Utilising

AIS DATA

for data analysis

AIS is a communications system based on radio frequency (RF), which is a form of wireless communications that uses the transmission and reception (sending and receiving) of electromagnetic waves. These waves work very much the same as do wireless transmissions from and to cellular telephones.

A ship's AIS transponder (the device that sends and receives signals) uses a very high frequency (VHF) RF transmitter to broadcast important information to receiver devices on other ships or land-based systems. By sending and receiving regular communications about their identity, location and course, vessels can avoid collision and navigate safely, even when they can't see each other.

Since 2004, the International Maritime Organization (IMO) has required AIS transponders to be aboard most vessels. The Safety of Life at Sea (SOLAS) Convention states:

"All ships of 300 gross tonnage and upwards engaged on international voyages and cargo ships of 500 gross tonnage and upwards not engaged on international voyages and passenger ships irrespective of size shall be fitted with an AIS."

HOW AIS WORKS

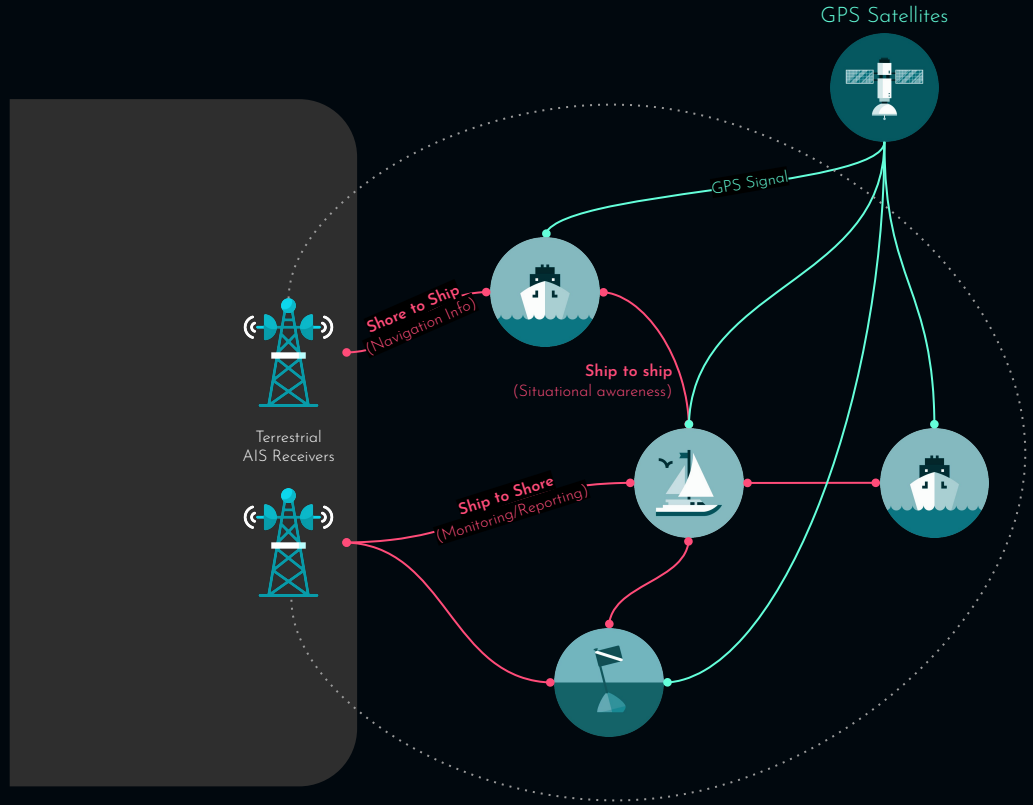
How AIS Works

AIS devices send out information about the ship automatically and regularly, typically every few seconds.

AIS transponders on nearby ships or on land receive these signals. The information is displayed either on radar or on a chart plotter, showing ships' positions and call sign information.

When other ships and maritime traffic services know these key details, they can use them to ensure ships are following a safe course and to prevent collisions. So ship personnel don't need to physically see where other vessels are located in order to avoid them.

AIS combines technologies. It integrates a standardised VHF transponder with a positioning system, such as a GPS receiver, with other electronic navigation sensors, such as a gyrocompass or rate-of-turn indicator.

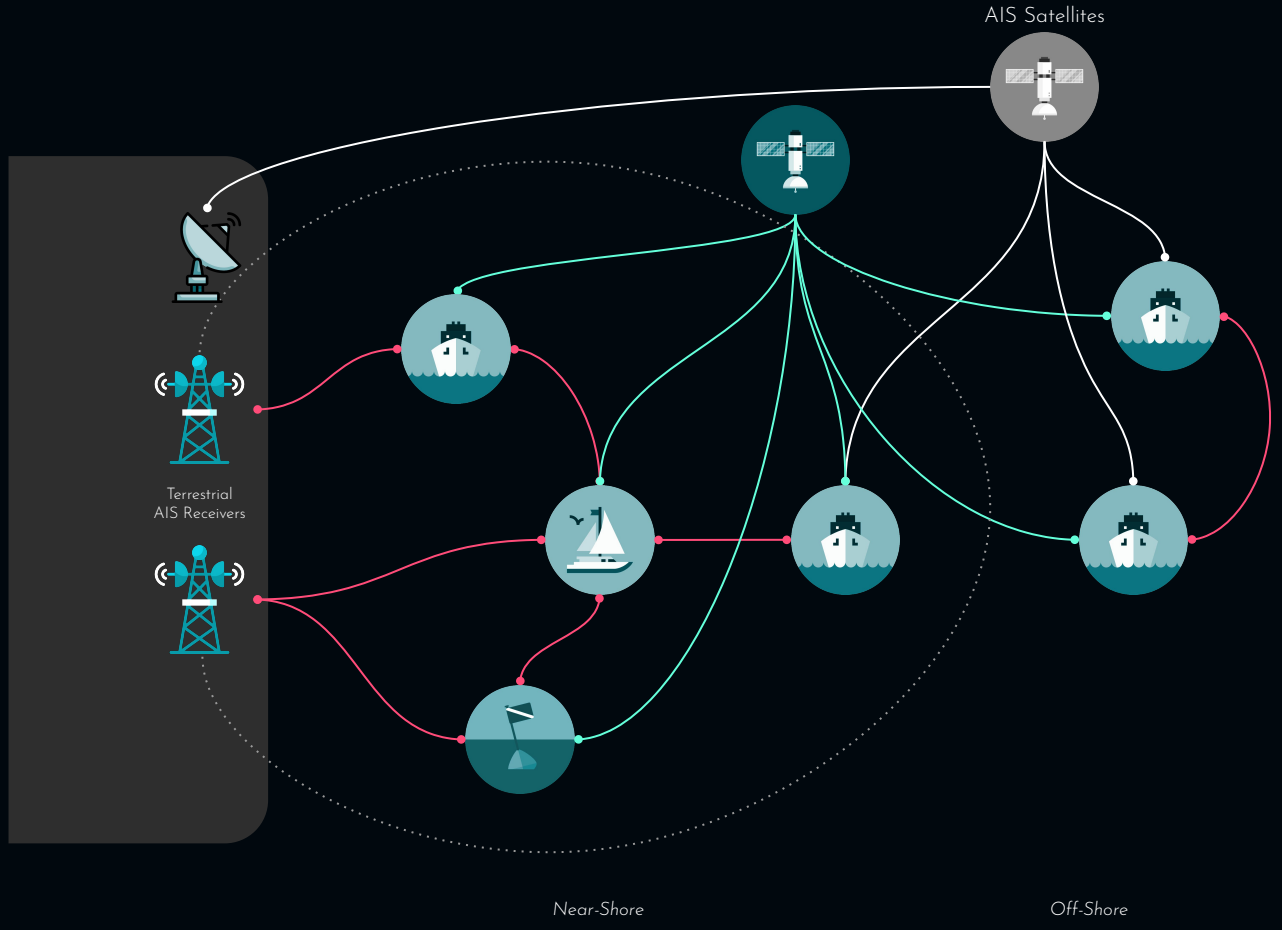


How AIS Works

AIS doesn't have unlimited range. Its signal transmission is limited to approximately 50 nautical miles. This range limitation can prevent maritime authorities from getting a complete picture of maritime traffic outside of their borders and on a bigger scale.

Satellite AIS greatly extends the range of traditional AIS, as signals are sent and received from many kilometers above land and sea, so the barrier of the horizon doesn't limit these signals.

With AIS, devices need to be fairly close together to communicate. S-AIS removes these barriers and can be implemented without additional hardware upgrades.



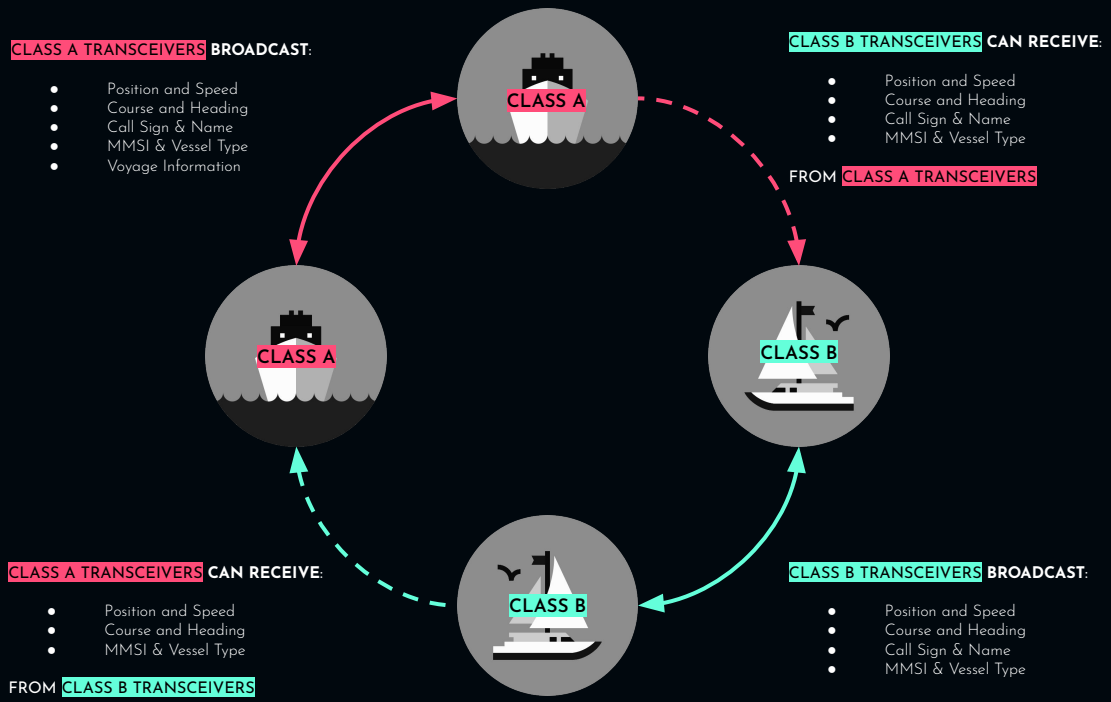
Class A vs Class B AIS Transponders

CLASS A:

Mandated for **all vessels 300 GT** and above engaged on international voyages, **all cargo vessel 500 GT** and above not engaged on international voyages as well as **all passenger ships**

CLASS B:

Provides limited functionality and is intended for non-SOLAS vessels. Primarily used for vessels such as pleasure crafts



How AIS Works

SOTDMA

Self-Organised Time Division Multiple Access

AIS operates on two VHF channels: AIS 1 and AIS 2 (channels 87B and 88B)

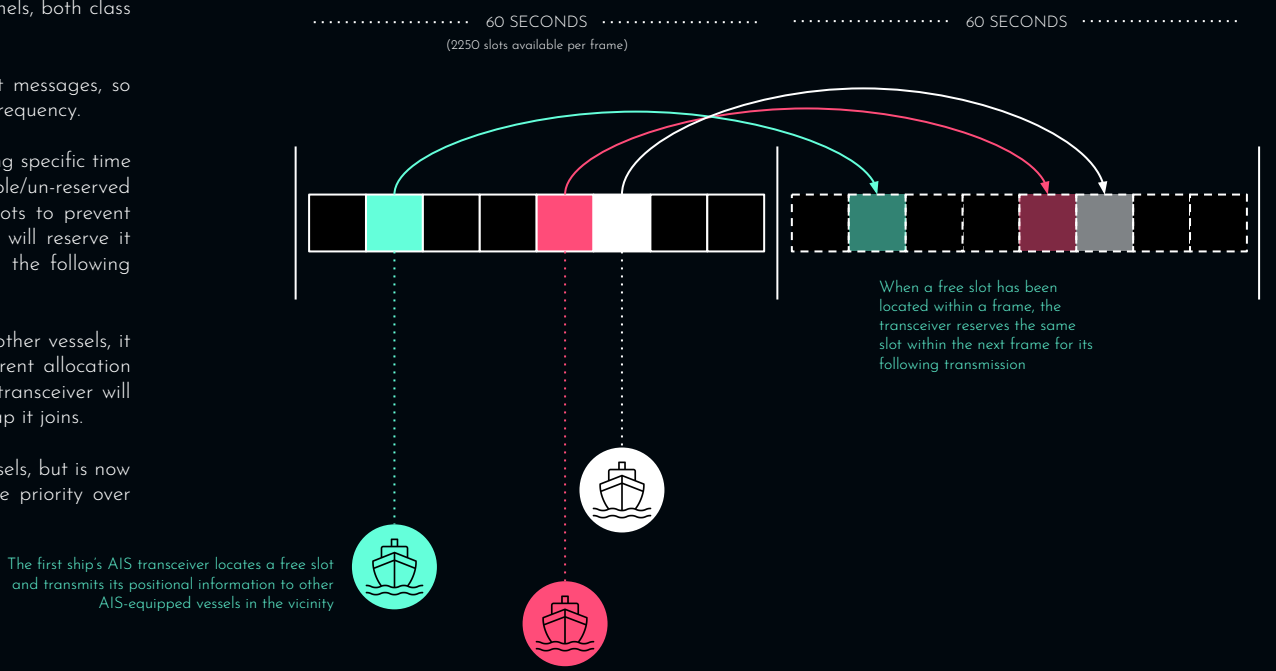
All vessels with AIS transponders share those channels, both class A and B.

SOTDMA is used to manage when ships transmit messages, so they don't talk over each other on the same radio frequency.

Ships take turns transmitting their AIS data by using specific time slots. The AIS transceiver will first scan for available/un-reserved slots in the AIS frame map, avoiding occupied slots to prevent conflicts. Once it finds a free slot, the transceiver will reserve it and transmit. It will also reserve the same slot in the following frame.

As the ship moves into new areas and encounters other vessels, it will also encounter a new AIS slot map with different allocation based on what the new ships have reserved. The transceiver will continue to scan for available slots on each new map it joins.

Originally SOTDMA was only used by Class A vessels, but is now authorised for Class B, although Class A still have priority over the slots



CSTDMA

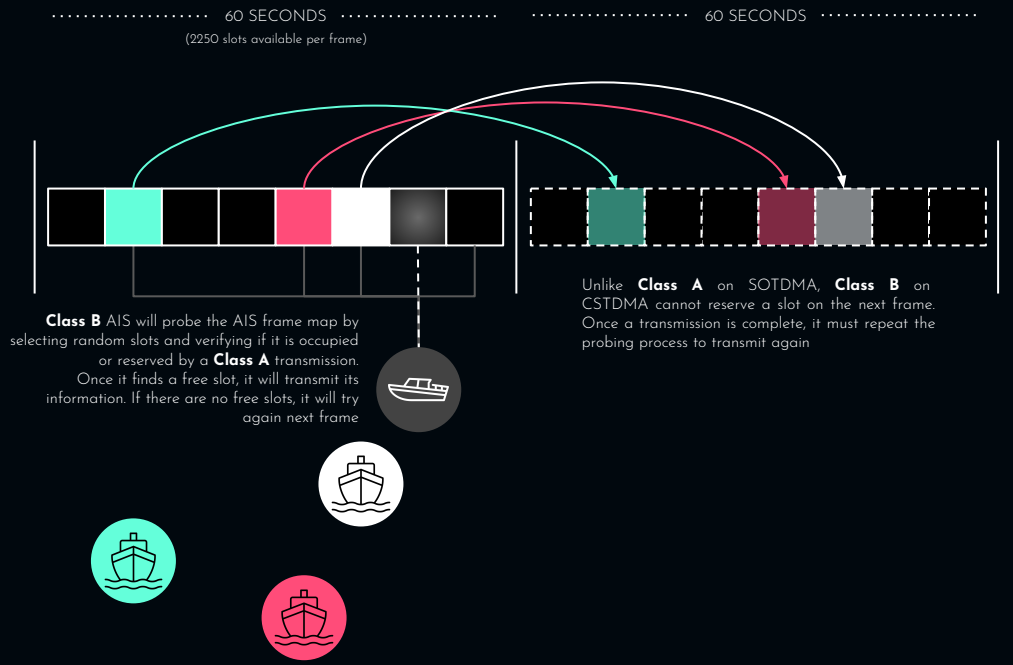
Carrier-Sense Time Division Multiple Access

CSTDMA permits ships with Class B AIS transceivers to exchange AIS information on the same AIS frame map used by Class A devices broadcasting via SOTDMA.

Class B devices continuously monitor the background noise level on AIS radio channels while at the same time selecting and "listening in" on random slots on the AIS Frame Map.

If the randomly selected slot emits a signal that is "louder" than the background noise, the Class B AIS transceiver will assume the slot is taken and will randomly select another slot. Once it finds a slot whose signal strength is close to the background noise, the Class B transceiver will assume that the slot is free and broadcast its AIS data.

The transceiver must repeat this process for every broadcast as CSTDMA does not permit Class B AIS devices to reserve slots on future frames. This ensures that Class A transceivers are always guaranteed priority on the AIS Frame Map in order to maintain safety in navigation.



TERRESTRIAL vs SATELLITE AIS

Terrestrial vs Satellite AIS

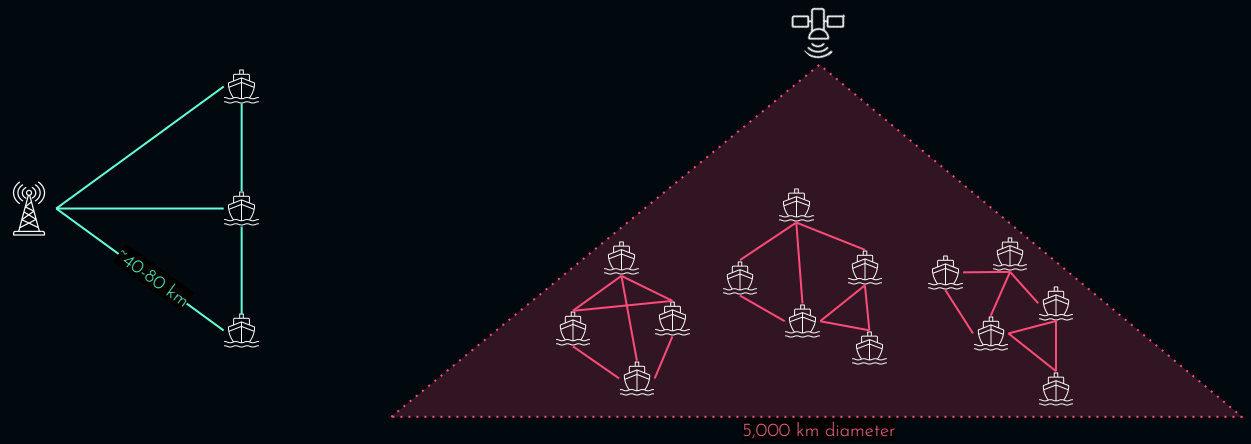
A satellite AIS message and a terrestrial AIS message contain the same core data

They're both receiving the same VHF broadcast from the vessel

But they differ in how, when, and sometimes how accurately that data is received and reported.

FEATURE	TERRESTRIAL AIS	SATELLITE AIS
RANGE	~40-80 km from coast	Global
LATENCY	Real-time or near real-time	Delayed (can be minutes or hours)
UPDATE FREQUENCY	High (multiple reports per minute possible)	Depends on satellite passes
CONGESTION HANDLING	Better (Shorter range, fewer collisions)	Worse (signals may overlap from space)
MESSAGE QUALITY	Usually better (less collisions/data loss)	More likely to suffer from collisions or lower fidelity

Terrestrial vs Satellite AIS



Satellites See *Too Much* at Once

A satellite's AIS receiver can see a very large footprint — up to 5,000+ km in diameter. That means it's trying to pick up signals from thousands of ships simultaneously, all transmitting on just two VHF channels.

Unlike a coastal receiver, which might handle a few dozen vessels in range, satellites can be overwhelmed by signal density.

Weaker AIS signals (especially from Class B transponders) are more likely to be lost entirely in this noise.

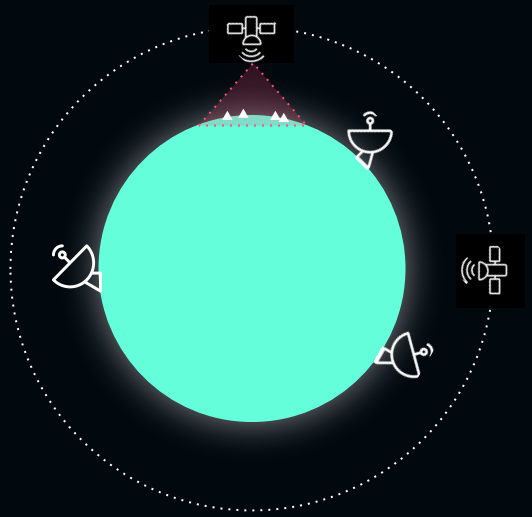
VHF Channel Collisions Get Worse from Orbit

AIS uses a time-division multiple access (TDMA) protocol — ships choose their transmission slot to avoid collision. This works well when vessels are near each other and can coordinate. But from space ships can't "hear" each other because they're too far apart. So they unknowingly transmit at the same time, causing signal collisions.

The satellite receiver often can't decode any of the overlapping signals, leading to lost data.

This occurs in mostly in high traffic areas such as the English Channel, South China Sea, Singapore Strait or Gulf of Mexico

Terrestrial vs Satellite AIS



Satellite Orbits Limit Coverage Frequency

Most AIS satellites are in Low Earth Orbit (LEO) – they move quickly and only have brief windows of time to receive AIS signals from a given region.

This means a satellite might pass over a vessel only a few times per day. You'll only get AIS updates from that vessel when the satellite is overhead – hence the lower frequency of messages.

Satellite Data Transmission Is Not Always Real-Time

Satellites don't always transmit data to Earth immediately. Instead, they store the AIS data onboard and downlink it when they pass over a ground station.

This can introduce latency ranging from a few minutes to several hours, depending on the satellite operator, the location of ground stations and data volume

AIS DATA

CLASS A vs CLASS B

Key AIS Data Fields

CLASS A

DYNAMIC DATA	STATIC DATA	
Automatically transmitted **every 2 to 10 seconds** depending on the vessel's speed and course while underway and **every 3 minutes while anchored**	Entered at the start of each voyage by the subject vessel's crew. Transmitted **every 6 minutes** regardless of the vessel's movement status.	
	VESSEL INFORMATION	VOYAGE-SPECIFIC INFORMATION
Maritime Mobile Service Identity number (MMSI)	Vessel Name	Destination
Latitude & Longitude	Dimensions	ETA
Position Accuracy	Type of Vessel and/or Cargo	Navigation Status
Time of message (UTC)	Call Sign	
Course (COG) and Speed (SOG) Over Ground	IMO Number	
True Heading(requires external source)	Maximum Draught	
Rate of Turn (requires external source)		
Additional | Receiver Autonomous Integrity, Communication state, Assigned Flag Mode, Data Terminal Equipment	**Additional |** Type of Electronic Position Fixing Device, AIS version, Special Maneuver Indicator	**Additional |** Special Maneuver Indicator

NOTE: Vessel flag is derived from the first 3 digits of the MMSI. For example, New Zealand flagged vessels all have a MMSI beginning 512

Key AIS Data Fields

CLASS B

DYNAMIC DATA	STATIC DATA	
Automatically transmitted **every 30 seconds** if vessel's SOG over 2 knots and **every 3 minutes while anchored**	Entered at the start of each voyage by the subject vessel's crew. Transmitted **every 6 minutes** regardless of the vessel's movement status.	
	VESSEL INFORMATION	VOYAGE-SPECIFIC INFORMATION
Maritime Mobile Service Identity number (MMSI)	Vessel Name	Destination
Latitude & Longitude	Dimensions	ETA
Position Accuracy	Type of Vessel and/or Cargo	Navigation Status
Time of message (UTC)	Call Sign	
Course (COG) and Speed (SOG) Over Ground	IMO Number	
True Heading(requires external source)	Maximum Draught	
Rate of Turn (requires external source)		
Additional | Receiver Autonomous Integrity, Communication state, Assigned Flag Mode, Data Terminal Equipment	**Additional |** Type of Electronic Position Fixing Device, AIS version, Special Maneuver Indicator, Class B Band, Class B Display, Class B DSC, Frequency Management, Type of Unit, Unit ID	Additional | Special Maneuver Indicator

NOTE: Vessel flag is derived from the first 3 digits of the MMSI. For example, New Zealand flagged vessels all have a MMSI beginning 512

VESSEL IDENTIFICATION

Vessel identification methods

	NAME	CALL SIGN	MMSI	IMO
FUNCTION	**Basic form of vessel identification**	**Required for radio comms**. It is used when communicating over the ship's radio and is generally associated with a vessel's radio license.	Primarily used to **identify and address radio communication equipment on a vessel**. It is also used in systems like VHF radio, AIS and satellite communication. The first 3 digits are the country code, with the first digit also representing the region A 7 digit MMSI is a base station A 9 digit MMSI is a vessel	**Uniquely identifies ships**. It is a seven-digit number that remains with the vessel throughout its life, regardless of changes in name, ownership, or flag.
ASSIGNMENT	**Assigned by vessel owner**	A call sign is **issued by a country's telecommunication authority, ship registry, or relevant licensing authority**	**Assigned by national authorities** responsible for maritime communications in each country. They are typically obtained by vessel owners or operators.	**Assigned by the International Maritime Organization**, a United Nations agency responsible for regulating shipping. The numbers are assigned to ships over 100 gross tons and certain types of smaller vessels.
PROS / CONS	Easier to remember & communicate A vessel's name is generally not required to be unique Vessel name is not required when reporting on AIS Not included in position messages	A MMSI and call sign are often associated AIS transponder does not require a call sign, so not all vessels with an AIS transponder will have a call sign Intended to be unique, but not guaranteed Call signs can be reused by other vessels Not included in position messages	Ability to ascertain vessel flag from code All vessels with an AIS transponder must have a MMSI Included in position messages A vessel may have multiple MMSI codes as they are device specific, not vessel specific. A vessel's MMSI must change if the vessel re-flags A MMSI can be reused by other vessels	IMO numbers are unique to a vessel and do not change if sold/reflagged Not all vessels require an IMO Not included in position messages

LESS RELIABLE ----------→ MORE RELIABLE

UNDERSTANDING AIS DATA LIMITATIONS

AIS Data Issues

AIS Data was designed to enhance safety of navigation, not for data analysis.

DATA INACCURACY

AIS data is only as accurate as the information provided. Manual entry, onboard sensor errors, and outdated records often lead to incorrect data that undermines analysis.

Static Information Errors

MMSI Jumping

Location Spoofing or Drift

Incorrect Navigation Status

Sensor Errors

Timestamp Misalignment

DATA LOSS

With more than 200,000 AIS users communicating across just two VHF channels, there are numerous gaps in data coverage and transmission failures as well as intentional data loss

Signal Collision

Transmission Gaps

Terrain Attenuation

Capacity of Shore-Based Station

Satellite Latency or Filtering

	Issue	Why it occurs	How to spot it
DATA INACCURACY	Static information Errors	Static info (ship name, type, dimensions, destination) is manually entered by crew and rarely updated.	Look for vessels with inconsistent or missing IMO numbers, strange destinations like "ZZZZZ", or outdated ship type.
	MMSI Jumping	Reuse of MMSIs (e.g. when a ship changes flag), faulty transponders, or intentional identity swapping.	Same vessel track appears under multiple MMSIs or identical MMSIs broadcast from multiple locations.
	Location Spoofing or Drift	GPS signal interference or deliberate spoofing (e.g. to hide illegal activity).	Sudden jumps in position, impossible speeds (>60 knots), or identical coordinates from multiple ships (clones).
	Incorrect Navigation Status	Crews may forget to update AIS status (e.g. still showing "Under Way" when anchored).	Vessel speed is 0 but status says "Under Way," or a ship is docked but claims "Not under command."
	Sensor Errors	Faulty onboard sensors like gyrocompasses or speed logs feed incorrect data to AIS.	Inconsistent heading/course versus track, jittery speed values at low speed.
	Timestamp Misalignment	Onboard systems may not sync time properly or use local time zones.	Time-ordered positions are out of sequence, or timestamps don't align with other vessel data in the same area.
DATA LOSS	Signal Collision	Too many vessels broadcasting on just two VHF channels leads to overlapping messages being dropped.	Dense traffic areas with many ships but inconsistent reporting intervals or missing data points.
	Transmission Gaps	Vessels at anchor or moving slowly transmit less often; or intentionally turn off AIS.	Long time gaps between positions, especially near exclusive economic zone boundaries or conflict zones.
	Terrain Attenuation	Hills, buildings, or ship structures block VHF signals from reaching shore receivers.	Ships near coastlines or ports vanish from tracking temporarily, especially behind terrain.
	Capacity of Shore-Based Station	Limited reception range or overcapacity in high-traffic zones.	Ports with heavy congestion showing intermittent or missing data for some vessels, even when others are fine.
	Satellite Latency or Filtering	Satellite AIS prioritises certain signals (e.g. Class A over Class B) and may delay or drop messages.	Sparse offshore coverage, especially in equatorial or polar regions; class B vessels under-represented.