



## **Fitting Out a New Cruising Boat – Things to Consider**

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## ***Introduction***

The main thing to consider when setting up a cruising boat is what you intend to do with it. A boat used mainly for weekend cruises needs far simpler equipment aboard than one that is to be used for extended live aboard cruising.

A boat that is over specified:

- costs more to set up than it should
- is more complex to operate for both the owner and anyone else who needs to drive it
- represents a greater maintenance commitment
- may be heavier than necessary – particularly a sailing catamaran

A boat that is under specified:

- will not perform to the owners expectations
- will not be as easy to navigate as you would like
- may not be safe or comfortable in the event of a fault
- may suffer from flat batteries, which is a nuisance and will significantly reduce their service life
- might not be as comfortable to live on as the first mate probably expects

## ***Navigation***

### **What you get**

The boat will probably come equipped with a basic good quality GPS. It will give a position to within about ten metres anywhere in the world. The difficulty is that the position is displayed as a latitude and longitude, which must then be plotted onto a chart.

### **What you need to know**

The basics of boat navigation are to be able to mark your position on a chart of the local area. This means you need your current latitude and longitude, an appropriate chart and the knowledge to accurately transfer the information from the GPS to the chart.

In addition you need to be able to plan your journey and plot your intended course via waypoints onto the chart. Once the course has been plotted you need to be able to convert the heading read from the chart to a compass heading to steer, adjusting for the earths magnetic variation. These two headings are always different and you need to be able to convert from one to the other wherever you are.

If you do not clearly understand this, go and do a coastal navigation course.

The significant risk with GPS navigation is that it relies on electronic equipment. You therefore need to consider the following risks:

- You could lose electrical power and therefore the GPS
- The GPS itself could fail
- Since the GPS system belongs to the US military, they could degrade or turn off the signal in a war situation. (This is unlikely, but should not be overlooked)



If you are travelling within sight of the coast it is relatively easy to navigate by using prominent coastal features. Away from the coast the options are more limited, though it must be said that most skippers these days do not carry a sextant and current almanac and probably could not use them effectively anyway.

## Options

Many boats are fitted with chart plotters. These have an electronic copy of the appropriate charts, often with a lot of other useful information. Chart plotters use a GPS signal to automatically superimpose your position onto the chart on screen. They are easy to use, both to locate your current position and to plot a future course. The chart plotter can be mounted at the helm station, at the nav. station or in many cases both.

Another option is to use a laptop computer as a chart plotter. There is a wide range of navigation software available, and the laptop can be interfaced with a GPS or have its own GPS receiver.

Chart plotters suffer from the same risks as the GPS plus they leave you exposed to the possibility of being left without any charts at all in the event of power or equipment failure.

The best guard against the downsides of electronic navigation is redundancy, examples are:

- Carry paper charts in addition to electronic (and know how to use them)
- Carry more than one GPS. This could be the ships GPS plus a chart plotter with an independent GPS receiver.
- Carry an additional hand held GPS with spare batteries.
- Install two chart plotters with their own mapping cartridges, or a chart plotter and a PC with built in charts.
- Understand the principals of coastal navigation and carry binoculars and a hand-bearing compass.

## Seeing in the dark

Navigating at night, or even entering an anchorage at night presents its own special problems. Ships, small boats, navigation marks and buoys that are obvious during the day can be almost invisible at night. Even ships can be difficult to pick out among the background shore lights when coastal cruising at night (and that can be scary!)

Radar is the best solution for night-time navigation and is reasonably priced. (Maybe \$3,000 – \$5,000 if a compatible chart plotter is fitted.)

Radar works by sending out a high frequency beam from a rotating antenna and watching for reflections from distant objects. These reflections appear as blobs on the radar screen. A large or close object makes a big reflection, while a small object produces a small reflection. Radar gives an accurate indication of both the direction and distance of an object, but little information about what it is, thus a ship and a hill could look the same. It takes experience to interpret the radar display but modern sets automate a lot of the technicalities. At least the inexperienced operator can tell that there is something out there and where to look to find it.

Most chart plotters have the ability to plug in a radar scanner thus sharing the screen, rather than the traditional stand alone radar screen. Most can even superimpose the radar reflections over the chart, making it much easier to interpret.



The size of the scanner (also called the antenna) determines the narrowness of the beam it sends out. A small antenna produces a relatively wide beam, which cannot differentiate objects that are close together. It is also only useable over shorter distances. Antennas are classified according to their maximum useable distance. So a 24 Nautical Mile (NM) radar would have an antenna that is about 18 inches mounted inside a 500mm diameter radome and produce a beam about 5° wide. A 72 NM unit will have a 48 inch rotating open antenna and produce a beam of about 1.5°. A small boat is unlikely to require anything more than a 24 or 48 NM antenna.

A new device that can make navigating among large shipping much safer is the AIS (Automatic Identification of Ships). By law all ships over 300 tonnes are required to transmit an AIS signal on a particular VHF band. This signal includes the name and size of the ship plus its position, course, speed and rate of turn, all in a digital format. Since AIS works in the VHF band it has a range of around 30NM.

An AIS receiver is available which can receive, interpret and display this information. It can be readily overlaid onto a chart plotter display.

It is possible to purchase a “lite” version of an AIS transmitter for smaller boats. This is called a Class B AIS transmitter. Commercial ships have a class A unit.

The class B transmitter makes all of your details available to any other ships with an AIS receiver, but in the event of heavy traffic a ship’s master can remove class B signals from his screen to reduce confusion.

## ***Power***

### **What you get**

The new boat will be equipped with a 12 volt (occasionally 24 volt) electrical system. This will consist of two battery banks, one for motor starting and the other to supply all the other electrical equipment. Both batteries will be charged by alternators mounted on the engines. The boat may also be fitted with a shore power connection for use with mains power in the marina.

### **How much power do you need**

The power requirements of cruising boats vary widely. A boat connected to shore power all week and used for overnight trips on the weekend will probably be fine with the standard equipment. Boats that spend long periods away from shore need a well designed power management system.

The starting point in determining power requirements is to think about how the boat will be used. Some possible scenarios to consider are:

- Anchoring out overnight with several guest on board
- Sailing day and night on long ocean passages
- Living aboard and anchoring out every night for weeks on end
- Running the engines for several hours each day while moving from place to place

You need to carefully consider what equipment you are likely to use in each situation and how long you are likely to use it.

Some items that use a lot of power are:

Fridge or freezer – perhaps 50 AmpHours (AH) per 24 hours

Standard anchor light – 20 AH per night

Household microwave 10 minutes – 20 AH



(An AmpHour is a current of 1 Amp supplied for one hour.

Air conditioning for a few hours each day - at least 100 AH and very likely much more.

The design of your system involves deciding what types of equipment you intend to use and estimating how long they are likely to be used for on average each day. The consumption figures of all equipment are then added up to determine your likely total power usage. As an example a conservatively run 12 metre live aboard cruising boat might use 100 – 120 AH per day. Add a watermaker and a few other bits and pieces and this could easily reach 200 – 250 AH per day.

Adding a washing machine, extra refrigeration or even air conditioning will push the power requirement up even further.

For owners not conversant with electricity it is well worthwhile to think about planned usage and then work through the power requirement calculations with an experienced person.

### **Keeping track of usage**

In any situation that involves the boat being away from shore power for more than a few days at a time it is important to install a good quality battery monitor (that measures the total AH into and out of the batteries) so that the skipper can readily check the state of charge of the battery. A car's fuel gauge is a good analogy.

### **Where will you get the power from**

In practice the power requirements will come from a range of sources. All have benefits and disadvantages and none should be relied upon in isolation.

#### *Shore power*

Shore power is the most reliable and largest capacity source, but you cannot be away from it for more than a few days. It is ideal for a boat that spends its week days at the marina or on a private pontoon and then cruises for one or two days each weekend.

When the boat is used this way it only needs a moderately sized battery charger. It must, however be a three stage charger to avoid over charging the battery. An automotive charger is never sufficient.

The charger should have a minimum amp rating about one twentieth the amp hour capacity of the battery. I.e a 400 AH battery should have a minimum of a 20 Amp charger.

#### *Main motors*

The main motors are fitted as standard with reasonably sized alternators that will supply your power needs while they are running.

There are a couple of problems with the standard alternators. The first arises because the voltage regulators fitted are not particularly sophisticated and will not charge at maximum rate for very long. For example a 70 Amp alternator might only deliver a maximum of 50 Amps for ten minutes or so and then gradually decline to 15 Amps even though the batteries are nowhere near charged. This means the motors end up running for a long time at low load, consequently:

- A diesel's life expectancy is compromised if it is run for long hours at low load
- Engine hours will build quickly
- Excessive fuel usage



- They are noisy while running, particularly in an anchorage

The second problem arises if you do not run the motors for long enough each day to completely recharge the batteries. In this instance the batteries will gradually decline over many days or weeks, to the point where they are permanently damaged.

Because of these limitations, if the main motors are to be used as the primary power generation source they should be fitted with larger alternators and a three stage regulator specifically designed for battery charging. This is relatively expensive and does not solve all of the problems.

### *Solar*

Solar panels are reasonably expensive to install, but they cost nothing to run, are silent and will last for a long time – in excess of 20 years. The amount of power they produce depends on:

- The area of panel installed
- The amount of time the panel is exposed to the sun with no shade on any part of it. (A shadow from the boom (or even a rope) can reduce the output by 90%)
- The number of hours of full sunlight per day
- The latitude and orientation of the panels

Very roughly, 100W of solar panel might produce 40 – 50 AH on a clear Spring day in Queensland. Probably a little over half that on average.

A conservatively run cruising boat can get nearly all of its power requirements from 200 – 300 watts of solar in good weather. It is quite feasible to set up a boat to leave on a mooring with a smaller solar array to keep the basic systems in operation and the battery fully charged.

The main disadvantage with solar for a live aboard boat is that a backup power source is required to cover the inevitable cloudy week.

### *Wind*

Wind generators can contribute a useful amount of power in windy weather. The amount of power is basically related to the blade diameter, but most generators need 5 – 7 knots of wind before they produce any power. Given that most cruisers select anchorages protected from the wind, they are unlikely to produce anything like their rated output for most of the time.

There are two other problems with wind generators. In strong wind they spin to a high speed before they cut out and so are quite noisy, even in a marina if the owner does not turn them off. Secondly they have to be rigidly mounted in a position where the blades cannot possibly strike anything, particularly crew members in any wind direction.

They are probably at their best on a sailing boat on extended ocean passages.

### *Generator*

If a large amount of power is required, particularly for air conditioning, a generator is the preferable and often the only solution. With careful design the generator size and running time can be reduced, however there will always be a certain amount of noise (unless you use a “Whispergen”) and a constant usage of fuel.



It is reasonably simple to set up a power system using a generator and inverter that will provide continuous AC power without running the generator continuously. In fact the generator running time can be reduced to only a few hours per day. The system operation can easily be made fully automatic.

In addition, with modern inverters it is possible to use the inverter to drive short term peak loads or to supplement the generator to provide large electric motor starting currents. This feature can significantly reduce the size of generator required.

Generators can be AC or DC, diesel or petrol. All have their advantages and disadvantages.

The major drawbacks of generators are that they are noisy and that they need a continuous fuel supply. Placing the generator in a soundproof enclosure substantially reduces the noise, but in a quiet anchorage the owner and his neighbours are always aware of its presence.

It is not uncommon for an inexperienced owner to specify a relatively large generator to supply maximum load they can foresee. This leads to the generator being run for very long hours at low load, with the consequent noise, vibration, weight, excessive wear and fuel problems. With proper design a much smaller generator with vastly reduced running time can be used.

### *Whispergen*

A relatively new generator option is the Whispergen. It has been developed in New Zealand based on a heat engine first invented in the early 1800s. It operates by using a different system than a normal diesel motor and so is virtually silent, particularly when it is mounted in its enclosure inside the engine compartment.

It is a small DC generator, producing 800 Volt Amps, or about 65 Amps at 12 Volts using only about 0.75 litres of diesel per hour. It also produces a significant amount of heat that can be used for hot water heating. Its control system can be arranged to start the unit whenever the battery state of charge drops or the hot water temperature falls. Thus it provides continuous power along with continuously available hot water – an attractive proposition, but it is relatively new to the marine market and quite expensive. Think in the order of \$20,000.

Theoretically the Whispergen could be set up as the main power source for a very well equipped boat, but I have not seen one yet.

### **How will you store it – the main battery**

Batteries are easily and permanently damaged by deeply discharging them. Flatten any battery a few times and the capacity and life will be severely compromised – hence the recommendation to install and use a battery monitor. It is not possible to assess the state of charge with any degree of accuracy with a voltmeter. A half charged battery exhibits essentially the same voltage as a fully charged one and a battery showing a noticeably low voltage is already virtually flat. A deep cycle battery should not be discharged below 40%, preferably 50%.

Deep cycle batteries are the only ones that should be considered for the house bank. Never use automotive batteries for anything but the starter battery and even then only the best quality should be considered. Marine batteries are more sturdily built to handle the harsh marine environment – hence their higher cost.

Wet cell batteries are the most efficient in terms of life/cost considerations, but they require constant observation and maintenance. Poor maintenance can result in irreparably damaged batteries in a very short time. They also produce hydrogen gas while charging so certain ventilation requirements must be met.



Gel and AGM batteries are maintenance free and do not gas. They cost more than wet cell batteries, but will last for a similar time to well maintained wet cells.

Batteries are one of those devices for which the term “you get what you pay for” could have been written and there are a wide range to choose from.

A new boat will probably come equipped with a moderately sized bank of wet cell batteries. Since it is not possible to mix batteries it is probably best to adjust the size of the bank if necessary, by the addition of extra cells of the same type. When the time for replacement comes, then consider alternative types.

The house battery should be designed to suit the loads they are intended to carry. The system designer will take into account:

- The number of AmpHours expected to be taken from the battery between charges
- The maximum current expected to be taken from the battery at any one time
- The current rating of the charging source
- The length of time it is desired to run the generator or motor for each charge, if necessary.

If the battery is too small for the task:

- The time between recharges will be irritatingly short. This is a particular problem when a boat that is normally charged with shore power is taken away for a few days.
- It will not accept a high charging current ie. The battery charger Amp rating should not be more than about one third of the battery capacity.
- They are likely to be quite deeply discharged, which will significantly reduce their service life
- They may be damaged if the load in Amps exceeds about 25% of the AH capacity for an extended time. (such as a large inverter running at high power)

Generally the house bank should have a capacity of at least four times the expected usage between charges – bigger is always better from an electrical point of view. The disadvantages of a large battery bank are cost, weight and space and maintenance.

### **12 volts vs 240 volts**

Traditionally boats have used 12V power systems, with any 240V requirements being met by use of a generator. Modern inverters have evolved to the point where it is realistic to use 12V or 240V appliances, or any mixture of the two.

All of the instruments and communications equipment on a boat will be 12V, but high power devices such as watermakers, microwaves or TVs can be either. High power devices running on 12V draw very large currents and consequently must be connected with heavy wiring. 240V appliances are relatively cheap and convenient.

With an appropriately sized inverter and battery the boat can be set up to provide all of the 12V and 240V requirements from the main battery. Any of the range of charging devices can then be used to keep the battery charged. The important thing is to ensure that the system is balanced; there is sufficient power coming in to replace all of the power going out.



## Inverters

Inverters are electronic devices that convert DC power from a battery into 240V AC power that will operate domestic appliances. They are available in two types: Modified sinewave or pure sinewave. Modified sinewave inverters are much cheaper but tend to produce a lot of high frequency noise that can interfere with radio signals, their output is not smooth and may not operate some equipment properly, particularly computers. They are useful for applications where power is only required infrequently to drive specific types of loads, for example a mobile phone charger.

True Sinewave inverters produce an output that exactly matches the normal AC mains power. Even though they cost considerably more, they are the only type to consider for a marine power system. They will operate any equipment that draws less than their rated output and will cause minimal interference.

The size of the inverter is determined by the maximum expected AC load. Some examples of AC loads are:

Toaster ~ 750 Watts

TV ~ a few hundred Watts

Kettle ~ 1800 – 2400 Watts (occasionally 1200 Watts)

Microwave ~ 1400 Watts

Hair drier ~ 2400 Watts

Small marine hot water service 750 Watts (but you need to run it for at least an hour to heat up)

Air conditioning 4000 Watts or more

As a guide the maximum power for any device that can be plugged into a domestic socket is 2400 Watts.

Any equipment with a large electric motor requires much more power to start it than it needs to run, hence a 10KWatt generator might be installed to operate a 4 KW air conditioner. This can be overcome by using an inverter capable of assisting a smaller generator to supply brief high loads.

Inverters will normally be between 1600 and 3000 Watts. These will draw between 140 and 250 Amps from a 12V battery at full load! It is possible to connect two or more inverters together to supply more power.

Many modern inverters can act as a two way device, producing 240V when only 12V is available and charging the 12V battery when 240V is available. Their control systems are also able to automatically coordinate all of the power requirements of the boat including:

starting and stopping a generator,

temporarily reducing battery charger current to make more power available for other devices

disabling some devices such as air conditioners or electric hot water services when only 12V power is available.

It is not difficult to design a power system around an inverter that will provide continuously available AC power with minimal generator running time and fully automatic control. When setting up a power system for a live aboard cruising boat it is well worthwhile to get some expert assistance at the design stage.



## ***Water***

### **What you get**

The new boat will be equipped with large fresh water tanks, a hot water service heated from the engine cooling system and a pressure pump so that both hot and cold water are available by simply turning on the taps.

### **What you need**

If you are extremely frugal with water you might be able to get usage down to 15 – 20 litres per person per day, but this requires considerable commitment. Being a bit more generous and allowing each person a quick shower each day and a hose down after each swim and some hand washing etc. you might use 50 litres per person per day. However a ten minute shower at home could easily use 100 litres of water, so the sky is the limit.

As with everything else, what you need depends on what you want to do. Most boats carry enough water for a week away or maybe two with care. If you want to cruise for longer periods, water will be a problem since it is generally difficult to get access to mains water unless you stay in a marina.

### **Watermakers**

Watermakers produce fresh clean water from sea water by forcing the sea water through extremely fine filters that remove the salt and almost all other impurities. The resulting water is as clean as you get in bottled water.

They operate at extremely high pressure and the filters are very expensive so the units themselves are expensive. They are generally 30, 60 or 120 litres per hour in cruising boats. Think in the order of 10 – \$20,000. Much larger sizes are available.

A 12V watermaker might use 0.5 AH per litre of water.

## ***Hot Water***

### **What you get**

The boat will probably have a marine hot water service of about 20 – 30 litres, heated by the engine cooling system. Thus hot water will be available while the engine is running and for another 12 hours or so, until it either runs out or cools down. The hot water service will have a 240V element, which is only connected if shore power is installed. It is not recommended to run the hot water service from the batteries because of the large power requirement. There should be some form of disconnect to ensure this does not happen accidentally.

### **How much is enough**

Many boats in the past have not had any hot water and many long term cruisers in the tropics get by without it because they don't want the expense or energy drain.

The middle of the road option is to only have hot water when the motors are used to go somewhere, or when in a marina.

Continuous hot water can be made available but because of the power required they all involve burning some form of fuel.



## Options

Gas hot water services are sometimes used on boats, particularly the instantaneous type that make the hot water as required. The downsides are:

- A gas HWS must be ventilated to the outside air, so it can be difficult to locate.
- Gas usage is quite high and it is difficult to carry sufficient gas offshore.

If a generator is fitted to the boat it is realistic to simply use the standard electric element. It is necessary to ensure that the HWS is large enough to last for the period when the generator is not running each day.

Diesel fired heaters are available that almost silently produce hot water while consuming very moderate amounts of fuel – around 0.2 – 0.6 litres per hour.

As previously mentioned, a Whispergen produces hot water along with electricity.

The hot water tank has one set of inlet/outlet fittings as standard. These are normally connected to the main engine cooling system. If a separate water heater is installed it can be connected to these fittings, or a specialised tank can be purchased with two sets of fittings to allow both connections to be made independently. A secondary water heater should not be teed into the existing heat exchanger hoses.

## *Heating / Air Conditioning*

### What you get

Windows

### Heating options

For boats used in cooler climates heating can considerably extend the cruising season or allow them to venture into otherwise untenable environments.

The only really practical form of boat heating is diesel. They can be either stand alone air heaters (0.12 – 0.4 litres per hour) or a central unit (0.2 – 0.9 litres per hour) that heats a fluid that is circulated around the boat providing heat to individual fan units in each cabin. The latter can also be used to heat the HWS.

A Whispergen could also be used to operate the heating system

### Cooling options

The simple cooling option is to install fans in each cabin. This is relatively inexpensive and consumes minimal power. The degree of cooling is limited.

The only real option is air conditioning. For a cruising multihull, with large internal volume and large windows, this will result in a large power hungry unit or several smaller units. Probably 4 – 6 KW, depending on the environment it is used in. It will also be expensive, think 20 – \$50,000.

In addition a large generator will be required, which will need to be running almost all of the time the air conditioner is running.

It is possible to moderate the cost and power requirements by only air conditioning selected areas – but that sort of defeats the purpose, doesn't it?



## ***Communications***

### **What you get**

The boat will be equipped with a VHF radio at the nav. station. This will communicate up to 20 - 30 miles.

### **Options**

The main thing to consider with communications is the distance you intend to be from civilisation. Radio used to be the only option, but now mobile phones and satellite services are viable alternatives.

For coastal cruising VHF radio is sufficient for communicating with other boats, Volunteer Marine Radio (VMR) and Coastguard stations.

Mobile phones will work close to the coast, with some limitations, see below. Also reasonable internet service can be achieved through the mobile network.

### ***Radio***

Traditionally boats have used VHF radio for coastal work and an HF radio (sometimes called Single Side Band or SSB) for long distance work.

Possible improvements to the standard VHF include:

- An external speaker at the helm station
- A remote control head with speaker, microphone and basic controls at the helm station
- A Digital Selective Calling (DSC) radio interfaced with the GPS. This has a number of advantages, but the main one is probably the ability to send a digital distress signal at the press of a button. The signal includes the ship's identification and location and will transmit further than normal voice communications.
- A handheld VHF can be carried in order to provide backup and portability. This can be protected against lightning strike and is independent from the ships batteries.

HF radio can achieve worldwide coverage but is more complex to operate and voice quality can be quite variable. The main advantage may be the ability to receive weather updates anywhere in the world.

Marine HF can be received over very long distances, but relies on someone listening on the selected frequency at the time of the transmission. It should be noted that many cruisers, in an effort to conserve power only turn their HF radio on when they want to use it. Additionally Australian coast stations do not continuously monitor the HF bands any more. DSC is available on HF sets.

It is quite complex to set up an HF radio properly and this is one job that should be left to an expert. Think in terms of several thousand dollars. On a catamaran it will probably include a 6 metre whip antenna, though other options are available.

Very slow email is also possible over HF using services such as Sailmail. This is a bit complex to set up, with a specialised modem required to interface between the HF radio and computer. Sailmail is an annual subscription service.



### *Mobile Phone*

Mobile phones will operate out to sea for about the same range as they reach on land. Close to main towns and cities any service should be adequate. For operation off more remote coasts and further offshore Telstra's "NextG" network is the best option at present. This might work 20 – 30 miles offshore. If there is no coverage ashore there will obviously be no coverage at sea.

Wireless internet is available from a number of carriers. This can provide quite reasonable internet speeds within the range of the network. Again the Telstra NextG network probably provides the best range at decent Internet speed.

### *Satellite*

There are a number of satellite providers providing varying levels of service. They use one of two forms of service. One needs a satellite in a position that can "see" both the phone and a land based station. This type of provider will publish a map showing coverage footprints. They tend to provide service over designated land and surrounding sea area, with relatively large areas with no coverage.

The second type (more expensive) uses a network of satellites that can talk to each other, so service will be available when the user can be seen by any satellite. Depending on the network chosen, this will be over most or all of the world.

Satellite will provide voice communication and some form of data. Different providers offer different data speed capability, with greater speed definitely costing more money. Speeds available vary between email only, to moderate internet speed.

Satellite services cost between about \$2,000 and \$12,000 to set up.

From a safety viewpoint, satellite has a number of pros and cons:

- A satellite phone is portable and has its own batteries, so it can be taken ashore or into a liferaft if necessary. It can also be protected from lightning strike.
- A satellite phone is as easy as a normal mobile phone to use with full phone book capabilities etc. HF on the other hand needs some experience to use effectively. Someone who has never used an HF set before may have difficulty establishing communications.
- Satellite is a point to point service and so relies on knowing the number to call and having someone competent answer it. HF on the other hand transmits over a wide area so anyone can respond.
- HF is relatively cheap to use, while any satellite service will represent a significant ongoing cost.

## ***Lightning protection***

### **Why is lightning a risk?**

Lightning is a very high voltage, high current discharge between the clouds and earth. The forces involved are so great that it is not possible to produce insulation strong enough to withstand it. As a result when an object is struck by lightning, very large currents will pass through it and the associated voltage will permanently damage its insulation. In addition large voltages can be induced into adjacent wiring, damaging equipment that is not even attached to the object struck.



The charge in storm clouds will discharge to earth whenever it finds a path that it can spark across. When a boat is at sea, it often represents the highest point in the vicinity, thus representing the shortest path to earth. For the sake of the following discussion the sea is taken as the electrical earth.

Lightning strike is potentially catastrophic, but on the other hand is very rare. Consequently most boat owners do not do much to reduce the potential for damage. This is more due to the difficulty and expense, with no guarantee of success, rather than lack of concern.

### **No such thing as total protection**

It is not possible to protect anything completely from the effects of lightning. Because of the immense amount of energy involved the consequences of a strike cannot be predicted, therefore cannot be protected against. It is however possible to reduce the risk of damage in the event of a strike.

### **What are the problems?**

When an object becomes part of the path for the electricity to flow to earth, a large current will flow through it. If the object is metallic and large enough (like an aluminium mast), the current will flow through it without damage. The problems arise if the conductor does not go all the way to earth or is too small. In such cases the current will flow through it and then jump to earth, or to another conductor on its path to earth.

In a traditional monohull with the mast stepped onto a metallic keel, most of the current will flow straight down the mast and out the keel to the sea. This will reduce but not eliminate the risk. If you consider, as an analogy, a garden hose with water freely flowing out the end and you prick a hole part way along the hose. Although water still flows out the end of the hose, some will also come out the hole. Similarly, with the current flowing down the mast, some will leak out down the shrouds. Because of the large amount of energy involved, this leakage may still be catastrophic.

Similar parallel paths towards earth include the mast top radio antenna and cable and the wires to the masthead lights. The only insulator between these wires and the ship's earth is a transistor in the case of the radio and a switch in the case of the lighting wires. These may either fry or explode in the event of a strike.

Another problem for electronic equipment is the fact that a large current spike through a conductor induces voltage into other conductors. This is the principal that allows electric motors to work, but in the case of a lightning strike the very large current flow will induce large voltages in the wires leading to electronic equipment, which may lead to equipment failure.

Catamarans have the potential for much greater damage than a monohull because the mast is stepped on the deck and there is no direct path to earth. The current will therefore flow down the mast and then jump to any or all nearby objects that lead toward earth. These will include the wires inside the mast and the ship's wiring that passes in the vicinity of the mast in the saloon and the anchor locker. There are large cables from the anchor winch at the base of the mast leading to the engine bay and earth via the motors with the saildrives immersed in the sea. Thus all the paths to earth on a catamaran involve current passing through something else, potentially destroying all of them.

### **Reducing the risks**

The primary concern in a thunderstorm is the protection of people. Try to avoid touching, or getting in between two metal objects, particularly if one of them is earthed. Also avoid as far as possible being in the water, or being on the boat and touching the water. Lightning striking the water nearby can easily electrocute a person in the water, even if they are not touching anything. The best place to be is inside the boat, away from the mast and the nav. station.



Protecting equipment involves trying to create alternate paths to earth that are easier for the energy to get through than going through your important equipment.

Some things to consider are:

- Any alternative paths must be constructed with heavy wiring that is capable of carrying the heavy current involved. 13mm<sup>2</sup> being the minimum.
- The huge energy involved does not like to go around corners, so the wiring paths must be as straight as possible.
- If possible avoid using the saildrive as the connection between the boat's wiring and the seawater. (This is the only connection on most catamarans!)
- Care must be taken with grounding cables run inside the boat below the waterline, because lightning could blow through the hull to the seawater.
- Electronic equipment wiring should be run without loops or coils. (To reduce the size of induced voltages)
- Earthed surge suppressors should be connected to electronic equipment.
- Disconnect (rather than turn off) electronic equipment during thunderstorms. Do not do this when lightning is likely in the immediate vicinity, or you risk becoming part of the path to ground yourself if you are touching the wiring at the time of a strike.
- If the mast is well earthed, a lightning rod extending above everything else at the masthead may help to protect the fittings and wiring. Such a rod should be 15 – 20 mm round copper or aluminium securely bonded to the mast.
- Bottle brush type lightning protectors which claim to dissipate the charge buildup that precedes a strike are available to attach to the top of the mast. There is some controversy about whether they are any better than a plain lightning rod, but in any event they will not do anything if the mast is not well earthed.

In practice if you do plan to undertake some form of lightning protection on a sailing catamaran, I would consider, in order of importance:

- Arrange to earth the mast to the sea. Perhaps a heavy cable or bar clamped to the mast and extended down through the bridgedeck, with some method of lowering it or an attached cable and ground plate of 0.2m<sup>2</sup> or so, into the water at the first sign of storm activity.
- A reasonably heavy cable around the perimeter of the boat at about deck level, forming a loop, connected to the mast and chainterlocks and bonded to all main metal components. 6-8 heavy down conductors should then be spaced around the boat from this loop, terminating with metallic through hull "air terminals" just above the water line.
- Connecting surge suppressors or lightning arrestors to the leads of electronic equipment.
- Remove spare cable coiled behind electronic equipment. Installers often leave spare wire coiled to avoid having to cut it off and reterminate.

All of these things will help, but as I said at the beginning of this section: There are no guarantees when it comes to lightning.



### **Protecting specific items**

After all of the doom and gloom of the preceding, there is one piece of good news. A device called a Faraday cage will protect anything inside of it from the effect of a high voltage surge. A Faraday cage is simply an enclosure of metallic conductive material. Regardless of the electric field outside the enclosure, the inside will remain at a constant voltage. A cake tin or a cooking pot with a well fitting lid makes an ideal Faraday cage. Wrapping an electronic device in aluminium foil would probably even work. I normally keep a handheld VHF and GPS in such a tin.

#### *References:*

*Boat Owners Mechanical and Electrical Manual. Nigel Calder*

*Electricity On Board. Reinout Vader*

*Marine Lightning Protection Inc. ([www.marinelightning.com](http://www.marinelightning.com))*

*Various Manufacturer's handbooks and brochures*