AIS Overview and Installation Considerations

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About the Author

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AIS Introduction

Automatic Identification System or AIS is a safety tool available to mariners. It makes use of transceivers operating in the marine VHF band to broadcast a host of information from a boat, the most important being a vessel's identity and its real-time position, course and speed. In addition, personal AIS beacons can be attached to lifejackets so that a man-overboard (MOB) search and rescue can be executed quickly. AIS monitors the progress of other vessels —and their AIS monitors you—to reduce the risk of collision. A properly AIS-equipped vessel will have an electronic display which can predict potential collisions. With the vessel name and Marine Mobile Service Identity (MMSI) number available on the AIS, direct voice or Digital Selective Calling (DSC) contact can be made to avoid a collision.

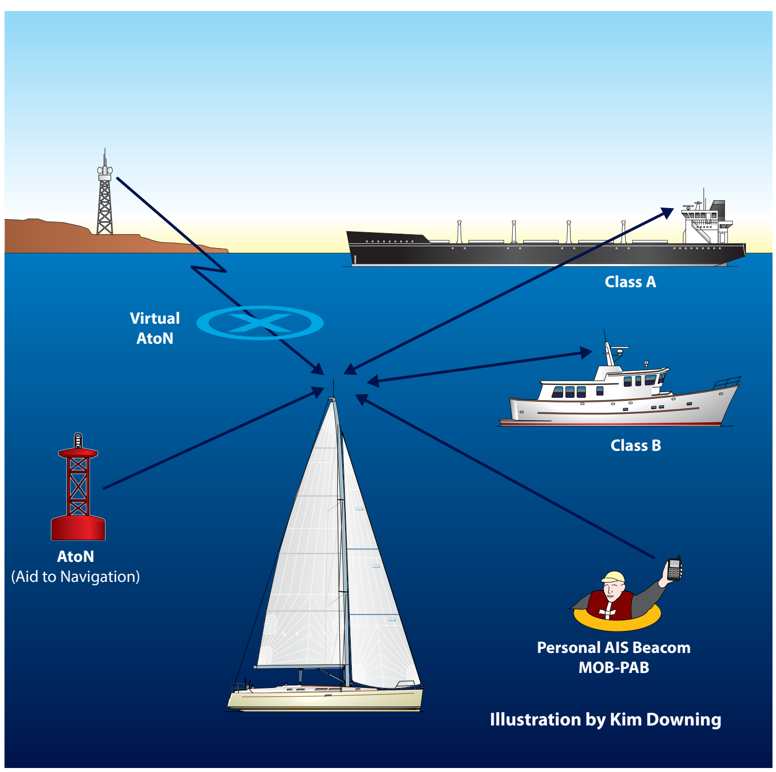

Illustration by Kim Downing

AIS transceivers are required by U.S. and international law on certain vessels, including ships over 300 gross tons on international voyages, certain passenger vessels, commercial vessels over 65 feet, and ships carrying hazardous cargo. It is also frequently required by organizers of offshore racing events. AIS is voluntary on most others, and not all vessels have AIS transceivers. Some boats have receive-only AIS without a transmitter, enabling them to 'see' others though they cannot be 'seen' themselves. In low visibility conditions with lots of AIS targets, it is easy to assume that every boat has AIS but other means, such as radar and listening, should always be used in addition to AIS to prevent collisions.

In summary, AIS is used on ships, barges, and both pleasure and commercial boats to signal a vessel's position, course and speed. It can also be used to send weather data and, every three minutes, mark the location of an aid to navigation (AtoN) such as a buoy. It can even be used to represent a buoy that might not be physically present – a virtual buoy. Each application of AIS is identified by the messages it transmits. Onboard displays such as chart plotters can decode these messages and plot the position of the AIS target with a unique symbol.

To get the most from your AIS installation, several key choices must be made about equipment, cables and antennas. This article addresses the available options.

What You Need to Know

Two classes of AIS are available for use on your boat – Class A and Class B, including a recently approved Class B variation.

Class A is higher power, transmits more frequently, always has a display and keyboard, is usually meant for ships and other commercial vessels, and costs more. Class B is fully interoperable with Class A, works fine with the power it has, transmits position every 30 seconds, is available as a 'black box' without a display, is affordable, and is all that most pleasure boats need. Personal AIS beacons (PABs) are available for life jackets. These battery-operated low-power devices have a limited range, however, because their antenna is short and can be blocked by waves.

All AIS devices have internal Global Positioning System (GPS) and some have internal GPS antennas, but be careful of a below-deck installation on some boats. They also need a VHF antenna. Unless disallowed for your application, both Class A and Class B AIS can share the boat's VHF antenna and cable by using a 'low-loss' splitter. This minimizes the need for cabling and gets the antenna to the top of a mast, where it is more likely to receive signals from a PAB with a half-submerged antenna. If the VHF radio is in use, however, the AIS receiver and, with almost all AIS transceivers, the transmitter as well, are blocked. Early splitters sometimes split the power between AIS and VHF, each getting a portion. Check carefully but today's 'splitter' is really a low-loss radio frequency (RF) switch that delivers all power to either the AIS or VHF and has an amplifier for the received signals.

Alternatively, AIS can have its own dedicated antenna and cable. This allows the VHF radio to be used without interfering with the AIS, and provides an independent installation with the option of swapping cables if something breaks. The problem is where to put the dedicated antenna. It should not share the top of a mast with the VHF (too close; they should be four feet apart) and in any lower spot on a sailboat, such as a spreader, the mast and shrouds will interfere with the signal. Radar arch or pole mounts work but at the expense of AIS range; with both AIS and VHF antennas, height is far more important than power. Mounting a dedicated AIS antenna is easier on a powerboat where antennas can be spread out, but the highest locations can get crowded with equipment.

Getting the AIS 'transmit' signal to the antenna and the 'receive' signal back again requires good cables and connectors. Recommendations such as the Newport Bermuda Race 2016 Safety Requirements allow for either a dedicated antenna or a splitter, and require that coaxial cables to either the VHF antenna or AIS antenna have no more than a 40% power loss. That sounds like a lot of power loss, but with a 60-to-70-foot mast, it is about all you can manage. The tables below show which cable to use; as a rule, if the cable running to the antenna has the diameter of a No. 2 pencil, it is too small.

If you already have AIS installed, there are certain things about the installation that you should check. In addition, with either a new or existing installation several tests will help you determine if everything is working correctly. The System Checkup section below provides further detail and guidance.

Classes of AIS

Class A is generally used on commercial vessels, though its use is permitted on all other vessels including pleasure craft. Unlike a Class B, Class A meets International Maritime Organization (IMO) Safety of Life at Sea (SOLAS) requirements and has certain mandatory features such as a display, keyboard and a Pilot Plug for connection to a pilot's laptop. It is not available as a 'black box' and has higher transmitted power (12.5 watts) than a Class B. In the transmission scheme, it has priority over a Class B. Class A transmits static information including name, MMSI, call sign, dimensions, cargo, destination and ETA every six minutes, and more dynamic data such as position, rate of turn, course and speed at more frequent intervals:

AIS Class A Position Report

Moored <3 knts †	3 minutes
Moored >3 knts †	10 seconds
0 to 14 knots	10 seconds
0 to 14 knots	* 3-1/3 secs
14 to 23 knots	6 seconds
14 to 23 knots	* 2 secs
>23 knots	2 seconds

† Moored or at anchor status set manually by user

* Faster rate when changing course

Class B is available at lower cost with fewer features. It is interoperable with Class A, so that each can receive and process each other's messages. There are two versions of Class B, mostly having to do with priority in sending messages and how frequently messages are sent; the messages are the same.

Class B-CSTDMA (carrier-sense time division multiple access). Carrier sense (CS) means that Class B-CS senses the VHF channel to make sure it is free of traffic and only then transmits. If the channel is busy, it waits and tries again, so it has lower priority than other transmitters. Class B-CS transmits at two watts and sends static information including name and dimensions every six minutes. It sends its MMSI, position, speed and course message less frequently than a Class A:

Class B – CSTDMA Position Report

<2 knots	3 minutes
Otherwise	30 +/- 4 seconds *

* Subject to channel availability

AIS Class B – SOTDMA (self-organizing time division multiple access). Class B–SO was recently approved as an intermediate step between Class A and Class B. Class B–SO is intended for applications that need some of the performance capability of Class A, but not features such as a keyboard and display. It would find use on barges, for example, rather than ships. Class B AIS must be certified as one or the other: If a Class B AIS is not clearly advertised as Class B–SOTDMA, then it is a Class B-CSTDMA."

Class B-SO has the same transmit priority as Class A and participates in the same self-organizing transmission process where it finds an empty transmission slot, announces it and claims it, then uses it for delivering future messages. It has priority over Class B-CS and in addition transmits at five watts of VHF power at a faster rate:

AIS Class B – SOTDMA Position Report

<2 knots	3 minutes
2 to 14 knots	30 seconds
14 to 23 knots	15 seconds *
>23 knots	5 seconds **

* 30 seconds if the channel is busy

** 15 seconds if the channel is busy

All AIS transceivers use both VHF and GPS to function, and AIS technical standards mandate a dedicated GPS receiver. Class A has internal and external receivers - the vessel's primary positioning system as an input for comparison and an internal GPS for backup.

Class B devices require an internal GPS receiver though the antenna element is usually external. A few designs have an internal antenna but this is not a good choice for many applications, especially if the unit is mounted below decks, as aluminum or steel hulls and boats with heavy wooden decks can have trouble acquiring GPS signals. An external antenna should be mounted according to the manufacturer's instructions with a clear view of the sky; antenna height is not usually an issue with a GPS antenna. AIS technical standards do not require a dedicated VHF antenna and a voice VHF antenna can thus be shared by AIS. (It should be noted, however, that certain operational standards such as IMO standards for Class A AIS can and do require a separate dedicated AIS antenna.)

Personal Beacons. Personal beacons are meant to be attached to lifejackets. There is quite a variety of these beacons using different technologies and the nomenclature is not settled, causing some confusion. The earliest were personal locator beacons (PLBs), personal 406 MHz EPIRBs that connect to the Cospas-Sarsat system by satellite; some have internal GPS for improved accuracy and response time. These personal beacons must be registered with NOAA but do not require an MMSI number. Also available is a beacon with an internal GPS that transmits a DSC man-overboard alert. This device requires the same MMSI number as the vessel. In this discussion, we are concerned with the personal AIS beacon or PAB, but sometimes called by other names such as AIS MOB. The PAB does not require an MMSI number to be programmed. Rather the manufacturer provides an MMSI-like identifier. Some PABs, however, also contain a DSC alert feature and that does require the same MMSI number as the vessel's DSC radio to be programmed.

The PAB or AIS MOB is derived from what is officially known as the AIS SART (Search and Rescue Transmitter). An AIS SART is intended to meet the physical and environmental performance standards adopted by IMO for mobile AIS equipment for use in lifeboats, life rafts and man-overboard situations. Besides specifications for battery life, temperature range and submersion depth, it requires an arrangement to elevate the antenna to one meter. It transmits at one watt, and is designed to have a range of five nautical miles from its one-meter-high antenna to a 50-foot (15m) high receiver.

Except for the more demanding environmental requirements and the antenna height, the PAB operates the same way as an AIS SART. It has no AIS receiver and is unaware of what time slots are in use; instead it announces the time slot it will use and counts on other AIS units to keep out of the way. Rather than a single message transmitted periodically, the PAB utilizes a once-per-minute burst transmission of eight messages over a 14-second interval to increase the probability of reception in various sea states.

Offshore Racing Safety Equipment Requirements

This is a moving target. Each organization running offshore race events updates its safety equipment requirements periodically, so be certain to check the latest requirements for the race in which you will be involved. Many of the major organizations that sponsor offshore races require the installation and use of AIS. However, except for transatlantic and other 'extreme' races which require a Class A such as some World Sailing events, either Class A or Class B AIS may be fitted. The Newport Bermuda Race 2016 Safety Requirements, based on the US Sailing Safety Equipment Requirements, are similar to those of other organizations:

- Section 3.8.1 - Installed VHF Radio and Antenna: A yacht shall have a permanently installed 25-watt VHF radio connected to a masthead antenna by a co-axial feeder cable with no more than a 40% power loss. All permanently installed VHF radios shall have DSC capability, have an antenna of at least 15" (381 mm) in length, be connected to or have an internal GPS, and have the assigned MMSI number (unique to the yacht) programmed into the VHF.

- Section 3.9 - AIS: All yachts shall have an AIS Transponder, sharing a masthead VHF antenna via a low loss AIS antenna splitter. An acceptable alternative is a dedicated AIS antenna that is a minimum of 15" (0.381 m), mounted with its base at least 3 meters above the water, and fed with coax that has a maximum 40% power loss.

Class A or Class B AIS?

Unless you are participating in an event that requires the installation of Class A AIS you can use either one, including the new Class B – SOTDMA as it becomes available. All classes of AIS are fully interoperable and can receive and process each other's messages. In practical terms for most boats, Class B – CSTDMA works well and provides for the reception of AIS targets from larger and faster vessels as well as safety messages, with the same range and reliability as the more expensive options. Since range is mostly dependent on antenna height and quality, even the lower power level of Class B's two watts will make your vessel visible to others at a useful range of several miles, with an update rate sufficient for you to avoid a collision. Although Class A and Class B-SO have priority over Class B-CS when channels are crowded, it would take several hundred large and fast vessels operating in the area to have an impact on performance.

But there is no question that Class A AIS has higher power, greater range, more ability to overcome any radio noise onboard, and a faster update rate. A sailboat traveling at six knots will move about 300 feet between Class B-CS 30-second updates, while a vessel traveling at 18 knots will move 900 feet – but only 185 feet with Class A six-second updates. The positions will of course change even more if any messages are missed.

While the most useful AIS target presentation is the chart plotter, all Class A units have at least a minimum display capability. It is optional on both versions of Class B AIS, a valuable feature if the chart plotter fails. An alternative display backup is seen in the newer models of VHF radio. These include an AIS receive-only function with a small display; it is also possible to switch received AIS information from the VHF to the chart plotter in the event of failure of the primary AIS.

AIS (and VHF) Antenna Installation Choices

For message reliability, AIS transmissions alternate between two VHF frequencies that are at the high end of the marine VHF band. In fact, these frequencies were once the marine VHF voice channels 87B (161.975 MHz) and 88B (162.025 MHz), the second parts of two duplex voice channels. These channels are now dedicated worldwide to AIS operations. As such, they make use of the same type of connectors, cables and antenna that voice VHF installations use.

There are two common AIS antenna configurations in use:

1. An AIS transceiver equipped with its own coaxial cable, leading to a dedicated AIS antenna located at least three meters above the water and at least four feet from another VHF antenna or conductive material. For mast-mounted antennas, unless the space at the masthead is very large, the two antennas must not be co-located at the masthead.
2. An AIS transceiver and a VHF radio connected to a low-loss RF switching device, commonly called a 'splitter.' The output of the RF switch connects to the existing VHF cable and antenna.

Except when required by regulations that specify a dedicated antenna, Class A and Class B vessels are free to use either configuration. There are advantages and disadvantages to both.

A Little Math. Before getting into choices of antenna location and coaxial cable, it might be helpful to understand some of the basics of VHF radio. In a radio system, signal power loss and gain are measured in decibels or dB, named in honor of Alexander Graham Bell. Decibels come from the early days of the telephone industry and are used to represent the percentage of power lost or gained. The formula uses a logarithmic function which represents percentages; because logarithms compress the scale of numbers, it is useful when looking at power losses along miles of telephone wire, or miles of radio coverage. A few sample values are all we need:

dB = 10log (P_{OUT}/P_{IN})	% Power Loss / Gain (approx)
0.2 dB	5 %
0.5 dB	10 %
1 dB	20 %
2 dB	37 %
2.2 dB	40 %
3 dB	50 %
6 dB	75 %
9 dB	87 %

Once the VHF signal leaves the antenna, it starts spreading out and the energy is diluted over an imaginary surface that grows as the square of the distance. Each time the distance doubles, the area the signal must cover increases by four and the power then drops to one quarter of its previous value or a 75% loss (six dB). Other losses to the signal occur as it travels over seawater between antennas, weakening the signal even more. It is complicated, but there may be an additional loss of between three and six dB for each doubling of distance. Thus, the VHF signal power available at the receiver can drop 87% (nine dB) or more each time the distance doubles.

Because of its high frequency, VHF is a line of sight system and that means that for all practical purposes, the signal is not very useful if the two antennas cannot 'see' each other. There is a little bending, but the line of sight of radio signals on a round earth is determined by the height of the two antennas. It takes a lot of extra power to get beyond this:

Range (nautical miles) = 1.225 x (√h1 + √h2) (h = antenna height in feet)

MOB (antenna at sea level) to 9.8-foot (3m) above water antenna: Range = 3.8 NM

MOB (antenna at sea level) to 50-foot (15m) above water antenna: Range = 8.7 NM

More than doubling the range with antenna height is a big deal – to accomplish the same thing without increasing antenna height could take an eightfold increase in power, if even possible.

Radio Line of Sight in Nautical Miles Between Two Antennas of Heights h1 and h2 in Feet

		h1									
		0*	10	12	15	20	30	40	60	80	100
h2	0*	0	3.9	4.2	4.7	5.5	6.7	7.7	9.5	11.0	12.2
	10	3.9	7.7	8.1	8.6	9.4	10.6	11.6	13.4	14.8	16.1
	12	4.2	8.1	8.5	9.0	9.7	11.0	12.0	13.7	15.2	16.5
	15	4.7	8.6	9.0	9.5	10.2	11.4	12.5	14.2	15.7	17.0
	20	5.5	9.4	9.7	10.2	11.0	12.2	13.2	15.0	16.4	17.7
	30	6.7	10.6	11.0	11.4	12.2	13.4	14.5	16.2	17.7	19.0
	40	7.7	11.6	12	12.5	13.2	14.5	15.5	17.2	18.7	20.0
	60	9.5	13.4	13.7	14.2	15	16.2	17.2	19.0	20.4	21.7
	80	11.0	14.8	15.2	15.7	16.4	17.7	18.7	20.4	21.9	23.2
	100	12.2	16.1	16.5	17.0	17.7	19.0	20.0	21.7	23.2	24.5

***Antenna at sea level will have less than calculated range due to sea state.**

VHF Cable Selection. No matter the configuration, it is sensible to get as much power as possible to the antenna. It takes some effort to get even one-half of the available VHF power to the antenna on a sailboat; a properly installed 25-watt VHF radio will provide about 12.5 watts to the antenna. On a powerboat, cable runs are often shorter and higher quality, and heavier cable can be used. This can make up to 90% more power available to the antenna, thus helping to overcome the lack of antenna height.

Whether considering a voice VHF antenna, an AIS antenna, or an installation using an RF switch/splitter with a common antenna, the same approach applies. The total loss will depend on the type of coaxial cable and its length, the number of connections in the cable, and, if used, any losses in the RF switch/splitter. This loss applies to the signal between the transmitter and the antenna, and happens again on the way back from the antenna to the receiver.

Many boats have several connectors in the coaxial feed from the radio to the antenna: one connector at the radio, two plus a barrel connector at the foot of the mast and another one at the antenna. These connections are not perfect and have a small amount of reflection and insertion loss. It is hard to get a handle on this, but some testing at marine band frequencies shows a loss of less than 0.1dB for each connection. For an installation with a connection at the base of the mast, the total loss is possibly 0.5 dB.

Cable Type	Dia inch	Bend Radius Inch	Wght lbs/ foot		Total Cable Lgth feet	Loss dB/ foot	Total Loss dB
RG-58	0.20	2.0	0.029		37	0.059	2.2
RG-8X	0.24	2.4	0.04		57	0.047	2.2
RG-8/U	0.41	4.5	0.10		88	0.025	2.2
RG-213	0.41	5.0	0.10		88	0.025	2.2
LMR-300	0.30	0.9	0.055		92	0.024	2.2
LMR-400	0.41	1.0	0.068		147	0.015	2.2
LMR500	0.50	1.25	0.099		169	0.013	2.2
LMR-600	0.59	1.5	0.131		220	0.010	2.2
LMR900	0.87	3.0	0.269		314	0.007	2.2

While powerboats should use cable with the lowest loss possible to compensate for lower antenna heights, the offshore equipment requirements from the various sailing organizations recommend an installation with a cable loss of less than 2.2 dB (40%). The NMEA Installation Standard recommends an installation with a cable and connector loss of less than three dB (50%). The table above provides the characteristics for several coaxial cable types and the maximum cable length allowed for each to stay below 40% cable loss. Multiply the total cable length for your installation by the Loss (dB/foot) value to determine an acceptable coaxial cable type.

AIS/VHF Splitter Losses. If a splitter is used with a single VHF antenna, additional losses should be considered. Strictly speaking, in radio terminology a signal splitter is a passive device that splits power between two channels – neither channel getting full power. To be clear - that is not what you want to choose for your installation. While stuck with the 'splitter' misnomer, what the AIS application requires is a low-loss RF switch that connects the VHF or the AIS transmitter to the antenna when in transmit mode, isolating the other receiver. When in receive mode and not transmitting, the antenna is connected to both the AIS and VHF receivers and the 'splitter' should have sufficient gain (using an amplifier) to overcome splitter loss.

It is important to review the specifications of the 'splitter' to be installed. Devices with a low-loss switch do not have zero loss, but generally are one dB or less. That one dB can be taken into account when selecting the cable and connectors - the goal being to keep the total loss at three dB or less for a sailboat installation, and ideally lower than that for a powerboat with its lower antenna. On the receiver side, a good splitter will either advertise that it has an amplifier or will specifically state that it is zero loss in AIS and VHF receive mode. A table in the System Checkup section at the end of this article lists the characteristics of some of the known splitters.

In summary, a practical low-loss splitter will always be slightly degraded in performance compared to a dedicated AIS antenna. It will lose up to one dB (10-20%) transmit power and even though it has an amplifier to make up for receiver loss, the amplifier is located with all the other electronic equipment on board rather than at the top of the mast. It can thus amplify local noise, reducing the receiver signal-to-noise ratio to an extent. However, amplifiers and filters specifically designed for this environment can reduce this local noise and minimize its effect.

Total Loss

Total Loss <3dB = Cable Loss + Connector Loss + Splitter Loss

As an example, consider a Beneteau 45 with a 68-foot mast and 20 feet of coaxial cable from the nav station to the base of the mast with connectors before the mast step:

RG-8/U cable: Total Loss = 2.2dB (cable) + 0.5dB (connectors) + 1dB (splitter if used) = 3.7dB

A better choice would be:

LMR-400 cable: Total Loss = 1.32dB (cable 88x0.014) + 0.5dB + 1dB = 2.82dB

LMR-400 is the same physical size as RG-8/U and a little lighter. It is readily available at essentially the same cost as RG-8/U, but maybe not at the local blue-box store.

Operational Considerations

The goal of the above sections is to get as much out of the AIS/VHF antenna system as possible. But there are other things to consider when deciding on a dedicated AIS antenna versus the installation of a splitter. Some of the pluses and minuses are listed below. It is important to know a couple of things:

1. When a splitter is installed, the use of the VHF radio to make calls will block AIS transmit and receive functions for most splitters for the duration of the call. AIS message traffic, transmitted or received, will not resume until the next scheduled update – up to 2 to 30 seconds (three minutes for nearly stationary vessels) and up to 46 seconds in a MOB situation. This loss of AIS allows changes in your course and position to go undetected by other vessels and could hamper emergency efforts, including MOB recovery. It is therefore recommended that, when critical things are happening and when AIS should not be disrupted, a handheld VHF be used. AIS transmissions will not interfere with voice VHF reception, however.

2. The use of a splitter allows both AIS and VHF signals to come to/from the highest point on the boat - the top of the mast on a sailboat - giving the greatest range possible under all conditions. This could be critically important in a MOB situation, when a personal AIS beacon antenna is barely out of the water and with significant wave action present. When a person is in the water with a PAB, the antenna may be at zero height or even underwater when the sea state is high, and the reception range is short. Actual AIS SART testing (IEC Standard 61097-14) from a survival suit in the water with a 0.2m antenna height to a 50-foot (15m) high antenna provided a range of 4.2 nautical miles, which is less than one-half of the calculated line of sight distance of 9.6 NM [1]. The range from a personal AIS beacon to a 10-foot (3m) high AIS receiving antenna is unknown, but could be as short as 2 +/- miles based on this testing.

Antenna Choices 'Pluses' and 'Minuses'

Dedicated AIS Antenna	Splitter Configuration
+ AIS and VHF voice can transmit at the same time and AIS messages can be received while making a voice call (although there is still a chance that a locally strong VHF transmission will block weak AIS signals, such as one from a MOB using a personal AIS beacon)	+ Places the AIS antenna at the highest point on the boat. In a MOB situation, this increases the theoretical line-of-sight range over an AIS antenna at 10 feet (3m) from about 4 NM to 10 NM for a 70-foot mast, increasing the search area six or seven times
+ Provides a totally redundant antenna installation with the most direct connection possible between the AIS and VHF to their respective antennas, minimizing the chances of one failure taking out both AIS and VHF	+ Allows for an AIS installation on boats where there is no practical way to install an additional antenna
+ Provides a ready spare antenna for either system with the swap of a couple of coaxial cables	+ Reduces windage and clutter of a second antenna installation
+ The AIS antenna can be specifically tuned to 162 MHz, a slight improvement	+ Makes installation easier. The VHF antenna should be designed with broad enough bandwidth for both AIS and VHF operation
- Unless there is a second mast or some other way of getting the AIS antenna high, the AIS antenna may not be at the highest point on the boat, reducing range and search area, especially important in a MOB situation	- Voice VHF transmissions will block AIS transmitting [2] and receiving for the length of the voice call. AIS will resume at the next scheduled update in up to 2 to 30 seconds (three minutes for nearly stationary vessels) and up to 46 seconds in a MOB situation
- Requires the installation of a second coaxial cable and antenna	- Introduces an active device, the RF switch, in the path of both VHF and AIS. That and any other single failure can take out both AIS and VHF
- An antenna mounted below the masthead and among other boat structures can have an inconsistent pattern due to the conductive mast and rigging, possibly reducing range	- Risk that inferior 'splitter' will be used

[1] Testing using an AIS SART on a 1-meter pole showed ranges of 8.1 to 9.5 NM, while a 0.5-meter pole provided 6.8 and 8.4 NM range, more like line of sight calculations.

[2] The Garmin AIS-600 Class B transceiver with internal splitter will continue to transmit AIS while the VHF is transmitting.

Summary

The final choice should be made with the above pros and cons in mind. There is little doubt that a dedicated AIS antenna is the most robust and reliable solution, providing redundancy and, usually, full operation of AIS and VHF simultaneously. It lends itself particularly to boats where there is a good place for the extra antenna such as some powerboats, ketch, yawl and schooner rigs or very large sailboats where a spreader can be used if it is far enough from an aluminum mast and shrouds; this precludes a dedicated antenna on many smaller boats. If it is not possible to locate the AIS antenna sufficiently high or separated from the VHF antenna, then the use of an RF switch/splitter is a viable solution, so long as sufficient attention is paid to the choice of splitters and cable type. The installation of a dedicated antenna may be a little more difficult but the parts cost will be similar.

System Checkup

If you already have AIS installed or are planning on installing AIS using existing coaxial cables and antennas, here are a few things to check:

Coax Cable Type and Size. If possible, find the printed cable type on the cable (e.g., RG-213/U, RG-8X), locate the Loss (dB/foot) in the table above or search the cable type online, and compare the total cable loss for the estimated total length against the maximum loss of 2.2 dB recommended for sailboats. A powerboat installation can often achieve even less loss and can readily deliver more power to the antenna by using a heavier cable than the one sometimes provided by the antenna manufacturer.

As a rule, for most sailboats with a 45-foot or taller mast, if the cable markings cannot be found and the existing cable diameter is close to a quarter-inch instead of nearly half-inch, then the cable is too small.

Cable and Antenna Condition. Cables, connectors, and antennas do fail so with any installation, especially an older one or one with connectors in or near the bilge, it is important to check things. A VHF radio might work fairly well with a defective cable/antenna so a problem can be hard to detect, whereas AIS is like digital TV versus older analog broadcast TV: you don't just get a poor picture, you don't get one at all. There are likely many VHF installations that appear to work but perhaps receive only two weather channels instead of four, and the transmit range is shorter than it could be. A visual inspection is a good start but not enough. Check the cable for obvious cuts, crushing and splices, and make sure that the connector body is solid on the cable and does not rotate. Perform a continuity test with the antenna removed because some antennas are open-circuit when tested with an ohm-meter and others look like short circuits. Test the cable first for open-circuit, then jumper one end and test for short-circuit at the other end. Shield or center-pin connections on connectors are often the first to fail, but often the shield will 'rot' and turn to brownish powder several feet up the cable when salt-laden moisture wicks; this cannot be seen and may not show up in the continuity test.

Some AIS transceivers and some splitters have built-in test functions, with at least an indicator light, to detect problems caused by defective cables or antennas so performance can be monitored. Otherwise the best move after a visual check is to purchase a VHF meter. Alternatively, you can borrow one or have a technician run the test, but suitable meters only cost about fifty to a hundred dollars and can be used periodically. Shakespeare ART-3 works well and can also assess receiver sensitivity with a test signal. Other models are readily available. It is best to insert the meter in the antenna cable at the radio and use a 36-inch coax jumper cable (half-wave) to insert the meter. As a second choice, use the meter at the mast step connectors. The meter measures output power. More importantly, it measures the reflected power, though 'rejected' power is more descriptive. A faulty cable or antenna will reject a portion of the power sent to it and reflect it back to the radio. If testing a dedicated AIS antenna, you will need to use a VHF radio - a handheld will work - with the right connector adapters as a signal source. The meter instructions will describe the acceptable results.

If performance is suspect, or if using an old cable that may have increased loss with age and moisture absorption and may not have high reflected power, it may be worth having a technician measure the actual loss of the cable with the antenna removed. You may find it simpler to replace the cable if there are doubts.

Antenna. When reviewing an antenna installation, carefully consider its height and location. Higher is better, and it should be at least three meters above the water. AIS, like VHF, will work on a low rail or stern deck mount, but its range will be limited to possibly only five to ten miles to other boats and maybe less than two miles to a person in the water with a personal AIS beacon – maybe not a problem if the MOB just occurred but if it happens unnoticed it could be a different story.

The antenna should be properly designed. If dealing with an antenna company, tell them it is to be uni-directional with vertical polarization and a gain of at least 2.15 dBi (the antenna's gain over a theoretical isotropic antenna) in the direction of the horizon. The whip portion should be in the range of 15 inches (quarter-wave) to 36 inches (half-wave) for sailboats. Avoid the so-called 'rubber-ducky' antennas used on handhelds – they too will 'work' but their transmit and receive signal is five dB or about two-thirds less than the other antennas. Powerboats should follow the guidelines for selecting a VHF antenna. Larger powerboats with less roll and pitch often use a longer antenna, six dB gain or more with lengths exceeding eight feet. The longer antenna will focus the AIS/VHF energy more toward the horizon and provide a bit more 'gain' in that direction. On the other hand, this would be a disadvantage for a boat that heels because the narrow beam is instead directed into the water and up to the sky.

VHF antennas are designed to be more responsive at a particular frequency and slightly less so above and below that point. When using a dedicated AIS antenna, choose one specifically tuned to the AIS center frequency of 162 MHz rather than a standard VHF antenna tuned to the main portion of the marine VHF band (156 – 157 MHz). When using a splitter, it is recommended that a special AIS/VHF antenna be selected. An antenna with a broader bandwidth than a standard VHF antenna and tuned to a frequency between Channel 16 (156.8 MHZ) and AIS (162 MHz) will perform better for both AIS and VHF.

The AIS antenna should be mounted at least four feet horizontally from conductive objects such as masts, four feet from VHF antennas, three feet from GPS and SSB antennas, two feet from radar antennas and as much as six feet from a satellite terminal. Except for large boats, this will usually preclude masthead mounting of a dedicated AIS antenna due to the close proximity to the main VHF antenna, and will preclude spreader mounting on sailboats because of the close distance to the mast or shrouds, particularly with respect to the tip of the antenna.

'Splitter' Installation. With the brand and model number of the splitter in hand, go to the manufacturer to determine some critical specifications:

- AIS and VHF loss when transmitting. Don't believe 'zero'; look for one dB or less.
- AIS and VHF loss when receiving. You can believe 'zero' if the manufacturer has included an amplifier in the design to boost the signal before splitting it.
- An indicator for normal antenna operation. Some splitters have this and if not, most AIS transceivers have a diagnostic display which is at least accessible with a tablet, laptop or Wi-Fi connection.

It may be necessary to make a few calls or review operator manuals. Specifications available on some websites can be incomplete or vague, using terms such as 'minimal insertion loss.' The table below provides the characteristics of some splitters but the list is not comprehensive. In particular, it may not include some older, discontinued models currently installed on some boats. It does include several splitters intended strictly for AIS receivers which should not be used with a transceiver. They are listed here because they are called splitters; their model numbers should be checked. This is not an endorsement of any brand or model. The specifications come from the manufacturers and have not been verified:

[See full page chart on page 9]

Final Check. For new or existing installations, it is important to check that the AIS function is not being interfered with by other equipment on the boat. AIS involves the reception of sometimes weak radio signals which can be degraded by radio frequency interference produced by some electrical and electronic devices. Without test equipment, it will take some patience and trial and error to determine if a problem exists.

It is recommended that the AIS system be operated first with all unrelated equipment turned off – engine, alternator, inverters, radar, sailing instruments, wind instruments, computers, GPS, refrigeration, etc. as well as light fixtures that are fluorescent or LED, especially navigation and masthead lights. Using a tablet, laptop or the AIS screen locate the diagnostics display provided by the AIS and monitor the Radio Signal Strength Indication (RSSI) values for the two AIS frequencies while turning on all equipment. Give the values a minute or so to stabilize and look for changes in the RSSI readout to identify equipment that could be interfering with AIS reception. If the RSSI display is not available then observe AIS targets on the display screen, especially weaker, more distant Class B targets that are underway, while turning equipment on. Look for targets that disappear after a few minutes, but note that it will take time before the system drops a target.

If a significant problem is noticed, then it is necessary to track down the offending equipment by systematically turning things off.

Testing. Testing of the installation can be performed with the help of another AIS-equipped boat. Most boat owners are more than willing to confirm that they are receiving your signal and gain knowledge about their own visibility. With Class B AIS when underway at different distances, position updates should occur every 30 seconds.

An alternative is to access Marinetraffic.com using a downloaded smartphone app which costs around six dollars. AIS-receiving stations in your area and their antenna heights are displayed on the map under the 'Ports and Other Layers' setting. While not real-time enough to see every report, your AIS performance may be checked at various distances from the receiver station.

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Editorial assistance by CCA member Zdenka Seiner Griswold.

Layout by CCA member Doug Bruce.

The author and the CCA have prepared this article with care and believe it to be accurate. However, the reader is cautioned to determine the best installation for his or her boat.

Brand & Model	AIS Tx Loss	VHF Tx Loss	AIS Rx	VHF Rx	Notes
AMEC CUBO-161	-2 dB	-2.5 dB	0 dB	0 dB	Replaced by CUBO-162
AMEC CUBO-162	<1 dB	<1 dB	0 dB	0 dB	Built-in test function
B&G NSPL-400	<1 dB	<1 dB	0 dB	0 dB	Part of Navico Group
Banten 260	no	spec.	found		Claims use with transceiver
COMAR AST200	-0.8 dB	-0.8 dB	-4 dB	-4 dB	
COMAR ASR100	-	-	-	-	Receive only
Digital Yacht SPL250	<1 dB	<1 dB	<4 dB	<4 dB	Replaced by SPL2000
Digital Yacht SPL1500	<1 dB	<1 dB	0 dB	0 dB	
Digital Yacht SPL2000	<1 dB	<1 dB	0 dB	0 dB	
em-trak AIS S100	<1 dB	<1 dB	0 dB	0 dB	
Garmin AIS 600	no	spec.	found		Class B transceiver with internal splitter, built-in test
Glomex RA201	-	-	-	-	Receive only
GME AIS S120	<1 dB	<1 dB	0 dB	0 dB	
Hummingbird ASP-1	<1 dB	<1 dB	0 dB	0 dB	
KMJ SPL100	-	-	-	-	Receive only
Lowrance NSPL-400	<1 dB	<1 dB	0 dB	0 dB	Part of Navico Group
Navico NSPL-400	<1 dB	<1 dB	0 dB	0 dB	Part of Navico Group
OceanSat AIS-VHF Splitter	<1 dB	<1 dB	0 dB	0 dB	
Plastimo AdvanSea SPLIT-110	<1 dB	<1 dB	0 dB	0 dB	
Raymarine AIS100	<1 dB	<1 dB	0 dB	0 dB	
Simrad NSPL-400	<1 dB	<1 dB	0 dB	0 dB	Part of Navico Group
SiTex MDA-3 Metadata	<1 dB	<1 dB	0 dB	0 dB	
Smart Radio VHF-AIS Ant. Splitter	-	-	-	-	Receive only
SRT Iris	<1 dB	<1 dB	0 dB	0 dB	Class B SOTDMA with internal splitter
SRT Neon AIS Antenna Splitter	<1 dB	<1 dB	0 dB	0 dB	
True Heading AIS CTRX Graphine+	<0.5 dB	<0.5 dB	0 dB	0 dB	Class B transceiver with internal splitter, built-in test
True Heading AIS CTRX Carbon+	<0.5 dB	<0.5 dB	0 dB	0 dB	Class B transceiver with internal splitter, built-in test
True Heading Antenna Splitter	-	-	-	-	Receive only
Vesper SP160	-1 dB	-1 dB	+12 dB	-1.5 dB	Built-in test function
Watcheye S AIS Splitter	<1 dB	<1 dB	0 dB	0 dB	
Weather Dock EasySplit A027	<1 dB	<1 dB	<4 dB	<4 dB	Discontinued during 2017
Weather Dock EasyTRX2 S-IS	-1 dB	-1 dB	0 dB	0 dB	Class B transceiver with internal splitter, built-in test
Weather Dock EasySplit A026	-	-	-	-	Receive only

About the Author

Frank Cassidy is a member of The Cruising Club of America (CCA) and prepared this paper for the CCA's Safety & Seamanship Committee. He has a Bachelor of Science degree in Electrical Engineering and a Master of Science in Applied Physics; his entire career has been in marine electronics and includes the development of Loran-C transmitters and receivers, instruments for both power and sail, and vessel traffic-control systems in the Suez and Panama Canals utilizing early AIS-like tracking systems. He was the Engineering Vice President at Datamarine International, Chairman of the NMEA Standards Committee, and led the development of the NMEA 2000 Network Standard for the NMEA.