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Legislation Committee
Answers to questions on notice
Environment and Energy portfolio

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Topic: Icebreaker – Functional Requirements

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Senator Xenophon asked:

Please provide details of the top level functional requirements of the Icebreaker.

Answer:

The Australian flagged research supply icebreaker will have a range of 90 days, break 1.65 metres of ice at three knots, store 1200 tonnes dry cargo, store 1.9 million litres bulk fuel storage and accommodate 116 expeditioners.

The research supply icebreaker has a functional requirement to handle:

- waves up to sea state nine (14 metres plus significant wave height)
- wind speed up to Beaufort 12 (hurricane)
- air temperature ranging from −30° Celsius to 45° Celsius, and
- water temperatures ranging from −2° Celsius to 32° Celsius.

It will have the capability to:

- travel at an efficient cruising speed of 12 knots, with a maximum sustained speed of 16 knots in open water
- break ice at a continuous three knots in ice of 1.65 metre thickness
- transfer personnel and cargo from the icebreaker to the stations using a range of means over water, over ice and by air, including the capability to operate and support four light helicopters or two medium helicopters
- handle, stow and transport up to
    - 1200 tonnes of solid cargo consisting primarily of containers and break bulk cargo, including large items of plant and equipment using the ships own cargo cranes, and
    - 1,900,000 litres of bulk liquid cargo (Special Antarctic Blend diesel used for station operations)
- support voyages for up to 90 days, which includes the ability to remain within the Antarctic area for up to 80 days
- accommodate 116 personnel with modern services including a specialised medical facility, and
- ensure a high standard of environmental compliance

The vessel will be able to sustain multidisciplinary and concurrent science operations, and support numerous sample and data collection systems, including for sea-floor, sea-ice, sea life and atmospheric research. It will have the capability to deploy, operate and with location precision recover a range of equipment and instruments in a range of conditions including:

- drop keels and a moon pool to support a wide range of scientific research operations and modes
- a multi-beam bathymetric echo sounder for mapping the sea floor at full ocean depth
- sub-bottom profiler to analyse the physical properties of the sea floor
- scientific echo-sounders for biomass assessment and fisheries sonar systems, and
- hydrophones and underwater cameras.

It will have a dynamic range of fixed and portable work spaces, facilities and services to support experimentation and analysis and the capability to deploy a specialised marine tender.

Further details

Australia's new Antarctic science and resupply ship is truly a ship of the future.

The new icebreaker has been designed so that it can support scientific research that answers the critical questions of today. But it must also cope with future research demands (for the 30 year lifetime of the ship), some of which are currently unknown.

To ensure this, scientists involved in the design consultation had to do a bit of crystal ball gazing, to consider what the science of the future could look like and what future capabilities would be needed on the ship to support that.

A silent ship

Some of the most important scientific functions of the ship are the abilities to find and 'see' marine organisms such as krill, fish and jellyfish beneath the ship, and to map the seafloor and surrounds. To do this the ship has a large number of different acoustic instruments, mounted in its hull and two keels that drop below the hull. These instruments send pings of sound out into the environment and listen to the returning echo to create images of the surroundings. To work properly, however, they need a relatively quiet environment – a difficult ask in a ship with large engines and propellers.

As a result, a significant amount of work has gone into the design of the ship's hull and propulsion system, to reduce noise associated with the engines, gear boxes and propellers, as well as bubble formation (which make noise when they pop) and the downward sweep of bubbles which 'blinds' the acoustic instruments.

With this fundamental performance requirement solved, a flexible scientific platform that can react to changing scientific needs, has been created.

New icebreaker built for heavy lifting

It may not sound like cutting-edge science, but a large aft deck, with a matrix of attachment points, good winches and lifting equipment, and a range of power supplies and water, are keys to enabling a wide range of science and future-proofing the ship.

The aft deck supports a wide range of activities including:

- deploying many types of fishing nets;
- seismic mapping of the layers of sediment and rock under the ocean;
- extracting sediment cores up to 24 metres long;
- collecting large volumes of water from hundreds of metres below the ocean's surface;
- deploying large instrumented mooring systems;
- operating autonomous underwater vehicles; and
- deploying many types of towed and lowered camera and instrument systems.

The aft deck also supports fourteen 20-foot containers and six 10-foot containers, which can be positioned by overhead cranes. These containers will house specialised scientific equipment, with eight of the containers having services for laboratories of the future – negating the need to build specialised laboratories into the ship for research that hasn't yet been conceived.

The heavy lifting equipment (winches, cranes and an A-frame) can lift and move items up to 30 tonnes around the deck and over the stern. The different attachment points on the deck mean that scientists can bring specialised winches and other large equipment onboard, and safely secure items when not being used.

Scientists studying trace metals, such as iron, in the ocean, will have access to the clean water they need (free from trace metal contamination associated with the ship and instruments). Krill researchers will be able to fill tanks, housed in shipping containers, with seawater cooled to as low as −1.8°C, to keep collected krill in pristine condition. And glaciologists will be able to process and store ice cores, ice algae and other cooled or frozen samples at different temperatures down to −135°C.

Side and moon pool deployments from the new icebreaker

Deploying equipment over the side (or stern) of the ship works well in the open ocean and in good weather. But when the weather is particularly rough, or the ship is in sea ice, some research has to stop. But not anymore.

The moon pool is a 13 metre vertical shaft, four metres square, which runs from the science deck, through the ship's hull, to the open ocean. When its top and bottom hatches are opened the moon pool allows the deployment of equipment such as CTDs (conductivity, temperature and depth instruments), nets, underwater vehicles and other instruments, within the relative comfort and protection of the ship.

CTDs will regularly be deployed from the icebreaker through a side door or the moon pool. These metal rosettes contain up to 36 12-litre plastic bottles and are used to collect water samples at different depths, up to 6500 metres. The rosette is lowered by a cable from a door out over the side of the ship (or down through the moon pool) to the required depth – usually to the bottom. As the rosette descends and ascends over a few hours, a remotely triggered device allows the water bottles to be closed selectively, so that samples of water are collected from different depths. These water samples are then analysed to provide oceanographers with information about the physical and chemical properties of different water masses.

Using CTDs and other water profiling instruments, scientists have been able to observe that the Southern Ocean is warming, freshening, become less oxygenated and more acidic. These measurements are important for understanding the response of the Southern Ocean to climate change and changes in its ability to take up heat and carbon dioxide, which in turn will affect local and regional climates.

Trace metal rosettes have a similar setup to CTDs but are prepared for deployment in a very clean environment, free of trace metals such as iron. They are used to study elements that exist in very low (trace) amounts in the ocean, and that are important for biological and chemical processes – iron, for example, is critical to the growth of phytoplankton.

Noisy science on the new icebreaker

A big part of marine science involves collecting marine creatures from the seafloor and water column to understand their distribution, abundance and diversity. Krill, for example, are one of the most important organisms in the Southern Ocean food chain – providing food for fish, penguins, seals, whales and seabirds. Krill are also fished by humans for food and aquaculture. To manage krill stocks sustainably, we need to understand how much krill is in the ocean (its 'biomass') and how it is distributed.

Scientists have also identified fragile organisms such as jellyfish and salps as important prey species. It is hypothesised that these species may increase in importance in the ecosystem, if krill are negatively impacted by climate change.

To find these and other organisms, the new icebreaker has acoustic instruments ('bioacoustic transducers') that can identify when organisms are present and then measure their biomass in the water column. These instruments are mounted in the ship's hull and in two drop keels that can be lowered up to three metres below the ship. The instruments send pings of sound out into the environment and listen to the returning echo as the sound bounces off objects in the water. If a school of krill, for example, is in the area, the echo will appear as a large, bright mass on associated computer screens. The strength of these returning echoes provide a measure of the amount of biomass in the water column. A team can then drop a net from the back of the ship or through the moon pool, to collect samples from the water.

Other important acoustic instruments are the multi-beam echosounders. A large low frequency multi-beam (8x8 metres in size) will be used to map a swath of the seafloor and continental shelf up to 25 kilometres wide in one pass, and work at depths to 11 000 metres. A higher frequency multibeam will be used for higher resolution measurements on the continental shelves. A third sideways looking multibeam will allow schools of fish and swarms of krill to be imaged to understand their swirling movements.

Among other things, maps of the seafloor generated using multi-beam echosounders:

- provide insights into the geological and glacial history of the area;
- allow scientists to identify areas for further study or for trawls for specific organisms;
- provide information about volcanic activity; and
- provide safer navigational charts in areas close to the Antarctic coast, such as around stations.

Among the other acoustic instruments onboard the new ship are hydrophones to listen for marine mammals, a fisheries sonar that allows scientists to find schools of fish or krill, and Acoustic Doppler Current Profilers, which provide information on the three-dimensional water currents beneath the ship.

For geoscientists, a sub-bottom profiler will generate images of the layers of seafloor sediments and rocks up to 200 metres depth, providing information on the processes of seafloor habitat formation. The sub-bottom profiler will also be used to identify soft sediment suitable for coring. Tiny fossilised plants and animals in these sediment cores, as well as the sediment's physical and chemical properties, can be analysed for information about past ocean conditions and climate (paleoclimate).

New icebreaker ice research platform

The research capabilities of an icebreaking ship would not be complete without the ability to conduct sea ice and ice sheet research. This icebreaker's capabilities will allow year-round voyages into thicker and stronger ice.

Many of the needs of glaciology research overlap with other scientific disciplines on the ship, as the Antarctic cryosphere has strong interactions and connections with the atmosphere, ocean and marine and terrestrial ecosystems. These needs include access to satellite imagery, weather and wave radar data, meteorological observations, multibeam imagery of the seafloor, atmospheric sampling, and biological and oceanic data.

Among the more specific requirements however, is the need to use the ship as a base from which to deploy people or instruments by helicopter to remote locations on the Antarctic ice sheet or within the sea ice zone. Other airborne operations will include 'remote sensing' of ice thickness and snow cover using specially-equipped helicopters or Unmanned Aerial Vehicles. Scientists will also deploy locally on to the sea ice from an access ramp off the ship or by watercraft or helicopter. Once on the ice they will collect ice cores, measure the temperature, thickness and other properties of sea ice and snow, and investigate its chemistry and the ecosystem it supports.

The new ship also has a retractable boom, extending about 10 metres in front of where the ship breaks the ice, on which to mount sensors. These sensors include an 'electromagnetic induction, laser altimeter and snow radar sensor package'. As the ship travels, this sensor suite will provide real-time information on snow and ice thickness that will enhance ship navigation and planning of on-ice field experiments. Ice profile data from the sensor will also improve knowledge of the thickness distribution of Antarctic sea ice and snow cover and help to calibrate satellite estimates of sea ice thickness.

Atmospheric research on the new icebreaker

Not all science on the new icebreaker will be conducted in the ocean or sea ice. A range of meteorological measurements and atmospheric research will be conducted from the upper decks.

Meteorological measurements support forecasting and climate information services such as those provided by the Bureau of Meteorology and the World Meteorological Organisation for, among other things, weather and shipping forecasts and climate modelling. Meteorological data such as sea ice properties, temperature, wind speed and wave heights are also important for the day-to-day operation of the ship at sea.

Atmospheric research includes studying interactions between the atmosphere, ice and ocean, which help us understand large-scale patterns of climate variability that can influence weather and climate in Australia and other parts of the world. Atmospheric research incorporates meteorological data, but also relies on specialist instruments to study aerosols, clouds, gravity waves, cosmic rays, ozone and ozone depleting substances.

To support the meteorological and atmospheric science needs the ship includes:

- a weather radar, in prime position at the very top of the ship, to measure precipitation and winds out to hundreds of kilometres from the ship, in support of vessel operations and scientific research;
- balloon inflation and launching facilities – to launch balloon-borne sondes that collect data on temperature, wind speed and direction, humidity and ozone concentration;
- a 'ceilometer' to measure cloud height and properties (useful for helicopter operations and cloud research);
- an ice navigation radar to differentiate between open water, ice pans, leads in ice fields, and the thicker ice ridges that impact operations in ice zones;
- a wave monitoring radar to measure wave and swell height and direction, and surface currents;
- receivers to collect real-time polar orbiting environmental satellite imagery for sea ice analysis, weather analysis and forecasting;
- instruments to measure aerosols, ozone, greenhouse gases (carbon dioxide and methane), and other gases relating to volcanic and human activity and bacterial action in the oceans and soils (carbon monoxide, nitrous/nitric oxide).
- an 'automatic total sky imager' (a camera) to calculate fractional cloud cover and sunshine duration.

The upper and heli decks will also have capacity to accommodate emerging and anticipated future research needs, including the launch and retrieval of Unmanned Aerial Vehicles and drones and tethered devices such as kites and balloons. The upper deck has space for four 20 foot containers to house specialist laboratories and other equipment such as a LIDAR (light detection and ranging) instrument, used to study climate in the middle atmosphere (10–100 km above).

New icebreaker offers enhanced cargo capacity

As well as providing a platform for science the new icebreaker must resupply Australia's three Antarctic stations and its subantarctic station on Macquarie Island. To do this the ship can carry a whopping 1200 tonnes below decks, in up to 96 20-foot shipping containers.

The ship also has storage for fourteen 20-foot and six 10-foot science containers on the aft deck, four more science containers above the heli-hanger, and seven containers at the front of the heli-deck.

The two below-deck holds, however, are the workhorses of station resupply. Each hold can carry 48 containers. The forward hold is designed for dangerous cargo (such as drums of aviation fuel), while the rear hold can accommodate another 48 shipping containers or a mix of containers and oddly-shaped cargo, such as heavy vehicles. There is additional storage in the holds for smaller items around the container locations, and further containers and very large items can be carried on the cargo hold hatches.

This cargo capacity is a major increase on the 19 containers that can be carried in the holds of *Aurora Australis*, and potentially enables the resupply of two stations in one voyage, rather than one at a time.

To move all these containers and heavy equipment around, the ship has two 55 tonne 'knuckle-boom' cranes that can be used in rough seas, a 15 tonne crane on the heli-deck and a 15 tonne side-loading crane that can move containers from the wharf to the science aft deck.

Once at station there are a range of options for transferring cargo from ship to shore.

Watercraft

Two barges will be able to carry over 45 tonnes each, enabling each to carry a truck loaded with a 20 foot container to and from the ship. In a loop between the ship and station the trucks will be able to be loaded with cargo by the ship's cranes, and roll off the barge to take the cargo ashore (a system called 'load on-roll off'). To facilitate this, cranes will move cargo out of the holds into temporary positions on the deck, so that cargo returning to Australia can be slotted straight in.

The icebreaker comes with four smaller watercraft or 'tenders'. Two personnel transfer tenders are located either side of the vessel, with 'motion compensated deployment systems' to allow deployment and recovery in moderate seas. A third tender can be deployed from the stern to support operations in sea ice. These tenders can move up to eight passengers and their equipment ashore at a time. The fourth science tender includes an A-frame, small winch and multibeam echosounder, to enable studies of inshore areas, including shallow uncharted areas where it is dangerous to send the icebreaker.

Helicopters

The new ship can house four AS350 B3 helicopters or two medium-sized helicopters similar to Sikorsky S92s. This capacity will enable the ship to be utilised by a range of other agencies outside the Antarctic season, including for humanitarian missions.

The B3s can sling load up to 1200 kg at a time from ship to shore. Four helicopters will be able to operate at a time, with one potentially landing on the aft helideck, another sling loading cargo from the front, and two others in-transit or off-loading ashore.

Concurrent activities

One of the exciting new possibilities enabled by the size of the ship is concurrent operations. For example, both main cargo cranes could be loading barges while helicopters load cargo from the heli-deck. Similarly, science operations can occur at the stern, side and forward sea ice boom at the same time. This will significantly reduce the time needed for resupply and science operations.

Refuelling

The ship can carry up to 1.9 million litres of fuel – enough to refuel two stations. To facilitate over-water and over-ice refuelling operations the ship has a 'dynamic positioning system', which allows the ship to hold its position in high winds, tides and sea states within ±20 metres. This means the ship can get closer to the station than the Aurora Australis, so that during refuelling over water and ice there is less hose pipe interacting with sea ice, and improved pumping efficiency – reducing the time required to refuel and the hazards involved.

The size and scale of the new ship offers a new paradigm for science and resupply operations – it is now up to the Australian Antarctic Division to make the most of it.