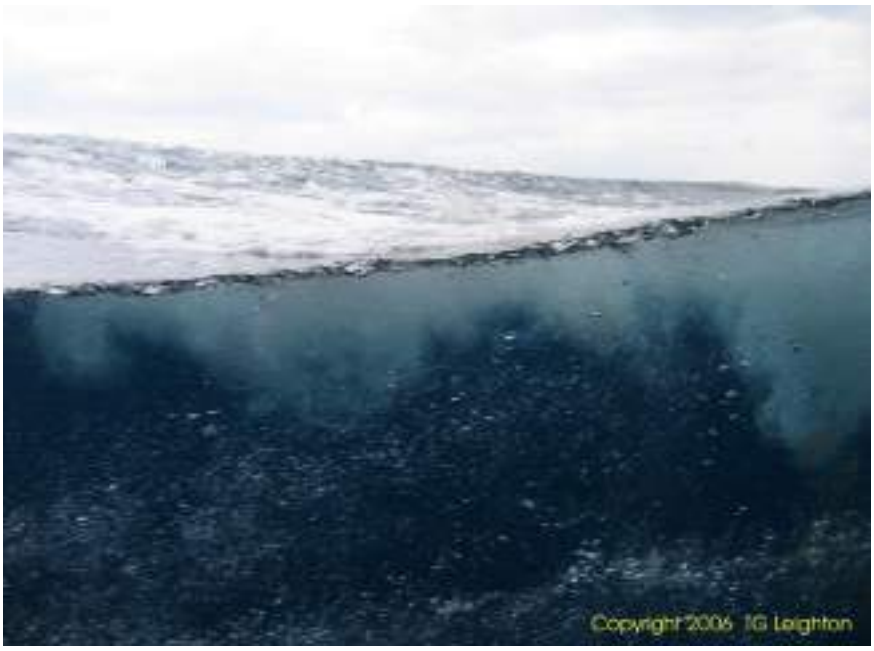


Fig 86) Bubble clouds shown under the sea.

Countermeasures

Active (powered) countermeasures may be launched by a submarine under attack to raise the noise level, provide a large false target, and obscure the signature of the submarine itself.

Passive (i.e., non-powered) countermeasures include:

- Mounting noise-generating devices on isolating devices.
- Sound-absorbent coatings on the hulls of submarines, for example anechoic tiles.

Chirp Technology

A chirp is a signal in which the frequency increases (up-chirp) or decreases (down-chirp) with time. In some sources, the term chirp is used interchangeably with sweep signal. It is commonly applied to sonar, radar, and laser systems, and to other applications, such as in spread-spectrum communications (see chirp spread spectrum). This signal type is biologically inspired and occurs as a phenomenon due to dispersion (a non-linear dependence between frequency and the propagation speed of the wave components). It is usually compensated for by using a matched filter, which can be part of the propagation channel. Depending on the specific performance measure, however, there are better techniques both for radar and communication. Since it was used in radar and space, it has been adopted also for communication standards. For automotive radar applications, it is usually called linear frequency modulated waveform (LFMW).

In spread-spectrum usage, surface acoustic wave (SAW) devices are often used to generate and demodulate the chirped signals. In optics, ultrashort laser pulses also exhibit chirp, which, in optical transmission systems, interacts with the dispersion properties of the materials, increasing or decreasing total pulse dispersion as the signal propagates. The name is a reference to the chirping sound made by birds; see bird vocalization.

Types of Chirp (Only Name)

- Linear
- Exponential
- Hyperbolic

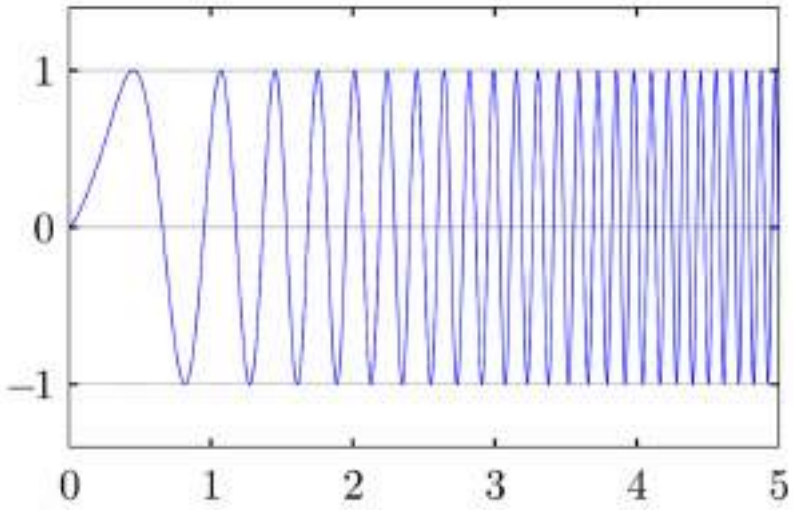


Fig 87) A linear chirp waveform; a sinusoidal wave that increases in frequency linearly over time

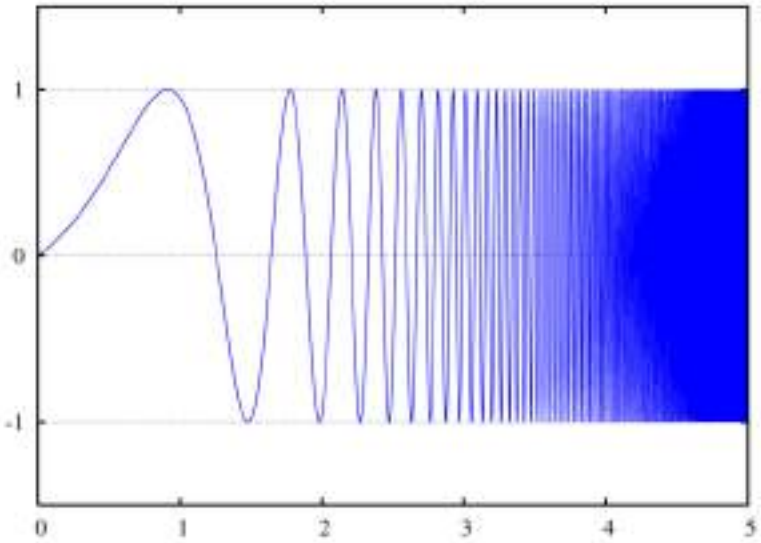


Fig 83) An exponential chirp waveform; a sinusoidal wave that increases in frequency exponentially over time

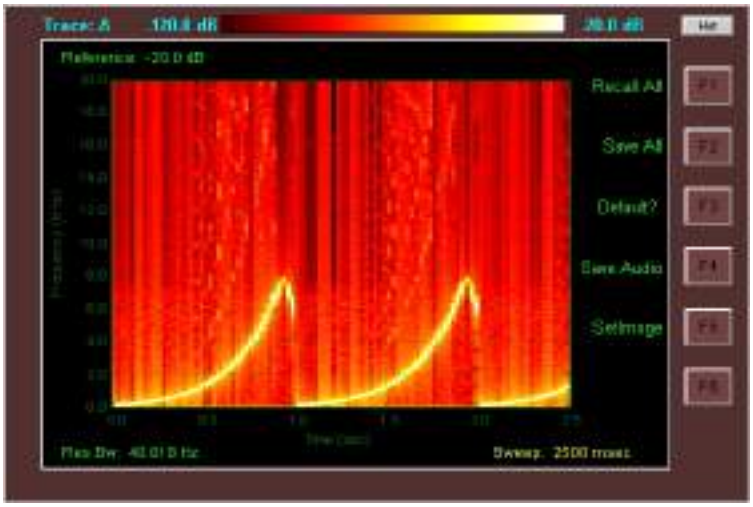


Fig 89) Spectrogram of an exponential chirp.

Fishers

Fishing is an important industry that is seeing growing demand, but world catch tonnage is falling as a result of serious resource problems. The industry faces a future of continuing worldwide consolidation until a point of sustainability can be reached. However, the consolidation of the fishing fleets is driving increased demands for sophisticated fish finding electronics such as sensors, sounders and sonars. Historically, fishermen have used many different techniques to find and harvest fish. However, acoustic technology has been one of the most important driving forces behind the development of the modern commercial fisheries.

Sound waves travel differently through fish than through water because a fish's air-filled swim bladder has a different density than seawater. This density difference allows the detection of schools of fish by using reflected sound. Acoustic technology is especially well suited for underwater applications since sound travels farther and faster underwater than in air. Today, commercial fishing vessels rely almost completely on acoustic sonar and sounders to detect fish. Fishermen also use active sonar and echo sounder technology to determine water depth, bottom contour, and bottom composition.

Companies such as sub-companies of NAVICO, eSonar, Raymarine, Marport Canada, Wesmar, Furuno, Krupp, and make a variety of sonar and acoustic instruments for the deep-sea commercial fishing industry. For example, net sensors take various underwater measurements and transmit the information back to a receiver on board a vessel. Each sensor is equipped with one or more acoustic transducers depending on its specific function. Data is transmitted from the sensors using wireless acoustic telemetry and is received by a hull mounted hydrophone. The analog signals are decoded and converted by a digital acoustic receiver into data which is transmitted to a bridge computer for graphical display on a high-resolution monitor.

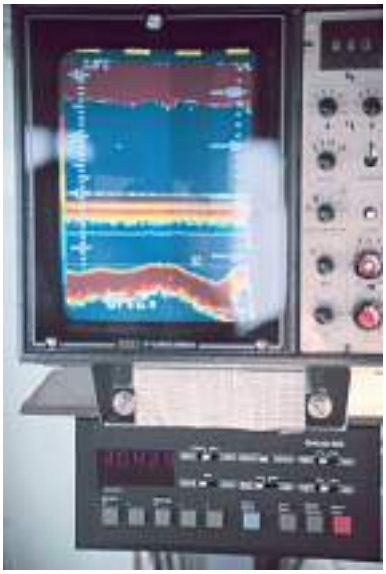


Fig 84) Cabin display of a fish finder sonar

Echo Sounding

Echo sounding is a type of sonar used to determine the depth of water by transmitting acoustic waves into water. The time interval between emission and return of a pulse is recorded, which is used to determine the depth of water along with the speed of sound in water at the time. This information is then typically used for navigation purposes or in order to obtain depths for charting purposes. Echo sounding can also refer to hydroacoustic "echo sounders" defined as active sound in water (sonar) used to study fish. Hydroacoustic assessments have traditionally employed mobile surveys from boats to evaluate fish biomass and spatial distributions. Conversely, fixed-location techniques use stationary transducers to monitor passing fish.

The word sounding is used for all types of depth measurements, including those that don't use sound, and is unrelated in origin to the word sound in the sense of noise or tones. Echo sounding is a more rapid method of measuring depth than the previous technique of lowering a sounding line until it touched bottom.

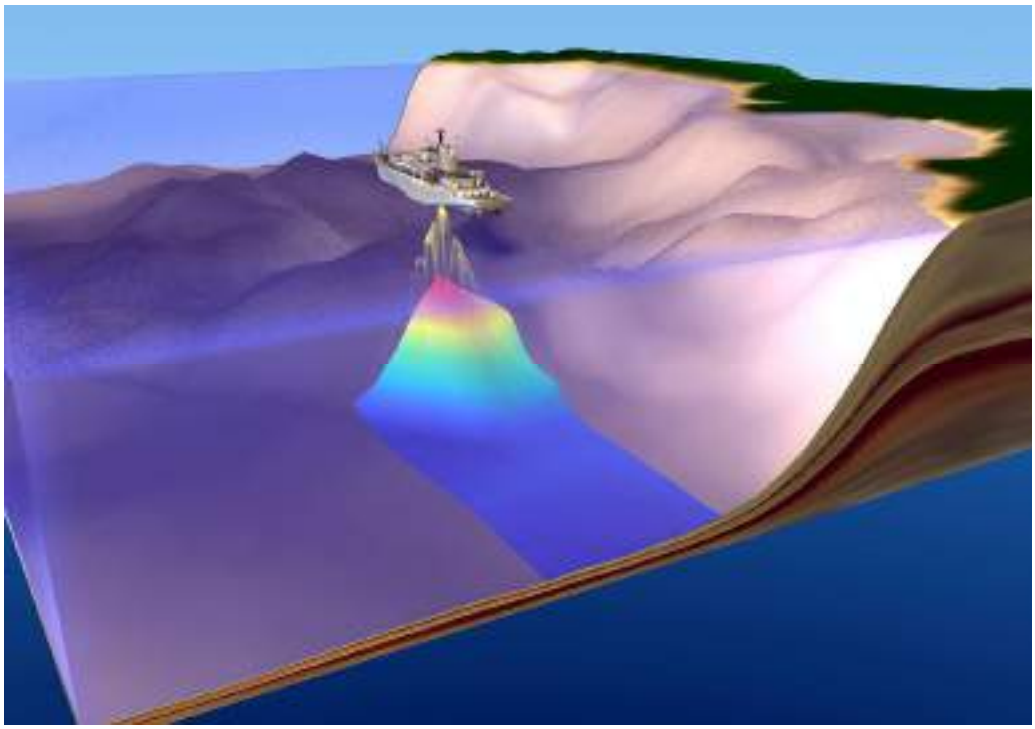


Fig 85) Illustration of echo sounding using a multibeam echosounder.

Technique

Distance is measured by multiplying half the time from the signal's outgoing pulse to its return by the speed of sound in the water, which is approximately 1.5 kilometers per second [T÷2× (4700 feet per second or 1.5 kil per second)] For precise applications of echo sounding, such as hydrography, the speed of sound must also be measured typically by deploying a sound velocity probe into the water. Echo sounding is effectively a special purpose application of sonar used to locate the bottom. Since a traditional pre-SI unit of water depth was the fathom, an instrument used for determining water depth is sometimes called a fathometer. The first practical fathometer was invented by Herbert Grove Dorsey and patented in 1928.

Most charted ocean depths use an average or standard sound speed. Where greater accuracy is required average and even seasonal standards may be applied to ocean regions. For high accuracy depths, usually restricted to special purpose or scientific surveys, a sensor may be lowered to measure the temperature, pressure and salinity. These factors are used to calculate the actual sound speed in the local water column.

Fishfinder

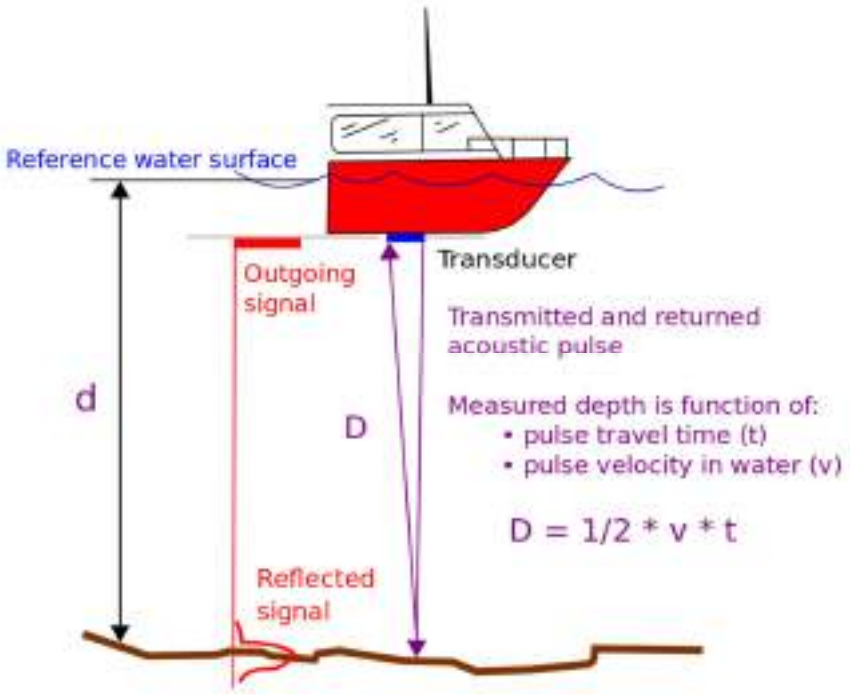


Fig 86) Diagram showing the basic principle of echo sounding

A fishfinder or sounder (Australia) is an instrument used to locate fish underwater by detecting reflected pulses of sound energy, as in sonar. A modern fishfinder displays measurements of reflected sound on a graphical display, allowing an operator to interpret information to locate schools of fish, underwater debris, and the bottom of body of water. Fishfinder instruments are used both by sport and commercial fishermen. Modern electronics allows a high degree of integration between the fishfinder system, marine radar, compass and GPS navigation systems.

Fathometer

Fish finders were derived from fathometers, active sonar instruments used for navigation and safety to determine the depth of water. The fathom is a unit of water depth, from which the instrument gets its name. The fathometer is an echo sounding system for measurement of water depth. A fathometer will display water depth and can make an automatic permanent record of measurements. Since both fathometers and fishfinders work the same way, and use similar frequencies and can detect both the bottom and fish, the instruments have merged.

General interpretation

The image above, at right, clearly shows the bottom structure—plants, sediments and hard bottom are discernible on sonar plots of sufficiently high power and appropriate frequency. Slightly more than halfway up from the bottom to the left of the screen center and about a third away from the left

side, this image is also displaying a fish – a light spot just to the right of a 'glare' splash from the camera's flashbulb. The X-axis of the image represents time, oldest (and behind the soundhead) to the left, most recent bottom (and current location) on the right; thus, the fish is now well behind the transducer, and the vessel is now passing over a dip in the ocean floor or has just left it behind. The resulting distortion depends on both the speed of the vessel and how often the image is updated by the echo sounder.

Fish arches

With the Fish Symbol feature disabled, an angler can learn to distinguish between fish, vegetation, schools of baitfish or forage fish, debris, etc. Fish will usually appear on the screen as an arch. This is because the distance between the fish and the transducer changes as the boat passes over the fish (or the fish swims under the boat). When the fish enters the leading edge of the sonar beam, a display pixel is turned on. As the fish swims toward the center of the beam, the distance to the fish decreases, turning on pixels at shallower depths. When the fish swims directly under the transducer, it is closer to the boat so the stronger signal shows a thicker line. As the fish swims away from the transducer, the distance increases, which shows as progressively deeper pixels.

The image to the right shows a school of white bass aggressively feeding on a school of threadfin shad. Note the school of baitfish near the bottom. When threatened, baitfish form a tightly packed school, as the individuals seek safety in the center of the school. This typically looks like an irregularly shaped ball or thumbprint on the fishfinder screen. When no predators are nearby, a school of baitfish frequently appears as a thin horizontal line across the screen, at the depth where the temperature and oxygen levels are optimal. The nearly-vertical lines near the right edge of the screen show the path of fishing lures falling to the bottom.



Fig 87) Display of a consumer type fishfinder

General history in sporting and fishing

By the early 1970's, a common pattern of depth finder used an ultrasonic transducer immersed in water, and an electromechanical readout device. A neon lamp mounted on the end of an arm was rotated around a circular scale at a fixed speed by a small electric motor. The circular scale was calibrated in terms of depth of water. The instrument was arranged to send out a pulse of ultrasonic waves as the lamp passed the zero point of the scale. The transducer was then arranged to detect any reflected ultrasound impulses; the lamp would flash when an echo returned to the transducer, and by its position on the scale would indicate the elapsed time and therefore the depth of the water. These also gave a small flickering flash for echoes off of fish. Like today's low-end digital fathometers, they kept no record of the depth over time and provided no information about bottom structure. They had poor accuracy, especially in rough water, and were hard to read in bright light. Despite the limitations, they were still usable for rough estimates of depth, such as for verifying that the boat had not drifted into an unsafe area.

Eventually, CRTs were married with a fathometer for commercial fishing and the fishfinder was born. With the advent of large LCD arrays, the high-power requirements of a CRT gave way to the LCD in the early 1990s and fishfinding fathometers reached the sporting markets. Nowadays, many fishfinders available for hobby fishers have color LCD screens, built-in GPS, charting capabilities, and come bundled with transducers. Today, sporting fishfinders lack only the permanent record of the big ship navigational fathometer, and that is available in high end units that can use the ubiquitous computer to store that record as well.

Fishfinders may use higher frequencies to improve the image of underwater objects. Side-looking transducers provide additional visibility of underwater objects on either side of the boat's path.



Fig 88) Sonar image of a white bass feeding frenzy

Commercial and naval units

Commercial and naval fathometers of yesteryear used a strip chart recorder where an advancing roll of paper was marked by a stylus to make a permanent copy of the depth, usually with some means of also recording time (Each mark or time 'tic' is proportional to distance traveled) so that the strip charts could be readily compared to navigation charts and maneuvering logs (speed changes). Much of the world's ocean depths have been mapped using such recording strips. Fathometers of this type usually offered multiple (chart advance) speed settings, and sometimes, multiple frequencies as well. (Deep Ocean—Low Frequency carries better, Shallows—high frequency shows smaller structures (like fish, submerged reefs, wrecks, or other bottom composition features of interest.) At high frequency settings, high chart speeds, such fathometers give a picture of the bottom and any intervening large or schooling fish that can be related to position. Fathometers of the constant recording type are still

mandated for all large vessels (100+ tons displacement) in restricted waters (i.e., generally, within 15 miles (24 km) of land).

What is a CHIRP Sonar?

CHIRP sonar is a powerful bottom-tracking and fish-finding tool. By continuously sweeping through a range of frequencies, CHIRP exceeds many common limitations of single-frequency broadband sonar. Offering substantially less noise and greater target separation giving you the ability to discern individual baitfish within a school, or to see multiple closely-spaced game fish.

How Does CHIRP Sonar Work?

More pulses, means more detail. By continuously sweeping through a range of frequencies, CHIRP exceeds many common limitations of single-frequency broadband sonar.

Low, Medium & High CHIRP

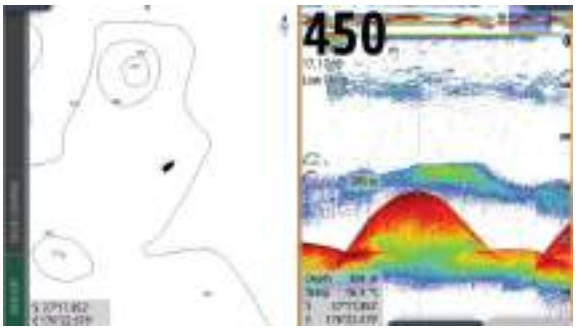


Fig 95) Low Chirp

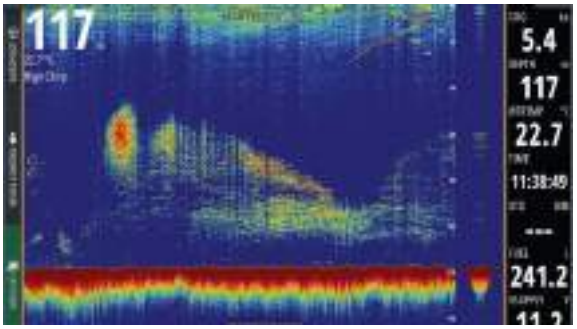


Fig 89) Medium Chirp

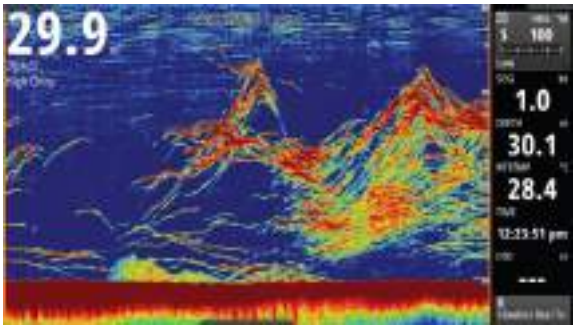


Fig 97) High Chirp

Dual Channel Chirp

Dual-channel CHIRP transducers, are able to sweep two frequency ranges simultaneously. This offers the ability to scan the upper water column in high resolution with High CHIRP, while at the same time employing Low CHIRP for superior bottom tracking for the ultimate in fish finding technology.

Transducers

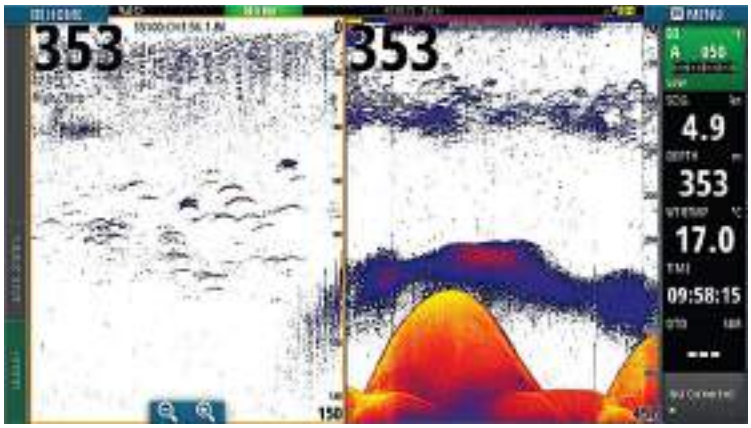


Fig 90) High & Low Chirp at the same time

The transducer is the heart of a fishfinder system, changing electrical pulses into sound waves or acoustic energy and back again. It is the device that sends out the sound waves and then receives the echoes, so the fishfinder can interpret what is below the surface of the water.



Fig 91) An AIRMAR Transducer installed on a boat

Airmar has the most advanced transducers on the market and is compatible with a range of Simard's Multifunction Displays. From broadband transducers with high sensitivity to Chirp-ready transducers, Airmar will take the fishing to the next level.

NAVICO Featured Sonars, Sounders & Echosounders Products

Echosounders calculate water depth by measuring the time it takes for the acoustic signal to reach the bottom and the echo to return to the ship.

The most common system for measuring water depth, and preventing collisions with unseen underwater rocks, reefs, etc., is the echosounder.

Simrad Echosounders include its revolutionary sonar technology, and it produced from a variety of echosounder modules for professional mariners and serious fishermen.



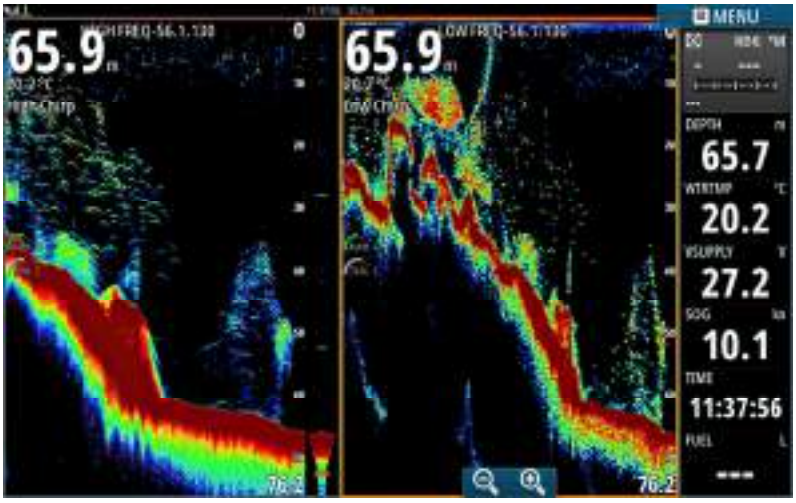


Fig 92) Sonar display

S2009 Fish Finder

The S2009 combines CHIRP-enabled sonar with a 9-inch portrait display for maximum vertical detail, and intuitive keypad-driven operation for reliable control in all conditions. This dedicated echosounder integrates seamlessly with other Simrad displays, while offering charter captains and long-range sportfishing vessels the reliability of a self-contained sonar platform.



Fig 101) S2009 Fish Finder

Integrated CHIRP Echosounder

S2000 series displays feature a built-in echosounder module with CHIRP technology to deliver higher resolution, improved target separation, and greater image clarity than traditional sonar. Simrad technology makes CHIRP available not only for special-purpose CHIRP transducers, but also for traditional single-frequency transducers. This offers a cost-effective upgrade to CHIRP technology by installing an S2000 series fish finder for use with your existing transducer. Installation is simple thanks to a plug-and-play port for Simrad and Airmar transducers with blue seven-pin connectors, and a range of optional adapters to enable easy retrofit to other transducer types.

9-inch Portrait Display

Fig 93) Simrad equipment used in serious fishermen's boats

The S2009 maximizes screen size where limited mounting space is available, with a compact 9-inch portrait display that’s perfect for center consoles. Its vertical layout shows the water column with a high level of detail, making it easy to distinguish individual fish arches and other key features. Direct-access menu keys beside the display provide intuitive control of on-screen menu options, enabling one-button access to key settings and features. With reliable, long-life operation and clear tactile feedback, the S2009’s large buttons are suitable for use in rough seas, while travelling at speed, and with wet or gloved hands.

Networking & Expansion

It’s easy to share sonar data with other Simrad displays over an Ethernet network. S2000 series fish finders can also be used as dedicated displays for the built-in sonar module on Ethernet-connected Simrad multifunction displays, freeing your main display for other purposes such as navigation or radar. Other devices can be integrated via NMEA 2000® and NMEA 0183® connectivity, enabling additional functionality such as marking a waypoint on your chartplotter straight from the fish finder’s history in order to revisit a promising spot.

Key Features

- Integrated CHIRP-enabled sounder

- 9-inch portrait display

S2016 Fish Finder

The S2016 combines CHIRP-enabled sonar with a 16-inch widescreen display for an extensive on-screen history, and intuitive keypad-driven operation for reliable control in all conditions. This dedicated echosounder integrates seamlessly with other Simrad displays, while offering charter captains and long-range sportfishing vessels the reliability of a self-contained sonar platform.



Fig 102) S2016 Fish Finder

16-inch Widescreen Display

The S2016 offers a combination of excellent vertical detail and a lengthy on-screen echosounder history, with a high-definition 16-inch widescreen display. This reduces your need to zoom or scroll, while making it easy to backtrack to promising areas. Direct-access menu keys beside the display provide intuitive control of on-screen menu options, enabling one-button access to key settings and features. With reliable, long-life operation and clear tactile feedback, the S2016's large buttons are suitable for use in rough seas, while travelling at speed, and with wet or gloved hands. An HDMI output lets you mirror the built-in screen on a secondary display, delivering echosounder visibility at a second station without a second fish finder.

Key Features

- Integrated 16-inch widescreen HD display
- Dual-display mirroring option with HDMI output
- High depth penetration and ping speed
- Simple operation with 8 direct-access menu keys
- Customize your view to highlight targets of interest
- Bracket or flush-mount installation (bracket included)

S3009 Navigation Echosounder

The Simrad S3009 Navigational Echosounder meets the requirement for reliable and accurate bottom tracking and depth recording on a wide range of commercial vessels. Exceeding the latest performance standards for IMO compliance, the S3009 features modern controls for easy operation. The single-transducer S3009 system is cost effective, compact, and easy to install in tight spaces. An S3009 expanded system is also available, which adds the S5100 transceiver to enable separate bow and stern transducers.



Fig 103) Simrad S3009 Navigation Echosounder

IMO Type Approved Echosounder

The S3009 IMO Echosounder is designed to meet operational needs and SOLAS carriage requirements for workboats, passenger and merchant vessels. The S3009 meets type-approval standards including IMO resolutions A.224(VII) and MSC.74 (69) Annex 4.

Simple, Modern Interface for Easy Operation

The S3009 provides quick access to common tasks such as setting alert depth and changing draft settings.

Single or Dual Transducer Capability

Available as a compact all-in-one system, or an expanded system with the S5100 transceiver, the S3009 uses standard 50 kHz and 200 kHz transducers and can be tailored to specific vessel requirements.

Highly Reliable Data with On-Screen Scrollback and SD storage

The S3009 shows 5, 10, 15, 30, or 60 minutes of data on the primary display and allows scrollback to view previously recorded depth information. A removable SD card can be used to store more than 12 hours of data.

Sophisticated Alert Management

The S3009 features an Alerts Acknowledge button as well as BAM integration for remote alert management. The Alert page displays active alerts and a historical log of alert conditions.

Supports 50 kHz and 200 kHz Transducers

Standard 70 mm diameter transducers facilitate easy installation with existing tanks and gate valves.

High Resolution Display

See data the way you prefer. The S3009 features ten levels of day/night brightness adjustment, and seven color combinations. Bold bottom-tracking lines can be adjusted for clear interpretation of bottom track.

Industry-Standard Connectivity

The S3009 provides an IEC61162-1/2 (NMEA 0183®) interface to connect with Simrad ECDIS solutions and other Simrad or third-party bridge equipment. IEC 61162-3 (NMEA 2000®) and Ethernet networking are also supported.

Key Features

- IMO type approved echosounder with integrated display
- Meets IMO resolutions A.224(VII), MSC.74 (69) Annex 4
- Highly accurate depth recording with 12 hour stored history
- Cost effective and compact system for smaller, single-transducer vessels
- Expanded S3009+S5100 system supports split screen readout with bow and stern transducers
- 9-inch 480x800-pixel high-brightness LCD
- Easy-access front SD card slot for recording depth data
- Industry standard 50 kHz and 200 kHz transducers
- Complements Simrad and other Navigation equipment with standard IEC interfaces

Commercial Radar



Fig 104) Long-range radar antenna, used to track space objects and ballistic missiles.

Introduction

Radar (radio detection and ranging) is a detection system that uses radio waves to determine the distance (ranging), angle, or velocity of objects. It can be used to detect aircraft, ships, spacecraft, guided missiles, motor vehicles, weather formations, and terrain. A radar system consists of a transmitter producing electromagnetic waves in the radio or microwaves domain, a transmitting antenna, a receiving antenna (often the same antenna is used for transmitting and receiving) and a receiver and processor to determine properties of the object(s). Radio waves (pulsed or continuous) from the transmitter reflect off the object and return to the receiver, giving information about the object's location and speed.

Radar was developed secretly for military use by several countries in the period before and during World War II. A key development was the cavity magnetron in the United Kingdom, which allowed the creation of relatively small systems with sub-meter resolution. The term RADAR was coined in 1940 by the United States Navy as an acronym for "radio detection and ranging". The term radar has

since entered English and other languages as a common noun, losing all capitalization. During RAF RADAR courses in 1954/5 at Yatesbury Training Camp "radio azimuth direction and ranging" was suggested. The modern uses of radar are highly diverse, including air and terrestrial traffic control, radar astronomy, air-defense systems, antimissile systems, marine radars to locate landmarks and other ships, aircraft anti-collision systems, ocean surveillance systems, outer space surveillance and rendezvous systems, meteorological precipitation monitoring, altimetry and flight control systems, guided missile target locating systems, self-driving cars, and ground-penetrating radar for geological observations. High tech radar systems are associated with digital signal processing, machine learning and are capable of extracting useful information from very high noise levels.

Other systems similar to radar make use of other parts of the electromagnetic spectrum. One example is LIDAR, which uses predominantly infrared light from lasers rather than radio waves. With the emergence of driverless vehicles, radar is expected to assist the automated platform to monitor its environment, thus preventing unwanted incidents.



Fig 105) typical rotating X band marine radar antenna on ship. It radiates a narrow vertical fan-shaped beam of microwaves perpendicular to the long axis of the antenna, horizontally out to the horizon. With each rotation the beam scans the surrounding surface.

History

First experiments

As early as 1886, German physicist Heinrich Hertz showed that radio waves could be reflected from solid objects. In 1895, Alexander Popov, a physics instructor at the Imperial Russian Navy school in Kronstadt, developed an apparatus using a coherer tube for detecting distant lightning strikes. The next year, he added a spark-gap transmitter. In 1897, while testing this equipment for communicating between two ships in the Baltic Sea, he took note of an interference beat caused by the passage of a third vessel. In his report, Popov wrote that this phenomenon might be used for detecting objects, but he did nothing more with this observation.

The German inventor Christian Hülsmeyer was the first to use radio waves to detect "the presence of distant metallic objects". In 1904, he demonstrated the feasibility of detecting a ship in dense fog, but not its distance from the transmitter. He obtained a patent for his detection device in April 1904 and later a patent for a related amendment for estimating the distance to the ship. He also obtained a British patent on September 23, 1904[10] for a full radar system, that he called a telemobiloscope. It operated on a 50 cm wavelength and the pulsed radar signal was created via a spark-gap. His system already used the classic antenna setup of horn antenna with parabolic reflector and was presented to German military officials in practical tests in Cologne and Rotterdam harbor but was rejected.

In 1915, Robert Watson-Watt used radio technology to provide advance warning to airmen and during the 1920s went on to lead the U.K. research establishment to make many advances using radio techniques, including the probing of the ionosphere and the detection of lightning at long distances. Through his lightning experiments, Watson-Watt became an expert on the use of radio direction finding before turning his inquiry to shortwave transmission. Requiring a suitable receiver for such studies, he told the "new boy" Arnold Frederic Wilkins to conduct an extensive review of available shortwave units. Wilkins would select a General Post Office model after noting its manual's description of a "fading" effect (the common term for interference at the time) when aircraft flew overhead.

Across the Atlantic in 1922, after placing a transmitter and receiver on opposite sides of the Potomac River, U.S. Navy researchers A. Hoyt Taylor and Leo C. Young discovered that ships passing through the beam path caused the received signal to fade in and out. Taylor submitted a report, suggesting that this phenomenon might be used to detect the presence of ships in low visibility, but the Navy did not immediately continue the work. Eight years later, Lawrence A. Hyland at the Naval Research Laboratory (NRL) observed similar fading effects from passing aircraft; this revelation led to a patent application as well as a proposal for further intensive research on radio-echo signals from moving targets to take place at NRL, where Taylor and Young were based at the time.

Similarly, in the UK, L. S. Alder took out a secret provisional patent for Naval radar in 1928. W.A.S. Butement and P. E. Pollard developed a breadboard test unit, operating at 50 cm (600 MHz) and using pulsed modulation which gave successful laboratory results. In January 1931, a writeup on the apparatus was entered in the Inventions Book maintained by the Royal Engineers. This is the first official record in Great Britain of the technology that was used in Coastal Defense and was incorporated into Chain Home as Chain Home (low).

Just before the World War 2

Before the Second World War, researchers in the United Kingdom, France, Germany, Italy, Japan, the Netherlands, the Soviet Union, and the United States, independently and in great secrecy, developed technologies that led to the modern version of radar. Australia, Canada, New Zealand, and South Africa followed prewar Great Britain's radar development, and Hungary generated its radar technology during the war.

In France in 1934, following systematic studies on the split-anode magnetron, the research branch of the Compagnie Générale de Télégraphie Sans Fil (CSF) headed by Maurice Ponte with Henri Gutton, Sylvain Berline and M. Hugon, began developing an obstacle-locating radio apparatus, aspects of which were installed on the ocean liner Normandie in 1935.

During the same period, Soviet military engineer P.K. Oshchepkov, in collaboration with Leningrad Electrotechnical Institute, produced an experimental apparatus, RAPID, capable of detecting an aircraft within 3 km of a receiver. The Soviets produced their first mass production radars RUS-1 and RUS-2 Redut in 1939 but further development was slowed following the arrest of Oshchepkov and his subsequent gulag sentence. In total, only 607 Redut stations were produced during the war. The first Russian airborne radar, Gneiss-2, entered into service in June 1943 on Pe-2 dive bombers. More than 230 Gneiss-2 stations were produced by the end of 1944. The French and Soviet systems, however, featured continuous-wave operation that did not provide the full performance ultimately synonymous with modern radar systems.

Full radar evolved as a pulsed system, and the first such elementary apparatus was demonstrated in December 1934 by the American Robert M. Page, working at the Naval Research Laboratory. The following year, the United States Army successfully tested a primitive surface-to-surface radar to aim coastal battery searchlights at night. This design was followed by a pulsed system demonstrated in

May 1935 by Rudolf Kühnhold and the firm GEMA [de] in Germany and then another in June 1935 by an Air Ministry team led by Robert Watson-Watt in Great Britain.

In 1935, Watson-Watt was asked to judge recent reports of a German radio-based death ray and turned the request over to Wilkins. Wilkins returned a set of calculations demonstrating the system was basically impossible. When Watson-Watt then asked what such a system might do, Wilkins recalled the earlier report about aircraft causing radio interference. This revelation led to the Daventry Experiment of 26 February 1935, using a powerful BBC shortwave transmitter as the source and their GPO receiver setup in a field while a bomber flew around the site. When the plane was clearly detected, Hugh Dowding, the Air Member for Supply and Research was very impressed with their system's potential and funds were immediately provided for further operational development. Watson-Watt's team patented the device in GB593017.

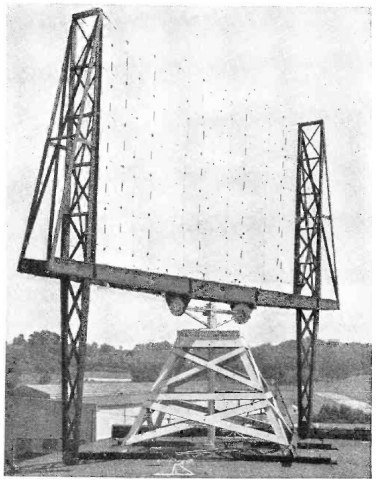


Fig 106) Experimental radar antenna, US Naval Research Laboratory, Anacostia, D. C., late 1930s

Development of radar greatly expanded on 1 September 1936 when Watson-Watt became Superintendent of a new establishment under the British Air Ministry, Bawdsey Research Station located in Bawdsey Manor, near Felixstowe, Suffolk. Work there resulted in the design and installation of aircraft detection and tracking stations called "Chain Home" along the East and South coasts of England in time for the outbreak of World War II in 1939. This system provided the vital advance information that helped the Royal Air Force win the Battle of Britain; without it, significant numbers of fighter aircraft, which Great Britain did not have available, would always need to be in the air to respond quickly. If enemy aircraft detection had relied solely on the observations of ground-based individuals, Great Britain might have lost the Battle of Britain. Also vital was the "Dowding system" of reporting and coordination to provide the best use of radar information during the tests of early radar deployment during 1936 and 1937.



Fig 107) The first workable unit built by Robert Watson-Watt and his team

Given all required funding and development support, the team produced working radar systems in 1935 and began deployment. By 1936, the first five Chain Home (CH) systems were operational and by 1940 stretched across the entire UK including Northern Ireland. Even by standards of the era, CH was crude; instead of broadcasting and receiving from an aimed antenna, CH broadcast a signal floodlighting the entire area in front of it, and then used one of Watson-Watt's own radio direction finders to determine the direction of the returned echoes. This fact meant CH transmitters had to be much more powerful and have better antennas than competing systems but allowed its rapid introduction using existing technologies.



Fig 94) Memorial plaque commemorating Robert Watson-Watt and Arnold Wilkins



Fig 109) A Chain Home tower in Great Baddow, Essex, United Kingdom

During World War 2

A key development was the cavity magnetron in the UK, which allowed the creation of relatively small systems with sub-meter resolution. Britain shared the technology with the U.S. during the 1940 Tizard Mission.

In April 1940, Popular Science showed an example of a radar unit using the Watson-Watt patent in an article on air defense. Also, in late 1941 Popular Mechanics had an article in which a U.S. scientist speculated about the British early warning system on the English east coast and came close to what it was and how it worked. Watson-Watt was sent to the U.S. in 1941 to advise on air defense after Japan's attack on Pearl Harbor. Alfred Lee Loomis organized the secret MIT Radiation Laboratory at Massachusetts Institute of Technology, Cambridge, Massachusetts which developed microwave radar technology in the years 1941–45. Later, in 1943, Page greatly improved radar with the monopulse technique that was used for many years in most radar applications.

The war precipitated research to find better resolution, more portability, and more features for radar, including complementary navigation systems like Oboe used by the RAF's Pathfinder.

Applications

The information provided by radar includes the bearing and range (and therefore position) of the object from the radar scanner. It is thus used in many different fields where the need for such positioning is crucial. The first use of radar was for military purposes: to locate air, ground and sea targets. This evolved in the civilian field into applications for aircraft, ships, and automobiles.

In aviation, aircraft can be equipped with radar devices that warn of aircraft or other obstacles in or approaching their path, display weather information, and give accurate altitude readings. The first commercial device fitted to aircraft was a 1938 Bell Lab unit on some United Air Lines aircraft. Aircraft can land in fog at airports equipped with radar-assisted ground-controlled approach systems in which the plane's position is observed on precision approach radar screens by operators who thereby give radio landing instructions to the pilot, maintaining the aircraft on a defined approach path to the runway. Military fighter aircraft are usually fitted with air-to-air targeting radars, to detect and target enemy aircraft. In addition, larger specialized military aircraft carry powerful airborne radars to observe air traffic over a wide region and direct fighter aircraft towards targets.

Marine radars are used to measure the bearing and distance of ships to prevent collision with other ships, to navigate, and to fix their position at sea when within range of shore or other fixed references such as islands, buoys, and lightships. In port or in harbor, vessel traffic service radar systems are used to monitor and regulate ship movements in busy waters.

Meteorologists use radar to monitor precipitation and wind. It has become the primary tool for short-term weather forecasting and watching for severe weather such as thunderstorms, tornadoes, winter storms, precipitation types, etc. Geologists use specialized ground-penetrating radars to map the composition of Earth's crust. Police forces use radar guns to monitor vehicle speeds on the roads. Smaller radar systems are used to detect human movement. Examples are breathing pattern detection for sleep monitoring and hand and finger gesture detection for computer interaction. Automatic door opening, light activation and intruder sensing are also common.

Radar technology has recently been used for vital sign monitoring and human activity monitoring. The heartbeat and respiration rate are estimated by measuring the human body movements caused by ejection of blood into the great vessels and inhalation and exhalation of air into and out of the lungs using radar. Human activities are detected by classifying the radar return patterns using machine learning algorithms.



Fig 110) EISCAT radar in Sodankylä, Finland

Principles

Radar Signal

A radar system has a transmitter that emits radio waves known as radar signals in predetermined directions. When these signals contact an object, they are usually reflected or scattered in many directions, although some of them will be absorbed and penetrate into the target. Radar signals are reflected especially well by materials of considerable electrical conductivity such as most metals, seawater, and wet ground. This makes the use of radar altimeters possible in certain cases. The radar signals that are reflected back towards the radar receiver are the desirable ones that make radar detection work. If the object is moving either toward or away from the transmitter, there will be a slight change in the frequency of the radio waves due to the Doppler effect.

Radar receivers are usually, but not always, in the same location as the transmitter. The reflected radar signals captured by the receiving antenna are usually very weak. They can be strengthened by electronic amplifiers. More sophisticated methods of signal processing are also used in order to recover useful radar signals.

The weak absorption of radio waves by the medium through which they pass is what enables radar sets to detect objects at relatively long ranges at which other electromagnetic wavelengths, such as visible light, infrared light, and ultraviolet light, are too strongly attenuated. Weather phenomena, such as fog, clouds, rain, falling snow, and sleet, that block visible light are usually transparent to radio waves. Certain radio frequencies that are absorbed or scattered by water vapor, raindrops, or atmospheric gases (especially oxygen) are avoided when designing radars, except when their detection is intended.

Illumination

Radar relies on its own transmissions rather than light from the Sun or the Moon, or from electromagnetic waves emitted by the target objects themselves, such as infrared radiation (heat). This process of directing artificial radio waves towards objects is called illumination, although radio waves are invisible to the human eye as well as optical cameras.

Reflection

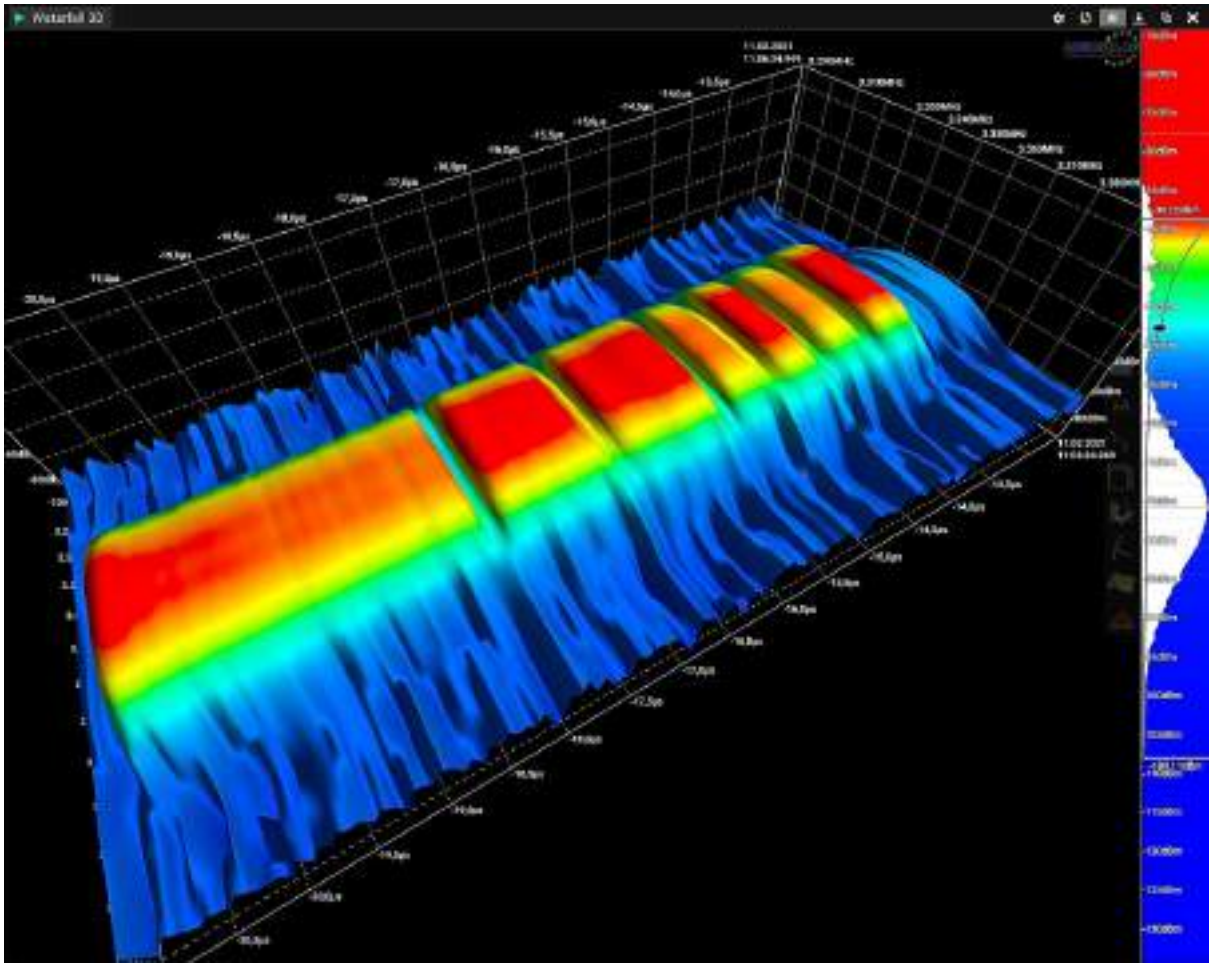


Fig 111) 3D Doppler Radar Spectrum showing a Barker Code of 13

If electromagnetic waves travelling through one material meet another material, having a different dielectric constant or diamagnetic constant from the first, the waves will reflect or scatter from the boundary between the materials. This means that a solid object in air or in a vacuum, or a significant change in atomic density between the object and what is surrounding it, will usually scatter radar (radio) waves from its surface. This is particularly true for electrically conductive materials such as metal and carbon fiber, making radar well-suited to the detection of aircraft and ships. Radar absorbing material, containing resistive and sometimes magnetic substances, is used on military vehicles to reduce radar reflection. This is the radio equivalent of painting something a dark color so that it cannot be seen by the eye at night.

Radar waves scatter in a variety of ways depending on the size (wavelength) of the radio wave and the shape of the target. If the wavelength is much shorter than the target's size, the wave will bounce off in a way similar to the way light is reflected by a mirror. If the wavelength is much longer than

the size of the target, the target may not be visible because of poor reflection. Low-frequency radar technology is dependent on resonances for detection, but not identification, of targets. This is described by Rayleigh scattering, an effect that creates Earth's blue sky and red sunsets. When the two length scales are comparable, there may be resonances. Early radars used very long wavelengths that were larger than the targets and thus received a vague signal, whereas many modern systems use shorter wavelengths (a few centimeters or less) that can image objects as small as a loaf of bread.

Short radio waves reflect from curves and corners in a way similar to glint from a rounded piece of glass. The most reflective targets for short wavelengths have 90° angles between the reflective surfaces. A corner reflector consists of three flat surfaces meeting like the inside corner of a box. The structure will reflect waves entering its opening directly back to the source. They are commonly used as radar reflectors to make otherwise difficult-to-detect objects easier to detect. Corner reflectors on boats, for example, make them more detectable to avoid collision or during a rescue. For similar reasons, objects intended to avoid detection will not have inside corners or surfaces and edges perpendicular to likely detection directions, which leads to "odd" looking stealth aircraft. These precautions do not completely eliminate reflection because of diffraction, especially at longer wavelengths. Half wavelength long wires or strips of conducting material, such as chaff, are very reflective but do not direct the scattered energy back toward the source. The extent to which an object reflects or scatters radio waves is called its radar cross section.

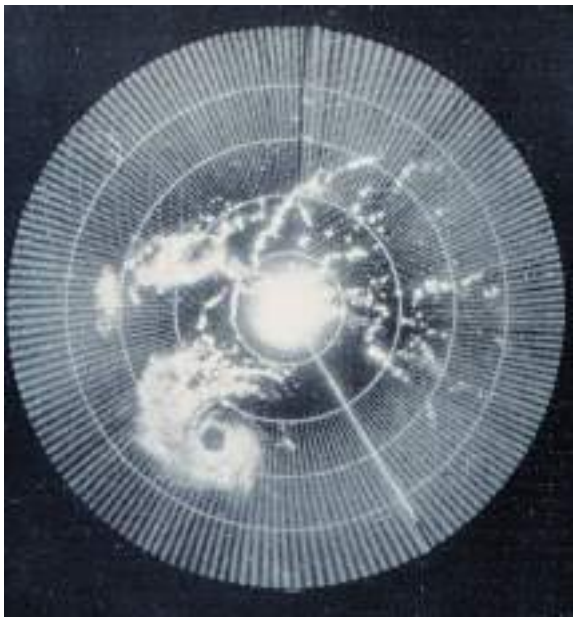


Fig 112) Brightness can indicate reflectivity as in this 1960 weather radar image (of Hurricane Abby). The radar's frequency, pulse form, polarization, signal processing, and antenna determine what it can observe.

Doppler effect

Frequency shift is caused by motion that changes the number of wavelengths between the reflector and the radar. This can degrade or enhance radar performance depending upon how it affects the detection process. As an example, Moving Target Indication can interact with Doppler to produce signal cancellation at certain radial velocities, which degrades performance.

Sea-based radar systems, semi-active radar homing, active radar homing, weather radar, military aircraft, and radar astronomy rely on the Doppler effect to enhance performance. This produces information about target velocity during the detection process. This also allows small objects to be detected in an environment containing much larger nearby slow-moving objects.

Doppler shift depends upon whether the radar configuration is active or passive. Active radar transmits a signal that is reflected back to the receiver. Passive radar depends upon the object sending a signal to the receiver.

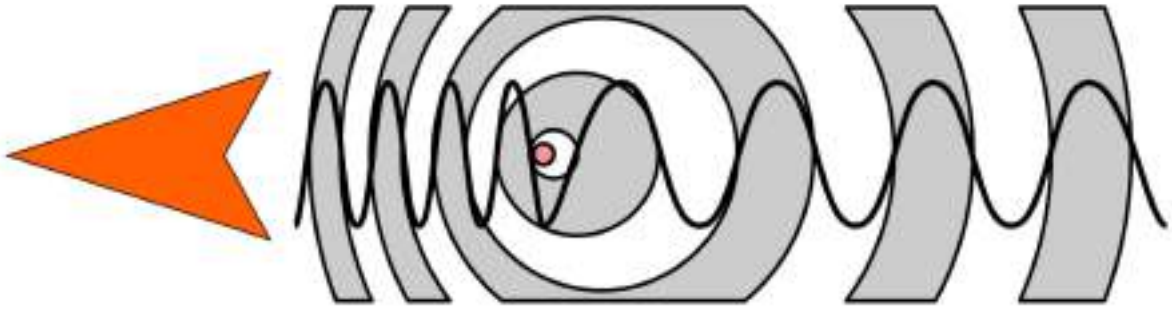


Fig 113) Change of wavelength caused by motion of the source.

Limiting Factors

Beam path and range

A radar beam follows a linear path in vacuum but follows a somewhat curved path in atmosphere due to variation in the refractive index of air, which is called the radar horizon. Even when the beam is emitted parallel to the ground, the beam rises above the ground as the curvature of the Earth sinks below the horizon. Furthermore, the signal is attenuated by the medium the beam crosses, and the beam disperses.

The maximum range of conventional radar can be limited by a number of factors:

- Line of sight, which depends on the height above the ground. Without a direct line of sight, the path of the beam is blocked.
- The maximum non-ambiguous range, which is determined by the pulse repetition frequency. The maximum non-ambiguous range is the distance the pulse can travel to and return from before the next pulse is emitted.
- Radar sensitivity and the power of the return signal as computed in the radar equation. This component includes factors such as the environmental conditions and the size (or radar cross section) of the target.

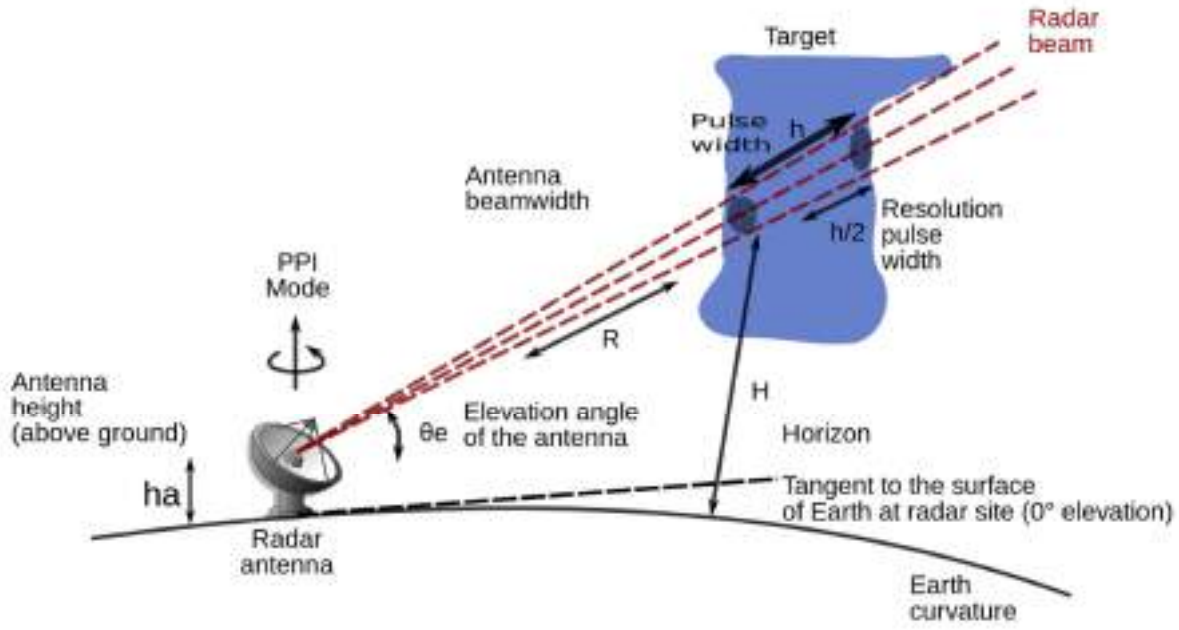


Fig 114) Beam path and range

Noise

Signal noise is an internal source of random variations in the signal, which is generated by all electronic components.

Reflected signals decline rapidly as distance increases, so noise introduces a radar range limitation. The noise floor and signal to noise ratio are two different measures of performance that affect range performance. Reflectors that are too far away produce too little signal to exceed the noise floor and cannot be detected. Detection requires a signal that exceeds the noise floor by at least the signal to noise ratio.

Noise typically appears as random variations superimposed on the desired echo signal received in the radar receiver. The lower the power of the desired signal, the more difficult it is to discern it from the noise. Noise figure is a measure of the noise produced by a receiver compared to an ideal receiver, and this needs to be minimized.

Shot noise is produced by electrons in transit across a discontinuity, which occurs in all detectors. Shot noise is the dominant source in most receivers. There will also be flicker noise caused by electron transit through amplification devices, which is reduced using heterodyne amplification. Another reason for heterodyne processing is that for fixed fractional bandwidth, the instantaneous bandwidth increases linearly in frequency. This allows improved range resolution. The one notable exception to heterodyne (down conversion) radar systems is ultra-wideband radar. Here a single cycle, or transient wave, is used similar to UWB communications (Ultra-Wide Band), see List of UWB channels.

Noise is also generated by external sources, most importantly the natural thermal radiation of the background surrounding the target of interest. In modern radar systems, the internal noise is typically about equal to or lower than the external noise. An exception is if the radar is aimed upwards at clear sky, where the scene is so "cold" that it generates very little thermal noise. There is an appealing intuitive interpretation of this relationship in a radar. Matched filtering allows the entire energy received from a target to be compressed into a single bin (be it a range, Doppler, elevation, or azimuth bin). On the surface it would appear that then within a fixed interval of time one could obtain perfect, error free, detection. To do this one simply compresses all energy into an infinitesimal time slice.

What limits this approach in the real world is that, while time is arbitrarily divisible, current is not. The quantum of electrical energy is an electron, and so the best one can do is match filter all energy into a single electron. Since the electron is moving at a certain temperature (Plank spectrum) this noise source cannot be further eroded. We see then that radar, like all macro-scale entities, is profoundly impacted by quantum theory.

Noise is random and target signals are not. Signal processing can take advantage of this phenomenon to reduce the noise floor using two strategies. The signal can also be split among multiple filters for pulse-Doppler signal processing, which reduces the noise floor by the number of filters. These improvements depend upon coherence.

Interference

Radar systems must overcome unwanted signals in order to focus on the targets of interest. These unwanted signals may originate from internal and external sources, both passive and active. The ability of the radar system to overcome these unwanted signals defines its signal-to-noise ratio (SNR). SNR is defined as the ratio of the signal power to the noise power within the desired signal; it compares the level of a desired target signal to the level of background noise (atmospheric noise and noise generated within the receiver). The higher a system's SNR the better it is at discriminating actual targets from noise signals.

Clutter

Clutter refers to radio frequency (RF) echoes returned from targets which are uninteresting to the radar operators. Such targets include natural objects such as ground, sea, and when not being tasked for meteorological purposes, precipitation (such as rain, snow or hail), sand storms, animals (especially birds), atmospheric turbulence, and other atmospheric effects, such as ionosphere reflections, meteor trails, and Hail spike. Clutter may also be returned from man-made objects such as buildings and, intentionally, by radar countermeasures such as chaff.

Some clutter may also be caused by a long radar waveguide between the radar transceiver and the antenna. In a typical plan position indicator (PPI) radar with a rotating antenna, this will usually be seen as a "sun" or "sunburst" in the center of the display as the receiver responds to echoes from dust particles and misguided RF in the waveguide. Adjusting the timing between when the transmitter sends a pulse and when the receiver stage is enabled will generally reduce the sunburst without affecting the accuracy of the range, since most sunburst is caused by a diffused transmit pulse reflected before it leaves the antenna. Clutter is considered a passive interference source, since it only appears in response to radar signals sent by the radar.

Clutter is detected and neutralized in several ways. Clutter tends to appear static between radar scans; on subsequent scan echoes, desirable targets will appear to move, and all stationary echoes can be eliminated. Sea clutter can be reduced by using horizontal polarization, while rain is reduced with circular polarization (meteorological radars wish for the opposite effect, and therefore use linear polarization to detect precipitation). Other methods attempt to increase the signal-to-clutter ratio.

Clutter moves with the wind or is stationary. Two common strategies to improve measure or performance in a clutter environment are:

- Moving target indication, which integrates successive pulses and
- Doppler processing, which uses filters to separate clutter from desirable signals.

The most effective clutter reduction technique is pulse-Doppler radar. Doppler separates clutter from aircraft and spacecraft using a frequency spectrum, so individual signals can be separated from multiple reflectors located in the same volume using velocity differences. This requires a coherent transmitter. Another technique uses a moving target indicator that subtracts the receive signal from

two successive pulses using phase to reduce signals from slow moving objects. This can be adapted for systems that lack a coherent transmitter, such as time-domain pulse-amplitude radar.

Constant false alarm rate, a form of automatic gain control (AGC), is a method that relies on clutter returns far outnumbering echoes from targets of interest. The receiver's gain is automatically adjusted to maintain a constant level of overall visible clutter. While this does not help detect targets masked by stronger surrounding clutter, it does help to distinguish strong target sources. In the past, radar AGC was electronically controlled and affected the gain of the entire radar receiver. As radars evolved, AGC became computer-software controlled and affected the gain with greater granularity in specific detection cells. Clutter may also originate from multipath echoes from valid targets caused by ground reflection, atmospheric ducting or ionospheric reflection/refraction (e.g., anomalous propagation).

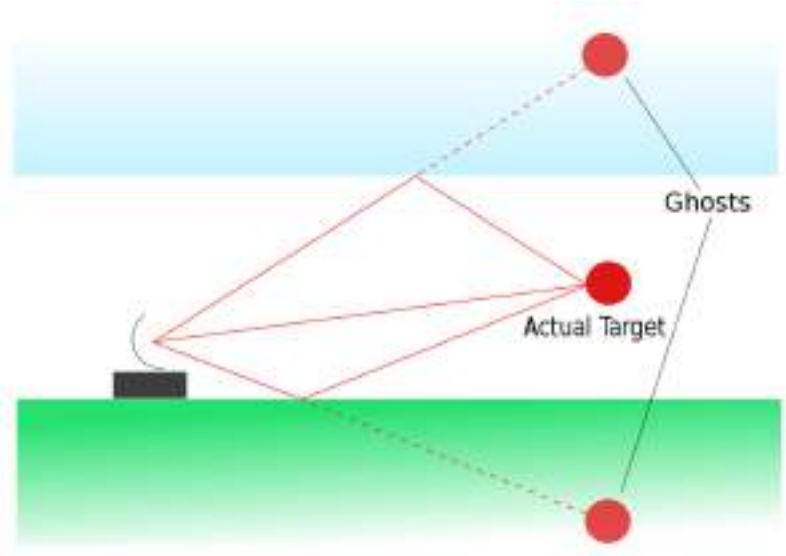


Fig 115) Radar multipath echoes from a target cause ghosts to appear.

This clutter type is especially bothersome since it appears to move and behave like other normal (point) targets of interest. In a typical scenario, an aircraft echo is reflected from the ground below, appearing to the receiver as an identical target below the correct one. The radar may try to unify the targets, reporting the target at an incorrect height, or eliminating it on the basis of jitter or a physical impossibility. Terrain bounce jamming exploits this response by amplifying the radar signal and directing it downward. These problems can be overcome by incorporating a ground map of the radar's surroundings and eliminating all echoes which appear to originate below ground or above a certain height. Monopulse can be improved by altering the elevation algorithm used at low elevation. In newer air traffic control radar equipment, algorithms are used to identify the false targets by comparing the current pulse returns to those adjacent, as well as calculating return improbabilities.

Jamming

Radar jamming refers to radio frequency signals originating from sources outside the radar, transmitting in the radar's frequency and thereby masking targets of interest. Jamming may be intentional, as with an electronic warfare tactic, or unintentional, as with friendly forces operating equipment that transmits using the same frequency range. Jamming is considered an active interference source, since it is initiated by elements outside the radar and in general unrelated to the radar signals.

Jamming is problematic to radar since the jamming signal only needs to travel one way (from the jammer to the radar receiver) whereas the radar echoes travel two ways (radar-target-radar) and are therefore significantly reduced in power by the time they return to the radar receiver in accordance with inverse-square law. Jammers therefore can be much less powerful than their jammed radars and still effectively mask targets along the line of sight from the jammer to the radar (main lobe jamming). Jammers have an added effect of affecting radars along other lines of sight through the radar receiver's sidelobes (sidelobe jamming).

Main lobe jamming can generally only be reduced by narrowing the main lobe solid angle and cannot fully be eliminated when directly facing a jammer which uses the same frequency and polarization as the radar. Sidelobe jamming can be overcome by reducing receiving sidelobes in the radar antenna design and by using an omnidirectional antenna to detect and disregard non-main lobe signals. Other anti-jamming techniques are frequency hopping and polarization.

Radar Signal Processing (Distance Measurement)

Transit time

One way to obtain a distance measurement is based on the time-of-flight: transmit a short pulse of radio signal (electromagnetic radiation) and measure the time it takes for the reflection to return. The distance is one-half the round-trip time multiplied by the speed of the signal. The factor of one-half comes from the fact that the signal has to travel to the object and back again. Since radio waves travel at the speed of light, accurate distance measurement requires high-speed electronics. In most cases, the receiver does not detect the return while the signal is being transmitted. Through the use of a duplexer, the radar switches between transmitting and receiving at a predetermined rate. A similar effect imposes a maximum range as well. In order to maximize range, longer times between pulses should be used, referred to as a pulse repetition time, or its reciprocal, pulse repetition frequency.

These two effects tend to be at odds with each other, and it is not easy to combine both good short range and good long range in a single radar. This is because the short pulses needed for a good minimum range broadcast have less total energy, making the returns much smaller and the target harder to detect. This could be offset by using more pulses, but this would shorten the maximum range. So, each radar uses a particular type of signal. Long-range radars tend to use long pulses with long delays between them, and short-range radars use smaller pulses with less time between them. As electronics have improved many radars now can change their pulse repetition frequency, thereby changing their range. The newest radars fire two pulses during one cell, one for short range (about 10 km (6.2 mi)) and a separate signal for longer ranges (about 100 km (62 mi)).

Distance may also be measured as a function of time. The radar mile is the time it takes for a radar pulse to travel one nautical mile, reflect off a target, and return to the radar antenna. Since a nautical mile is defined as 1,852 m, then dividing this distance by the speed of light (299,792,458 m/s), and then multiplying the result by 2 yields a result of 12.36 μs in duration.

Frequency Modulation

Another form of distance measuring radar is based on frequency modulation. In these systems, the frequency of the transmitted signal is changed over time. Since the signal takes a finite time to travel to and from the target, the received signal is a different frequency than what the transmitter is broadcasting at the time the reflected signal arrives back at the radar. By comparing the frequency of the two signals the difference can be easily measured. This is easily accomplished with very high accuracy even in 1940s electronics. A further advantage is that the radar can operate effectively at relatively low frequencies. This was important in the early development of this type when high-frequency signal generation was difficult or expensive.

This technique can be used in continuous wave radar and is often found in aircraft radar altimeters. In these systems a "carrier" radar signal is frequency modulated in a predictable way, typically varying up and down with a sine wave or sawtooth pattern at audio frequencies. The signal is then sent out from one antenna and received on another, typically located on the bottom of the aircraft, and the signal can be continuously compared using a simple beat frequency modulator that produces an audio frequency tone from the returned signal and a portion of the transmitted signal.

The modulation index riding on the receive signal is proportional to the time delay between the radar and the reflector. The frequency shift becomes greater with greater time delay. The frequency shift is directly proportional to the distance travelled. That distance can be displayed on an instrument, and it may also be available via the transponder. This signal processing is similar to that used in speed detecting Doppler radar. Example systems using this approach are AZUSA, MISTRAM, and UDOP.

Terrestrial radar uses low-power FM signals that cover a larger frequency range. The multiple reflections are analyzed mathematically for pattern changes with multiple passes creating a computerized synthetic image. Doppler effects are used which allows slow moving objects to be detected as well as largely eliminating "noise" from the surfaces of bodies of water.

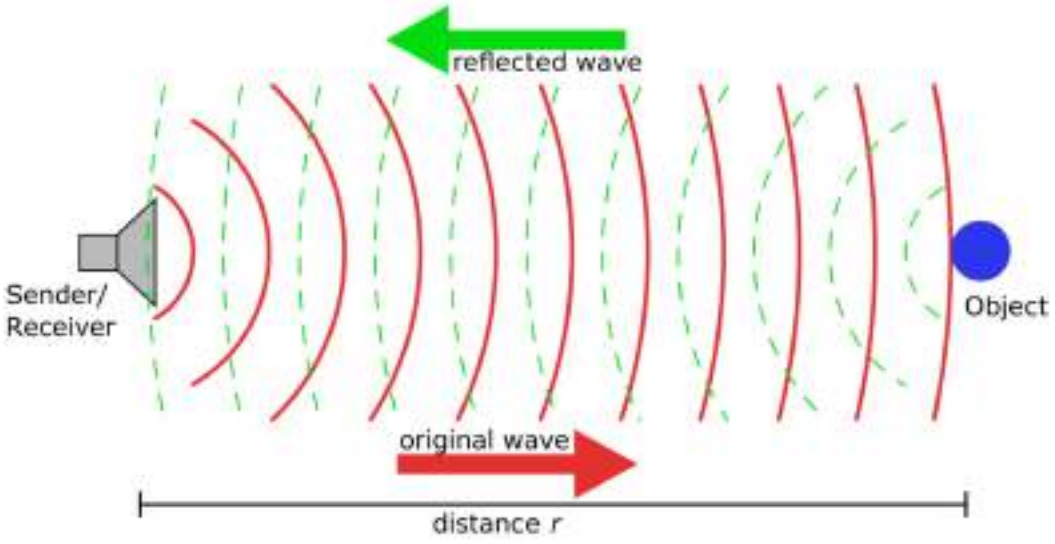


Fig 116) Continuous wave (CW) radar. Using frequency modulation allows range to be extracted.

Pulse Compression

Pulse compression is a signal processing technique commonly used by radar, sonar and echography to increase the range resolution as well as the signal to noise ratio. This is achieved by modulating the transmitted pulse and then correlating the received signal with the transmitted pulse. [The two techniques outlined above both have their disadvantages. The pulse timing technique has an inherent tradeoff in that the accuracy of the distance measurement is inversely related to the length of the pulse, while the energy, and thus direction range, is directly related. Increasing power for longer range while maintaining accuracy demands extremely high peak power, with 1960s early warning radars often operating in the tens of megawatts. The continuous wave methods spread this energy out in time and thus require much lower peak power compared to pulse techniques, but requires some method of allowing the sent and received signals to operate at the same time, often demanding two separate antennas.

The introduction of new electronics in the 1960s allowed the two techniques to be combined. It starts with a longer pulse that is also frequency modulated. Spreading the broadcast energy out in time

means lower peak energies can be used, with modern examples typically on the order of tens of kilowatts. On reception, the signal is sent into a system that delays different frequencies by different times. The resulting output is a much shorter pulse that is suitable for accurate distance measurement, while also compressing the received energy into a much higher energy peak and thus reducing the signal to noise ratio. The technique is largely universal on modern large radars.

Radar Signal Processing (Speed Measurement)

Speed is the change in distance to an object with respect to time. Thus, the existing system for measuring distance, combined with a memory capacity to see where the target last was, is enough to measure speed. At one time the memory consisted of a user making grease pencil marks on the radar screen and then calculating the speed using a slide rule. Modern radar systems perform the equivalent operation faster and more accurately using computers.

If the transmitter's output is coherent (phase synchronized), there is another effect that can be used to make almost instant speed measurements (no memory is required), known as the Doppler effect. Most modern radar systems use this principle into Doppler radar and pulse-Doppler radar systems (weather radar, military radar). The Doppler effect is only able to determine the relative speed of the target along the line of sight from the radar to the target. Any component of target velocity perpendicular to the line of sight cannot be determined by using the Doppler effect alone, but it can be determined by tracking the target's azimuth over time.

It is possible to make a Doppler radar without any pulsing, known as a continuous-wave radar (CW radar), by sending out a very pure signal of a known frequency. CW radar is ideal for determining the radial component of a target's velocity. CW radar is typically used by traffic enforcement to measure vehicle speed quickly and accurately where range is not important.

When using a pulsed radar, the variation between the phase of successive returns gives the distance the target has moved between pulses, and thus its speed can be calculated. Other mathematical developments in radar signal processing include time-frequency analysis (Weyl Heisenberg or wavelet), as well as the chirplet transform which makes use of the change of frequency of returns from moving targets ("chirp").

Pulse-Doppler signal processing

Pulse-Doppler signal processing includes frequency filtering in the detection process. The space between each transmit pulse is divided into range cells or range gates. Each cell is filtered independently much like the process used by a spectrum analyzer to produce the display showing different frequencies. Each different distance produces a different spectrum. These spectra are used to perform the detection process. This is required to achieve acceptable performance in hostile environments involving weather, terrain, and electronic countermeasures.

The primary purpose is to measure both the amplitude and frequency of the aggregate reflected signal from multiple distances. This is used with weather radar to measure radial wind velocity and precipitation rate in each different volume of air. This is linked with computing systems to produce a real-time electronic weather map. Aircraft safety depends upon continuous access to accurate weather radar information that is used to prevent injuries and accidents. Weather radar uses a low PRF. Coherency requirements are not as strict as those for military systems because individual signals ordinarily do not need to be separated. Less sophisticated filtering is required, and range ambiguity processing is not normally needed with weather radar in comparison with military radar intended to track air vehicles.

The alternate purpose is "look-down/shoot-down" capability required to improve military air combat survivability. Pulse-Doppler is also used for ground-based surveillance radar required to defend personnel and vehicles. Pulse-Doppler signal processing increases the maximum detection distance

using less radiation in close proximity to aircraft pilots, shipboard personnel, infantry, and artillery. Reflections from terrain, water, and weather produce signals much larger than aircraft and missiles, which allows fast moving vehicles to hide using nap-of-the-earth flying techniques and stealth technology to avoid detection until an attack vehicle is too close to destroy. Pulse-Doppler signal processing incorporates more sophisticated electronic filtering that safely eliminates this kind of weakness. This requires the use of medium pulse-repetition frequency with phase coherent hardware that has a large dynamic range. Military applications require medium PRF which prevents range from being determined directly, and range ambiguity resolution processing is required to identify the true range of all reflected signals. Radial movement is usually linked with Doppler frequency to produce a lock signal that cannot be produced by radar jamming signals. Pulse-Doppler signal processing also produces audible signals that can be used for threat identification.

Radar Signal Processing (Peripherals)

Reduction of interference effects

Signal processing is employed in radar systems to reduce the radar interference effects. Signal processing techniques include moving target indication, Pulse-Doppler signal processing, moving target detection processors, correlation with secondary surveillance radar targets, space-time adaptive processing, and track-before-detect. Constant false alarm rate and digital terrain model processing are also used in clutter environments.

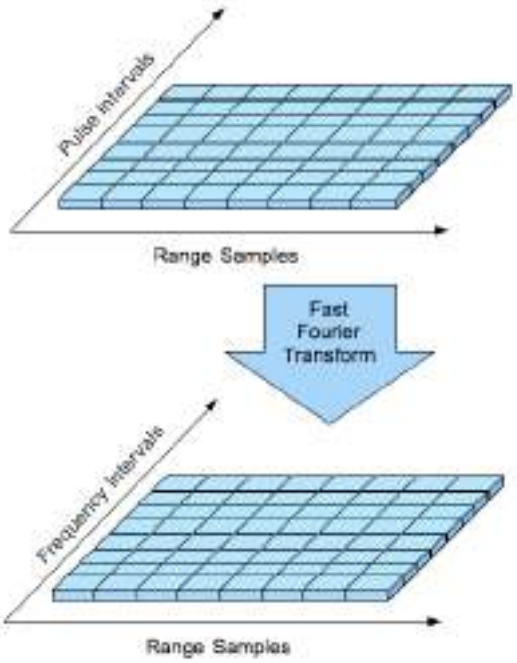


Fig 117) Pulse-Doppler signal processing. The Range Sample axis represents individual samples taken in between each transmit pulse. The Range Interval axis represents each successive transmit pulse interval during which samples are taken. The Fast Fourier Trans

Plot and track extraction

A Track algorithm is a radar performance enhancement strategy. Tracking algorithms provide the ability to predict future position of multiple moving objects based on the history of the individual positions being reported by sensor systems.

Historical information is accumulated and used to predict future position for use with air traffic control, threat estimation, combat system doctrine, gun aiming, and missile guidance. Position data is accumulated by radar sensors over the span of a few minutes.

There are four common track algorithms.

- Nearest neighbor algorithm
- Probabilistic Data Association
- Multiple Hypothesis Tracking
- Interactive Multiple Model (IMM)

Radar video returns from aircraft can be subjected to a plot extraction process whereby spurious and interfering signals are discarded. A sequence of target returns can be monitored through a device known as a plot extractor.

The non-relevant real time returns can be removed from the displayed information and a single plot displayed. In some radar systems, or alternatively in the command-and-control system to which the radar is connected, a radar tracker is used to associate the sequence of plots belonging to individual targets and estimate the targets' headings and speeds.

Engineering

A radar's components are:

- A transmitter that generates the radio signal with an oscillator such as a klystron or a magnetron and controls its duration by a modulator.
- A waveguide that links the transmitter and the antenna.
- A duplexer that serves as a switch between the antenna and the transmitter or the receiver for the signal when the antenna is used in both situations.
- A receiver. Knowing the shape of the desired received signal (a pulse), an optimal receiver can be designed using a matched filter.
- A display processor to produce signals for human readable output devices.
- An electronic section that controls all those devices and the antenna to perform the radar scan ordered by software.
- A link to end user devices and displays.

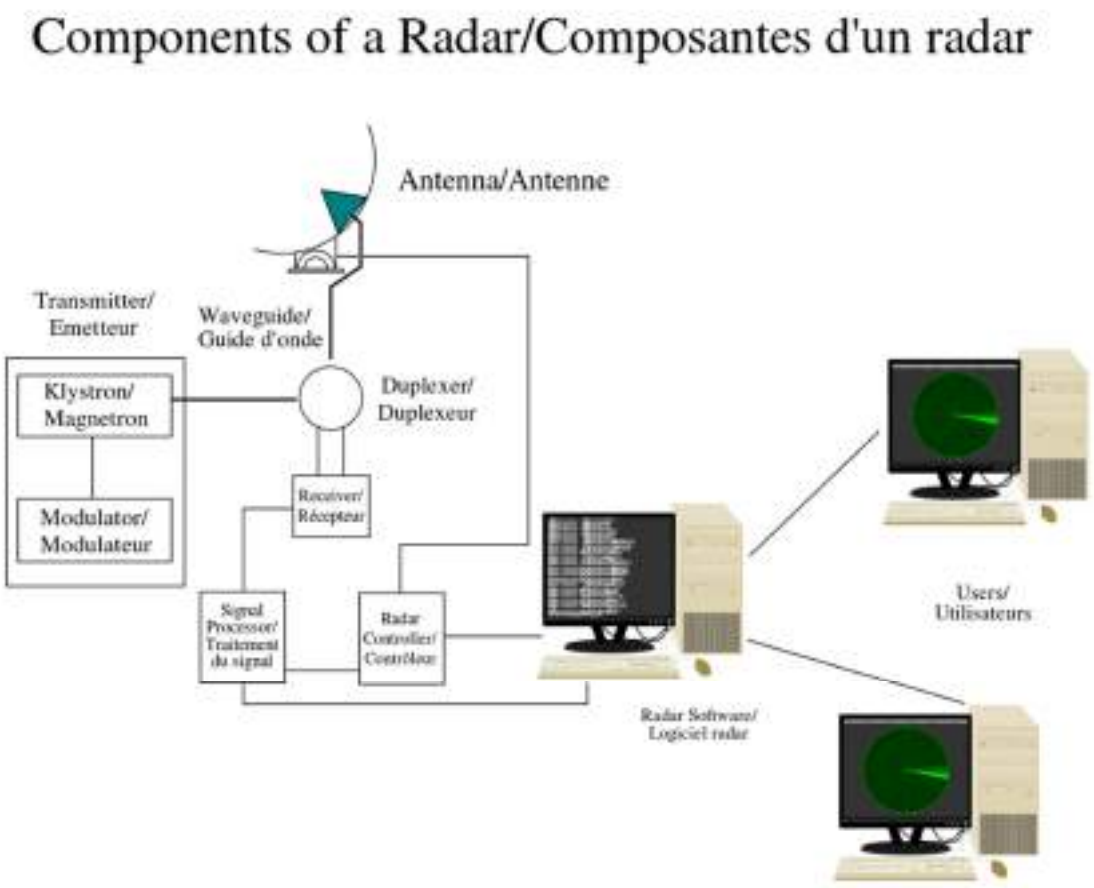


Fig 118) Radar components

Antenna design

Radio signals broadcast from a single antenna will spread out in all directions, and likewise a single antenna will receive signals equally from all directions. This leaves the radar with the problem of deciding where the target object is located.

Early systems tended to use omnidirectional broadcast antennas, with directional receiver antennas which were pointed in various directions. For instance, the first system to be deployed, Chain Home, used two straight antennas at right angles for reception, each on a different display. The maximum return would be detected with an antenna at right angles to the target, and a minimum with the antenna pointed directly at it (end on). The operator could determine the direction to a target by rotating the antenna so one display showed a maximum while the other showed a minimum. One serious limitation with this type of solution is that the broadcast is sent out in all directions, so the amount of energy in the direction being examined is a small part of that transmitted. To get a reasonable amount of power on the "target", the transmitting aerial should also be directional.

Parabolic reflector

More modern systems use a steerable parabolic "dish" to create a tight broadcast beam, typically using the same dish as the receiver. Such systems often combine two radar frequencies in the same antenna in order to allow automatic steering, or radar lock.

Parabolic reflectors can be either symmetric parabolas or spoiled parabolas: Symmetric parabolic antennas produce a narrow "pencil" beam in both the X and Y dimensions and consequently have a higher gain. The NEXRAD Pulse-Doppler weather radar uses a symmetric antenna to perform detailed volumetric scans of the atmosphere. Spoiled parabolic antennas produce a narrow beam in one dimension and a relatively wide beam in the other. This feature is useful if target detection over a wide range of angles is more important than target location in three dimensions. Most 2D surveillance radars use a spoiled parabolic antenna with a narrow azimuthal beamwidth and wide vertical beamwidth. This beam configuration allows the radar operator to detect an aircraft at a specific azimuth but at an indeterminate height. Conversely, so-called "nodder" height finding radars use a dish with a narrow vertical beamwidth and wide azimuthal beamwidth to detect an aircraft at a specific height but with low azimuthal precision.

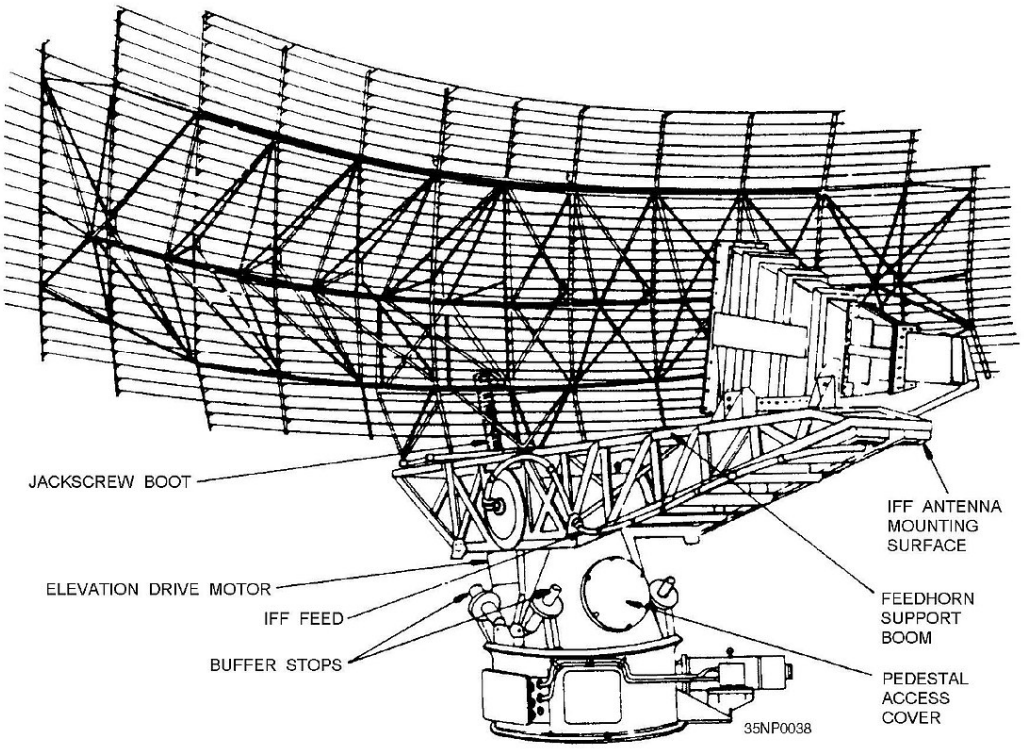


Fig 119) AS-3263/SPS-49(V) antenna (US Navy)

Types of Scan

- **Primary Scan:** A scanning technique where the main antenna aerial is moved to produce a scanning beam, examples include circular scan, sector scan, etc.
- **Secondary Scan:** A scanning technique where the antenna feed is moved to produce a scanning beam, examples include conical scan, unidirectional sector scan, lobe switching, etc.
- **Palmer Scan:** A scanning technique that produces a scanning beam by moving the main antenna and its feed. A Palmer Scan is a combination of a Primary Scan and a Secondary Scan.
- **Conical scanning:** The radar beam is rotated in a small circle around the "boresight" axis, which is pointed at the target.

Slotted Waveguide

Applied similarly to the parabolic reflector, the slotted waveguide is moved mechanically to scan and is particularly suitable for non-tracking surface scan systems, where the vertical pattern may remain constant. Owing to its lower cost and less wind exposure, shipboard, airport surface, and harbor surveillance radars now use this approach in preference to a parabolic antenna.



Fig 120) Slotted waveguide antenna

Phased Array

Another method of steering is used in a phased array radar.

Phased array antennas are composed of evenly spaced similar antenna elements, such as aerials or rows of slotted waveguide. Each antenna element or group of antenna elements incorporates a discrete phase shift that produces a phase gradient across the array. For example, array elements producing a 5-degree phase shift for each wavelength across the array face will produce a beam pointed 5 degrees away from the centerline perpendicular to the array face. Signals travelling along that beam will be reinforced. Signals offset from that beam will be cancelled. The amount of reinforcement is antenna gain. The amount of cancellation is side-lobe suppression.

Phased array radars have been in use since the earliest years of radar in World War II (Mammut radar), but electronic device limitations led to poor performance. Phased array radars were originally used for missile defense (see for example Safeguard Program). They are the heart of the ship-borne Aegis Combat System and the Patriot Missile System. The massive redundancy associated with having a large number of array elements increases reliability at the expense of gradual performance degradation that occurs as individual phase elements fail. To a lesser extent, Phased array radars have been used in weather surveillance. As of 2017, NOAA plans to implement a national network of Multi-Function Phased array radars throughout the United States within 10 years, for meteorological studies and flight monitoring.

Phased array antennas can be built to conform to specific shapes, like missiles, infantry support vehicles, ships, and aircraft.

As the price of electronics has fallen, phased array radars have become more common. Almost all modern military radar systems are based on phased arrays, where the small additional cost is offset by the improved reliability of a system with no moving parts. Traditional moving-antenna designs are still widely used in roles where cost is a significant factor such as air traffic surveillance and similar systems.

Phased array radars are valued for use in aircraft since they can track multiple targets. The first aircraft to use a phased array radar was the B-1B Lancer. The first fighter aircraft to use phased array radar was the Mikoyan MiG-31. The MiG-31M's SBI-16 Zaslon Passive electronically scanned array radar was considered to be the world's most powerful fighter radar, until the AN/APG-77 Active electronically scanned array was introduced on the Lockheed Martin F-22 Raptor.

Phased-array interferometry or aperture synthesis techniques, using an array of separate dishes that are phased into a single effective aperture, are not typical for radar applications, although they are widely used in radio astronomy. Because of the thinned array curse, such multiple aperture arrays, when used in transmitters, result in narrow beams at the expense of reducing the total power transmitted to the target. In principle, such techniques could increase spatial resolution, but the lower power means that this is generally not effective.

Aperture synthesis by post-processing motion data from a single moving source, on the other hand, is widely used in space and airborne radar systems.



Fig 121) Phased array: Not all radar antennas must rotate to scan the sky.

Frequency Bands

Antennas generally have to be sized similar to the wavelength of the operational frequency, normally within an order of magnitude. This provides a strong incentive to use shorter wavelengths as this will result in smaller antennas. Shorter wavelengths also result in higher resolution due to diffraction, meaning the shaped reflector seen on most radars can also be made smaller for any desired beamwidth.

Opposing the move to smaller wavelengths are a number of practical issues. For one, the electronics needed to produce high power very short wavelengths were generally more complex and expensive than the electronics needed for longer wavelengths or didn't exist at all. Another issue is that the radar equation's effective aperture figure means that for any given antenna (or reflector) size will be more efficient at longer wavelengths. Additionally, shorter wavelengths may interact with molecules or raindrops in the air, scattering the signal. Very long wavelengths also have additional diffraction

effects that make them suitable for over the horizon radars. For this reason, a wide variety of wavelengths are used in different roles.

The traditional band names originated as code-names during World War II and are still in military and aviation use throughout the world. They have been adopted in the United States by the Institute of Electrical and Electronics Engineers and internationally by the International Telecommunication Union. Most countries have additional regulations to control which parts of each band are available for civilian or military use.

Other users of the radio spectrum, such as the broadcasting and electronic countermeasures industries, have replaced the traditional military designations with their own systems.

Band name	Frequency range	Wavelength range	Notes
HF	3–30 MHz	10–100 m	Coastal radar systems, over-the-horizon (OTH) radars; 'high frequency'
VHF	30–300 MHz	1–10 m	Very long range, ground penetrating; 'very high frequency'. Early radar systems generally operated in VHF as suitable electronics had already been developed for broadcast radio. Today this band is heavily congested and no longer suitable for radar due to interference.
P	< 300 MHz	> 1 m	'P' for 'previous', applied retrospectively to early radar systems; essentially HF + VHF. Often used for remote sensing because of good vegetation penetration.
UHF	300–1000 MHz	0.3–1 m	Very long range (e.g., ballistic missile early warning), ground penetrating, foliage penetrating; 'ultra-high frequency'. Efficiently produced and received at very high energy levels, and also reduces the effects of nuclear blackout, making them useful in the missile detection role.
L	1–2 GHz	15–30 cm	Long range air traffic control and surveillance; 'L' for 'long'. Widely used for long range early warning radars as they combine good reception qualities with reasonable resolution.
S	2–4 GHz	7.5–15 cm	Moderate range surveillance, Terminal air traffic control, long-range weather, marine radar; 'S' for 'sentimetric', its code-name during WWII. Less efficient than L, but offering higher resolution, making them especially suitable for long-range ground-controlled interception tasks.

C	4–8 GHz	3.75–7.5 cm	Satellite transponders; a compromise (hence 'C') between X and S bands; weather; long range tracking
X	8–12 GHz	2.5–3.75 cm	Missile guidance, marine radar, weather, medium-resolution mapping and ground surveillance; in the United States the narrow range 10.525 GHz ±25 MHz is used for airport radar; short-range tracking. Named X band because the frequency was a secret during WW2. Diffraction off raindrops during heavy rain limits the range in the detection role and makes this suitable only for short-range roles or those that deliberately detect rain.
K	18–24 GHz	1.11–1.67 cm	From German Kurz, meaning 'short'. Limited use due to absorption by water vapor at 22 GHz, so K_u and K_a on either side used instead for surveillance. K-band is used for detecting clouds by meteorologists, and by police for detecting speeding motorists. K-band radar guns operate at 24.150 ± 0.100 GHz.
K_u	12–18 GHz	1.67–2.5 cm	High-resolution, also used for satellite transponders, frequency under K band (hence 'u')
K_a	24–40 GHz	0.75–1.11 cm	Mapping, short range, airport surveillance; frequency just above K band (hence 'a') Photo radar, used to trigger cameras which take pictures of license plates of cars running red lights, operates at 34.300 ± 0.100 GHz.
mm	40–300 GHz	1.0–7.5 mm	Millimeter band, subdivided as below. Oxygen in the air is an extremely effective attenuator around 60 GHz, as are other molecules at other frequencies, leading to the so-called propagation window at 94 GHz. Even in this window the attenuation is higher than that due to water at 22.2 GHz. This makes these frequencies generally useful only for short-range highly specific radars, like power line avoidance systems for helicopters or use in space where attenuation is not a problem. Multiple letters are assigned to these bands by different groups. These are from Baytron, a now defunct company that made test equipment.
V	40–75 GHz	4.0–7.5 mm	Very strongly absorbed by atmospheric oxygen, which resonates at 60 GHz.

W	75–110 GHz	2.7–4.0 mm	Used as a visual sensor for experimental autonomous vehicles, high-resolution meteorological observation, and imaging.

Table 3) Radar frequency bands

Modulators

Modulators act to provide the waveform of the RF-pulse. There are two different radar modulator designs:

High voltage switch for non-coherent keyed power-oscillators These modulators consist of a high voltage pulse generator formed from a high voltage supply, a pulse forming network, and a high voltage switch such as a thyratron. They generate short pulses of power to feed, e.g., the magnetron, a special type of vacuum tube that converts DC (usually pulsed) into microwaves. This technology is known as pulsed power. In this way, the transmitted pulse of RF radiation is kept to a defined and usually very short duration.

Hybrid mixers, fed by a waveform generator and an exciter for a complex but coherent waveform. This waveform can be generated by low power/low-voltage input signals. In this case the radar transmitter must be a power-amplifier, e.g., a klystron or a solid-state transmitter. In this way, the transmitted pulse is intrapulse-modulated and the radar receiver must use pulse compression techniques.

Coolant

Coherent microwave amplifiers operating above 1,000 watts microwave output, like travelling wave tubes and klystrons, require liquid coolant. The electron beam must contain 5 to 10 times more power than the microwave output, which can produce enough heat to generate plasma. This plasma flows from the collector toward the cathode. The same magnetic focusing that guides the electron beam forces the plasma into the path of the electron beam but flowing in the opposite direction. This introduces FM modulation which degrades Doppler performance. To prevent this, liquid coolant with minimum pressure and flow rate is required, and deionized water is normally used in most high-power surface radar systems that utilize Doppler processing.

Coolanol (silicate ester) was used in several military radars in the 1970s. However, it is hygroscopic, leading to hydrolysis and formation of highly flammable alcohol. The loss of a U.S. Navy aircraft in 1978 was attributed to a silicate ester fire. Coolanol is also expensive and toxic. The U.S. Navy has instituted a program named Pollution Prevention (P2) to eliminate or reduce the volume and toxicity of waste, air emissions, and effluent discharges. Because of this, Coolanol is used less often today.

Regulations

A radiodetermination system based on the comparison of reference signals with radio signals reflected, or retransmitted, from the position to be determined. Each radiodetermination system shall be classified by the radiocommunication service in which it operates permanently or temporarily. Typical radar utilizations are primary radar and secondary radar, these might operate in the radiolocation service or the radiolocation-satellite service.

Track Algorithm

A track algorithm is a radar and sonar performance enhancement strategy. Tracking algorithms provide the ability to predict future position of multiple moving objects based on the history of the individual positions being reported by sensor systems.

Marine Radar

Marine radars are X band or S band radars on ships, used to detect other ships and land obstacles, to provide bearing and distance for collision avoidance and navigation at sea. They are electronic navigation instruments that use a rotating antenna to sweep a narrow beam of microwaves around the water surface surrounding the ship to the horizon, detecting targets by microwaves reflected from them, generating a picture of the ship's surroundings on a display screen.

Radar is a vital navigation component for safety at sea and near the shore. Captains need to be able to maneuver their ships within feet in the worst of conditions and to be able to navigate "blind", when there is no visibility at night or due to bad weather. In addition to vessel-based marine radars, in port or in harbor, shore-based vessel traffic service radar systems are used by harbormasters and coast guard to monitor and regulate ship movements in busy waters.

Radars are rarely used alone in a marine setting. A modern trend is the integration of radar with other navigation displays on a single screen, as it becomes quite distracting to look at several different screens. Therefore, displays can often overlay an electronic GPS navigation chart of ship position, and a sonar display, on the radar display. This provides a combined view of surroundings, to maneuver the ship.

In commercial ships, radars are integrated into a full suite of marine instruments including chartplotters, sonar, two-way marine radio, satellite navigation (GNSS) receivers such as the US Global Positioning System (GPS), and emergency locators (SART). With digital data buses to exchange data, these devices advanced greatly in the early 21st century. For example, some have 3D displays that allow navigators to see above, below and all around the ship, including overlays of satellite imaging.

Collision avoidance

As required by COLREGS, all ships shall maintain a proper radar lookout if it is available on board to obtain early warning of risk of collision. Radar plotting with the use of an EBL and VRM, or the ARPA should be used to get the information of movement and the risk of collision (bearing, distance, CPA (closest point of approach), TCPA (time of closest point of approach) of other ships in vicinity.

Navigation

Marine radar systems can provide very useful radar navigation information for navigators onboard ships. The ship's position could be fixed by the bearing and distance information of a fixed, reliable target on the radar screen.

Radar controls

Marine radar has performance adjustment controls for brightness and contrast, also manual or automatic adjustment of gain, tuning, sea clutter and rain clutter suppression, and interference reduction. Other common controls consist of range scale, bearing cursor, fix/variable range marker (VRM) or bearing/distance cursor (EBL).

X Band

The X band is the designation for a band of frequencies in the microwave radio region of the electromagnetic spectrum. In some cases, such as in communication engineering, the frequency range of the X band is rather indefinitely set at approximately 7.0–11.2 GHz. [citation needed] In radar engineering, the frequency range is specified by the Institute of Electrical and Electronics Engineers (IEEE) as 8.0–12.0 GHz. The X band is used for radar, satellite communication, and wireless computer networks.

S Band

The S band is a designation by the Institute of Electrical and Electronics Engineers (IEEE) for a part of the microwave band of the electromagnetic spectrum covering frequencies from 2 to 4 gigahertz (GHz). Thus, it crosses the conventional boundary between the UHF and SHF bands at 3.0 GHz. The S band is used by airport surveillance radar for air traffic control, weather radar, surface ship radar, and some communications satellites, especially those used by NASA to communicate with the Space Shuttle and the International Space Station. The 10 cm radar short-band ranges roughly from 1.55 to 5.2 GHz. The S band also contains the 2.4–2.483 GHz ISM band, widely used for low power unlicensed microwave devices such as cordless phones, wireless headphones (Bluetooth), wireless networking (Wi-Fi), garage door openers, keyless vehicle locks, baby monitors as well as for medical diathermy machines and microwave ovens (typically at 2.495 GHz). India's regional satellite navigation network (IRNSS) broadcasts on 2.483778 to 2.500278 GHz.

NAVICO Featured Radar Products



Fig 122) Simrad radar solutions are characterized by state-of-the-art award-winning technology, reduced weight, and compact dimensions

Simrad Radars are in daily use all over the world with different users for different needs such as trawlers, ferries, patrol vessels, work boats and mega yachts.

Simrad radar solutions are characterized by state-of-the-art award-winning technology, reduced weight, and small and compact dimensions, thereby offering the best solution for installation even on small High-Speed Crafts.

From Open Array and Solid-State Radar to Special Radar Applications such as VTS and Oil Spill detection, Simrad Radars provide unlimited possibilities for on-water monitoring.



Fig 123) Simrad Devices Installed on a fishing boat

HALO Dome Radars

Simrad's revolutionary HALO pulse compression dome radars deliver industry-leading 360-degree sweeps every second at close range, for the ultimate in collision avoidance of stationary and fast-moving targets. With high-quality short, mid and long-range detection, these feature-packed dome antennas ensure targets can be seen vividly - even in the toughest environmental conditions.



Fig 124) Simrad HALO 24

HALO™ Open Array Radars

HALO™ radars deliver an unprecedented mix of long and short detection range, with precise target definition and minimal clutter. Quick start-up and maximum ocean-going reliability ensure you have coverage when you need it, while low-power pulsed transmissions mean Halo radars are safe to run in anchorages and marinas.



Fig 125) Simrad HALO 6

HD Digital Radar

Simrad's HD Digital Radar is ideal for smaller go-fast center console sportfishing vessels and powerboats with limited top space. Experience unparalleled situational awareness, with exceptional detection of small or distant targets and minimized screen-clutter. With a proven history of oceangoing reliability, this commercial-grade radar will withstand a sustained wind load of up to 100 knots, and features a long-life magnetron and brushless motor for maximum service life.



Fig 126) HD Digital Radar TXL-10S-4

Simrad HALO-6 Pulse Compression Radar

Halo™ radar delivers an unprecedented mix of long and short detection range, with precise target definition and minimal clutter. Quick start-up and maximum ocean-going reliability ensure you have coverage when you need it, while low-power pulsed transmissions mean Halo Radar is even safe to run in anchorages and marinas.



Fig 127) Simrad HALO 6

Product details

See Near and Far, Simultaneously

Halo™ radar delivers an unprecedented mix of short- and long-range performance with its 6-foot open array, from just six meters (20 feet) to as far as 72 nautical miles. Monitor two distance ranges simultaneously in Dual Range mode, and take full advantage of Halo radar to keep an eye on faraway weather cells while monitoring channel markers and high-speed watercraft up close. Pulse Compression technology means no compromises in detection at either range. Advanced digital signal processing helps to eliminate sea clutter, while Beam Sharpening technology provides enhanced separation between small or distant targets.

Safety, Weather, and Bird-Finder Radar

Halo radar delivers a comprehensive range of features to enhance your situational awareness and on-water safety. Monitor selected collision hazards with MARPA target tracking, or automatically highlight all approaching targets with the optional Velocity Track™ Doppler motion-tracking upgrade. Keep watch on distant storm cells in Weather mode, your own real-time meteorological service. Halo radar also works as a powerful bird-finder, a must-have tool for sportfishing enthusiasts and pro anglers. Halo radar's smart Weather and Bird modes require no manual tuning, just set the mode and go.

Ready in an Instant

Collision hazards won't wait for your radar to start up – why should you? Halo radar's solid-state technology is ready instantly from standby, and in just 16-25 seconds from a cold start. Avoid the 2–3-minute warm-up time associated with traditional pulse radar and trust Halo Radar to produce an immediate, accurate radar image when you need it. Halo radar's low-power pulsed transmissions

make it safe to run in anchorages and marinas, providing additional coverage in these high-collision-risk environments. Fast 48 RPM operation provides frequent position updates, while an advanced brushless motor and helical geartrain ensure quiet operation.

Minimum product requirements

Halo™ radar requires an Ethernet-connected Simrad multifunction display or Radar Control Unit. Velocity Track and MARPA Target Tracking functionality requires a heading sensor and GPS receiver. VelocityTrack™ functionality is an optional on-water upgrade, and requires the purchase of a one-time upgrade code.

Key Features

- True 72nm range with 6-foot open array antenna
- Beam Sharpening for enhanced target separation
- Simultaneous Dual Range operation
- Dedicated Harbor, Offshore, Weather, and Bird modes
- High-speed 48 RPM operation for rapid updates
- Ready instantly from standby, and in 16-25 seconds from power-on
- MARPA target tracking (up to 10 targets, 20 in dual range)
- VelocityTrack™ Doppler technology for collision avoidance

Simrad HALO-4 Pulse Compression Radar



Fig 128) Simrad HALO 4

Key Features

- True 64nm range with 4-foot open array antenna
- Beam Sharpening for enhanced target separation
- Simultaneous Dual Range operation
- Dedicated Harbor, Offshore, Weather, and Bird modes
- High-speed 48 RPM operation for rapid updates
- Ready instantly from standby, and in 16-25 seconds from power-on
- MARPA target tracking (up to 10 targets, 20 in dual range)

- VelocityTrack™ Doppler technology for collision avoidance

Simrad HALO-3 Pulse Compression Radar



Fig 129) Simrad HALO 3

Key Features

- True 48nm range with 3-foot open array antenna
- Beam Sharpening for enhanced target separation
- Simultaneous Dual Range operation
- Dedicated Harbor, Offshore, Weather, and Bird modes
- High-speed 48 RPM operation for rapid updates
- Ready instantly from standby, and in 16-25 seconds from power-on
- MARPA target tracking (up to 10 targets, 20 in dual range)
- VelocityTrack™ Doppler technology for collision avoidance

HALO Radars Compact descriptions

Solid-State Pulse Compression Radar Technology

- Superior target detection and definition
- 300' to 72nm instrumented radar ranges — model dependent
- 3X shorter (6m) min range than conventional pulse radars
- Meets latest, tough EU RF emission regulations
- Works exclusively with SIMRAD NSS and NSO evo2 MFD systems

Commercial Grade - built for long life, reliable duty cycle

- No magnetron — uses 25W GaN technology
- No maintenance for brushless motor
- No degradation of performance over lifecycle

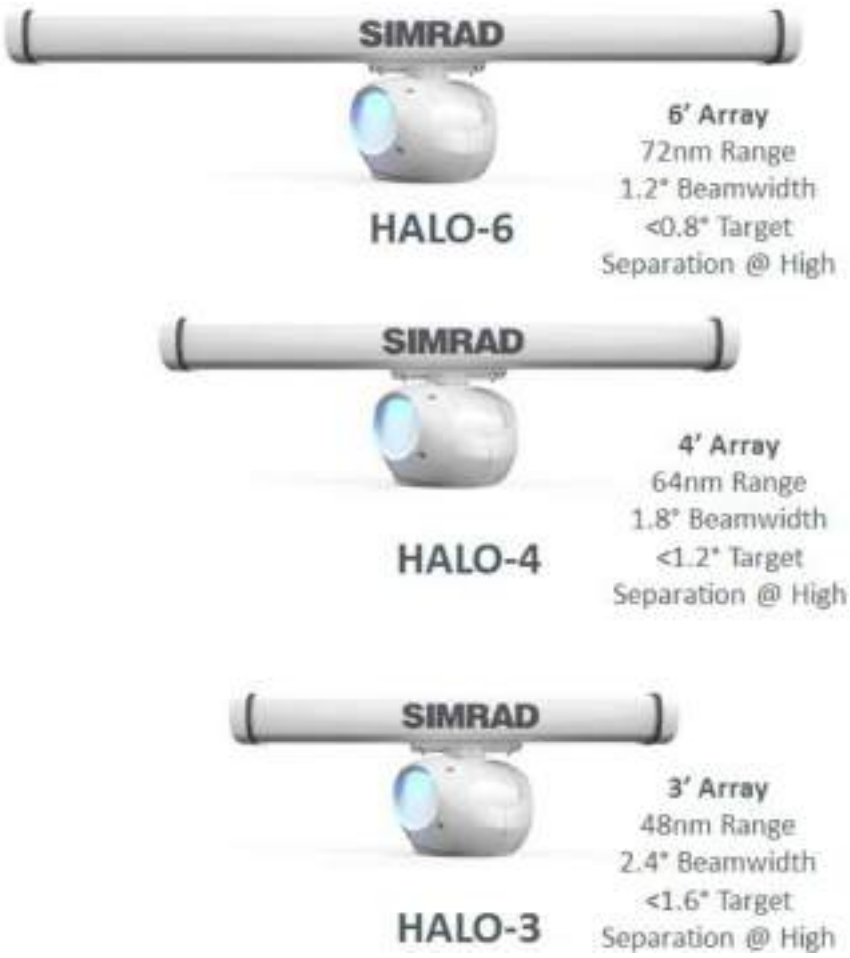
Shares benefits from both Simrad "Broadband" 4G FMCW and Conventional "Pulse" Radars

- Updated Navico digital signal processing (DSP)
- Outstanding Auto USE Modes (Bird, Custom, and 6 more)

- See weather cells clearly >65nm HALO-4 — model dependent
- High Performance 4G-like features and MORE
- Dual Range split PPI mode with 10 MARPA targets each
- Beam sharpening with control on all models

High speed mode — up to 48RPM (quiet running)

- No Tuning EVER Required - Super Fast Range changes
- Instant On — Low Power STBY — Low Radiation Hazard
- Sector Blanking is included
- Low Probability of Intercept with Frequency/Time Agility



HALO Pulse Compression Radars have:

- Solid State Broadband X-Band 7SW Transceiver in pedestal using Pulse Compression Technology - no magnetron lifetime degradation or AFC tuning issues EVER.
- Unprecedented Target Resolution using Bearmsharpening (with Target Separation Control) for all the open array antennas. Makes a 4' look like a 6' Array and a 6' look like an 8' array.

- Two Radars in one. Versatile Dual Range (like 4G) with independent controls and up to 20 MARPA targets total in dual mode.
- Auto Harbor and Offshore Modes with no Captain diddling required.
- Fast Updating and SUPER QUIET High-Speed Operation up to 48RPM max (radar mode dependent).
- A serious fishing BIRD Finder Mode, and allows future USE Modes.
- Instant ON with minimum warmup time.
- Highest Reliability with solid state Brushless Motor driver - no motor brushes to ever wear out and replace. Sealed hearings/gearbox and Delrin Polymer Helical Gears never need greasing.
- Operates from either 12 or 24V systems with new RI-12 Interface box.
- Only 3X the standby power of 46.
- Meets upcoming Low Emission standards for radars. Latest EU 00B spectrum emissions are met even with shortest 4Ons short pulse.



Fig 130) Halo Radar

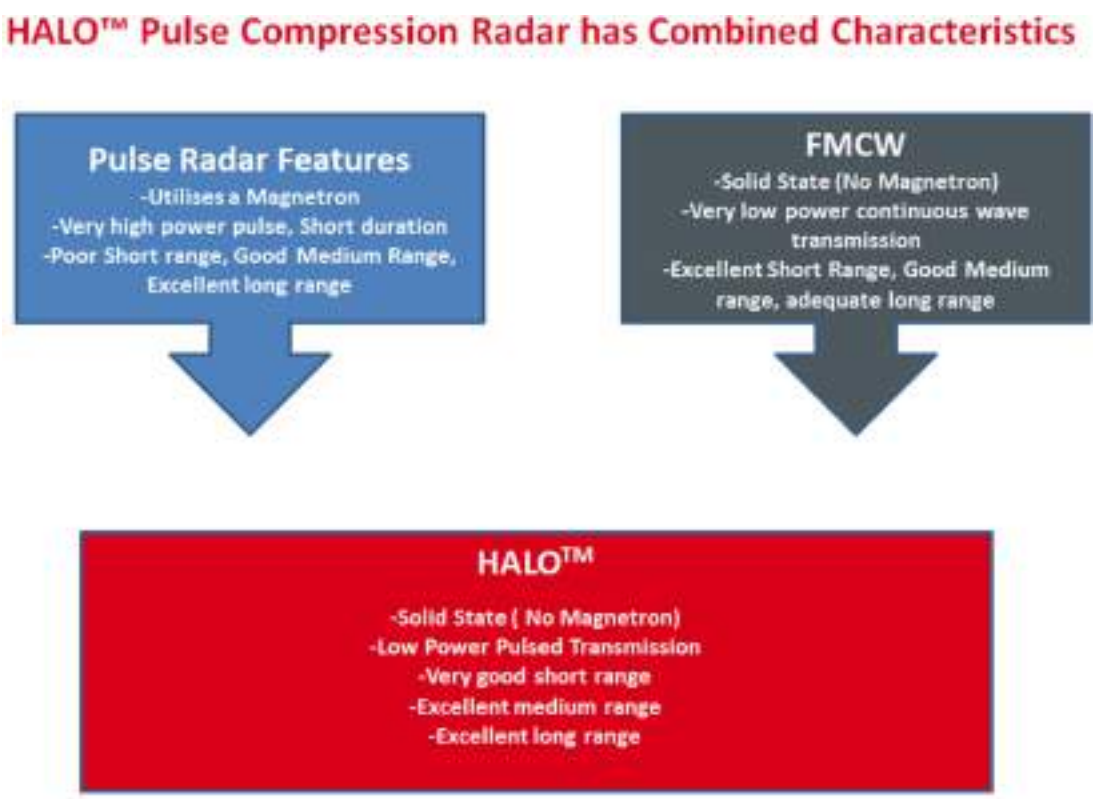


Fig 95) Halo Characteristics

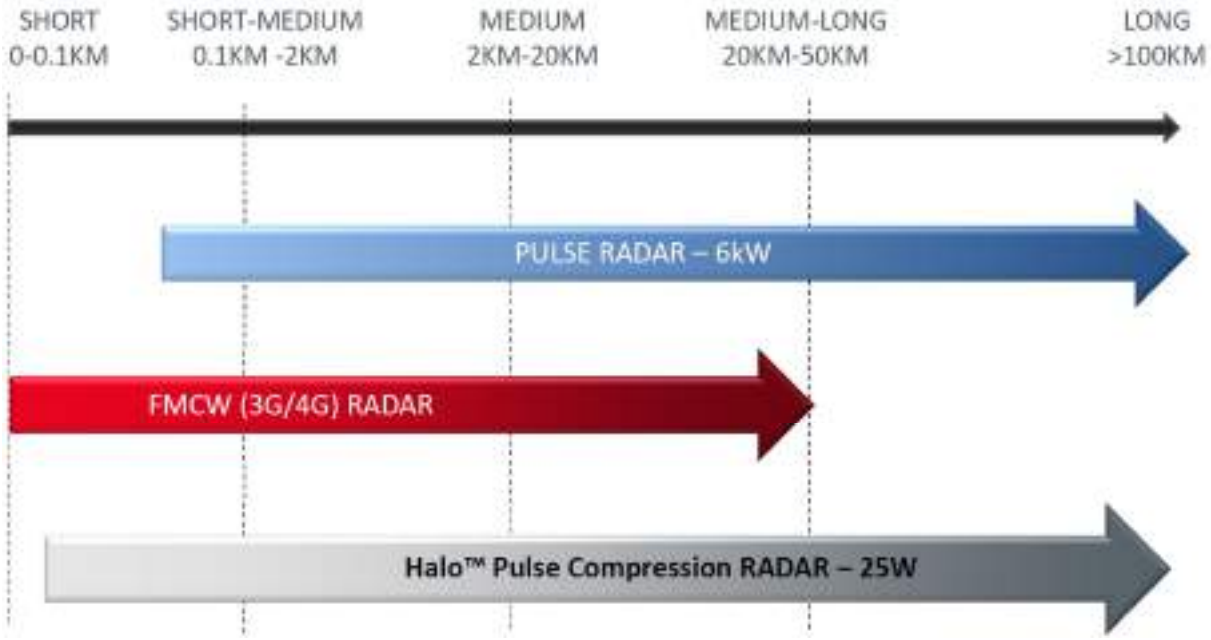


Fig 132) Range

Globally Unique and Revolutionary with High Performance

Halo Radar delivers a maximum range comparable to traditional 6kW pulse radar, at up to 48/64/72nm with the HALO-3/4/6-foot open array antenna. It offers unprecedented 6m (20ft)

minimum range, peering into that pulse-radar blind spot where once only FMCW (3G/4G) Broadband Radar could operate and has unique BIRD finder and Auto “Hands Off” USER modes.

Unmatched Target Resolution – Beam Sharpening

Whether you’re looking at a flock of birds or a string of channel markers, separating one radar target from another is key. Beam Sharpening with Target Separation Control provides unmatched target resolution, granting the Halo Pulse Compression Radar’s 3/4/6-foot open array antenna the same effective target resolution as a 4/6/8-foot array without beam sharpening.

Dual Range

With Dual Range, Halo Radar functions like two arrays in one – monitor two distance ranges simultaneously with independent displays, controls, and totally independent MARPA target tracking. Take full advantage of Halo Radar’s combination of short-, mid-, and long-range performance to keep an eye on faraway weather cells, while monitoring channel markers and high-speed watercraft up close. Dual Range operation is available with Simrad NSS and NSO display systems and our DSP technology has NO target detection degradation in Dual Range mode.

Instant ON with Quiet Running

Less startup time (16-25 sec), no tuning, no magnetron lifetime issues, and no motor brushes that ever wear out. Helical gear design assures very low rotational acoustical noise – even at 48RPM.

BLUE Accent Lighting

Display your Halo Radar on the water with soft-glow, dual-beam Blue LED accent lighting, integrated into the pedestal and customizable with 4-level brightness control.

Unique Product Features

Unique Product Features	Customer Benefit
Range	Halo-3 with 48nm; Halo-4 with 64nm; Halo-6 with 72nm
Operational Modes	Hands off "out of the box" radar operation. Has Harbor, Offshore, BIRD, Custom, Weather, and other USER modes
"Best in Class" Quiet Scanner	Even lower acoustic rotational noise than competition belt drive designs used in some Super HD models
High Speed	Up to 48 RPM Note: Rotational speed is Mode and MFD model dependent
Directional Sidelobe Reduction	Advanced signal processing allows you to see small targets better next to large targets such as ships and bridges
Sector Blanking	Up to 4 sectors and any angle
Low electromagnetic emissions	Meets Radar Low Emission Standard ITU-R SM.1541-4 (09/2011) – "Unwanted emissions in the out-of-band domain - NOT as safe as 3G/4G. "Cannot be hugged". - Can run in anchorages and marinas
Connectivity and Installation	Connects to range of SIMRAD evo2 multi-function displays via Ethernet using RI-12 interface box. Same radar cable to scanner as 3G/4G. Easier to install with small diameter connectors and thinner/lighter cabling than competitor Open Arrays. Various Radar Mounts are available from 3 major suppliers Scanstrut, SeaView, and Edson

Table 4) Unique Product Features

Target Consumer Summary

Top 3 Target Groups	Top 3 Market Demands
OEM Boat Builders 28' -40'	• High performance radar in small package – Halo-3 or Halo-4 are key candidates to fit "Go Fast" fishing machines that refuse to have the room for a 6' array • Hands off AUTO modes, Short + Long range performance, BIRD MODE with great weather detection • Quality azimuth resolution with less clutter
OEM Coastal Cruisers	• Smaller stylish Halo-4 radar package to compliment a Glass Bridge • For those who do not want to put on a 6' array • Safe for the family - Brand awareness - Quiet running
Commercial Fishing Vessels	• Reliability and rugged design is key. These customers normally uses Halo-6. • Designed for 10,000 hr operation with solid state Transmitter components with sealed mechanical geartrain that requires no annual service. Easy to service, if ever required – parts are available. • Daily operation – Both short and long range in 1 radar eliminates some of the need for 2 radars on board

Table 5) Target Consumer Summary

Competitor Comparison

	FURUNO	RAYMARINE	GARMIN	SIMRAD HALO™
	"UHD" Models 3.5' DRS4A 4kW; 4' DRS6A 6kW	4 models HD/SHD Series 4/6'HD 4kW; 4/6'SHD 6kW	3 models xHD2 Series 4' xHD2 4kW; 4/6'xHD2 6kW	3 models SIMRAD HALO™ Pulse Compression Radar 3'/4'/6'
Range	48/64nm	72nm all models (Range scale)	36/48/72nm	48/64/72nm
Closest target to Radar	30m	30m	30m	6m (20') – BIG WINNER!
360° Usable Range	x	x	x	✓
Safe Distance from Array (100W/m²; 10W/m²)	1.2m/1.2m/2.4m No Data	Data not published	1.4/1.7/1.7/2/2.5/2.8m 4.5/15.1/5.5/6.2/7.8/8.7m	TBD
Warm up Time	90-180sec	75sec all models	90-180sec	16-25sec Instant On
Operating Power (min/max/standby at high wind range)	No Data - PS box	Typ:70/30/Sleep 1.2W	55/145W	40/150/6.5W @ 13.6Vdc
Scanner rotation speed	24/36/48rpm	24/48 with SHD +E/G series)	24/48rpm	Variable 16/24/36/48rpm
True Dual Range	✓	✓	✓	✓ With NSS and NSOevo2
Interface - radar data	Ethernet (NavNet 3D)	Ethernet (Seatalk HS) ✓ (SHD)	Ethernet	Ethernet
Beam sharpening	x	x	x	YES – all lengths
Advanced MARPA	Yes – 30 target APRA	✓ – Basic 10 target only	x – Basic 10 target only	x – 20 target dual range mode
Advanced Use modes	✓ - GST	✓Harbour/Offshore/BIRD/Buoy/Coastal	✓ Offshore/Harbor/BIRD - GST	✓ Offshore/Harbor/BIRD/Custom/4 Others - GST
Auto STC	✓	✓	✓	✓
Directional Sidelobe Suppression	✓	✓	unknown	✓
Scan-to-scan integration	✓	x	unknown	x
3G/4G + Pulse same boat simultaneous operation	x	x	x	✓ (Needs >9ft vertical separation)

Table 6) Competitor Comparison

Simrad HALO-24 Dome Radar



Fig 133) Simrad HALO 24

HALO24 revolutionizes radar by offering an almost real-time view, with industry-first 60 RPM operation at close range for the ultimate in collision avoidance. Identify hazards in an instant with VelocityTrack™ Doppler technology, and enjoy simultaneous short and long-range coverage—up to 48 nautical miles—from one compact 24-inch dome antenna.

HALO24 revolutionizes radar by offering an almost real-time view, with industry-first 60 RPM operation at close range for the ultimate in collision avoidance. Identify hazards in an instant with VelocityTrack™ Doppler technology, and enjoy simultaneous short and long-range coverage—up to 48 nautical miles—from one compact 24-inch dome antenna.



Fig 134) HALO 24 60 RPM operation at close range

Perfect for a wide range of coastal bay boats, HALO24 comes in a compact dome antenna and delivers high-quality short, mid and long-range detection. Monitor two distance ranges at once in Dual Range mode which enables you to keep an eye on far away weather cells while watching for collision hazards up close. HALO24 radar's pulse compression technology means no compromises in detection at either selected range, while beam sharpening provides enhanced separation between small or distant targets.



Fig 135) NSS12evo3

HALO24 radar delivers a full 360 degree sweep every second, thanks to its industry-first 60 RPM rotation at ranges up to 1.5 nautical miles. These ultra-fast updates give you an almost real-time view at close range, offering the ultimate view for collision avoidance.

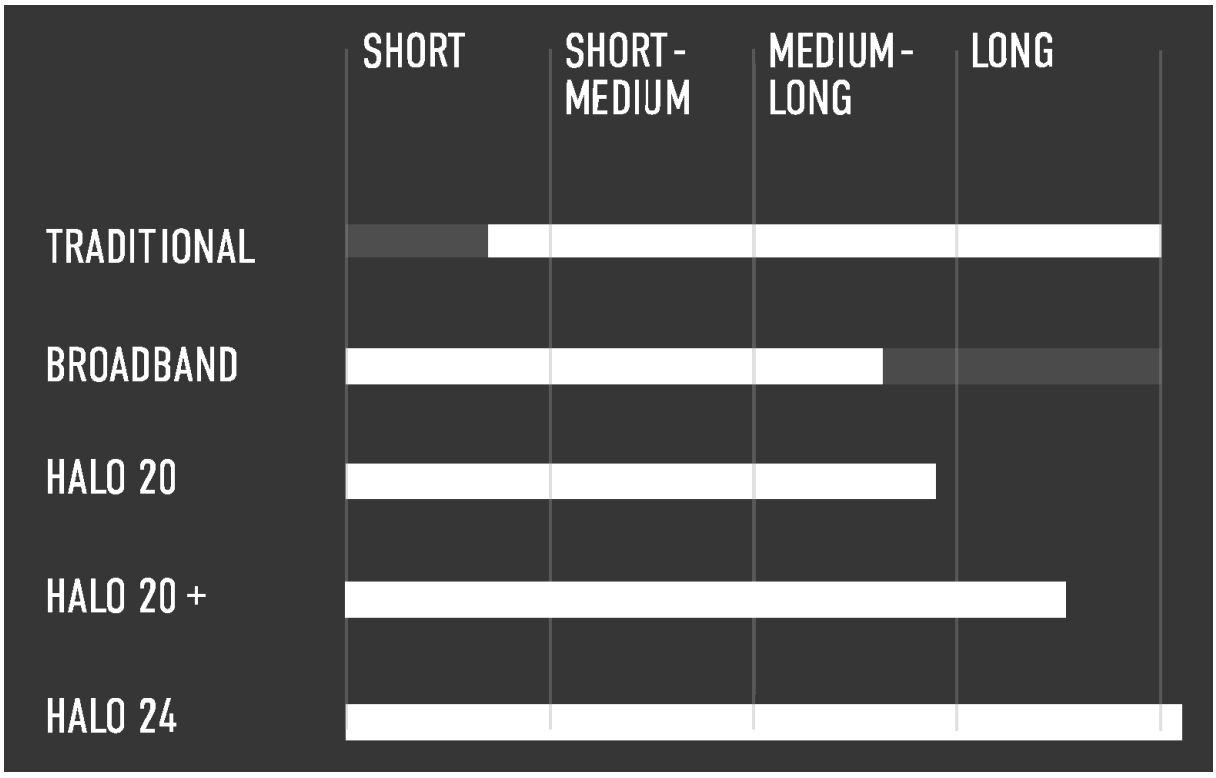


Fig 136) HALO series in compare with others

VelocityTrack™ Doppler Technology Built-In

VelocityTrack™ technology provides instant visual feedback on whether targets are coming towards you or moving away. Simple color-coding highlights potential hazards, improving your situational awareness and further reducing your risk of collision. HALO24 radar automatically checks every target in range; there's no need to manually select individual targets, and no limit to the number of targets on screen at one time. Velocity Track and MARPA use requires a good quality heading and GPS source.

HALO24 radar wakes instantly from its low-power standby mode, delivering this high-speed radar coverage exactly when and where you need it. Even if your HALO24 radar is completely powered down start-up is a matter of seconds, not minutes like traditional pulse radar. Whether you're



Fig 137) Operating in 60 RPM

navigating through crowded waterways or contending with poor visibility, HALO24 radar immediately cuts through the clutter to give you a clear and current picture of your surroundings.



Fig 138) HALO 24 on-board

Key Features

- 48 nm range from a compact 24-inch dome
- Advanced pulse compression technology with beam sharpening
- Simultaneous Dual Range operation sees both near and far
- Ultra-fast 60 RPM operation at ranges up to 1.5 nm
- VelocityTrack™ Doppler technology for collision avoidance
- Easy operation with harbor, offshore, weather, and bird modes
- MARPA target tracking (up to 10 targets, 20 in dual range)
- Ready instantly from standby

Simrad HALO-20+ Radar

HALO20+ delivers an almost real-time view, with industry-leading 60 RPM operation at close range for the ultimate in collision avoidance. Identify hazards in an instant with VelocityTrack™ Doppler technology, and enjoy simultaneous short and long-range coverage—up to 36 nautical miles—from a compact 20-inch dome antenna.

Perfect for a wide range of coastal bay boats, HALO20+ comes in a compact dome antenna and delivers high-quality short, mid and long-range detection. Monitor two distance ranges at once in Dual Range mode which enables you to keep an eye on far away weather cells while watching for collision hazards up close. HALO20+ radar's pulse compression technology means no compromises in detection at either selected range, while beam sharpening provides better separation between small



Fig 139) HALO-20+

and distant targets. HALO20+ radar wakes instantly from its low-power standby mode, delivering high-speed radar coverage exactly when and where you need it. Even if your HALO20+ is completely powered down start-up is a matter of seconds, not minutes like traditional pulse radar. Whether you're navigating through crowded waterways or contending with poor visibility, HALO20+ radar immediately cuts through the clutter to give you a clear and current picture of your surroundings.

Key Features

- 36 nm range from a compact 20-inch dome
- Advanced pulse compression technology with beam sharpening
- Simultaneous Dual Range operation sees both near and far
- Ultra-fast 60 RPM operation at ranges up to 1.5 nm
- VelocityTrack™ Doppler technology for collision avoidance
- Easy operation with harbor, offshore, weather, and bird modes
- MARPA target tracking (up to 10 targets, 20 in dual range)
- Ready instantly from standby

Simrad HALO-20 Radar

A cost-effective way to increase situational awareness and collision avoidance, HALO20 is a compact dome radar with pulse compression technology that detects collision hazards and other targets in close

and up to 24 nautical miles away. With its small footprint and low profile, HALO20 is the perfect radar solution for budget-conscious boaters with small sportfishing vessels and dayboats.

Extend your view from the bow of your boat out to 24 nautical miles with pulse-compression radar technology that not only delivers a powerful mix of short and long-range detection, but provides precise target definition with minimal clutter. HALO20 radar delivers a comprehensive range of features to enhance your situational awareness and on-water safety. Monitor selected collision hazards with MARPA target tracking, tracking up to 10 targets. Whether you're navigating through crowded waterways or contending with poor visibility, HALO20 radar cuts through the clutter to give you a clear and current picture of your surroundings.

Harbor, Offshore and Weather modes tune HALO20 radar's advanced signal processing to help ensure that targets can be seen vividly – even in the toughest environmental conditions.



Fig 140) HALO-20 Radar

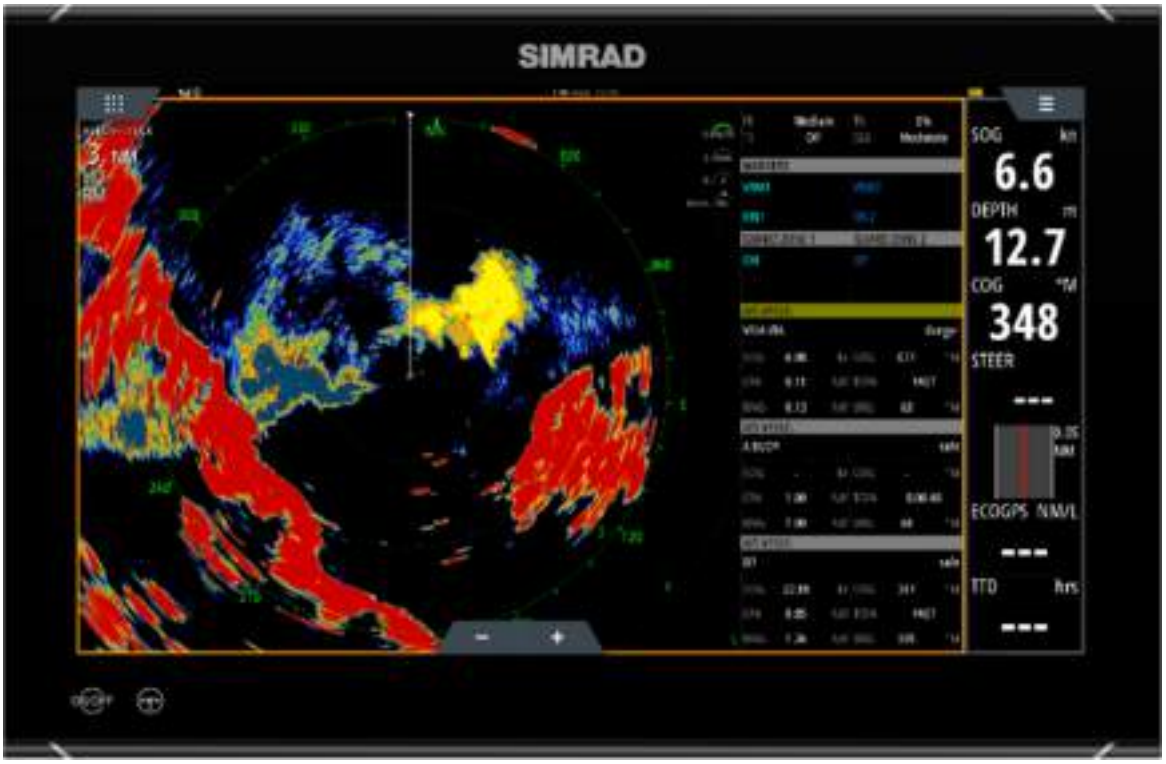


Fig 141) HALO-20 Ready to use display interface



Fig 142) HALO Radar installed on a recreational boat

Key Features

- 10W Pulse Compression
- 24 nm range from a compact 20-inch dome
- Unrivalled short range
- Radiation safe
- Easy operation with harbor, offshore and weather mode
- MARPA target tracking
- InstantOn™
- Low Power Consumption
- Guard Zones

HD Digital Radar TXL-10S-4



Fig 143) HD Digital Radar TXL-10S-4

Simrad's HD Digital 10kW/64nm birdfinder radar features a high performance 4-foot open array scanner with compact pedestal design, ideal for smaller go-fast center console sportfishing vessels and powerboats with limited top space. Experience unparalleled situational awareness, with exceptional detection of small or distant targets and minimized screen-clutter. With a proven history of oceangoing reliability, this commercial-grade radar will withstand a sustained wind load of up to 100 knots, and features a long-life magnetron and brushless motor for maximum service life.

64nm Range With 64nm instrumented range and 1.8° beam resolution, the 10kW TXL-10S-4 is suitable for both offshore and inshore use.

Target Detection and RACON/SART Triggering When installed 15m (50’) above the waterline, the TXL-10S-4 scanner complies with tough IMO IEC62388 Annex D target detection specifications. In addition, it will trigger RACON navigational aids and SART locator beacons at a minimum of 5nm range, when installed just 5m (17’) high.

Dual EBL/VRM, Dual Guard Zones Rapidly determine the bearing and distance to any radar target with dual Electronic Bearing Lines (EBL) and Variable Range Markers (VRM). Dual Guard Zones alarm on targets both entering and existing the zone, with independently configurable range and sensitivity.

Key Features

- 4-foot open-array antenna with slim pedestal design
- 64nm instrumented range with 1.8 beam resolution
- Meets IMO IEC62388 Annex D target detection specifications (triggers RACONs and SARTs at 5nm range)
- Automatic Tune, Gain, and Sea Clutter adjustments in Harbor and Offshore Modes
- Dual EBL/VRM, Dual Guard Zones
- TrueColor display for improved target distinction
- Radar overlay on charts (requires heading sensor)
- 10-target MARPA tracking (requires heading sensor)
- iPad/Android tablet control with optional Go Free wireless module
- Ethernet connectivity, compatible with all Simrad NSE/NSS/NSO multifunction displays

R5000 X- and S-Band Radar



Fig 144) R5000 Radar Series

Simrad R5000 radar systems are available in a range of configurations to meet the requirement for an IMO type-approved X-Band or S-Band radar system aboard CAT 1(H) and CAT 2(H) SOLAS vessels. A modular design makes it easy to create a single or multi-radar system for commercial vessels of any size and type.

Key Features

- The SimradR5000 radars fully complies and exceeds IMO/Solas regulations
- Thanks to its modular design, it can be either assembled to form a stand-alone single Radar System or as an advanced multi-installation Radar System.
- Radar Sensors are available in X-Band and S-band, both up-mast and down-mast mounting configuration.
- Crystal-clear widescreen display presentation
- Direct Digital Interface (DDI) between Radar Control Stations and Radar Sensors
- Radar Sensors with integrated target tracking and video radar processor
- Fast commissioning by advanced automatic sharing data function
- Makes this radar the only logical choice for the professional mariner

IMO/Solas Requirements

1. All ships of 300 gross tonnage and upwards and passenger ships, irrespective of size, shall be fitted with a 9 GHz X-band Radar.
2. All ships of 500 gross tonnage and upwards shall have an automatic tracking aid.

3. All ships of 3000 gross tonnage and upwards shall have a 3 GHz S-band radar or where considered appropriate by the administration a second 9 GHz X-band radar, functionally independent of those referred to in point 1.

Categories of Ships

	CAT 3	CAT 2	CAT 1
Size of ship/craft	<500 gt	500 gt to <10 000 gt and HSC < 10 000 gt	All ships/craft ≥10 000 gt
Minimum operational display area diameter	180 mm	250 mm	320 mm
Minimum display area	195 mm x 195 mm	270 mm x 270 mm	340 mm x 340 mm
Auto acquisition of targets	-	-	-
Minimum acquired radar target capacity	20	30	40
Minimum activated AIS target capacity	20	30	40
Minimum sleeping AIS target capacity	100	150	200
Trial maneuver	-	-	Yes

Table 7) Categories of Ships

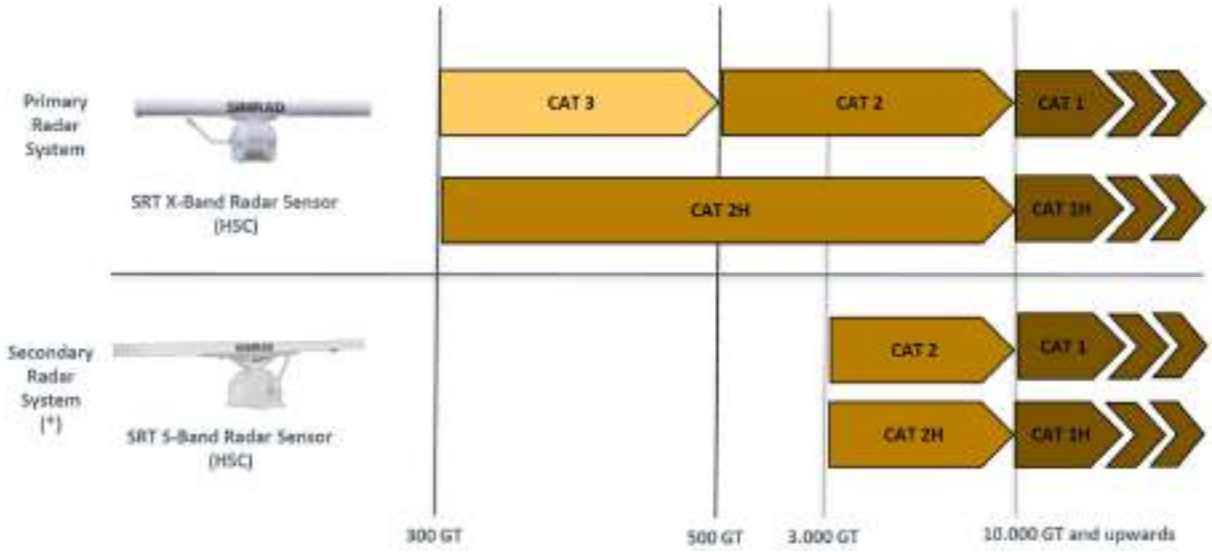


Fig 145) IMO/Solas Requirements

Target Consumer summary

TOP 3 TARGET GROUPS	TOP 3MARKET DEMANDS	
▪ Workboat ▪ Commercial Fishing ▪ Navy	▪ High performance radar with specific operational features. ▪ Product reliability. ▪ Comprehensive service network with spares availability.	
▪ Superyacht ▪ Passenger ▪ Ferry ▪ RoRo	▪ Flexible multi station installations. ▪ Product reliability. ▪ Comprehensive service network with spares availability.	
▪ Merchant	▪ Reliable, easy and friendly to use. ▪ Product reliability. ▪ Comprehensive service network with spares availability.	

Table 8) Target Consumer summary

R3016 Radar Control Unit



Fig 146) R3016 Radar Control Unit

The R3016 is a dedicated Radar Control Unit with integrated 16-inch widescreen display, compatible with a range of Simrad radar solutions including Halo™ Pulse Compression, Broadband 3G™/4G™, and HD Digital Radar.

16-inch Widescreen Radar Control Unit

Incorporating a 16-inch widescreen display, the R3016 is ideal for pilothouse installation. Its high-definition display provides a large and detailed PPI: excellent for docking, anti-piracy, and other radar applications where small on-screen details are crucial. The widescreen format offers ample display space for alarms, indicators and target tracking information, and allows settings to be modified via on-screen menus without obscuring any part of the main radar display.

Rugged Design with Flexible Mounting Options

The R3016 may be flush mounted, ideal for installation aboard new vessels. Alternatively, the included gimbal bracket is well suited to outside installations or pilothouse refits. With watertight rear connectors, the R3016 is IPX6 water-resistant from all sides, in either flush or bracket-mount installation.

Keypad Operation with Direct-Access Menu Keys

The R3016 is operated by an integrated keypad and rotary dial. Direct-access menu keys beside the display operate adjacent on-screen menu options, for quick and intuitive access to key settings and

features. With reliable, long-life operation and clear tactile feedback, the R3016's large buttons are suitable for use in rough seas, while travelling at speed, and with wet or gloved hands.

Networking & Expansion

The R3016 Radar Control Unit connects to compatible Simrad radar systems via Ethernet, offering simple installation and easy networking of multiple control units and radar systems. The R3016 also provides four NMEA 0183® ports and NMEA 2000® connectivity for compatible devices such as heading and speed sensors, AIS, and GPS.

HDMI Output for Display Mirroring/Clone Station

An HDMI output gives the option of a secondary monitor mirroring the R3016's primary display. This may be used to add a second non-interactive radar display at another station, or combined with the optional Simrad O2000 Controller to create a remotely operated, fully functional clone station ideal for dual-helm vessels. The R3016 is compatible with Simrad MO-series marine monitors, and other standard HDMI-capable displays.

Main Features

- Dedicated Radar Control Unit
- Compatible with Simrad Halo™ Pulse Compression, Broadband 3G™/4G™, and HD Digital Radar systems
- Computer controlled auto tuning system
- Sensitivity anti-sea clutter time control to allow an optimum picture under adverse weather conditions
- Consistent automatic target tracking
- Meets IEC 62252 (pending) when paired with specified Simrad radar systems
- 16-inch 1366x768-pixel widescreen LCD
- HDMI output for an optional secondary display or
- remotely-operated 'clone' station
- Keypad and rotary-dial interface with 8 direct-access
- menu keys
- Bracket and flush-mount installation options
- Full-sized SD card slot for logs and software updates
- Ethernet, NMEA0183 & NMEA2000 connectivity

Marine VHF Radio

Introduction

Marine VHF radio is a worldwide system of two-way radio transceivers on ships and watercraft used for bidirectional voice communication from ship-to-ship, ship-to-shore (for example with harbormasters), and in certain circumstances ship-to-aircraft. It uses FM channels in the very high frequency (VHF) radio band in the frequency range between 156 and 174 MHz, inclusive, designated by the International Telecommunication Union as the VHF maritime mobile band. In some countries

additional channels are used, such as the L and F channels for leisure and fishing vessels in the Nordic countries (at 155.5–155.825 MHz). Transmitter power is limited to 25 watts, giving them a range of about 100 kilometers (62 mi; 54 nmi).

Marine VHF radio equipment is installed on all large ships and most seagoing small craft. It is also used, with slightly different regulation, on rivers and lakes. It is used for a wide variety of purposes, including marine navigation and traffic control, summoning rescue services and communicating with harbors, locks, bridges and marinas.

Background

Marine radio was the first commercial application of radio technology, allowing ships to keep in touch with shore and other ships, and send out a distress call for rescue in case of emergency. Guglielmo Marconi invented radio communication in the 1890s, and the Marconi Company installed wireless telegraphy stations on ships beginning around 1900. Marconi built a string of shore stations and in 1904 established the first Morse code distress call, the letters CQD, used until 1906 when SOS was agreed on. The first significant marine rescue due to radio was the 1909 sinking of the luxury liner RMS Republic, in which 1,500 lives were saved. This and the 1912 RMS Titanic rescue brought the field of marine radio to public consciousness, and marine radio operators were regarded as heroes. By 1920, the US had a string of 12 coastal stations stretched along the Atlantic seaboard from Bar Harbor, Maine to Cape May, New Jersey.

The first marine radio transmitters used the longwave bands. During World War I amplitude modulation was developed, and in the 1920s spark radiotelegraphy equipment was replaced by vacuum tube radiotelephony allowing voice communication. Also in the 1920s, the ionospheric skip or skywave phenomenon was discovered, which allowed lower power vacuum tube transmitters operating in the shortwave bands to communicate at long distances.



Fig 96) A standard handheld marine VHF, mandatory on larger seagoing vessels under the Hi rules



Fig 148) A VHF set and a VHF channel 70 DSC set, the DSC on top

Types of equipment

Sets can be fixed or portable. A fixed set generally has the advantages of a more reliable power source, higher transmit power, a larger and more effective antenna and a bigger display and buttons. A portable set (often essentially a waterproof, VHF walkie-talkie in design) can be carried on a kayak, or to a lifeboat in an emergency, has its own power source and is waterproof if GMDSS-approved. A few portable VHFs are even approved to be used as emergency radios in environments requiring intrinsically safe equipment (e.g., gas tankers, oil rigs, etc.).



Fig 149) A vintage (76-89) marine VHF radiotelephone

Voice-only

Voice only equipment is the traditional type, which relies totally on the human voice for calling and communicating. Many lower priced handheld units are voice only as well as older fixed units.

Digital Selective Calling

DSC equipment, a part of the Global Maritime Distress Safety System (GMDSS), provides all the functionality of voice-only equipment and, additionally, allows several other features:

The ability to call another vessel using a unique identifier known as a Maritime Mobile Service Identity (MMSI). This information is carried digitally and the receiving set will alert the operator of an incoming call once its own MMSI is detected. Calls are set up on the dedicated VHF channel 70 which DSC equipment must listen on continuously. The actual voice communication then takes place on a different channel specified by the caller.

A distress button, which automatically sends a digital distress signal identifying the calling vessel and the nature of the emergency

A built in GPS receiver or facility to connect an external GPS receiver so that the user's location may be transmitted automatically along with a distress call.

When a DSC radio is bought new the user will get the opportunity to program it with the MMSI number of the ship it is intended to be used on. However, to change the MMSI after the initial programming can be problematic and require special proprietary tools. This is allegedly done to prevent theft.

Automatic identification system

More advanced transceiver units support AIS. This relies on a GPS receiver built into the VHF equipment or an externally connected one by which the transceiver obtains its position and transmits this information along with some other details about the ship (MMSI, cargo, draught, destination and some others) to nearby ships. AIS operates as a mesh network and full featured units relay AIS messages from other ships, greatly extending the range of this system however some low-end units are receive-only or do not support the relaying functionality.

AIS data is carried on dedicated VHF channels 87B and 88B at a baud rate of 9,600bit/s using GMSK modulation and uses a form of time division multiplexing.

Text messaging

Using the RTCM 12301.1 standard it is possible to send and receive text messages in a similar fashion to SMS between marine VHF transceivers which comply with this standard. However, as of 2019 very few transceivers support this feature. The recipient of the message needs to be tuned to the same channel as the transmitting station in order to receive it.

Regulation

In the United States, any person can legally purchase a Marine VHF radio and use it to communicate without requiring any special license as long as they abide by certain rules, but in a great many other countries a license is required to transmit on Marine VHF frequencies.

In the United Kingdom and Ireland and some other European countries Short Range Certificate is the minimum requirement to use a marine VHF radio. This is usually obtained after completing a course of around two days and passing an exam. This is intended for those operating on lakes and in coastal areas whereas a Long-Range Certificate is usually recommended for those operating further out as it also covers HF and MF radios as well as INMARSAT systems.

In the Middle East, any person can legally purchase a Marine VHF Radio and use it to communicate without requiring any special license as long as they abide by certain rules but in the Gulf’s countries, for importation of some telecommunication devices like VHF, TRA approved is required.

What is TRA approved?

Manufacturers of radio and telecommunications terminal equipment (RTTE) must ensure their products meet certain minimum essential requirements concerning health and safety, electromagnetic interference and radio spectrum matters.

Oman TRA

The Telecommunications Regulatory Authority (TRA) is the implementing authority of the Sultanate of Oman’s telecommunications policies. It was established in 2002 to liberalize and promote the telecommunications services in the Sultanate under the Telecommunications Act which was issued under the Royal Decree No. 30/2002.

In 2012, the Telecommunication Regulatory Authority was mandated to regulate Oman's Postal Sector in accordance with the Postal Service Regulatory Law, which was issued by the Royal Decree 71/2012 to reform, liberalize and develop the market within the Sultanate.

Vision

Enhanced Environment for a Digital Society

Mission

It is an independent authority responsible for regulating the Telecom and Postal Services sectors according to international best practices.

Automatic Transmitter Identification System (marine)

For use on the inland waterways within continental Europe, a compulsory Automatic Transmitter Identification System (ATIS) transmission conveys the vessel's identity after each voice transmission. This is a ten-digit code that is either an encoded version of the ship's alphanumeric call sign, or for vessels from outside the region, the ship MMSI prefixed with "9". The requirement to use ATIS in Europe, and which VHF channels may be used, are strongly regulated, most recently by the Basel agreements.

Channels & Frequencies

A marine VHF set is a combined transmitter and receiver and only operates on standard, international frequencies known as channels. Channel 16 (156.8 MHz) is the international calling and distress channel. Transmission power ranges between 1 and 25 watts, giving a maximum range of up to about 60 nautical miles (111 km) between aerials mounted on tall ships and hills, and 5 nautical miles (9 km; 6 mi) between aerials mounted on small boats at sea level. Frequency modulation (FM) is used, with vertical polarization, meaning that antennas have to be vertical in order to have good reception. For longer range communication at sea Marine MF and Marine HF bands and satellite phones can be used.

Half-duplex channels here are listed with the A and B frequencies the same. The frequencies, channels, and some of their purposes are governed by the ITU. For an authoritative list see. The original allocation of channels consisted of only channels 1 to 28 with 50 kHz spacing between channels, and the second frequency for full-duplex operation 4.6 MHz higher.

Improvements in radio technology later meant that the channel spacing could be reduced to 25 kHz with channels 60 to 88 interspersed between the original channels.

Channels 75 and 76 are omitted as they are either side of the calling and distress channel 16, acting as guard channels. The frequencies which would have been the second frequencies on half-duplex channels are not used for marine purposes and can be used for other purposes that vary by country. For example, 161.000 to 161.450 MHz are part of the allocation to the Association of American Railroads channels used by railways in the US and Canada.

Which VHF Radio Channels Can be Use?

Channel 16:

For hailing, safety and emergency use only

Channel 9:

Pleasure-boat hailing channel

Channels 68, 69, 71, 72 and 78A:

Recreational working channels

Channels 1, 7A, 8, 10, 11, 18A, 19A, 63, 77, 79A, 80A and 88A:

Commercial channels (Pleasure boaters are supposed to stay off them.)

Channel 13:

For requesting bridge openings, although in some areas it's channel 67.

Channels 24, 25, 26, 27, 28, 84, 85, 86 and 87:

Used by marine operators.

Channel 22:

Coast Guard working channel, the one where safety broadcasts are made after they alert you on channel 16 and ask you to switch over

Channel 6:

For Inter-ship safety communications

Channels 1, 5, 12, 14, 20, 63, 65A, 66A, 73, 74 and 77:

For port operations (Many of these are used by recreational boats in areas where no port operations exist.)

Channel 70:

A dedicated Digital Selective Calling (DSC) channel. DSC is an automated distress system that allows us to make digital phone calls through our VHFs.

Some notes:

1. Some radios enable channels 3A, 61A, and 64A when configured for "USA mode" even though those channels are allocated exclusively for Public Safety use by the FCC. The frequencies 156.075, 156.150, and 156.225 MHz are used for interoperability communication by police and fire departments in many areas.
2. Channel 22A is reserved for communication between the U.S. Coast Guard vessels and private vessels. The Coast Guard does not monitor 22A: Contact must first be established on 16.
3. UKSAR land-based search and rescue teams have access to the half-duplexed versions of 24, 62, 63, 64, 85 for operational and training needs. These include mountain rescue teams in England, Wales and Scotland.
4. CCG public operations moved from 22A to 04A to avoid interference from USCG stations in northern Washington state.

Operating procedure

Marine VHF mostly uses half-duplex non-relayed transmission. Ship to ship communication is over a single radio frequency, while ship to shore uses two frequencies, but typically only one of the parties can transmit at a time. (Not to be confused with simplex communication, for example radio broadcasting, where one party transmits always transmits.) The transceiver is normally in receive mode; to transmit the user presses a "push to talk" button on the set or microphone which turns the transmitter on and the receiver off. Some channels, however, are "duplex" transmission channels where communication can take place in both directions simultaneously when the equipment on both ends allow it. Each full-duplex channel has two frequency assignments. Duplex channels can be used to place calls over the public telephone network for a fee via a marine operator. When full-duplex is used, the call is similar to one using a mobile phone or landline. When half-duplex is used, voice is only carried one way at a time and the party on the boat must press the transmit button only when speaking. This facility is still available in some areas, though its use has largely died out with the advent of mobile and satellite phones. Marine VHF radios can also receive weather radio broadcasts, where they are available.

The accepted conventions for use of marine radio are collectively termed "proper operating procedure". These international conventions include:

Stations should listen for 30 seconds before transmitting and not interrupt other stations.

Maintaining a watch listening on Channel 16 when not otherwise using the radio. All calls are established on channel 16, except for distress working switch to a working ship-to-ship or ship-to-shore channel. (Procedure varies in the U.S. only when calls can be established on Ch. 9)

During distress operations silence maintained on Ch. 16 for other traffic until the channel is released by the controlling station using the pro-word "Silence Fini". If a station does use Ch. 16 during distress operations controlling station issues the command "silence mayday".

Using a set of international "calling" procedures such as the "Mayday" distress call, the "Pan-pan" urgency call and "Sécurité" navigational hazard call.

Using "pro-words" based on the English language such as Acknowledge, all after, all before, all stations, Confirm, Correct, Correction, in figures, in letters, Over, Out, Radio check, read back, Received, say again, Spell, Standby, Station calling, this is, Wait, Word after, Word before, Wrong (local language is used for some of these, when talking to local stations)

Using the NATO phonetic alphabet: Alfa, Bravo, Charlie, Delta, Echo, Foxtrot, Golf, Hotel, India, Juliett, Kilo, Lima, Mike, November, Oscar, Papa, Quebec, Romeo, Sierra, Tango, Uniform, Victor, Whiskey, X-ray, Yankee, Zulu

Using a phonetic numbering system based on the English language or a combination of English and Roman languages: Wun, Too, Tree, Fow-er, Fife, Six, Sev-en, Ait, Nin-er, Zero, Decimal; alternatively in marine communication: unaone, bissotwo, terrathree, kartefour, pantafive, soxisix, setteseven, oktoeight, novenine, nadazero

Slightly adjusted regulations can apply for inland shipping, such as the Basel rules (de: Regionale Vereinbarung über den Binnenschifffahrtsfunk) in Western Europe.

Navico Featured VHF Products



Fig 150) RS100-B VHF Marine Radio

Simrad VHF radios have earned a strong reputation for their robust construction and dependable reliability.

Whether fixed mounted or handheld, VHF radios are one of the most important communication and safety devices for boaters. From simple vessel-to-vessel or vessel-to-shore communications to calling out or responding to on-the-water emergencies, VHF radios deliver peace of mind while on the water.

RS100-B Simrad VHF and GPS-500



Fig 151) RS100-B Simrad VHF and GPS-500

Stay connected and navigate safely with the Simrad RS100-B VHF marine radio - integrated with a Class-B AIS transceiver and GPS, for complete visibility of and by other AIS-equipped vessels. The system supports up to eight handsets (four wired and four wireless) and four external speakers for vessel-wide communications.

Navigate safely with the Simrad RS100-B VHF marine radio - integrated with a Class-B AIS transceiver and GPS. Stay connected from anywhere on your vessel with up to eight handsets (four

wired and four wireless) and four external speakers. An external GPS-500 delivers advanced AIS functionality.

Complete visibility with integrated AIS

The RS100-B system features a Class-B AIS receiver and transmitter, so not only is your boat's position identifiable to nearby AIS-enabled vessels but theirs are also visible to you. The integrated AIS receiver is a valuable aid to help avoid collisions in crowded harbors and waterways. It monitors the location of all nearby AIS-enabled vessels, providing real-time information in any weather condition, night and day. AIS information can be viewed directly on the radio's screen or via a compatible multifunction device, as an overlay on a chart or radar screen.

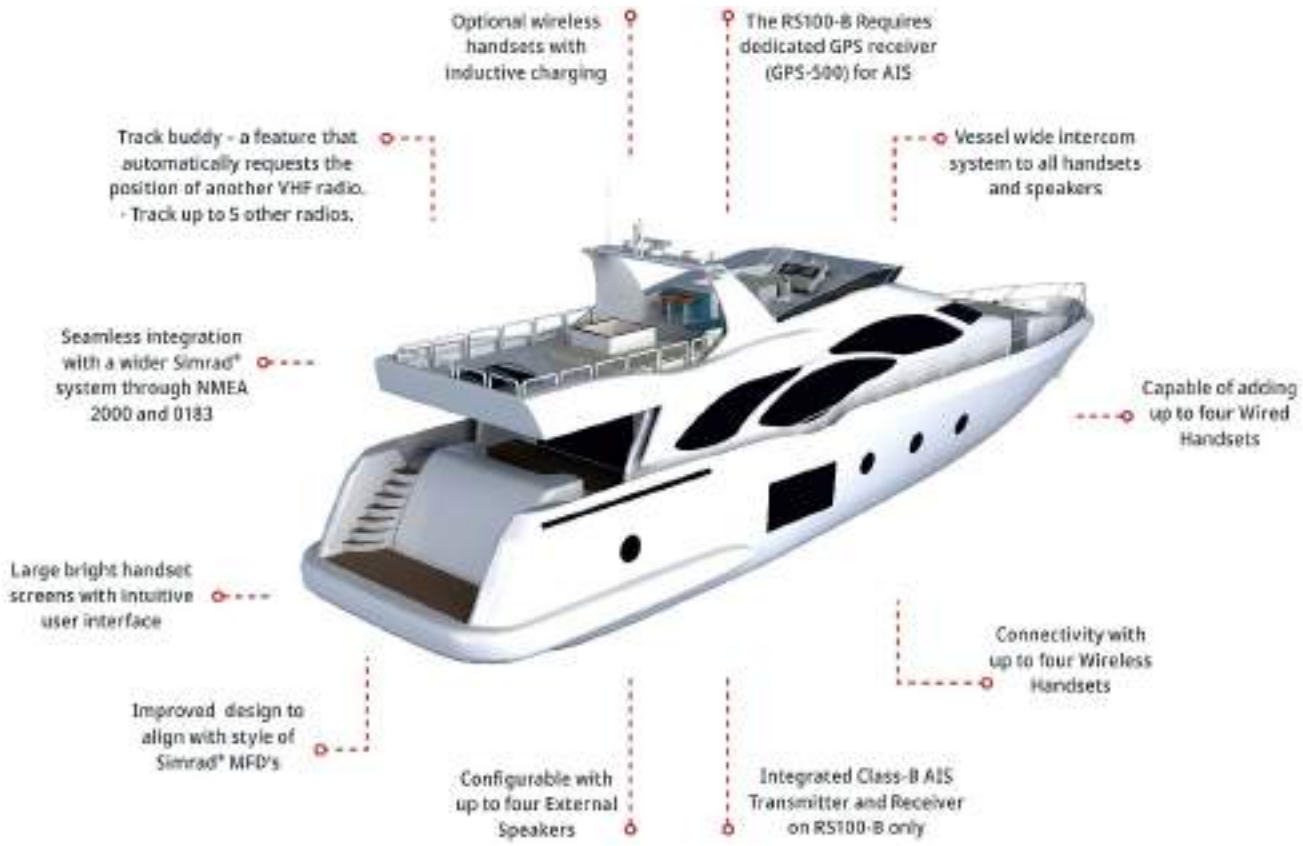


Fig 152) Modular system example

A modular system to fit any boat

The RS100-B is a modular VHF system that's expandable and customizable to suit any boat and any on-water communication needs. The standard package includes one wired handset and one external speaker. This setup is expandable up to eight handsets (four wired and four wireless) and four external speakers - ideal for use as an on-board intercom with Simrad HS40 wireless or HS100 wired handsets. The wireless handsets duplicate the radio display and controls on easy-to-read screens viewable under all lighting conditions, even bright sunlight. All primary functions are accessible from the handset with channel scan and favorites, alphanumeric keypad, clear audio, handset station naming and 60-second audio rewind.



Fig 153) Simrad devices installed on a recreational boat

Key Features

- Integrated Class-B AIS transmitter and receiver
- Bundled with dedicated GPS receiver, GPS-500 for AIS transmission
- Class D DSC approved VHF radio
- Integrated GPS receiver
- Connect up to four wireless and four wired handsets
- Add an optional loudhailer and up to four external speakers
- NMEA 0183® and NMEA 2000® connectivity
- 60-second audio rewind
- Configurable external speakers with volume offsetting
- Handset backlight settings can be grouped with NMEA 2000® backlight groups so MFD's and VHF Radios can have backlight controlled together
- Track Buddy – track up to five "buddies" using their VHF MMSI

RS40-B VHF Radio

Stay safer on the water with this VHF marine radio featuring a Class B AIS transceiver and built-in GPS. See and be seen by nearby AIS-equipped vessels thanks to an integrated Class B AIS transceiver, and add up to two optional wireless handsets to stay connected from anywhere on board.



Fig 154) RS40-B VHF Radio

See and Be Seen with Integrated AIS

The RS40-B includes a Class B AIS transceiver, which not only receives AIS targets but also transmits your boat's position to nearby AIS-equipped vessels. This helps other mariners to spot your boat through any conditions, day or night. A built-in AIS receiver monitors the position of other AIS-equipped vessels, helping you to proactively avoid collisions in crowded harbors and waterways. AIS information can be viewed on the radio's built-in screen, or overlaid on your chart or radar screen through a compatible multifunction display.

Removable Fist Mic

The RS40-B's removable fist mic can be connected to the front or rear of the radio, and optional extension cables allow the mic and radio to be mounted separately. This offers a simple and cost-effective solution for any mounting location, with no cable clutter. For example, the RS40-B can be mounted overhead, with no hanging cables, while the mic is connected to an extension socket on the dash below.

Expandable with Wireless Handsets

Add an optional HS40 wireless handset to take your radio anywhere on board. Each handset duplicates your radio's display and controls, enabling remote access to all key functions. Up to two handsets can be connected to a single RS40-B, and with multiple handsets connected your radio doubles as an on-board intercom.

Key Features

- Integrated Class B AIS transceiver
- Class D DSC approved VHF radio
- Integrated GPS receiver
- Removable fist mic supports front or rear connection
- Connect up to two wireless handsets
- Add an optional loudhailer or external speaker
- NMEA 0183® and NMEA 2000® connectivity

RS20S VHF Radio

Stay safe and in touch with this dependable Class D DSC approved VHF radio featuring an integrated GPS receiver. The versatile RS20S is ideal for a variety of boats from small RIBs to larger cruisers, and is designed to match the low-profile style of our glass bridge displays and accessories.



Fig 155) RS20S VHF Radio

An Easy-to-Use Radio for Any Vessel

See clearly in bright daylight with a high contrast black-on-white display, and inverted white-on-black night mode. A rotary dial makes channel selection easy, while large buttons provide quick access to other key functions. Dedicated Channel 16 keys, found on both the radio and its fist microphone, offer instant access to the emergency channel. An included gimbal bracket enables simple table-top, overhead, or bulkhead installation. Flush-mount installation is also possible, with an easy mount-from-front solution, to match the low-profile style of our glass bridge displays and accessories.

Class D DSC Approved

DSC, or "Digital Selective Calling", makes it easier to stay in touch with other boaters and enables you to broadcast your boat's location during an emergency. If you find yourself in trouble, the RS20's dedicated "distress" button will initiate a DSC distress call that sends your boat's position to anyone within VHF range. Used together with a traditional radio distress call, this makes it easier for other boaters with DSC-capable radios to register your situation and come to your aid. An integrated GPS receiver means your position can be sent even if your boat's other electronics are powered down.

Easy Access to All International Channels

The RS20S is designed for global use and supports all international channels. With tri-channel watch, easily scan between the current channel, emergency channel 16, and another user-configurable priority channel (in the USA, scan between the current channel, emergency channel 16, and calling channel 9). Alternatively, scan through all available channels or just your selected favorites. Emergency channels can be given priority when scanning to reduce the chance of missing distress calls or other urgent safety messages.

Key Features

- High-visibility display with inverted night mode
- Intuitive rotary dial and keypad controls
- Four-button fist microphone

- Class D DSC approved
- Integrated GPS receiver
- NMEA 2000® connectivity
- Dedicated emergency channel key
- Tri-channel watch function
- All international channels
- Easy bracket or flush-mount installation

Target Consumer Summary

Top 3 Target Groups	Market Demands	
Large cruising yachts (Typically, 40'+)	Flexible multi-handset installation options with intercom facilities	
Work boats	Flexible multi station installations, Professional features such as Alphanumeric keypad, horn key and hailer	
Offshore Sportfish Market	Flexible multi station installations, where dash/helm space is at a premium, professional features such as Alphanumeric keypad, horn key, scrambler and hailer	

Table 9) Target Consumer Summary

ECDIS (ELECTRIC CHART DISPLAY AND INFORMATION SYSTEM)



Fig 156) A typical ECDIS system

Introduction

The Electronic Chart Display and Information System (ECDIS) is a development in the navigational chart system used in naval vessels and ships. With the use of the electronic chart system, it has become easier for a ship's navigating crew to pinpoint locations and attain directions.

ECDIS complies with IMO Regulation V/19 & V/27 of SOLAS convention as amended, by displaying selected information from a System Electronic Navigational Chart (SENC). ECDIS equipment complying with SOLAS requirements can be used as an alternative to paper charts.

Besides enhancing navigational safety, ECDIS greatly eases the navigator's workload with its automatic capabilities such as route planning, route monitoring, automatic ETA computation and ENC updating. In addition, ECDIS provides many other sophisticated navigation and safety features, including continuous data recording for later analysis.

The ECDIS utilizes the feature of the Global Positioning System (GPS) to successfully pinpoint the navigational points. It also has to be noted that the ECDIS adheres to the stipulations set by the International Maritime Organization, and thus it adds to the trustworthiness of the electronic chart system.

ECDIS is basically a navigational information system, interfaced with other navigational equipment such as the GPS, Gyro, RADAR, ARPA, Echo Sounder etc.

ECDIS also incorporates and displays information contained in other nautical publications such as Tide Tables and Sailing Directions and incorporates additional maritime information such as radar information, weather, ice conditions and automatic vessel identification.

Advantages of ECDIS over paper charts

1. All information is processed and displayed in real-time
2. It eases the process of passage planning
3. One can get all necessary navigational information at a glance
4. Alarms and indications are in place to indicate and highlight dangers
5. Chart correction is made easier in ECDIS as compared to paper charts
6. Charts can be tailored as per the requirement of the voyage
7. Other navigational equipment such as the AIS, ARPA etc. can be overlayed and integrated
8. Charts can be oriented as per requirement
9. With the facility to zoom in and out, features can be examined as per necessity
10. One can obtain a more accurate ETA
11. Charts can be interrogated for detailed information
12. All in all, it enhances the safety of navigation

Types of ECDIS charts

1. Raster Chart (RNC): RNCs are a direct copy or a scan of the paper charts. It looks identical to a paper chart as all the information shown is directly printed. The chart only grows larger or smaller as per the zooming and when rotated, everything rotates.
2. Vector Chart (ENC): ENCs are computer-generated charts. The details on an ENC can be turned on and off depending on the requirement of the user. Objects on the ENC can be clicked for more details on the same. Depths can also be monitored to obtain a warning with regard to grounding. When zooming, the features grow large or small but the text remains the same.

ECDIS covered under the following

1. SOLAS Chapter 5
2. Port State Control Requirements
3. IMO Performance Standards for ECDIS
4. S 52 Standard (Display Standard)
5. S 57 Standard (Compilation Standard)
6. S 63 Standard (IHO Data Protection/Encryption Standard)

ENC (Electronic Navigational Chart) Layers

- Display Base (No information can be deleted)
- Standard Display
- Full Display
- Custom Display

Minimum Interface Requirement

- Position Sensor

- Heading Sensor
- Speed Sensor

ECDIS Compliance

- Approved ECDIS with approved backup
- Type approved hardware
- Type approved software
- Approved installation
- Official Chart Services
- Training of Officers

Chart Updating

Updates to the ECDIS charts may reach the ship in various ways, depending upon the capabilities of the service provider and the onboard communication facilities.

- On data distribution media (DVD)
- As an email attachment (SATCOM)
- As a broadcast message via SATCOM plus additional communication hardware
- As an internet download

Voyage Recording

- Minute by minute recording for the past 12 hours of the voyage
- Record of 4 hourly intervals of voyage track for a period of 6 months

Dual Fuel: Dual Fuel is the use of RNCs when ENCs are not available with approved paper chart backup.

Alarms and/or Indication in ECDIS

Alarms

1. Exceeding cross-track limits
2. Crossing selected safety contour
3. Deviation from the route
4. Critical Point Approach
5. Different datum from the positioning system

Alarms or Indication

1. Largest scale for alarm (present chart too small a scale)
2. Area with special conditions
3. Malfunction of ECDIS

Indication

1. The chart over scale (zoomed too close)
2. Larger scale ENC available
3. Different reference units
4. Route crosses safety contour
5. Route crosses specific area activated for alarms
6. System test failure

For ease of understanding, Indications may be either visual or audible whereas Alarms must be audible and may be visual as well.

Power Supply

- It should be possible to operate ECDIS and all equipment necessary for its normal functioning when supplied by an emergency source of electrical power
- Changing from one source of power supply to another or any interruption of supply for a period of up to 45 seconds should not require the equipment to be manually re-initialized

Carriage Requirement

- **Passenger Vessels > 500 GT**

  New Build – By July 2012

  Existing Build – By 2014 (Built before 1 July 2012)
- **Tankers > 3000 GT**

  New Build – By July 2012

  Existing Build – By 2015
- **Cargo Vessels > 10000 GT**

  New Build – By July 2013

  Existing Build – By 2018 (Built before 1 July 2013)
- **Cargo Vessels > 3000 GT**

  New Build – By July 2014
- **Cargo Vessels > 50000 GT**

  Existing Build – By 2016
- **Cargo Vessels > 20000 GT**

  Existing Build – By 2017

Limitations of ECDIS

1. The accuracy of the information received via AIS is only as good as the accuracy of the AIS information transmitted. The same is applicable for all other equipments interfaced with the ECDIS.
2. Position of ships received on ECDIS display might not be referenced to WGS 84 datum

3. Over-reliance on ECDIS for navigational safety should be avoided until it is confirmed that all the data transmitted, received and displayed are accurate
4. Users must be aware that any erroneous information is detrimental to the safety of own as well as other vessels
5. Some sensors might lack integrity with regard to accuracy and those that have not been tested
6. Not all ships are fitted with ECDIS and hence one cannot be sure of technical ability with regard to positioning as well as navigation; the kind that ECDIS provides

It is never prudent for the OOW to depend solely on the information on the ECDIS. IT is only an aid to navigation and never replaces the human quotient which brings in the skill and expertise with experience that an ECDIS can never provide.

IMO Performance Standards for ECDIS

1. The primary function of ECDIS is to contribute to safe navigation
2. ECDIS with adequate backup arrangements may be accepted as complying with the up-to-date charts required by Regulation V/20 of the 1974 SOLAS Convention
3. In addition to the general requirements for shipborne radio equipment forming part of the GMDSS and for electronics navigational aids contained in IMO Resolution A.694 (17), ECDIS should meet the requirements of this performance standard
4. ECDIS should be capable of displaying all chart information necessary for safe and efficient navigation originated by and distributed on the authority of government authorized hydrographic offices
5. ECDIS should facilitate simple and reliable updating of the electronic navigational chart
6. ECDIS should reduce the navigational workload compared to using the paper chart. It should enable the mariner to execute in a convenient and timely manner all route planning, monitoring and positioning currently performed on paper charts. It should be capable of continuously plotting the ship's position
7. ECDIS should have at least the same reliability and availability of presentation as the paper chart published by the Government-authorized hydrographic offices.
8. ECDIS should provide appropriate alarms or indications with respect to the information displayed or malfunction of the equipment

ECDIS Training

The institute must also be checked for approval from the respective governing body of a country (e.g., DG Shipping for India). With more and more ships inculcating ECDIS into their system, the knowledge, skill and understanding of ECDIS should be emphasized.

The same is achieved via simulators during the tenure of the course. Almost all institutes also put possession of a ROC ARPA certificate of proficiency as a prerequisite for entry into the ECDIS course.

Concept of ECDIS

The concept of ECDIS is something that is gaining more and more popularity in today's times. By adopting this electronic system of marking and charting navigational routes, it has become easier to avoid any unwanted accidents as the ship is dependent on modern technology rather than humanitarian aid.

Despite of some criticism from a few industry players, it can be easily said that ECDIS as an electronic Chart System is something that allows shipping companies and ship owners a lot of mental freedom when it comes to the safety of the vessel in the seawater by making ship navigation faster, simpler and sleeker.

NAVICO Featured AIS Products



Fig 157) Ship's bridge monitoring operation

Simrad ECDIS systems are Type-approved, competitively priced and benefit from modern and easy to learn user interfaces.

An Electronic Chart Display and Information System (ECDIS) is a geographic information system used for nautical navigation that complies with International Maritime Organization (IMO) regulations as an alternative to paper nautical charts.

ECDIS equipment complying with SOLAS requirements can be used as an alternative to paper charts. Besides enhancing navigational safety, ECDIS works to ease the navigator’s workload with its automatic capabilities such as route planning, route monitoring, automatic ETA computation and ENC updating. In addition, ECDIS provides other sophisticated navigation and safety features, including continuous data recording for later analysis.

The Simrad ECDIS systems are Type-Approved, competitively priced and benefit from modern and easy to learn user interfaces.

Simrad ECDIS900 MK15 24” 4S



Fig 158) Simrad ECDIS900 MK15 24” 4S

The Simrad MARIS ECDIS900 MK15 is an IMO type approved navigation system, designed for use aboard SOLAS vessels subject to ECDIS carriage mandates such as merchant cargo ships and tankers. Easy to use with integrated 24-inch flat panel display and a standard Windows PC interface, the ECDIS900 delivers precise navigation with comprehensive route planning and optimization tools, integrated chart management and ordering, universal radar overlay, and optional highly customizable conning display.

IMO Type Approval

The Simrad MARIS ECDIS900 is IMO type approved/IEC61174:2008 Ed3 compliant for use on all SOLAS ships and other vessels that must carry an Electronic Chart Display and Information System under the ECDIS Carriage Mandate. Under SOLAS amendments all existing large passenger, tanker, and cargo ships will be obliged to fit ECDIS on a rolling timetable that began in July 2012 and ends in July 2018. All new passenger ships over 500gt, tankers over 3,000gt, and cargo ships over 3,000gt are required to carry an ECIDS system.

The ECDIS900 is also designed to comply with additional regulations set by Flag States, Port State Control, and the OCIMF Ship Inspection Report Programme (SIRE)

All-in-One PC Solution

The ECDIS900 MK15 includes a 24-inch ‘all-in-one’ flat panel display with integrated Windows PC, suitable for pedestal, table or flush-mount installation. The single-unit design, including four integrated NMEA0183 ports, dual Ethernet ports, and AC/DC power supply, allows for simple installation in a variety of locations, including consoles or tables with limited space where a separate display and ECDIS processor may prove impractical.

Easy to Use

Based on a standard Windows interface using common controls including toolbars, tabbed panels, hotkeys, and right-click context or 'pop-up' menus, the ECDIS900 is quick to learn and easy to use. All ECDIS900 models include a standard keyboard and trackball, for fast and accurate data entry.

Advanced Route Planning and Optimization

The ECDIS900 offers powerful route planning tools, with integrated Voyage Decision Support (VDS) for route optimization.

Voyage Decision Support assists navigators in selecting a route most likely to provide an on-time arrival, avoid poor weather conditions, and optimize fuel consumption. Taking into consideration detailed ship information and both current and forecasted weather, VDS evaluates multiple route options and highlights the risks and benefits of each. The user may then select and begin navigation of the preferred route.

The ECDIS900's Search and Rescue (SAR) module automatically creates drift-compensated routes for search patterns, including Expanding Square, Sector, and Parallel Tracks.

Precise Navigation Tools

The ECDIS900 offers tools to facilitate safe and precise navigation, including position prediction and docking assistance.

The Predictor module calculates future ship positions based on GPS, gyro, speed and course data, and displays the full ship's outline extended forward in time. In narrow waters, this provides an accurate visual representation of the entire ship's position throughout turns – allowing the navigator to optimize speed and rate of turn accordingly.

The Docking module helps to facilitate safe docking maneuvers by calculating and clearly displaying the ship's distance and approach speed to both bow and stern docking points. During docking the ship's current, historical, and predicted future positions are also displayed graphically on the current chart.

Logbook

The ECDIS900 includes a digital ship's logbook, which automatically records all navigation events during a voyage. Logbook entries for any selected day can be replayed, displaying settings, charts, and events on the ECDIS screen as they originally occurred. Events and data logged include:

- Ship's position
- AIS and radar targets
- ENC in use/chart status
- Centre of the screen
- Active route and waypoint
- All alarms and acknowledgements
- Ship's settings (draft, safety contour, etc.)
- Manually plotted positions and Lines of Position (LOPs)
- All Navigation Editor ObjectsRadar Overlay
- The image from a connected radar may be displayed on the ECDIS900 as a chart layer, superimpose

Key Features

- 24-inch flat panel display with integrated PC
- Standard Windows interface with keyboard and trackball controls
- Advanced route planning and optimization tools, with special-purpose modules including SAR planning
- Precise navigation tools including position prediction and docking assistance
- Universal radar overlay
- Integrated chart management with online ordering and updates
- Supports ENCs (PRIMAR, IC-ENC, UKHO AVCS), UKHO ARCS, Professional+ charts, AIO (Admiralty Information Overlay)
- Choose between S-52 and INT1 chart presentation
- Dual- or triple-station PLECDIS options for paperless navigation
- Integration with BNWAS, Navtex, AIS, Autopilot, and Central Alarm system
- Optional conning display software with user-customizable pages

Simrad ECDIS900 MK5A W/ M5027



Fig 159) Simrad ECDIS900 MK5A W/ M5027

Simrad ECDIS900 MK5A is an IMO-type approved navigation system, designed for use aboard SOLAS vessels subject to ECDIS carriage mandates such as merchant cargo ships and tankers. Easy to use with a standard Windows PC interface, the ECDIS900 delivers precise navigation with comprehensive route planning and optimization tools, integrated chart management and ordering, universal radar overlay, and optional highly customizable conning display.

Key Features

- Standard Windows 7 interface with keyboard and trackball controls
- Advanced route planning and optimization tools, with special-purpose modules including SAR planning
- Precise navigation tools including position prediction and docking assistance
- Universal radar overlay
- Integrated chart management with online ordering and updates
- Supports ENCs (PRIMAR, IC-ENC, UKHO AVCS), UKHO ARCS, C-MAP Professional+ Charts, (AIO) ADMIRALTY Information Overlay
- Choose between S-52 and INT1 chart presentation
- Dual- or triple-station PLECDIS options for paperless navigation
- Integration with BNWAS, Navtex, AIS, Autopilot, and Central Alarm system
- Optional conning display software with user-customizable pages

Gyro compass

Introduction

A gyrocompass is a type of non-magnetic compass which is based on a fast-spinning disc and the rotation of the Earth (or another planetary body if used elsewhere in the universe) to find geographical direction automatically. The use of a gyrocompass is one of the seven fundamental ways to determine the heading of a vehicle. A gyroscope is an essential component of a gyrocompass, but they are different devices; a gyrocompass is built to use the effect of gyroscopic precession, which is a distinctive aspect of the general gyroscopic effect. Gyrocompasses are widely used for navigation on ships, because they have two significant advantages over magnetic compasses:

they find true north as determined by the axis of the Earth's rotation, which is different from, and navigationally more useful than, magnetic north, and

they are unaffected by ferromagnetic materials, such as in a ship's steel hull, which distort the magnetic field.

Aircraft commonly use gyroscopic instruments (but not a gyrocompass) for navigation and attitude monitoring; for details, see Flight Instruments and Gyroscopic autopilot.



Fig 160) Cutaway of an Anschütz gyrocompass

Operation

A gyroscope, not to be confused with a gyrocompass, is a spinning wheel mounted on a set of gimbals so that its axis is free to orient itself in any way. When it is spun up to speed with its axis pointing in some direction, due to the law of conservation of angular momentum, such a wheel will normally maintain its original orientation to a fixed point in outer space (not to a fixed point on Earth). Since the Earth rotates, it appears to a stationary observer on Earth that a gyroscope's axis is completing a full rotation once every 24 hours. Such a rotating gyroscope is used for navigation in some cases, for example on aircraft, where it is known as heading indicator or directional gyro, but cannot ordinarily be used for long-term marine navigation. The crucial additional ingredient needed to turn a gyroscope into a gyrocompass, so it would automatically position to true north, is some mechanism that results in an application of torque whenever the compass's axis is not pointing north.

One method uses friction to apply the needed torque: the gyroscope in a gyrocompass is not completely free to reorient itself; if for instance a device connected to the axis is immersed in a viscous fluid, then that fluid will resist reorientation of the axis. This friction force caused by the fluid results in a torque acting on the axis, causing the axis to turn in a direction orthogonal to the torque (that is, to precess) along a line of longitude. Once the axis points toward the celestial pole, it will appear to be stationary and won't experience any more frictional forces. This is because true north (or true south) is the only direction for which the gyroscope can remain on the surface of the earth and not be required to change. This axis orientation is considered to be a point of minimum potential energy.

Another, more practical, method is to use weights to force the axis of the compass to remain horizontal (perpendicular to the direction of the center of the Earth), but otherwise allow it to rotate freely within the horizontal plane. In this case, gravity will apply a torque forcing the compass's axis toward true north. Because the weights will confine the compass's axis to be horizontal with respect to the Earth's

surface, the axis can never align with the Earth's axis (except on the Equator) and must realign itself as the Earth rotates. But with respect to the Earth's surface, the compass will appear to be stationary and pointing along the Earth's surface toward the true North Pole.

Since the gyrocompass's north-seeking function depends on the rotation around the axis of the Earth that causes torque-induced gyroscopic precession, it will not orient itself correctly to true north if it is moved very fast in an east to west direction, thus negating the Earth's rotation. However, aircraft commonly use heading indicators or directional gyros, which are not gyrocompasses and do not align themselves to north via precession, but are periodically aligned manually to magnetic north.

History

The first, not yet practical, form of gyrocompass was patented in 1885 by Marinus Gerardus van den Bos. A usable gyrocompass was invented in 1906 in Germany by Hermann Anschütz-Kaempfe, and after successful tests in 1908 became widely used in the German Imperial Navy. Anschütz-Kaempfe founded the company Anschütz & Co. in Kiel, to mass produce gyrocompasses; the company is today Raytheon Anschütz GmbH. The gyrocompass was an important invention for nautical navigation because it allowed accurate determination of a vessel’s location at all times regardless of the vessel’s motion, the weather and the amount of steel used in the construction of the ship.

In the United States, Elmer Ambrose Sperry produced a workable gyrocompass system (1908: patent #1,242,065), and founded the Sperry Gyroscope Company. The unit was adopted by the U.S. Navy (1911), and played a major role in World War I. The Navy also began using Sperry's "Metal Mike": the first gyroscope-guided autopilot steering system. In the following decades, these and other Sperry devices were adopted by steamships such as the RMS Queen Mary, airplanes, and the warships of World War II. After his death in 1930, the Navy named the USS Sperry after him.

Meanwhile, in 1913, C. Plath (a Hamburg, Germany-based manufacturer of navigational equipment including sextants and magnetic compasses) developed the first gyrocompass to be installed on a commercial vessel. C. Plath sold many gyrocompasses to the Weems’ School for Navigation in Annapolis, MD, and soon the founders of each organization formed an alliance and became Weems & Plath.

The 1889 Dumoulin-Krebs gyroscope

Before the success of the gyrocompass, several attempts had been made in Europe to use a gyroscope instead. By 1880, William Thomson (Lord Kelvin) tried to propose a gyrostat to the British Navy. In 1889, Arthur Krebs adapted an electric motor to the Dumoulin-Froment marine gyroscope, for the French Navy. That gave the Gymnote submarine the ability to keep a straight line while underwater for several hours, and it allowed her to force a naval block in 1890.

In 1923 Max Schuler published his paper containing his observation that if a gyrocompass possessed Schuler tuning such that it had an oscillation period of 84.4 minutes (which is the orbital period of a notional satellite orbiting around the Earth at sea level), then it could be rendered insensitive to lateral motion and maintain directional stability.

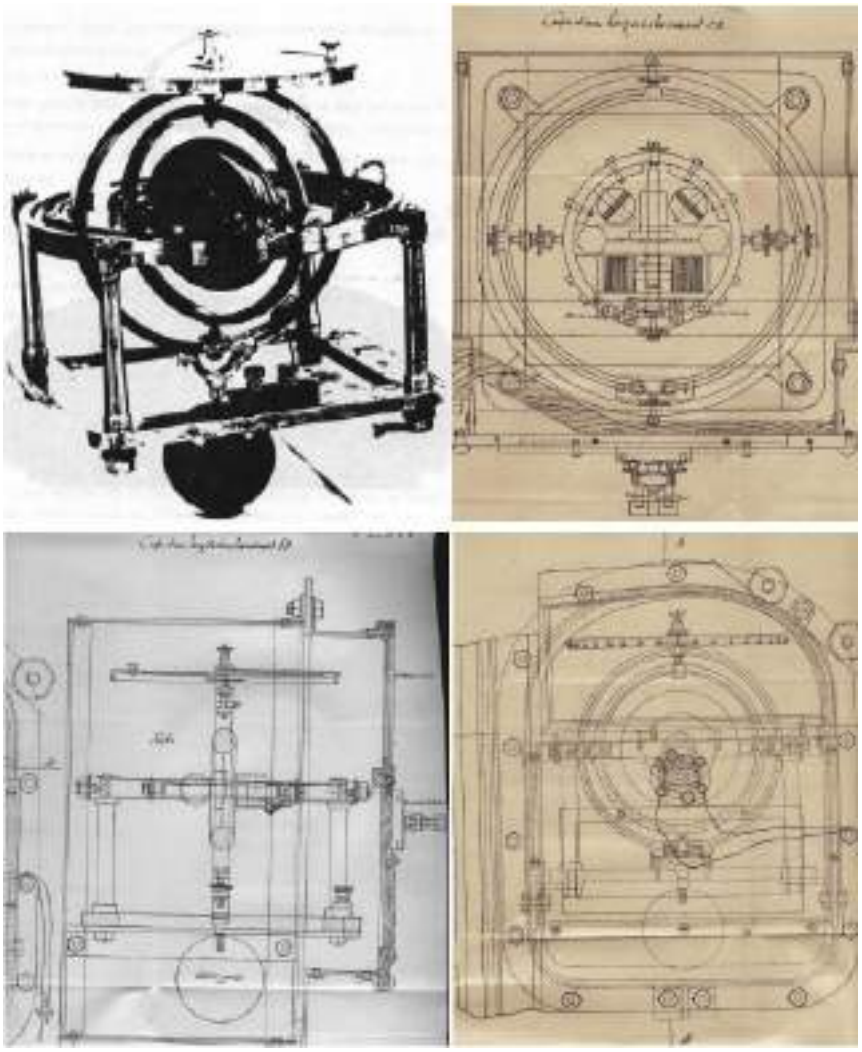


Fig 97) The 1889 Dumoulin-Krebs gyroscope

NAVICO Featured Gyro compass Products



Fig 162) Merchant Vessels

Flexible IMO system configuration options make both new and retrofit installations into existing systems simple.

Gyro Compass

A Gyro compass is a form of gyroscope, used widely on ships employing an electrically powered, fast-spinning gyroscope wheel and frictional forces among other factors utilizing the basic physical laws, influences of gravity and the Earth's rotation to find the true north.

The gyro is designed for high precision maritime applications such as offshore operations and seabed mapping.

Simrad's range of high-quality Gyro and GPS compasses offers something to complete every electronics system. Providing accurate and reliable data for safe navigation, our flexible IMO and non-IMO system configuration options make both new and retrofit installations into existing systems so simple.

The Simrad Gyrocompasses are the most reliable gyrocompasses on the market. With no liquids to change every other year like most other gyrocompasses, they are virtually maintenance-free.

A wide range of control units provide complete flexibility of system configuration for new installation and easy retrofit into existing repeater systems.

The standard range of interfaces can easily be expanded to provide signals for all vessel applications. The distribution of power and heading signals from the control units enables practical installation and easy retrofit.



Fig 163) Simrad GC85

GC85 Compact Gyro System MK2



Fig 164) GC85 Compact Gyro System MK2

The unique technology in the GC85 gyrocompass eliminates the need for annual service. The highest possible accuracy and stability is provided by a sophisticated and fully sealed sensitive element.

The Simrad GC85 gyrocompass is the ideal solution for the advanced DP system needed in offshore industry. Shipowners as well as DP system providers all over the world have learned that the Simrad GC series gyrocompass offers the most flexible gyro compass solution on the market. A combination of a Dual- and an Expanded system, consisting of all together three gyro compasses will offer a DP vessel all the heading and control information needed for effective operations under the harshest conditions. The simple and quick installation and set-up process as well as the fact that no annual service is required makes a Simrad gyro system the best solution for any 24/7 operator. The worldwide service and warranty network ensures extra support whenever needed.

GC80 Expanded Gyro System MK2

Fully IMO approved for standard craft and can be configured in a dual or triple gyrocompass system. The highest possible accuracy and stability is provided from new technology, by a sophisticated and fully sealed sensitive element.

The Simrad GC80 gyrocompass is the ideal solution for the advanced DP system needed in offshore industry. Shipowners as well as DP system providers all over the world have learned that the Simrad GC series gyrocompass offers the most flexible gyro compass solution on the market. A combination of a Dual- and an Expanded system, consisting of all together three gyro compasses will offer a DP vessel all the heading and control information needed for effective operations under the harshest conditions. The simple and quick installation and set-up process as well as the fact that no annual service is required makes a Simrad gyro system the best solution for any 24/7 operator. The worldwide service and warranty network ensures extra support whenever needed. System flexibility the most flexible Gyrocompass on the market, for installation, configuration and cost. A wide range of control units provide complete flexibility of system configuration for new installation and easy retrofit into existing repeater systems. The standard range of interfaces can easily be expanded to

provide signals for all vessel applications. The distribution of power and heading signals from the control units enables practical installation and easy retrofit.



Fig 165) GC80 Expanded Gyro System MK2

GC80 Compact Gyro System MK2



Fig 166) GC80 Compact Gyro System MK2

Fully IMO approved for standard and High-Speed Craft (GC85) and can be configured in a dual gyrocompass system. The highest possible accuracy and stability is provided from new technology, by sophisticated and fully sealed sensitive element.

The Simrad GC80 gyrocompass is the ideal solution for the advanced DP system needed in offshore industry. Shipowners as well as DP system providers all over the world have learned that the Simrad GC series gyrocompass offers the most flexible gyro compass solution on the market. A combination of a Dual- and an Expanded system, consisting of all together three gyro compasses will offer a DP vessel all the heading and control information needed for effective operations under the harshest conditions. The simple and quick installation and set-up process as well as the fact that no annual service is required makes a Simrad gyro system the best solution for any 24/7 operator. The worldwide service and warranty network ensures extra support whenever needed. System flexibility the most flexible Gyrocompass on the market, for installation, configuration and cost. A wide range of control units provide complete flexibility of system configuration for new installation and easy retrofit into existing repeater systems. The standard range of interfaces can easily be expanded to provide signals for all vessel applications. The distribution of power and heading signals from the control units enables practical installation and easy retrofit.

Bridge Instruments

Introduction

Professional Instrumentation series that simplifies the complex by integrating a multitude of analog-style gauges into one configurable digital data display.

Simrad marine instruments are tough, dependable, and designed to supply critical information to professional mariners in clear, easy-to-read formats.

NAVICO Featured Bridge Instruments Products

I3005 & I3007 Instrument

The Simrad® I3005 and I3007 Instrument Series offers a 5- or 7-inch superior color display with easy touch control, a variety of graphic layouts with the capability to enable up to eight different functions simultaneously. Offering a flexible installation that supports a wide variety of I/O signal types, both display sizes are approved for SOLAS vessels.



Fig 167) I3007



Fig 168) I3005

The Simrad® I3005 and I3007 Instrument Series offers a 5- or 7-inch superior color display with easy touch control, a variety of graphic layouts with the capability to enable up to eight different functions simultaneously.

Both I3005 and I3007 are IMO approved as a Rudder Angle Indicator, Heading Repeater, Rate of Turn Indicator (I3007 only), Propeller Pitch Indicator, Propeller Revolution Indicator, plus monitor other functions like Engine RPM, Wind Instruments, Digital Data Thruster Propeller Pitch Angle and Boat Speed.

Offering a flexible installation that supports a wide variety of I/O signal types, both display sizes are approved for SOLAS vessels.

The IS300 Series has the capability to enable the following simultaneously:

- **Heading Repeater –** IMO approved when paired with NMEA 2000, NMEA 0183, or LWE heading sensor, such as Simrad GPS and Gyro compasses.
- **Rudder Indicator –** IMO approved when connected in an Autopilot System that has the optional display of rudder demand. Reading rudder positions from all Simrad rudder feedbacks or is compatible with NMEA 0183 feedbacks from other third-party systems.
- **Rate of Turn Indicator –** 7" IMO approved and 5" non-IMO ROT Indicator with a configurable scale range and is compatible with Simrad GPS Compasses, HS60/70/80, Simrad Gyros GS80/85, and Simrad Magnetic Compasses Precision-9, RC-42
- **Propeller Pitch Indicator configurable for use with Propulsion and Thruster**

  (Note: Transducer/sensor not offered by Navico)
- **Propeller Shaft RPM –** IMO compliant with a selectable Scale Range

  (Note: Transducer/sensor not offered by Navico)
- **Engine RPM Indicator with a Selectable Scale Range from 200 up to 10,000**

  (Note: Transducer/sensor not offered by Navico)
- **Wind Instrument –** measuring True Wind Speed and Angle, Apparent Wind Speed and Angle, Beaufort Wind Speed Indicator with Selectable Orientations (relative to North or the Ships' Bow). Compatible with Simrad and B&G Sensors or any NMEA 2000 or NMEA 0183 Wind Sensors.
- **Digital Data -** data layout for display or a multitude of data types; Vessel, Environmental, Navigation, Engine, Depth, Speed, Heave, Pitch, Roll, Time & Date.

Note: Digital data types can only be selected from the available installed transducers and sensors.

Key Features

- Multiple instrument functions in one display
- Enable up to eight different functions
- Configurable for single or multi-purpose
- Switch easily between multiple functions
- Long distance viewing
- All common analog signal types supported
- Bridges data between NMEA 2000®, serial, Ethernet for more flexible & advanced installation requirements
- 2 x NMEA 0183 ports with up to a 38000 baud rate
- Suitable for all vessel sizes

SAL R1A Easy Tank Speed Log

The SAL R1a is an IMO type-approved speed log for measuring longitudinal speed through water (STW), based on proven Acoustic Correlation technology. The speed log is designed to meet requirements as specified by authorities and ship owners, with performance exceeding applicable IMO specifications. Its closed-ended installation is simple and cost-effective, with no need for a watertight compartment or piping above the waterline.



Fig 169) SAL R1A Easy Tank Speed Log

The SAL R1a is an IMO type-approved speed log for measuring speed through water (STW). It includes bottom arrangements, transducer, and electronics unit, all mounted in the bow area. A digital speed and distance display is also included for bridge installation.

Acoustic Correlation

Acoustic correlation is a proven and practical technology that measures sonar readings across two elements in a single transducer. This technology measures water speed slightly further away from the hull than electromagnetic technology and doesn't require the angular corrections of Doppler technology. This translates into less corrections required in the speed calculation algorithm, delivering stable and reliable speed through water measurements.

Easy Tank for Easy Installation

The SAL R1a's "Easy Tank" bottom arrangement provides a closed ended installation, with no need for a watertight compartment or piping above the waterline. The watertight arrangement is damage-resistant, and a watertight cable enables installation in wet environments. Bottom arrangements are available to suit both aluminum and steel hull constructions.

Connectivity

The speed log's electronics are enclosed in a splash-proof steel box, which can be mounted up to ten meters from the transducer. The remote bridge display connects to the electronics unit via an industry-standard IEC 61162-1/NMEA 0183® interface; the electronics unit also provides pulse and voltage outputs for connection to alternative display devices.

Key Features

- High performance due to proven Acoustic Correlation technology

- Flexible calibration allows highly accurate readings throughout the speed range
- Easy set-up and calibration from the bridge display
- Easy to install with only a few mechanical parts, lightweight bottom arrangements, and transducer mounting from inside the hull
- Space saving with compact bottom arrangements
- Safe due to a rugged mechanical design and watertight cable
- Closed ended installation means no need for a watertight compartment or piping above the waterline
- Pressure tested and approved according to PN16 (24 bar, 240 m)
- Complies with IMO resolution A.824(19)

Monitors

NAVICO Featured Monitors



Fig 170) Simrad M5000 Series Widescreen Marine Monitors

Type Approved displays to externally controlled pilothouse monitors, and multi-touch touchscreens

Whether you have a patrol boat, commercial fishing vessel, OSV or superyacht, there is a Simrad monitor to meet your needs.

From Type Approved displays to externally controlled pilothouse monitors, and multi-touch touchscreens with pinch to zoom gesture control, Simrad monitors are suited to all installations, maximizing views while minimizing use of crucial dash space.

M5000 Series Widescreen Marine Monitors

M5016, M5019, M5024 and M5027



Fig 171) M5024

Simrad M5000 Series marine monitors are available in 16, 19, 24 and 27-inch widescreen sizes, and are IEC62388 ed.1 compliant for use as part of a type-approved Simrad radar system. The 24-inch M5024 and 27-inch M5027 are also IHOS-52 color calibrated for ECDIS use, and forms part of the type-approved Simrad ECDIS system.

HD/Full HD Widescreen

The M5016 (16-inch) and M5019 (19-inch) monitors have a native resolution of 1366 x 768 pixels, in 16:9 widescreen ratio suitable for use with widescreen-optimized Simrad radar systems. The M5024 (24 inch) and M5027 (27 inch) monitors have a ‘Full HD’ native resolution of 1920 x 1080, in the same 16:9 ratio. All M5000 series displays feature an adjustable backlight with maximum 300-nit brightness suitable for pilothouse use.

Flush-Mount Installation

Ideal for flush-mount installation in a pilothouse or bridge console, all monitor sizes in the M5000 Series have a low profile of just 8mm. Flush mounting is possible with the included rear brackets or front screws, and VESA mounting is supported with an optional bracket.

All-Glass Look, Optically Bonded

A seamless glass front panel incorporating capacitive touch-sensitive menu keys offers a clean and distraction-free look, and is suitable for side-by-side mounting of multiple displays without the interruption of raised bezels or controls. M5000 Series monitors feature an LCD panel optically bonded to the display's glass surface to eliminate fogging, while Anti-Reflective and Anti Fingerprint coatings help to deliver optimal visibility in all conditions.



Fig 172) M5016-19-24-27

Main Features

- 15.6/18.5/24/27" LCD panel in 16:9 widescreen format
- High-resolution 1366 x 768-pixel display (M5016 & M5019)
- Full HD resolution 1920 x 1080-pixel display (M5024 & M527)
- Suitable for use as part of a type-approved Simrad radar system (IEC62388 ed.1 compliant)
- Suitable for use as part of a type-approved Simrad E5000 ECDIS system (IHO S-52 color calibrated) (M5024 & M5027)

- Optically bonded to eliminate fogging
- Low profile (8mm) flush-mount installation
- All-glass front panel with touch sensitive menu keys
- IP66 water resistant when flush mounted

MFD (Multi-function display) / Chartplotters

A multifunction display (MFD) is a small-screen (CRT or LCD) surrounded by multiple soft keys (configurable buttons) that can be used to display information to the user in numerous configurable ways. MFDs originated in aviation, first in military aircraft, and later were adopted by commercial aircraft, general aviation, automotive use, and shipboard use.

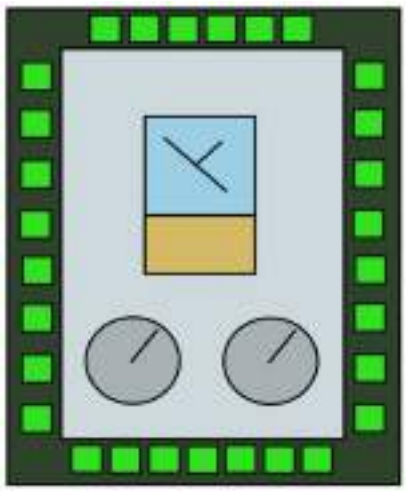


Fig 173) A schematic example of a multi-function display

NAVICO Featured MFDs / Chartplotters

Simrad NSS9-12-16 evo3s

The NSS9-12-16 sports a high-definition 9-12-16-inch all-weather display for maximum on-screen detail with advanced levels of functionality. Featuring a built-in 1kW CHIRP-enabled sonar and the new iMX 8 high-performance processor. Providing 2X faster page loading times, smoother transitions, and quicker chart rendering for a completely new MFD experience. Combine this with real-time monitoring, extensive networking, and system expansion options - and you have complete navigation control. Includes preloaded C-MAP® charts.



Fig 174) Simrad NSS16 evo3s

Make the most of your vessel

Take total control of your on-water experience. SolarMAX® IPS displays offer exceptional clarity and ultra-wide viewing angles in any light conditions, while the new iMX 8 high-performance processor delivers superfast response times for seamless screen transitions. Choose between all-weather touchscreen technology or keypad with a rotary dial as the situation demands. It's easy to monitor and control all of your on-board electronics with simple menus, customizable split-screen layouts, and a programmable function key for one-button access to the features you use most.

SolarMAX IPS displays ensure clear views in any conditions

Get a clear view under any lighting conditions with SolarMax IPS technology, which keeps everything in sight with ultra-wide viewing angles, even if you're wearing polarized sunglasses. These all-weather screens have been engineered to withstand the heat of the summer sun and are optically bonded to prevent condensation or fogging within the display. Instantly access and control all of your on-board electronics via simple menus and customizable split-screen layouts.

Built-in high performance echosounder

1kW CHIRP-enabled sonar provides exceptional bottom-tracking and fish-finding performance, including support for dual-channel CHIRP transducers that deliver multiple depth range coverage from a single unit. Dual transducer ports offer the convenience of connecting multiple transducers to a single display. Better-than-ever processing power easily powers Active Imaging™, providing picture-like views of fish-holding structure, and ForwardScan® sonar, which offers crystal clear views of the bottom ahead.

Fast and Simple networking connects a wide range of accessories

Industry-standard connectivity makes it easy to create multi-display systems and link displays to all of your on-board electronics; while the new iMX 8 high-performance processor ensures engine and fuel monitoring in real-time, control of on-board sound systems and much more. Expand your system with Simrad modules and accessories, fish smarter with the game-changing S5100 or StructureScan® 3D, see further with legendary HALO™ Pulse Compression radar, and free your hands from the wheel with a fully integrated Simrad autopilot.

Wireless connectivity to your smartphone or tablet

Mirror your display to compatible iOS and Android devices and enjoy access to charts, radar, sonar, engine data and more from anywhere on board. Wireless connectivity also enables easy on-line software upgrades through any internet hotspot, giving you access to the latest features and accessory support.

Radar options

Add Halo™ Pulse Compression radar system to cruise safely through crowded harbors, navigate in poor visibility, keep an eye on distant weather calls and even locate flocks of feeding birds that hint at good fishing spots.

Key Features

- iMX 8 Integrated processor for superior performance

- 16-inch SolarMAX ™ IPS display with ultra-wide viewing angles; viewable through Polarized sunglasses
- Switch seamlessly between touchscreen and keypad control
- Built in high-performance echosounder with 1kW CHIRP
- Built-in GPS receiver and wireless connectivity
- Control Simrad sonar, radar, autopilot, and other accessories
- Industry-standard connectivity to engines, sound system, and more
- TripIntel™ trip planning and support for automatic routing
- Choose low-profile flush mounting or convenient bracket mounting

Simrad NSS7-9-12-16 evo3

This 16-inch, Full HD display offers a large and clear view of charts, radar, sonar, and more. NSS16 evo3 is perfect for larger powerboats, giving you ultimate visibility and control from the helm while letting you take that view anywhere on board with wireless display mirroring and HDMI output.



Fig 175) Simrad NSS16 evo3

Make the most of the boat

Navigate, find fish, and take total control of your on-water experience with NSS evo3. SolarMAX™ HD displays offer exceptional clarity and ultra-wide viewing angles in any light conditions, while intuitive all-weather touchscreen technology and a keypad with rotary dial offer total control in any conditions. Built-in echosounder support lets you cruise confidently with ForwardScan sonar, or reveal the ultimate fishing spots with StructureScan® HD imaging and CHIRP-enabled sonar—just add your choice of transducer. Wireless connectivity links NSS evo3 to your smartphone or tablet, keeping you in control from anywhere on board.

Touchscreen plus keypad for intuitive and reliable control

NSS evo3 displays let you take control your way. Switch seamlessly between intuitive touchscreen control with multi-touch gestures, perfect for cruising on a flat day, and a built-in keypad with rotary control dial for fishing and boating adventures. Control every display function by either touch or keypad, giving you total flexibility to use whatever controls best suit the situation.

Chartplotter with built-in GPS makes navigation easy

Every NSS evo3 display is a full-featured chartplotter navigation display with a built-in GPS receiver that eliminates the need for an external antenna on many boats. Choose from a wide range of charts to find the best coverage for your favorite boating locations, anywhere in the world. Make plotting a route to your destination as simple as in-car navigation with C-MAP Easy Routing.

SolarMAX™ HD displays ensure clear views in any conditions

Get a clear view under any lighting conditions with SolarMAX™ HD technology, which keeps everything in sight with ultra-wide viewing angles, even if you're wearing polarized sunglasses. These all-weather screens have been engineered to withstand the heat of the summer sun, and are optically bonded to prevent condensation or fogging within the display. It's easy to monitor and control all of your on-board electronics with simple menus and customizable split-screen layouts.

Built-in echosounder supports fishing and safer cruising

A built-in echosounder enables many sportfishing and cruising activities: just add your choice of sonar transducer. StructureScan® HD imaging provides picture-like views of fish holding structure, while award-winning ForwardScan® sonar offers a safer cruising experience with a clear view of the bottom ahead. CHIRP-enabled sonar provides reliable bottom-tracking and fish-finding performance, including support for dual-channel CHIRP transducers to deliver coverage of multiple depth ranges. Dual transducer ports let you connect multiple transducers to a single display.

Simple networking connects you to a wide range of accessories

Industry-standard connectivity makes it easy to create multi-display systems and link your displays to all of your on-board electronics. Monitor your boat's engines and fuel efficiency, control your on-board sound system, and much more. Expand your system with Simrad modules and accessories: fish smarter with game-changing StructureScan® 3D imaging, see further with legendary Halo™ Pulse Compression radar, and free your hands from the wheel with a fully integrated Simrad autopilot.

Wireless connectivity to your smartphone or tablet

Mirror your display to compatible iOS and Android devices, and enjoy access to charts, radar, sonar, engine data, and more from anywhere on board. Check charts and weather radar to plot your next move from the saloon, or keep your fish-finding sonar display beside you while you cast your line. Wireless connectivity also enables easy online software upgrades through any internet hotspot, giving you access to the latest features and accessory support.

Radar Options

Broadband 4G™ Radar for greater situational awareness

Bring radar capabilities to your boat with this compact and easy-to-install dome radar system. Broadband 4G™ radar detects targets from right off the bow to as far as 36 nautical miles away. Use radar to cruise confidently through crowded harbors, navigate safely in poor visibility, and keep an eye on distant storm cells. Our Broadband Radar™ technology is safe to mount anywhere aboard powerboats of all sizes, and features no radiation hazard or external moving parts.

LOWRANCE Featured Products



Fish Finders / Chartplotters

The world's best fish finding sonar with powerful navigation performance that can be counted on.

Whether for a serious tournament angler, weekend warrior or just fish casually, LOWRANCE has a product that will be the perfect fit for the way fishers' fish and the water they fish, so they can have more success on the water.

HOOK REVEAL



HOOK REVEAL

From the world's best-selling series of fishfinders comes HOOK Reveal, a new fishfinder/chartplotter with one of our most popular features – FishReveal™. This powerful fishfinding tool combines the proven target identification of Lowrance CHIRP sonar with the high-resolution images of bottom detail and structure from DownScan Imaging™. That gives you the ultimate fishing view, allowing you to target fish and get the best view of how they are relating to structure without the need for a CHIRP-DownScan Imaging™ splitscreen display.

A Revelation in Easy Fishfinding

Casual, weekend anglers

- Freshwater and inshore coastal fishing
- Kayaks, fishing boats and near-coastal fishing boats

Key Features

- Autotuning Sonar
- FishReveal™
- Genesis Live Real-Time Mapping
- Double the Broadband and CHIRP sonar coverage of most fish finders
- Optional SideScan and DownScan Imaging™
- Easy to install

Tech Specs

- High-resolution SolarMAX™ display
- Available with GPS Plotter, Maps, DownScan, SideScan and deep-water performance (Model dependant)

Display Size

- 5", 7" and 9"

ELITE FS



ELITE FS

The Elite Fishing System (FS) combines the power of Lowrance's proven and newest fish finding tools with a more affordable display that's easier to use and install. From ActiveTarget™ live sonar and extreme high-resolution Active Imaging™ with Lowrance CHIRP sonar, SideScan and DownScan Imaging™ to preloaded C-MAP® Contour™+ Fishing Maps, Elite FS gives you all the tools you need to find and catch more fish.

Targeting fish just got easier

Avid Weekend Anglers

- Freshwater or saltwater fishing
- Deep or shallow water
- Freshwater and saltwater fishing boats and kayaks

Key Features

- ActiveTarget live sonar and Active Imaging compatible

- Full networking
- High Resolution Multi touch screen
- Best-in-class mapping
- Easy to use and install

Tech Specs

- Supports 50, 83, 200, 455 and 800 kHz sonar frequencies
- Integrated wireless, NMEA 2000® and Ethernet connectivity
- Full touchscreen control of Power Pole® anchors and Ghost® Trolling Motor

Display Size

- 7" and 9"

HDS LIVE



HDS LIVE

It’s no secret that HDS displays are used by more tournament fishing pros than all other fish finding brands combined, so we didn’t have to go back to the drawing board to build it; we just made the best fish finder/chartplotter in the world even better. HDS LIVE delivers premium performance and support for the best collection of innovative sonar features available – from Active Imaging™, StructureScan® 3D, FishReveal™ and ActiveTarget™ Live Sonar, to exciting navigation functionality like C-MAP® Genesis Live mapping – all designed to help you find more fish.

America's Number 1 Fish Finding Brand

Tournament & Serious Anglers

- Freshwater or saltwater fishing
- Deep or shallow water
- All sizes of freshwater and saltwater fishing boats

Key Features

- Brightest and Clearest SolarMAX™ HD displays
- Fastest chart redraws and sonar updates

- StructureScan® 3D, plus enhanced SideScan/DownScan Imaging™FishReveal™ Smart Target View

Tech Specs

- Supports 50, 83, 200, 455 and 800 kHz sonar frequencies
- Integrated wireless connectivity
- Mapping: 1-foot contours on more than 4,000 lakes, standard 10-foot contours on 11,000+ lakes, plus full coastal mapping

Display Size

- 7", 9", 12" and 16"







Fig 176) LOWRANCE Products

C-MAP



35 Years of Experience

Founded in Northern Italy in 1985 with a mission to serve boaters worldwide, C-MAP has 35 years' experience creating cartography and services for all types of leisure boater and commercial customer.

Setting the standard for navigation and situational awareness, C-MAP develops precise, reliable charts with safety and ease-of-use at their core, to satisfy the most demanding of user.

Continuous Innovation

C-MAP cartography products and services include multiple formats for lakes, coasts and oceans across the globe. With detailed coverage of over 8,000 lakes in the USA alone and over 7.2 million points of interest globally, C-MAP continues to invest in improving the coverage and quality of detail shown.

Its teams of experts are continually innovating and developing new formats and features for boaters, including Custom Depth Shading for a truly personalized experience, subscription free Easy Routing and Genesis Layer, which adds 1ft contours compiled from quality-controlled user data on top of the official charts. Reveal charts replace shaded relief data in selected areas with more accurate depth variations, revealing the best fishing and diving spots, presenting easy to interpret detail dynamically, as never seen before.

Extensive Partnerships

C-MAP products are compatible with more marine brands than any other company, including the leading brands; Simrad, Lowrance, B&G, Raymarine and Furuno. With the C-MAP App, users can experience a truly personalized and smooth end-to-end experience, with all the planning tools needed to get out on the water to hand at all times.

Trusted Expertise

Recreational customers can be assured they are in safe hands as C-MAP is also a trusted provider for the commercial marine sector, including the US Coastguard and many of the world's major shipping companies. Safety and accuracy remain key, with an additional focus on weather conditions and routing analyses to improve performance and efficiency, reducing costs and passage times.

C-MAP is a member of the Navico family of brands, alongside Simrad, Lowrance and B&G. A specialist marine electronics company, Navico has an unrivalled heritage in the industry, with over 70 years of developing, designing and manufacturing industry-leading products.

Better Sailing. Better Fishing. Better Cruising.

DISCOVER



DISCOVER all you need to make the most of your time on the water. Full-featured Vector Charts with High-Res Bathy, including integrated Genesis® social data, subscription-free Easy Routing™ and Custom Depth Shading. See things your way with C-MAP.

CORE FEATURES

- Every DISCOVER Chart Includes:
- Full Featured Vector Charts
- Tides & Currents
- Hi Res Bathymetry Layer
- Detailed Marina Port Plans
- Integrated Genesis Layer
- Custom Depth Shading
- 12 Months' Free Updates
- Subscription-Free Easy Routing

FULL-FEATURED VECTOR CHARTS

Full-Featured Vector charts make navigation easy by giving you accurate, up-to-date vector chart detail derived from official Hydrographic Office information.

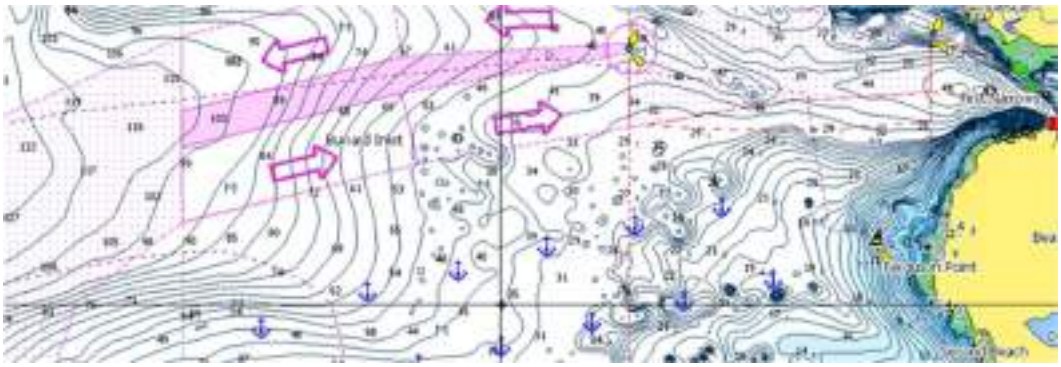


Fig 177) Vector charts

HI-RES BATHYMETRY LAYER

High-Res Bathymetry (HRB) Layer helps you identify shallow areas, drop offs, ledges, holes or humps by accurate contour lines down to 1-foot level of detail. Includes the very best of C-MAP HRB data, including C-MAP Team Lake Surveys (US only) and Genesis® social maps, quality controlled and fully integrated.



Fig 178) HI-RES BATHYMETRY LAYER

CUSTOM DEPTH SHADING

Custom Depth Shading allows you to set a safety depth, maintain a paper-like view or set your own custom shading – see things your way.

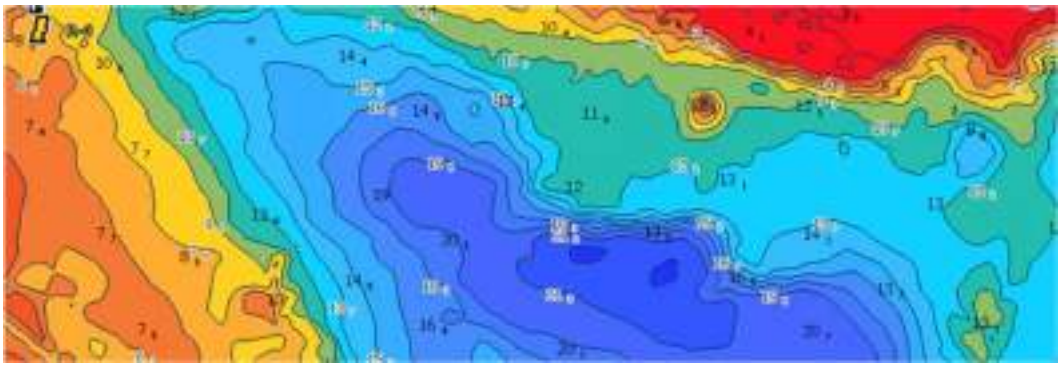


Fig 179) CUSTOM DEPTH SHADING

EASY ROUTING

Easy Routing helps you automatically plot the shortest, safest route based on detailed chart data and your personalized vessel information. With C-MAP Easy Routing is always subscription free.



Fig 180) EASY ROUTING

TIDES & CURRENTS

Tides & Currents show projections of water level and direction of tides to help plan your day out, whether cruising, angling or sailing.



Fig 181) TIDES & CURRENTS

DETAILED MARINA PORT PLANS

Docking in an unfamiliar port is no problem, when you have precise layouts of thousands of marinas, including slip spaces, restricted areas, and other valuable navigation information.



Fig 182) DETAILED MARINA PORT PLANS

Available Charts for the GULF Region

AFRICA & ARABIA SEA CONTINENTAL DISCOVER Chart



Fig 183) Region DISCOVER Chart

RED SEA TO THE GULF AND SEYCHELLES IS. REVEAL Chart



Fig 184) RED SEA TO THE GULF AND SEYCHELLES IS. Chart

PERSIAN GULF – OMAN DISCOVER Chart

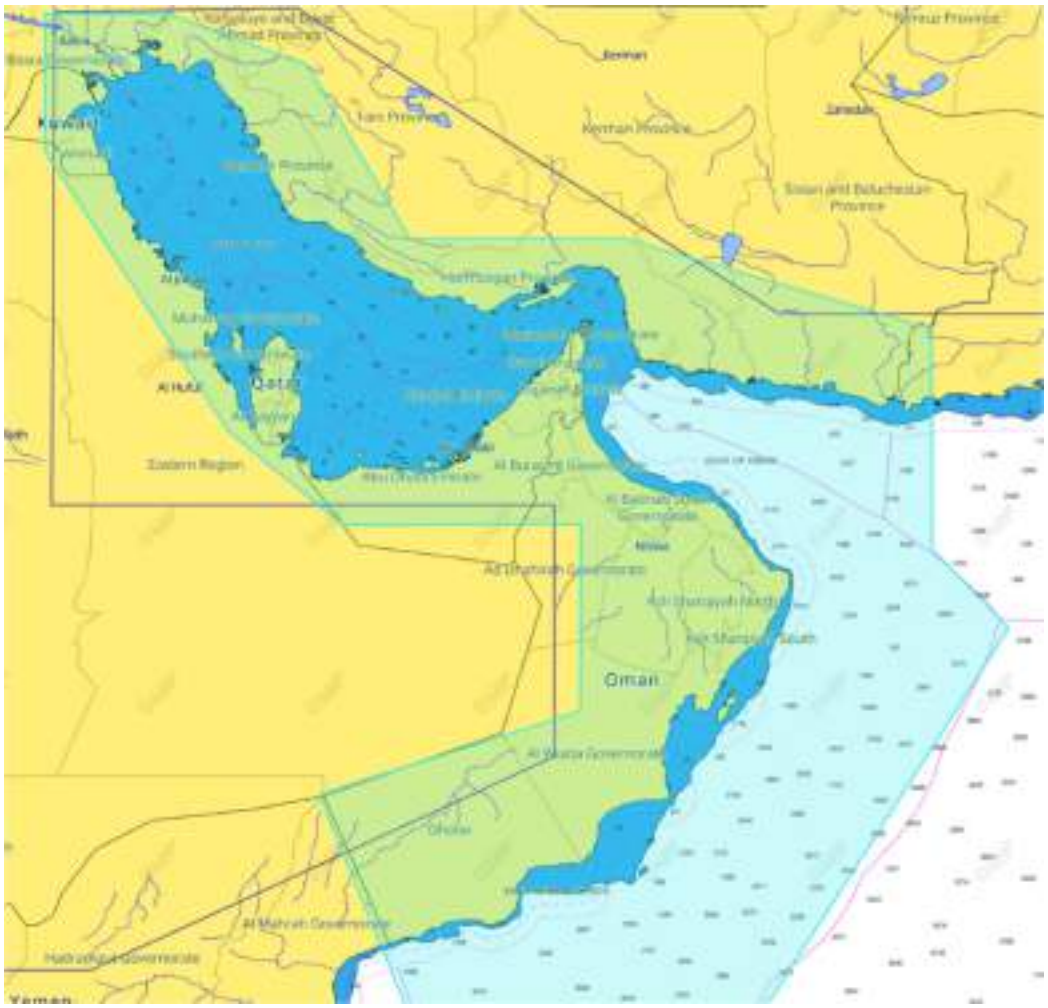


Fig 185) PERSIAN GULF - OMAN DISCOVER Chart

Landscape and Opportunities in the UAE/GCC Boat Market

The recent oil price collapse was seen as a wake-up call for Gulf States, urging them to look beyond oil and to diversify their economies. GCC economies are moving towards non-oil sector development, which will account for more than 80% of GDP in UAE and KSA.

The region has emerged as a major hub for leisure boating and is a thriving market for yachts and boats. This region accounts for 12% of the world's superyachts, which denotes that consumers in the region have a high propensity to buy. Marine infrastructure development and evolution of tourism are expected to open up new opportunities in the boat market. The major countries in the GCC boat market are Kuwait, Bahrain, UAE, Oman, and Qatar.

below figure is a detailed segmentation of the boat market in the UAE/GCC in line with the segmentation by the International rine Industry Associations.



Fig 186) Structure of the Boat Market in the UAE/GCC, 2018

Market Dynamics (Market Size Estimates)

The global recreational boat market is expected to be worth approximately $23 Billion in 2018 and is expected to reach $28-30 Billion by 2022. The marine industry in the UAE is a well-developed industry and is expected to be worth approximately $66 Billion in 2018.

However, the recreational boat industry is expected to be worth approximately $1.3-1.5 Billion (AED 4.8-5.5 Billion) in 2018. It is an emerging market with high spending power and is expected to provide significant opportunities for investors.

In 2016, the UAE imported ships, boats, and floating structures worth $951.5 Million, while it only exported for $447.5 Million, which mainly included re-exports to other GCC countries and other parts of the world.

below table, provides detailed information of the various component groups in the boat market and also gives their market share.

Building Materials	Hull, deck keel, rudder, deck hardware, interior fittings, etc. The share of the building materials in the boat market is expected to be around 40% ($0.56 Billion or AED 2.08 Billion).
Steering System	Technological advancements in the modern steering system have increased the convenience of riding a boat for boat owners and have reduced the complications. It forms a share of around 4-5% ($0.07 Billion or AED 0.26 Billion).
Electronic System	Control systems, monitoring systems, navigation systems, communication systems, and audio systems form an essential part of luxury and safety requirements. It forms a share of 12% ($0.17 Billion or AED 0.63 Billion).
Powering System	It includes engines, transmission, shaft, propeller, and forms a share of 9% ($0.13 Billion or AED 0.47 Billion).
Electrical	Electrical fittings such as lighting, charging system, wiring, batteries, navigation lights, etc., are expected to form a share of 3% ($0.04 Billion or AED 0.16 Billion).
Coatings	All paints both for interior and exterior purposes. It is used for both new boats and maintenance of old boats. It forms a main part in the periodical maintenance costs of the luxury boats with a share of 10% ($0.14 Billion or AED 0.52 Billion).
Lifting, Handling, Transportation, and Storage Systems	Different types of limited berthing facilities both wet and dry and increased use of these by workshops and service centers gives it a market share of 4% ($0.06 Billion or AED 0.20 Billion).
Accessories	After sales accessories and spare parts for the boats market has a share of 2-3% ($0.03 Billion or AED 0.10 Billion)

Table 10) Market share of the Component groups in the UAE/GCC Boat Market, 2018

In the UAE/GCC, only a few marine equipments are manufactured locally. The UAE/ GCC are largely an import-dependent market and almost 88% of the components are imported. Most of the identified key component groups are imported from various countries such as the US, France, Italy, Netherlands, Germany, etc.

Large boat builders directly import marine equipment from the manufacturers, while other boat builders, shipyards, boat workshops, and boat owners import through designated dealers or distributors.

Maritime Market Drivers in the GCC

Oman Freezones

There are three free zones - all supported by Oman's five airports, a planned new USD 20 billion rail network and a USD 10 billion world-class road network providing gateway distribution capabilities across the Sultanate and the wider Middle East.

The modern, technologically advanced ports of Salalah, Sohar and Duqm are unrivalled in their connectivity - strategically located within two weeks sail of all major global ports, and benefitting from rapid access to the growing Middle East, Indian and East-African markets.

Together, the ports run 200 weekly maritime services to 86 commercial ports across more than 40 countries providing a vast network for clients to make cost and time savings.

Freezones provide importers with significant benefits across the logistics sector. The existing free zones in Salalah and Sohar are soon to be joined by a third in Khazaen Economic City – situated near Barka, just outside Oman's capital city Muscat.

SOHAR Freezone

Situated between Dubai and Muscat, Sohar Free Zone is managed and operated by the Sohar Port Company.

SALALAH Freezone

Salalah Free Zone is situated adjacent to Salalah Port and is managed and operated by Salalah Free Zone Company, a subsidiary of ASYAD.

KHAZAEN Economic City

Khazaen Economic City is a world-class integrated economic city bringing together a broad range of logistics services.

Al Duqm Port & Drydock

Al Duqm Port & Drydock is a seaport located in Oman. The port is equipped with a Ship Repair Yard & Drydock facility, which is the first of its kind in Oman. Control of the port was transferred to the Ministry of Transport and Communications in May 2012.

Oman National Vision

Is aspired to be among the top ten global integrated logistics service providers.

Mission

To propel the development of Oman as a global logistics hub contributing to economic growth through an integrated group, offering globally competitive solutions.

Qatar Freezones

QNV 2030 has created opportunities for global companies to partner with Qatar and help deliver on the nation's signature Programmes.

Qatar Free Zones are an integral platform for international investors to support delivery of the major infrastructure projects in QNV.

Qatar National Vision 2030

QNV 2030 aims to transform Qatar from a developed economy to an advanced country by 2030, capable of sustaining its own development and providing a high standard of living for current population and future generations. QNV 2030 is delivered through national development strategies, with the second five-year strategy currently being implemented from 2018-22 which was designed with support from the World Bank.

What sets Qatar's approach apart is its ability to learn and reflect on where strategy implementation is succeeding, and where efforts need to be redoubled to deliver on QNV's objectives. This ability to clearly review and reflect on progress has resulted in departments and ministries across government improving how they manage and deliver on massive projects.

This dynamism is what ensures that Qatar's signature projects like the World Cup or the Port Expansion are delivered as promised, and provide confidence that Qatar is a nation that delivers on its plans.

Qatar Free Zones are made up of two free zones

Ras Bufontas

The airport free zone, is connected to the award-winning Hamad International Airport.

Umm Al Houl

The sea port free zone, sits next to the world's newest greenfield deep-seaport.

Dubai Industrial Strategy 2030

Aims to develop Dubai as a global platform and destination choice for international companies seeking growth and sustainability. Maritime is one of the six target subsectors. The strategy will aim to capitalize on promising opportunities through the localization of manufacturing capabilities in certain maritime sub-industries. It is expected that Dubai will expand its boats and yachts manufacturing activities to meet the domestic demand.

Dubai Maritime City (DMC)

It is a cluster dedicated to the maritime sector in Dubai that supports the development of maritime industry in Dubai and the GCC. It is also the world's first dedicated free zone built for the maritime industry. The facilities include yacht manufacturing, ship repair, marine engineering, technological expertise providers, office spaces, and other residential and leisure facilities for the marine community.

Dubai Canal

opened in November 2016 and is expected to increase the number of people using marine transport services. It is essentially changing the landscape of boating in the UAE by creating a waterway in the center of new communities.

Waterfront development of residential properties

is also expected to increase the demand for private boats and yachts. Water homes are a considerable turnkey project for Dubai Properties. The project is part of the firm's ambitions to introduce real estate innovation with centuries of ship building heritage that will transform waterfront living in the Emirates.

Restraints

Volatility in oil prices

has significantly affected the GCC economies, which are largely dependent on revenues from oil to finance the Government spending. The fall in prices have affected the Government budgets, which has resulted in delays or stalling of infrastructure developments.

Need for Standard Regulations for manufacture of boats in the GCC

There are no set boat manufacturing standards followed in the GCC, which has hampered the growth of the market.

VAT Implementation

Oman, the UAE and Saudi Arabia have implemented a VAT of 5%. This is expected to increase manufacturing cost of boats, which are already high priced, thereby affecting the demand in the region.

Challenges

High costs involved in boat/yacht maintenance can be daunting

A super yacht will require about 10 per cent of its purchase price to keep it running for just one year (Approximately AED 90 million for a large yacht).

Lack of adequate berthing facilities across the GCC

Most of the GCC residents are sea people and invest on boats or yachts for leisure. However, there are not adequate berthing facilities or marinas for the boats/yachts. Due to lack of facilities, customers hesitate to buy boats.

Shortage of Repair and Maintenance facilities in the GCC/UAE

Top luxury boats/yachts require repair and servicing from top professionals or companies that have an understanding of modern technology. Due to the shortage of facilities and import dependence of the market, boat owners are expected to spend on importing spare parts and services.

Conclusion

The UAE/GCC is a thriving market for leisure boats and yachts driven by marine tourism, increasing water-based sports activities, and coastline property developments. The GCC region has the highest share for the number of yachts owned globally, which is mainly due to the presence of large number of High-Net-Worth Individuals (HNWI).

Various development projects such as the Dubai Canal and Dubai Harbor are expected to place Dubai in the spotlight of the global leisure boat industry.

Oman has a significant role to play in commercial, fishing and leisure boat markets through the development of major industrial-cargo ports (Sohar, Duqm, Salalah), tourism facilities and resorts-marinas as well as multiple fishing harbors alongside its coastline.



Fig 187) Main maritime centers alongside Sultanate of Oman's coastline

Glossary

A

ACTIVE SONAR

A system consisting of one or more transducers to send and receive sound, equipment for the generation and detection of the electrical impulses to and from the transducer, and a display or recorder system for the observation of the received signals.

ADP

Ammonium dihydrogen phosphate, also known as monoammonium phosphate is a chemical compound with the chemical formula. ADP is a major ingredient of agricultural fertilizers and some fire extinguishers. It also has significant uses in optics and electronics.

AFC

In radio equipment, Automatic Frequency Control (AFC), also called Automatic Fine Tuning (AFT), is a method or circuit to automatically keep a resonant circuit tuned to the frequency of an incoming radio signal. It is primarily used in radio receivers to keep the receiver tuned to the frequency of the desired station.

AGC

Automatic Gain Control (AGC) is an audio pre-processor which automatically normalizes the output of the captured signal by boosting or lowering input from the microphone to match a preset level so that the output signal level is virtually constant.

AIS

AIS is an automatic tracking system that uses transponders on ships and is used by vessel traffic services.

AIS CLASS A

Class A AIS transponders (SOLAS Compliant) operate using Self-Organizing TDMA (SOTDMA) broadcast mode and transmit at a power level of 12.5 watts. Dynamic information is transmitted every 2 to 10 seconds while underway and every 3 minutes while at anchor.

AIS CLASS B

Class B AIS Transponders are mainly used by recreational vessels and smaller commercial vessels. Information transmitted by Class B transponders can be.

ALMANAC DATA

Almanac data is course orbital parameters for all SVs. Each SV broadcasts Almanac data for ALL SVs. This Almanac data is not very precise and is considered valid for up to several months. Ephemeris data by comparison is very precise orbital and clock correction for each SV and is necessary for precise positioning.

ALTITUDE

Altitude or height is a distance measurement, usually in the vertical or.

ANCHOR

A heavy object attached to a vessel by a cable, rope, or chain and dropped into the water to keep the vessel in place either by its weight or by its flukes, which grip the bottom.

ARPA

A marine radar with automatic radar plotting aid (ARPA) capability can create tracks using radar contacts. The system can calculate the tracked object's course, speed and closest point of approach (CPA), thereby knowing if there is a danger of collision with the other ship or landmass.

ARTIFICIAL INTELLIGENCE

The ability of a computer or other machine to perform those activities that are normally thought to require intelligence.

ASD

The Anti-Submarine Division its original name, was the former anti-submarine warfare, planning and prevention Directorate of the Admiralty Department from 1912-1963.

ASDIC

Asdic, later known as sonar, was a secret device for locating submerged submarines by using sound waves.

ATON

A marine Aid to Navigation (AtoN) is a device or system external to vessels that is designed and operated to enhance the safe and efficient navigation of vessels.

AUTO PILOT

An autopilot is a system used to control the path of an aircraft, car, marine craft or a spacecraft without requiring constant manual control by a human operator. Autopilots do not replace human operators.

AUV

AUV stands for autonomous underwater vehicle. they are unmanned, untethered vehicles used to conduct underwater research.

AWG

American Wire Gauge (AWG), also known as the Brown & Sharpe wire gauge, is a logarithmic stepped standardized wire gauge system used since 1857, predominantly in North America, for the diameters of round, solid, nonferrous, electrically conducting wire.

AZIMUTH

An azimuth is an angular measurement in a spherical coordinate system. The vector from an observer to a point of interest is projected perpendicularly onto a reference plane.

B

BEAM PATH AND RANGE

The path of a beam (typically in a particle accelerator) and its range.

BNWAS

A Bridge Navigational Watch Alarm System, abbreviated BNWAS, is an automatic system which sounds an alarm if the watch officer on the bridge of a ship falls asleep, becomes otherwise incapacitated, or is absent for too long a time. The BNWAS is automatically engaged when the ship's autopilot is activated.

BOUNCE

(with reference to an object) move quickly up, back, or away from a surface after hitting it.

BRIDGE

The bridge is a room or platform of a ship from which the ship can be commanded. When a ship is under way, the bridge is manned by an officer of the watch aided usually by an able seaman acting as a lookout.

BRUSHLESS MOTOR

A brushless DC electric motor (BLDC motor or BL motor), also known as an electronically commutated motor (ECM or EC motor) or synchronous DC motor, is a synchronous motor using a direct current (DC) electric power supply.

BUOYANCY

Buoyancy, or upthrust, is an upward force exerted by a fluid that opposes the weight of a partially or fully immersed object. In a column of fluid, pressure increases with depth as a result of the weight of the overlying fluid.

BUOYS

buoy, floating object anchored at a definite location to guide or warn mariners, to mark positions of submerged objects, or to moor vessels in lieu of anchoring.

C

CARBON BUTTON MICROPHONE

The carbon microphone, also known as carbon button microphone, button microphone, or carbon transmitter, is a type of microphone, a transducer that converts sound to an electrical audio signal. It consists of two metal plates separated by granules of carbon.

CCG

Clinical commissioning groups (CCGs) are NHS organizations set up by the Health and Social Care Act 2012 to organize the delivery of NHS services in England.

CDU

Control display unit, a device used to access a vessel’s Navigation Management Computer.

CHAIN HOME (CH)

Chain Home, or CH for short, was the codename for the ring of coastal Early Warning radar stations built by the Royal Air Force (RAF) before and during the Second World War to detect and track aircraft.

CHARTPLOTTER

A Chartplotter is a device used in marine navigation that integrates GPS data with an electronic navigational chart (ENC).

CHIRP

A chirp is a signal in which the frequency increases or decreases with time. In some sources, the term chirp is used interchangeably with sweep signal. It is commonly applied to sonar, radar, and laser systems, and to other applications, such as in spread-spectrum communications.

COAXIAL CABLE

Coaxial cable, or coax is a type of electrical cable consisting of an inner conductor surrounded by a concentric conducting shield, with the two separated by a dielectric.

COG

COG, Course Over Ground, indicates the direction of the boat's heading relative to the land. Over ground means.

COHERENT

(General Physics) physics (of two or more waves) having the same phase or a fixed phase difference.

COLREGS

The International Regulations for Preventing Collisions at Sea 1972 (COLREGs) are a set of rules to be followed by navigation officers to avoid collisions at sea. It is one of the most important International Conventions that all seagoing Officers must understand and be able to apply to real world situations.

CORRELATING

In statistics, correlation or dependence is any statistical relationship, whether causal or not, between two random variables or bivariate data. In the broadest sense correlation is any statistical association, though it actually refers to the degree to which a pair of variables are linearly related.

COUNTERMEASURES

A countermeasure is a measure or action taken to counter or offset another one. As a general concept it implies precision, and is any technological or tactical solution or system designed to prevent an undesirable outcome in the process. The first known use of the term is in 1923.

CPA

The Closest Point of Approach (CPA) is an estimated point at which the distance between the own ship and another object target will reach the minimum value. CPA is a valuable quantity in assessing ship safety with regards collision avoidance.

CQD

CQD (transmitted in Morse code as ▬▬ ■ ▬▬ ■ ▬▬ ▬▬ ■ ▬▬ ▬▬ ■ ■) is one of the first distress signals adopted for radio use. On 7 January 1904 the Marconi International Marine Communication Company issued.

CRT

A cathode-ray tube (CRT) is a vacuum tube containing one or more electron guns, the beams of which are manipulated to display images on a phosphorescent screen. The images may represent electrical waveforms (oscilloscope), pictures (television set, computer monitor), radar targets, or other phenomena.

CSTDMA

A method available for transmitting the AIS data telegrams. On the one hand, the CSTDMA (Carrier Sense Time-Division Multiple Access) method, is used primarily for pleasure boating (Class B). The CSTDMA method uses carrier-sensing to defer transmissions until no other stations are transmitting. If a free slot is found, the transmission starts. Then the transmission is stopped for a 30 second time interval before the next one starts..

CW RADAR

Continuous-wave radar (CW radar) is a type of radar system where a known stable frequency continuous wave radio energy is transmitted and then received from any reflecting objects.

D

DGPS

A Differential Global Positioning System (DGPS) is an enhancement to the Global Positioning System (GPS) which provides improved location accuracy, in the range of operations of each system, from the 15-metre (49 ft) nominal GPS accuracy to about 1–3 centimeters (0.39–1.18 in) in case of the best implementations.

DOCKING

platform extending from a shore over water, used to secure, protect, and provide access to a boat or ship.

DOPPLER EFFECT

The Doppler effect or Doppler shift is the change in frequency of a wave in relation to an observer who is moving relative to the wave source. It is named after the Austrian physicist Christian Doppler, who described the phenomenon in 1842.

DP VESSEL

Dynamic positioning (DP) is a computer-controlled system to automatically maintain a vessel's position and heading by using its own propellers and thrusters.

DSC

Digital selective calling or DSC is a standard for transmitting pre-defined digital messages via the medium-frequency (MF), high-frequency (HF) and very-high-frequency (VHF) maritime radio systems. It is a core part of the Global Maritime Distress Safety System (GMDSS).

E

EBL

An electronic means of measuring the radar bearing of a target with a rotating radial line on the radar screen. You can adjust the position of the line until it overlaps the target and read the bearing from numbers on the radar screen.

ECDIS

An Electronic Chart Display and Information System is a geographic information system used for nautical navigation that complies with International Maritime Organization regulations as an alternative to paper nautical charts.

ECHO SOUNDING

Echo sounding is a type of sonar used to determine the depth of water by transmitting acoustic waves into water.

ECHOSOUNDER

Echosounders are a type of sonar commonly used for a variety of tasks, including navigation, measuring bottom depth, and detecting schools of fish and plankton. Single beam echosounders emit a pulse of sound in a narrow cone (2°-12°).

EGNOS

The European Geostationary Navigation Overlay Service is a satellite based augmentation system developed by the European Space Agency and EUROCONTROL on behalf of the European Commission.

ELECTRONIC AMPLIFIERS

An amplifier, electronic amplifier or (informally) amp is an electronic device that can increase the power of a signal (a time-varying voltage or current).

ENC

An electronic navigational chart or ENC is an official database created by a national hydrographic office for use with an Electronic Chart Display and Information System (ECDIS).

ETA

Estimated time of arrival (ETA) in shipping is the estimated time the ship will arrive at anchorage (waiting outside the port) or at dock.

ETHERNET

Ethernet is a family of wired computer networking technologies commonly used in local area networks, metropolitan area networks and wide area networks. It was commercially introduced in 1980 and first standardized in 1983 as IEEE 802.3.

EXPONENTIAL

The exponential function is a mathematical function denoted by f(x)=\exp or e^{x}. It can be defined in several equivalent ways. Its ubiquitous occurrence in pure and applied mathematics has led mathematician W. Rudin to opine that the exponential function is, 99

F

FATHOMETER

trademark a type of echo sounder used for measuring the depth of water.

FCC

The Federal Communications Commission is an independent agency of the United States federal government that regulates communications by radio, television, wire, satellite, and cable across the United States.

FIBER OPTICS

Fiber-optic cables transmit data via fast-traveling pulses of light. Another layer of glass, called.

FISHFINDER

A fish finder helps detect a fish school and provides various underwater information, such as water depth, distribution of fish school, and the condition of the seabed by transmitting ultrasonic waves into the sea and receiving its reflection.

FLUSH-MOUNT INSTALLATION

A way of mounting a fixture, e.g., a socket so that the body of the fixture is inside the wall, leaving only a cover plate on top of the surface of the wall.

FLUXGATE COMPASS

The basic fluxgate compass is a simple electromagnetic device that employs two or more small coils of wire around a core of highly permeable magnetic material, to directly sense the direction of the horizontal component of the Earth's magnetic field.

FMCW

Frequency Modulated Continuous Wave (FMCW) radar is a form of radar where the frequency of the transmitted signal is continuously varied at a known rate over a defined time period. The reflected frequency signal is received by the radar and compared. The difference between the transmitted and reflected signals is directly proportional to the time of flight, which in turn is therefore proportional to the range.

FREQUENCY HOPPING

Frequency-hopping spread spectrum is a method of transmitting radio signals by rapidly changing the carrier frequency among many distinct frequencies occupying a large spectral band. The changes are controlled by a code known to both transmitter and receiver.

FREQUENCY MODULATION

Frequency modulation is the encoding of information in a carrier wave by varying the instantaneous frequency of the wave. The technology is used in telecommunications, radio broadcasting, signal processing, and computing.

G

GDOP

Dilution of precision (DOP), or geometric dilution of precision (GDOP), is a term used in satellite navigation and geomatics engineering to specify the error propagation as a mathematical effect of navigation satellite geometry on positional measurement precision, The larger the volume of the pyramid, the better (lower) the value of GDOP.

GLONASS

GLONASS is a Russian space-based satellite navigation system operating as part of a radionavigation-satellite service. It provides an alternative to GPS and is the second navigational system in operation with global coverage and of comparable precision.

GMDSS

The Global Maritime Distress and Safety System is a worldwide system for automated emergency signal communication for ships at sea developed by UN International Maritime Organization as part of SOLAS Convention.

GMSK MODULATION

GMSK – Gaussian minimum shift keying – is the original circuit switched GSM modulation system, allowing the GSM radio channel to be modulated at a data rate of 271kb/s whilst keeping the radio channel within a 200kHz bandwidth. This is the modulation system used for circuit switched and GPRS operations.

GPS

he Global Positioning System, originally Navstar GPS, is a satellite-based radionavigation system owned by the United States government and operated by the United States Space Force.

GROSS TONNAGE

Gross tonnage (GT, G.T. or gt) is a nonlinear measure of a ship's overall internal volume, it is calculated by measuring a ship's volume (from keel to funnel, to the outside of the hull framing) and applying a mathematical formula.

GT

Gross Tonnage.

GUNWALE

The gunwale is the top edge of the hull of a ship or boat. Originally the structure was the.

GYRO COMPASS

A gyrocompass is a type of non-magnetic compass which is based on a fast-spinning disc and the rotation of the Earth to find geographical direction automatically. The use of a gyrocompass is one of the seven fundamental ways to determine the heading of a vehicle.

H

HALF-DUPLEX CHANNELS

allows information to flow in both directions, but not at the same time. This allows the sender and receiver to communicate with one another, but one has to wait for the other when they do so.

HRB

The high-resolution bathymetry syntheses are composed primarily of MBES surveys enhanced by lidar in very shallow water. The original gridding, survey source, and other relevant information can be accessed on the UNH JHC/CCOM website.

HYBRID MAGNETO STRICTIVE-PIEZOELECTRIC TRANSDUCER

The Hybrid Transducer combines the high strain magneto strictive material, Terfenol-D, with that of Lead Zieconate Titanate piezoelectric ceramic, to create a double resonant, high power broadband device. This design provides a 1 kHz increase in bandwidth below the low end of the frequency band of a conventional piezoelectric Tonpilz transducers of the same size and weight.

HYDROACOUSTICS

Hydroacoustics is the study and application of sound in water. Hydroacoustics, using sonar technology, is most commonly used for monitoring of underwater physical and biological characteristics.

HYPERBOLIC

In mathematics, hyperbolic functions are analogues of the ordinary trigonometric functions, but defined using the hyperbola rather than the circle. Just as the points form a circle with a unit radius, the points form the right half of the unit hyperbola.

I

IEC INTERFACES

IEC 61968 is a series of standards under development that will define standards for information exchanges between electrical distribution systems. These standards are being developed by Working Group 14 of Technical Committee 57 of the IEC.

IEEE

The Institute of Electrical and Electronics Engineers is a professional association for electronic engineering and electrical engineering with its corporate office in New York City and its operations center in Piscataway, New Jersey.

IMM

The Interacting Multiple Model (IMM) estimator is a suboptimal hybrid filter that has been shown to be one of the most cost-effective hybrid state estimation schemes. ... In particular, the IMM estimator can be a self-adjusting variable-bandwidth filter, which makes it natural for tracking maneuvering targets.

IMO

The International Maritime Organization is a specialized agency of the United Nations responsible for regulating shipping. The IMO was established following agreement at a UN conference held in Geneva in 1948 and the IMO came into existence ten years later, meeting for the first time in 1959.

INTERNATIONAL TELECOMMUNICATION UNION

The International Telecommunication Union is a specialized agency of the United Nations responsible for all matters related to information and communication technologies. It was established in 17 May 1865 as the International Telegraph Union, making it the oldest international organization.

IONOSPHERIC REFLECTION

Due to the ability of ionized atmospheric gases to refract high frequency (HF, or shortwave) radio waves, the ionosphere can reflect radio waves directed into the sky back toward the Earth. Radio waves directed at an angle into the sky can return to Earth beyond the horizon.

IPX7

IPX7 Waterproof means the device has level 7 water sealing, while its protection against dust is unknown.

IRNSS

The Indian Regional Navigation Satellite System, with an operational name of NavIC, is an autonomous regional satellite navigation system that provides accurate real-time positioning and timing services. It covers India and a region extending 1,500 km around it, with plans for further extension.

ISM BAND

The ISM radio bands are portions of the radio spectrum reserved internationally for industrial, scientific and medical purposes, excluding applications in telecommunications.

ITU

The International Telecommunication Union is a specialized agency of the United Nations responsible for all matters related to information and communication technologies. It was established in 17 May 1865 as the International Telegraph Union, making it the oldest international organization.

J

JITTER

In electronics and telecommunications, jitter is the deviation from true periodicity of a presumably periodic signal, often in relation to a reference clock signal. In clock recovery applications it is called timing jitter.

K

KLYSTRON

A klystron is a specialized linear-beam vacuum tube, invented in 1937 by American electrical engineers Russell and Sigurd Varian, which is used as an amplifier for high radio frequencies, from UHF up into the microwave range.

L

LATITUDE

In geography, latitude is a geographic coordinate that specifies the north–south position of a point on the Earth's surface. Latitude is an angle which ranges from 0° at the Equator to 90° at the poles. Lines of constant latitude, or parallels, run east–west as circles parallel to the equator.

LCD

A liquid-crystal display is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polarizers. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in color or monochrome.

LFMW

linear frequency modulated waveform.

LIDAR

Lidar is an acronym for.

LIGHTVESSELS

lightvessel, or lightship, is a ship that acts as a lighthouse. They are used in waters that are too deep or otherwise unsuitable for lighthouse construction.

LINE OF SIGHT

An imaginary line from the eye to a perceived object.

LINEAR

Linearity is the property of a mathematical relationship (function) that can be graphically represented as a straight line. The word linear comes from Latin linearis,.

LONGITUDE

Longitude is a geographic coordinate that specifies the east–west position of a point on the Earth's surface, or the surface of a celestial body. It is an angular measurement, usually expressed in degrees and denoted by the Greek letter lambda. Meridians connect points with the same longitude.

LONGWAVE BANDS

In radio, longwave, long wave or long-wave, and commonly abbreviated LW, refers to parts of the radio spectrum with wavelengths longer than what was originally called the medium-wave broadcasting band.

LRIT

The Long Range Tracking and Identification (LRIT) is an international tracking and identification system incorporated by the IMO under its SOLAS convention to ensure a thorough tracking system for ships across the world. LRIT system forms a very important ambit in the SOLAS convention.

M

MAGNETIC COMPASS

magnetic compass, in navigation or surveying, an instrument for determining direction on the surface of Earth by means of a magnetic pointer that aligns itself with Earth's magnetic field. A magnetized needle stuck through a piece of cork makes a simple magnetic compass.

MAGNETIC NORTH

Magnetic north is the direction that a compass needle points to as it aligns with the Earth's magnetic field. What is interesting is that the magnetic North Pole shifts and changes over time in response to changes in the Earth's magnetic core.

MAGNETRON

The cavity magnetron is a high-power vacuum tube used in early radar systems and currently in microwave ovens. It generates microwaves using the interaction of a stream of electrons with a magnetic field while moving past a series of cavity resonators which are small, open cavities in a metal block.

MARPA

Mini-automatic radar plotting aid (or MARPA) is a maritime radar feature for target tracking and collision avoidance. Targets must be manually selected, but are then tracked automatically, including range, bearing, target speed, target direction (course), CPA (closest point of approach), and TCPA (time of closest point of approach), safe or dangerous indication, and proximity alarm. MARPA is a more basic form of ARPA (automatic radar plotting aid).

MERCHANT SHIPS

A merchant ship, merchant vessel, trading vessel, or merchantman is a watercraft that transports cargo or carries passengers for hire. This is in contrast to pleasure craft, which are used for personal recreation, and naval ships, which are used for military purposes.

MFD

A multifunction display is a small-screen surrounded by multiple soft keys that can be used to display information to the user in numerous configurable ways. MFDs originated in aviation, first in military aircraft, and later were adopted by commercial aircraft, general aviation, automotive use, and shipboard use.

MMSI

A Maritime Mobile Service Identity is a series of nine digits which are sent in digital form over a radio frequency channel in order to uniquely identify ship stations, ship earth stations, coast stations, coast earth stations, and group calls.

MODULE

each of a set of standardized parts or independent units that can be used to construct a more complex structure, such as an item of furniture or a building.

MORSE CODE

Morse code is a method used in telecommunication to encode text characters as standardized sequences of two different signal durations, called dots and dashes, or dits and dahs. Morse code is named after Samuel Morse, one of the inventors of the telegraph.

MTSAT

Multifunctional Transport Satellites (MTSAT) were a series of weather and aviation control satellites. They are replaced by Himawari 8 on 7 July 2015.

N

NATO PHONETIC ALPHABET

The International Radiotelephony Spelling Alphabet, commonly known as the NATO phonetic alphabet, NATO spelling alphabet, ICAO phonetic alphabet or ICAO spelling alphabet, is the most widely used radiotelephone spelling alphabet. The ITU phonetic alphabet and figure code is a rarely used variant that differs in the code words for digits.

NAUTICAL

Of, relating to, or characteristic of ships, shipping, sailors, or navigation on a body of water.

NAUTICAL MILES

A nautical mile is a unit of length used in air, marine, and space navigation, and for the definition of territorial waters. Historically, it was defined as the meridian arc length corresponding to one minute of latitude. Today the international nautical mile is defined as exactly 1852 meters.

NAVIGATION SYSTEM

A navigation system is a computing system that aids in navigation.

NAVSTAR

Navstar is a network of U.S. satellites that provide global positioning system (GPS) services. They are used for navigation by both the military and civilians. These 24 main GPS satellites orbit Earth every 12 hours, sending a synchronized signal from each individual satellite.

NAVTEX

NAVTEX (NAVigational TEleX), sometimes styled Navtex or NavTex, is an international automated medium frequency direct-printing service for delivery of navigational and meteorological warnings and forecasts, as well as urgent maritime safety information (MSI) to ships.

NEXRAD

NEXRAD or Nexrad (Next-Generation Radar) is a network of 160 high-resolution S-band Doppler weather radars operated by the National Weather Service (NWS), an agency of the National Oceanic and Atmospheric Administration (NOAA) within the United States Department of Commerce, the Federal Aviation Administration (FAA) within the Department of Transportation, and the U.S. Air Force within the Department of Defense. Its technical name is WSR-88D (Weather Surveillance Radar, 1988, Doppler).

NMEA 0183

NMEA 0183 is a combined electrical and data specification for communication between marine electronics such as echo sounder, sonars, anemometer, gyrocompass, autopilot, GPS receivers and many other types of instruments.

NMEA 2000®

NMEA 2000, abbreviated to NMEA2k or N2K and standardized as IEC 61162-3, is a plug-and-play communications standard used for connecting marine sensors and display units within ships and boats. The protocol is used to create a network of electronic devices—chiefly marine instruments—on a boat.

NOAA

The National Oceanic and Atmospheric Administration (NOAA) is an American scientific and regulatory agency within the United States Department of Commerce that forecasts weather, monitors oceanic and atmospheric conditions, charts the seas, conducts deep sea exploration, and manages fishing and protection of marine mammals and endangered species in the U.S.

NON-COHERENT

Coherent systems need carrier phase information at the receiver and they use matched filters to detect and decide what data was sent , while noncoherent systems do not need carrier phase information and use methods like square law to recover the data.

O

OMNIDIRECTIONAL BROADCAST

In radio communication, an omnidirectional antenna is a class of antenna which radiates equal radio power in all directions perpendicular to an axis (azimuthal directions), with power varying with angle to the axis (elevation angle), declining to zero on the axis.

ON-BOARD

on or in a ship, aircraft, or other vehicle.

OSCILLATOR

An electronic oscillator is an electronic circuit that produces a periodic, oscillating electronic signal, often a sine wave or a square wave or a triangle wave. Oscillators convert direct current from a power supply to an alternating current signal.

OSV

Also known as offshore support vessels, OSVs are specially designed ships for the logistical servicing of offshore platforms and subsea installations, from installation through the full service life of offshore fields.

P

PARABOLIC REFLECTOR

A parabolic reflector is a reflective surface used to collect or project energy such as light, sound, or radio waves. Its shape is part of a circular paraboloid, that is, the surface generated by a parabola revolving around its axis.

PATROL BOAT

A patrol boat (also referred to as a patrol craft, patrol ship or patrol vessel) is a relatively small naval vessel generally designed for coastal defense, border protection, immigration law-enforcement, search and rescue duties.

PEDESTAL

An architectural support or base, as for a column or statue.

PHASED ARRAY

In antenna theory, a phased array usually means an electronically scanned array, a computer-controlled array of antennas which creates a beam of radio waves that can be electronically steered to point in different directions without moving the antennas.

PID

Proportional Integral Derivative (PID) control automatically adjusts a control output based on the difference between a set point (SP) and a measured process variable (PV). The set point (SP) is the target value and process variable (PV) is the measured value that may deviate from the desired value.

PMN

Polymorphonuclear leukocytes, or granulocyte.

POLARIZATION

Polarization is a property applying to transverse waves that specifies the geometrical orientation of the oscillations. In a transverse wave, the direction of the oscillation is perpendicular to the direction of motion of the wave.

PPI

A plan position indicator (PPI) is a type of radar display that represents the radar antenna in the center of the display, with the distance from it and height above ground drawn as concentric circles. It is the most common type of radar display.

PRF

The pulse repetition frequency (PRF) is the number of pulses of a repeating signal in a specific time unit, normally measured in pulses per second. ... The PRF is normally much lower than the frequency.

PROTOTYPE

one of the first units manufactured of a product, which is tested so that the design can be changed if necessary, before the product is manufactured commercially.

PULSE

A pulse wave or pulse train is a kind of non-sinusoidal waveform that includes square waves (duty cycle of 50%) and similarly periodic but asymmetrical waves (duty cycles other than 50%). It is a term is used in synthesizer programming, and is a typical waveform available on many synthesizers.

PULSE COMPRESSION

Pulse compression is a signal processing technique commonly used by radar, sonar and echography to increase the range resolution as well as the signal to noise ratio. This is achieved by modulating the transmitted pulse and then correlating the received signal with the transmitted pulse.

PULSE-DOPPLER RADAR

A pulse-Doppler radar is a radar system that determines the range to a target using pulse-timing techniques, and uses the Doppler effect of the returned signal to determine the target object's velocity.

PZT

Lead zirconate titanate. Also called lead zirconium titanate, it is a ceramic perovskite material that shows a marked piezoelectric effect, meaning that the compound changes shape when an electric field is applied.

Q

QUARTZ PIEZOELECTRIC CRYSTALS

Piezoelectricity is the electric charge that accumulates in certain solid materials—such as crystals, certain ceramics, and biological matter such as bone, DNA, and various proteins—in response to applied mechanical stress. The word piezoelectricity means electricity resulting from pressure and latent heat. Quartz is probably the most well-known piezoelectric crystal, perhaps because of its use in quartz clocks and watches.

R

RACON NAVIGATIONAL AIDS

RACONs, also called radar responders, or radar transponder beacons, are receiver/transmitter transponder devices used as a navigation aid, identifying landmarks or buoys on a shipboard marine radar display.

RADAR

Radar is a detection system that uses radio waves to determine the distance, angle, or velocity of objects. It can be used to detect aircraft, ships, spacecraft, guided missiles, motor vehicles, weather formations, and terrain.

RADIO SPECTRUM

The radio spectrum is the part of the electromagnetic spectrum with frequencies from 3 Hz to 300 GHz.

RAF

The Royal Air Force is the United Kingdom's air and space force. It was formed towards the end of the First World War on 1 April 1918, becoming the first independent air force in the world, by regrouping the Royal Flying Corps and the Royal Naval Air Service.

RAIM

Receiver autonomous integrity monitoring is a technology developed to assess the integrity of global positioning system signals in a GPS receiver system. It is of special importance in safety-critical GPS applications, such as in aviation or marine navigation.

RF

Radio frequency is the oscillation rate of an alternating electric current or voltage or of a magnetic, electric or electromagnetic field or mechanical system in the frequency range from around 20 kHz to around 300 GHz.

RIBS

A rigid inflatable boat (RIB), also rigid-hull inflatable boat or rigid-hulled inflatable boat (RHIB), is a lightweight but high-performance and high-capacity unsinkable boat constructed with a rigid hull bottom joined to side-forming air tubes that are inflated with air to a high pressure so as to give the sides resilient rigidity along the boat's topsides.

RMS REPUBLIC

RMS Republic was a steam-powered ocean liner built in 1903 by Harland and Wolff in Belfast, and lost at sea in a collision in 1909 while sailing for the White Star Line.

RNC

Raster Navigational Chart (RNC).

ROT

Rate of turn indicator or ROTI on board vessels indicates the rate a ship is turning. It indicates the rate a ship is turning in degrees per minute (°/min) . It is one of the most important instruments a helmsman can have when steering a course.

RTCM CORRECTIONS

RTCM SC-104 is a standard that defines the data structure for differential correction information for a variety of differential correction applications. It was developed by the Radio Technical Commission for Maritime Services (RTCM) and has become an industry standard for communication of correction information.

RTTE

The radio waves must utilize the spectrum that is associated with all terrestrial or space radio communications. On the other hand, telecommunications terminal equipment is a product or device that enables communication of a relevant component.

RUDDER

A rudder is a primary control surface used to steer a ship, boat, submarine, hovercraft, aircraft, or other conveyance that moves through a fluid medium, Rudders are hydrofoils which are pivoting on a vertical axis. They are located normally at the stern behind propeller(s) to produce a transverse force and steering moment about the ship center of gravity by deflecting the water flow to the direction of the foil plane.

S

SAR

Search and rescue (SAR) is the search for and provision of aid to people who are in distress or imminent danger.

SART

A search and rescue transponder is a self-contained, waterproof transponder intended for emergency use at sea. These devices may be either a radar-SART, or a GPS-based AIS-SART. The radar-SART is used to locate a survival craft or distressed vessel by creating a series of dots on a rescuing ship's radar display.

SATCOM

The Satcom series was a family of communications satellites originally developed and operated by RCA American Communications. Satcom was one of the early geostationary satellites.

S-BAND

The S band is a designation by the Institute of Electrical and Electronics Engineers for a part of the microwave band of the electromagnetic spectrum covering frequencies from 2 to 4 gigahertz. Thus, it crosses the conventional boundary between the UHF and SHF bands at 3.0 GHz.

SBAS

A Satellite-based Augmentation System (SBAS) is a civil aviation safety-critical system that supports wide-area or regional augmentation – even continental scale - through the use of geostationary (GEO) satellites which broadcast the augmentation information.

SENC

SENC stands for System Electronic Navigational Chart. When an ENC is loaded into the system, it becomes a SENC. ECDIS converts ENC data into its own internal SENC format for optimal chart image creation. SENC data can differ between manufacturers.

SIGNAL PROCESSING

Signal processing is an electrical engineering subfield that focuses on analyzing, modifying, and synthesizing signals such as sound, images, and scientific measurements.

SIRE

The SIRE (Ship Inspection Report Programme) Programme is a unique tanker risk assessment tool of value to charterers, ship operators, terminal operators and government bodies concerned with ship safety.

SISO

In control engineering, a single-input and single-output system is a simple single variable control system with one input and one output. In radio it is the use of only one antenna both in the transmitter and receiver.

SNR

Signal-to-noise ratio is a measure used in science and engineering that compares the level of a desired signal to the level of background noise. SNR is defined as the ratio of signal power to the noise power, often expressed in decibels. A ratio higher than 1.

SOG

Speed over Ground (SOG) is the speed of the vessel in one hour with respect to the land or any other fixed object such as buoys. Speed through Water (STW) is the speed of the vessel in one hour with respect to the water or anything floating on water.

SOLAS

The International Convention for the Safety of Life at Sea is an international maritime treaty that sets minimum safety standards in the construction, equipment and operation of merchant ships. The convention requires signatory flag states to ensure that ships flagged by them comply with at least these standards.

SONAR

Sonar is a technique that uses sound propagation to navigate, measure distances, communicate with or detect objects on or under the surface of the water, such as other vessels.

SOS

SOS is a Morse code distress signal, used internationally, that was originally established for maritime use, (■■■▬▬▬▬▬■■■).

SOTDMA

SOTDMA (Self-Organized Time-Division Multiple Access) technology, which was used only by commercial vessels (Class A) but is now also authorized for pleasure boating at Class B level. With the SOTDMA method only the first free slot for the transmission has to be found. The next five slots are always reserved automatically.

SPAR BUOYS

A spar buoy is a tall, thin buoy that floats upright in the water and is characterized by a small water plane area and a large mass. Because they tend to be stable ocean platforms, spar buoys are popular for making oceanographic measurements.

STW

Speed through water is the speed of the ship with respect to the water such as anything floating on water. A ship with her engine stopped in water with 2 knots currents will have zero speed through water but will have 2 knots speed over ground.

T

TCPA

There are basically two alarms.

TELECOMMUNICATION

Telecommunication is the transmission of information by various types of technologies over wire, radio, optical, or other electromagnetic systems.

THD

A transmitting heading device (THD) is an electronic device that provides information about the ship's true heading. The THDs complying with the requirements contained in this part of ISO 22090 can be used for heading information as contained in chapter V of the SOLAS Convention.

TILLER

The tiller is what steers a boat — specifically, the handle attached to the rudder. Tillers are generally found on smaller boats because it would take too much force to steer larger ships with hand tillers. Rapid back and forth movement on the tiller helps create drag and slows the boat.

TRACK ALGORITHM

A track algorithm is a radar and sonar performance enhancement strategy. Tracking algorithms provide the ability to predict future position of multiple moving objects based on the history of the individual positions being reported by sensor systems.

TRANSDUCER

A transducer is a device that converts energy from one form to another. Transducers are often employed at the boundaries of automation, measurement, and control systems, where electrical signals are converted to and from other physical quantities (energy, force, torque, light, motion, position, etc.).

TRANSFLECTIVELCD

A transflective liquid-crystal display is a liquid-crystal display with an optical layer that reflects and transmits light. Under bright illumination the display acts mainly as a reflective display with the contrast being constant with illuminance.

TRANSMITTER

In electronics and telecommunications a radio transmitter or just transmitter is an electronic device which produces radio waves with an antenna. The transmitter itself generates a radio frequency alternating current, which is applied to the antenna.

TRANSPONDER

In telecommunication, a transponder is a device that, upon receiving a signal, emits a different signal in response. The term is a blend of transmitter and responder. It is variously abbreviated as XPDR, XPNDR, TPDR or TP.

TRIM TAB

Trim tabs do much the same thing for a boat. They provide lift in order to compensate for changes in speed, weight distribution, and water conditions. When they are deflected downward, the water force on the trim tab creates upward pressure, raising the stern and reducing hull resistance.

TRUE NORTH

True north is the direction along Earth's surface towards the geographic North Pole or True North Pole. Geodetic north differs from magnetic north, and from grid north.

U

UAV

An unmanned aerial vehicle, commonly known as a drone, is an aircraft without any human pilot, crew or passengers on board. UAVs are a component of an unmanned aircraft system, which include additionally a ground-based controller and a system of communications with the UAV.

UKSAR

United Kingdom Search and Rescue.

ULS

An upward looking sonar (ULS) is a sonar device pointed upwards looking towards the surface of the sea.

UPS

n uninterruptible power supply or uninterruptible power source (UPS) is an electrical apparatus that provides emergency power to a load when the input power source or mains power fails.

USCG

The United States Coast Guard is the maritime security, search and rescue, and law enforcement service branch of the United States Armed Forces and one of the country's eight uniformed services.

USNS

United States Naval Ship is the prefix designation given to non-commissioned ships that are property of the United States Navy.

UWB COMMUNICATIONS

Ultra-wideband (UWB, ultra wideband, ultra-wide band and ultraband) is a radio technology that can use a very low energy level for short-range, high-bandwidth communications over a large portion of the radio spectrum. UWB has traditional applications in non-cooperative radar imaging.

V

VDR

A VDR or voyage data recorder is an instrument safely installed on a ship to continuously record vital information related to the operation of a vessel. It contains a voice recording system for a period of at least last 12 hours. This recording is recovered and made use of for investigation in events of accidents in a compressed and digitized format.

VHF

Very high frequency is the ITU designation for the range of radio frequency electromagnetic waves from 30 to 300 megahertz, with corresponding wavelengths of ten meters to one meter. Frequencies immediately below VHF are denoted high frequency, and the next higher frequencies are known as ultra high frequency.

VHF RADIO

HF radio can refer to several communications services in the very high frequency (VHF) range.

VRM

VRM stands for Variable Range Marker. This function provides an accurate measurement of range to targets.

VTS

Vessel traffic services (VTS) are shore-side systems which range from the provision of simple information messages to ships, such as position of other traffic or meteorological hazard warnings, to extensive management of traffic within a port or waterway.

W

WAAS

The Wide Area Augmentation System is an air navigation aid developed by the Federal Aviation Administration to augment the Global Positioning System, with the goal of improving its accuracy, integrity, and availability.

WAVEFORM

In electronics, acoustics, and related fields, the waveform of a signal is the shape of its graph as a function of time, independent of its time and magnitude scales and of any displacement in time. In electronics, the term is usually applied to periodically varying voltages, currents, or electromagnetic fields.

WAVEGUIDE

waveguide is a structure that guides waves, such as electromagnetic waves or sound, with minimal loss of energy by restricting the transmission of energy to one direction. ... The original and most common meaning is a hollow conductive metal pipe used to carry high frequency radio waves, particularly microwaves.

WAVELENGTH

In physics, the wavelength is the spatial period of a periodic wave—the distance over which the wave's shape repeats.

X

X-BAND

The X band is the designation for a band of frequencies in the microwave radio region of the electromagnetic spectrum. In some cases, such as in communication engineering, the frequency range of the X band is rather indefinitely set at approximately 7.0–11.2 GHz.

Y

YACHTING

Yachting is the use of recreational boats and ships called yachts for racing or cruising. Yachts are distinguished from working ships mainly by their leisure purpose..

Resources

- https://navico.com/
- https://www.navico-commercial.com/
- https://www.lowrance.com/
- https://www.simrad-yachting.com/
- https://www.bandg.com/
- https://www.c-map.com/
- https://www.brunswick.com/
- https://www.airmartechnology.com/
- https://dspguide.com/
- Chirp Signals
- https://mathworld.wolfram.com/SweepSignal.html
- Weisstein, Eric W. "Sweep Signal". From MathWorld--A Wolfram Web Resource.
- https://casualnavigation.com/how-does-marine-gps-work/
- https://cultofsea.com/bridge-equipment/gps-global-positioning-system/
- https://marinegyaan.com/what-is-autopilot-its-principle-and-details/
- https://marinegyaan.com/what-is-gps/
- https://portal.ct.gov/DEEP/Boating/Safety/Marine-VHF-Radio--The-Basics
- https://www.brighthubengineering.com/seafaring/23017-gps-navigation-and-its-use-on-board-ships/
- https://www.discoverboating.com/resources/marine-gps-for-boats
- https://www.frost.com/frost-perspectives/landscape-and-opportunities-uaegcc-boat-market/
- https://www.getmyboat.com/journal/how-to/autopilot-systems-on-boats/
- https://www.marineinsight.com/marine-navigation/what-is-electronic-chart-display-and-information-system-ecdis/
- https://www.tra.org.bh/
- https://www.tra.gov.om/En/
- https://asyad.om/
- https://qfz.gov.qa/
- https://www.portofduqm.om/
- Mann, Steve and Haykin, Simon; The Chirplet Transform: A generalization of Gabor's Logon Transform
- "Echo Sounding / Early Sound Methods". National Oceanic & Atmospheric Administration (NOAA). NOAA Central Library
- "IHO Standards for Hydrographic Surveys"(5th Edition)
- "ENCs, ECDIS & S-100". International Hydrographic Organization
- "Maritime Safety Committee". International Maritime Organization
- "Maritime navigation and radiocommunication equipment and systems – Electronic chart display and information system (ECDIS) – Operational and performance requirements, methods of testing and required test results". International Electrotechnical Commission in the world
- Hodges, Richard P. (2013). Underwater Acoustics: Analysis, Design and Performance of Sonar. Hoboken, N.J.: John Wiley & Sons
- Jackson, Darrell; Richardson, Michael (2007). High-frequency seafloor acoustics (1. ed.). New York: Springer
- "Answers to Your Top Fish Finder Questions". Sport Fishing Magazine
- "Black Box Boating - Electronics for Power and Sail", Motor Boating, May 1970

- "Frost & Sullivan, Inc". Bloomberg Businessweek
- "Our Offices". Frost & Sullivan. Frost & Sullivan
- "Global Positioning System Standard Positioning Service Performance Standard: 4th Edition, September 2008"
- "GPS Accuracy". GPS.gov. National Coordination Office for Space-Based Positioning, Navigation, and Timing
- "Genesis of Satellite Navigation"
- "GPS and the World's First "Space War"". Scientific American
- "GNSS Positioning Approaches". GNSS Positioning Approaches – GPS Satellite Surveying, Fourth Edition – Leick. Wiley Online Library
- "New Algorithm for GNSS Positioning Using System of Linear Equations
- "GPS: Global Positioning System (or Navstar Global Positioning System)" Wide Area Augmentation System (WAAS) Performance Standard, Section B.3, Abbreviations and Acronyms
- "United States Updates Global Positioning System Technology". America.gov. February 3, 2006
- "Galileo navigation satellite system goes live". dw.com
- "The Seven Ways to Find Heading". The Journal of Navigation. Cambridge University Press
- Elliott-Laboratories (2003). The Anschutz Gyro-Compass and Gyroscope Engineering
- The Invention of Precision Navigational Instruments for Air and Sea Navigation
- "Kommunikationsverket 2010: Handbok i VHF-radiokommunikation för radiooperatör med kusttrafikcertifikat"
- Harbord, J.G. (1929). "The Commercial Uses of Radio". The Annals of the American Academy
- "U.S. VHF Channels". Navcen.uscg.gov
- Aircraft Digital Electronic and Computer Systems (2nd ed.). Routledge
- "All you ever wanted to know about British air defense radar"
- "Telephone History: Radar History"
- "Radar - The Great Detective"
- "Technical History of the Beginnings of Radar", IEE History of Technology Series, Vol. 6
- “Radar signals”, John Wiley & Sons
- MIMO radar: an idea whose time has come. IEEE Radar Conference
- "Waveform diversity in radar signal processing". IEEE Signal Processing Magazine
- "Waveform design and diversity for advanced radar systems". Institution of Engineering and Technology
- "Radio Detection and Ranging". Nature
- "Performance Assessment of an Integrated Radar Architecture for Multi-Types Frontal Object Detection for Autonomous Vehicle"
- “The Theory and Design of Chirp Radars,” Bell System Technical Journal 39, 745
- Modern Antenna Design, 2nd Ed. John Wiley & Sons
- Antenna Theory: Analysis and Design, 4th Ed. John Wiley & Sons
- The Focal Illustrated Dictionary of Telecommunications. Taylor & Francis
- "Indian Regional Navigational Satellite System Signal In Space Interface Control Document for Standard Positioning Service". Indian Space Research Organization
- "Today in Radio History (January 12)". Radio World
- "Performance Comparison of S-band, C-band, and X-band RF Linac based XFELs"
- "Datasheet for Newtec MDM2210 Terminal with S-Band Transmit Frequency"
- "Radar Bands". www.everythingweather.com
- "NATO Joint Civil/Military Frequency Agreement (NJFA)"

Resources

- "10GHz wideband transceiver". www.g3pho.free-online.co.uk
- "Radio Spectrum"
- "A Steep Learning Curve: The Impact of Sonar Technology, Training, and Tactics on the Initial Years of U.S. Navy Antisubmarine Warfare in World War II". Warship International
- "Sonar Research and Naval Warfare 1914–1954: A Case Study of a Twentieth-Century Science"
- Principles of Underwater Sound (3rd edition). Los Altos: Peninsula Publishing
- Stalin's Ocean-going Fleet: Soviet Naval Strategy and Shipbuilding Programmes, 1935–1953
- "Sonar". Encyclopedia Britannica
- Hendrick, Burton J. (August 1914). "Wireless under the water: a remarkable device that enables a ship's captain to determine the exact location of another ship even en the densest fog"
- "Fathometer"
- "Lightweight Actuation Transponder (LAT)". Sonardyne
- "World War II Naval Dictionary". USS Abbot (DD-629)
- "Japanese Sonar and Asdic"
- "Signal Processing". Applied Underwater Acoustics. Elsevier
- McClinton, A. T. (September 7, 1967). Project Artemnis Acoustic Source Summary Report. Washington, D.C.: U.S. Naval Research Laboratory
- "Fundamentals of Radar Tracking". Applied Technology Institute
- "Local Tracking". Radar Tutorial Dot EU
- "Performance Comparison of Tracking Algorithms for a Ground Based Radar". Ankara University
- "NAVICO BOUGHT BY GOLDMAN SACHS". Boating Magazine
- "Navico expands manufacturing plant in Mexico". Trade Only Today
- "Brunswick acquires Navico". sailingscuttlebutt.com
- "Divestment of C-MAP Commercial from Navico | Navico"
- "Gulf Cooperation Council – GCC Countries"
- "GCC Charter". Secretariat General of the Gulf Cooperation Council
- "Gulf Cooperation Council | History, Member Countries, Purpose, & Summits"
- [Kopacz, Urbański 1998]

END



FIRST MARITIME GENERAL TRADING COMPANY (FTZ) LLC

CR n°1324450

OSCO building - 4th floor - office n° 448 - Sohar Free zone - Sultanate of Oman - P.O Box 904 - P.C 322

Please visit our corporate website at:

https://www.1stmaritime.com

With a CAGR approaching 12% over the next decade (2022-2029), worldwide as well as regionally, marine navigation systems market growth will not only offer commercial opportunities, it will also encounter major technological shifts through autonomous vehicles, IoT, Global Navigation Satellite System (GNSS) evolutions. Virtually all market segments, merchant fleets, passenger fleets, navy, leisure boats are to embark. Customers will consequently put increasing pressure on manufacturers to address their new demands through the development of sound product range offer.

That is because we are confident Simrad, Lowrance, CMAP, B&G brands will successfully take up this challenge, that we proudly represent these brands in Oman among the GCC region.

And we are proud at First Maritime to uncover this third title of its Business textbooks series entitled « A handbook of Marine Navigation Systems » aimed at assisting our customers and partners to make the right decision when it comes to equip with navigation system equipment. Thanks for your trust.

FIRST MARITIME
General Trading Company

LIGHTHOUSE
Training program

info@1stmaritime.com

www.1stmaritime.com

Printed in 2022