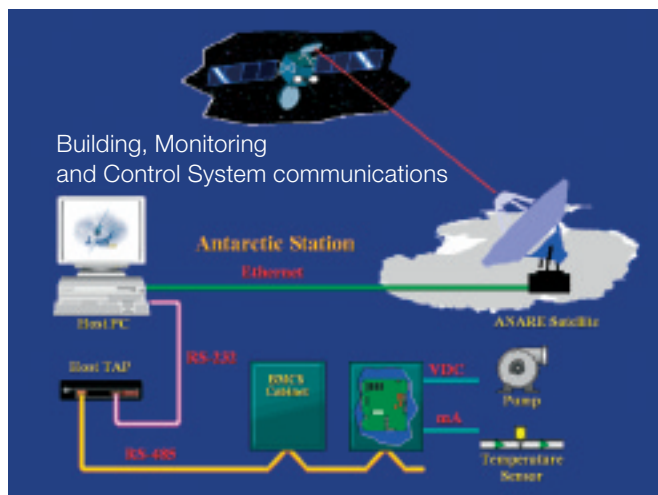


# Reducing energy use at Antarctic stations

JEREMY BONNICE



AUSTRALIA'S FOUR PERMANENT STATIONS—CASEY, DAVIS, Mawson and Macquarie Island—have a primary role as a base for the support of science. In 1997, the Antarctic Science Advisory Committee (ASAC) questioned the ongoing need for four permanent stations and suggested that a more flexible approach to supporting science may be more appropriate. The option of closing or mothballing one or more stations was suggested as one means of funding this flexibility.

Unfortunately, the integrated nature of the stations, primarily due to the use of heating water as the main means of heating the station buildings, makes the concept of mothballing, even for a single winter, a difficult and costly exercise. As a result, opportunities to reduce the operating costs of the stations through efficiencies in their operation are actively being sought. The aim is to provide the required flexibility with stations that are available throughout the year, but that require minimal costs to operate during the times of reduced station population.

This article discusses the use of a Building Monitoring and Control System (BMCS) as a tool to better understand the various engineering systems in place at Australia's continental stations so that their operation may be monitored and optimised.

## Station Description

In the early 1980s Australia commenced a program of replacing the old timber station buildings with modern, steel-framed, energy-efficient buildings. This rebuilding program was completed in the mid-1990s, leaving Australia with large, modern and comfortable stations.

The stations consist of a number of discrete buildings to reduce the impact of any fire. The buildings are thermally efficient and have sophisticated heating and ventilation systems.

Power at the stations is produced using diesel

generator sets. Each station has two powerhouses and the main powerhouse at each is fitted with four generator sets of 110 kW rated capacity. As station electrical load varies, either two or three of these engines is required to meet the electrical needs of the station.

Maximum use is made of the waste heat that is generated in the powerhouses by using it to heat water. This hot water is pumped around the stations and provides the primary means of heating the buildings. Fuel-fired boilers supplement this system when required. As a result of the integrated nature of the engineering systems on the stations, the systems need to be managed as a whole to allow the station energy usage, and hence operating costs, to be minimised.

The first step in managing any system is to understand it. A BMCS has been installed at Casey, Davis and Mawson stations, initially to monitor systems and provide data, and then to allow systems to be centrally controlled to optimise their use.

## The Building Monitoring and Control System Basics

A control system is not unlike a standard computer system in that it consists of inputs, outputs, hardware and software:

- The inputs to a control system are in the form of sensors and switches such as temperature sensors or push button switches.
- The hardware in the Australian Antarctic Division's case is a Single Board Computer (SBC). Other sorts of control system hardware include Distribution Control Systems (DCS), Programmable Logic Controllers (PLC) or Micro Controllers.
- The outputs for a control system can be either hardware-based such as starting a pump, opening a valve or turning on a light, or software-based such as raising an alarm, collecting field data or undertaking calculations.
- Software in a control system is usually programmable by the end user. Its main purpose is to let the hardware know how to monitor the inputs and control the outputs. Our system software is 'inet 2000'.

## The BMCS Project

The BMCS project commenced in late 1997. The initial step was to commission an audit of the existing local monitoring and control system (LMCS) and of the engineering systems at the stations in an attempt to quantify the value of any savings that may result from an upgrade to the LMCS. However, the impetus for the project came when the audit revealed that the existing data loggers used by the LMCS were not Y2K compliant. Additional funding became available in mid-1998. A specification was developed and tenders called in late

1998. A preferred tenderer was selected, and work commenced with a view to delivering equipment to the stations on the last voyage of the 1998–99 season.

This deadline was met, and in February 1999 the system was despatched with recently recruited and trained electricians to Mawson, Davis and Casey.

Across the three stations a total of 63 cabinets containing 115 Process Control Units were installed. Over the next five months, the Project Electricians between them connected up approximately 2,800 of the existing sensors and switches. Programming was carried out concurrently with the installation of the sensors and switches and was completed in October 1999. Thus, the initial system was up and running within eight months of the arrival of the equipment.

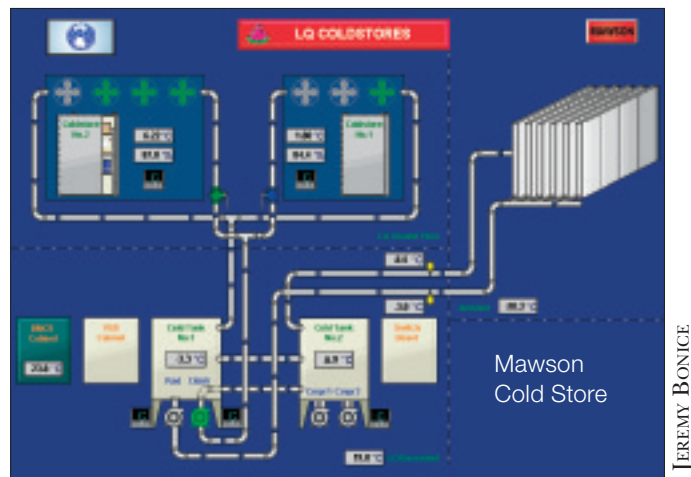
The present system can be monitored, programmed and configured from the AAD’s head office at Kingston. This is achieved through the AAD’s satellite-based Wide Area Network. This is particularly useful feature of the system in that it provides a way in which Head Office engineers can assist the on-site trades people in the maintenance and operation of the stations.

**Monitoring to Date**

It was mentioned earlier that hot water is pumped around the stations and provides the primary means of heating the buildings. The system of pipes, locally referred to as ‘Site Services’, that carry the heating hot water also carry potable and fire sprinkler water as well as the sewage (though not all in the same pipe!). These pipes are heat traced, which is perhaps best described as ‘electric blankets’ on the pipes. Designed to turn on when the pipe gets too cold, they prevent the pipe from freezing. The BMCS monitors the temperatures within these pipes and the status of the heat trace, and has been used to safely reduce the time that the heat trace is on, thus reducing the energy used by the system.

Water production at Mawson and Casey consists of a melt bell that utilises heat from the site services, supplemented by a diesel-fired boiler, to melt fresh water in melt lakes adjacent to the stations. At Davis, a reverse osmosis plant produces water over the summer months from a saline tarn. This water is stored in two 600 kl tanks for use over winter. The BMCS monitors the flow and pressure of the potable water system, and has been connected to storage tanks to give an indication of water levels and water production rates.

Within the main buildings, the BMCS is monitoring the temperature in a range of building spaces and controlling primary and zone specific air heating coils. More recent modifications have allowed the BMCS to control the whole heating, ventilation and air handling systems of some buildings to reduce the energy consumed while maintaining the building amenity. The system also monitors the status of electrical switchboards, fire panels



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and powerhouse engines.

Other uses to date include using the BMCS to monitor air quality (CO<sub>2</sub>, CO, Methane and Hydrogen Sulphide), and to monitor wind speed, wind direction and relative humidity through an interface with the meteorological automatic weather stations. A recent innovation uses the text alarms generated by the system to send alarms to pagers that are capable of receiving text messages. This system allows a duty trades person to be in 24-hour contact with the equipment for which they are responsible. Some quantified case studies are provided to illustrate the typical savings and efficiencies that have been achieved to date.

**Mawson Cold Store Project Case Study**

At Mawson station, a new cold store was constructed over the winter of 1999. The cold store uses outside radiators as heat rejection units and has conventional refrigeration compressors as a backup. The final result is two energy-efficient cold stores used for the long-term storage of fresh food, one at 6°C and one at 2°C.

When completed, the cold stores used on average 20 kWh per day compared to the original refrigerated containers that had an estimated usage of over 100 kW per day. The BMCS was connected to the system over the 1999-2000 summer to control the number of fans and pumps in use, and the total energy usage of the cold stores dropped to 16 kW—a saving over the ‘uncontrolled’ system of 20%. Over the 2000 winter, the colder outside temperatures allowed usage to drop to approximately 7 kW per day.

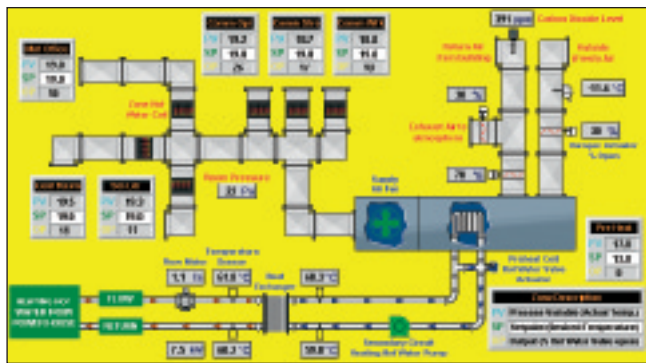
**Davis Workshop Lighting Project Case Study**

An energy audit was undertaken at Davis Station in 1998. An analysis of the results revealed that the Davis workshop seemed to have an inexplicably high energy usage, especially when compared to other similar sized buildings. Investigations revealed that the lighting was a major consumer of electrical power. The latest lighting systems were researched and it was decided to replace the existing system.

A total of 327 old fluorescent tubes were replaced with 172 triphosphor tubes mounted in new mirror-like reflectors. The new lights were rotated to maximise use of reflection from walls, and lowered. They were also powered through a proprietary 'Eco-Box' light voltage control system. The light switching system was also replaced using Clipsal's C-BUS technology. This allowed the automatic switching on of lights to provide a pathway, it allowed people to choose the amount of light they required, and it provided a means for people to switch off all the lights in the workshop with a single switch located at each exit. The C-BUS system included 15 PIRs, a total of 50 new switches, and the grouping of lights into 44 groups. The whole building was then connected to the BMCS for duplicate control. The end result was a 40% increase in the light levels available.

Other changes in the building included BMCS control of the air handling system, the workshop air compressor, and the floor heating coils. The total reduction in energy usage as a result has been estimated to be 56%. Based on the then pump price for diesel, this represents a pay-back of less than two years.

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### Mawson Heating Hot Water Pump Project Case Study

The design of the heating hot water pipe network includes a 'primary circuit' which travels around the station through each of the buildings. A 'secondary circuit' within each building uses a heat exchanger to remove the amount of heat required for the building from this primary circuit. The original design of the

system has the main circulating pump running at constant speed.

A Variable Speed Drive (VSD) controlled by the BMCS has been installed on the main site services heating hot water circulating pump over the 2000-01 summer. Initial results indicate that this may be our best ever return on investment! The variable speed drive slows down the rate at which the heating hot water is pumped around the station thus saving energy. It has no effect on the heating of the buildings as, during summer, they require very little heating.

When the pump operates in its normal mode, it consumes around 22 kW of power and pumps water around the station at a rate of 17 litres/second. Slowing the pump down to 70% (to 12 litres/second) the pump consumes 9 kW of power. Therefore, a 30% reduction in speed results in a 60% reduction in energy consumption. The VSD was initially run for almost three weeks from late December to mid-January and consumed 6.4 MWh of energy, compared with just over 10 MWh if the pump had run normally. Results such as these mean that the pay-back period, for all the materials and labour, is around 42 days. It is envisaged that savings can continue to be achieved up until the end of March and after that time, there will probably be no benefit as the pump will have to run at 100% of the time in order to keep up with the station heating load.

### Conclusions

The BMCS project has allowed the Australian Antarctic Division to gain a better understanding of energy usage at the three Antarctic Stations of Davis, Casey and Mawson. It has also allowed the automation of some of the station engineering systems, which have allowed them to be optimised resulting in a reduction in operating costs of the stations. It is expected that a number of other projects will be able to be completed over the coming years that will allow the operating costs to be reduced even further.

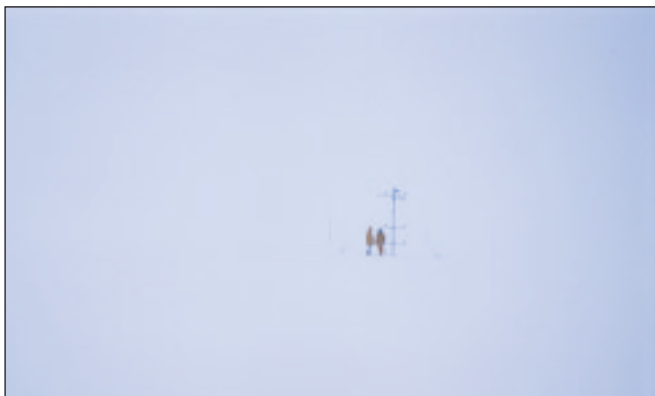
*Chris Paterson, Chief Engineer, AAD, & Jeremy Bonnice, Instrument and Control Engineer, AAD*

## Antarctic air transport link investigated

OVER THE PAST TWO YEARS, THE AAD HAS BEEN investigating the possibility of implementing an air transport system. An air transport system would transfer expeditioners to and from Antarctica with the aim of providing access to the ice more rapidly and more often. Investigations commenced with the research of and writing of a 'Scoping Study' which examined all the different aircraft, airfield and routing options. Later, after field studies during the 1999-2000 summer season, a report entitled *1999-2000 Investigations* was released. This report recommends that an inter-continental air

transport link be developed between Hobart and a compressed snow runway in the Casey area. It also recommends that an airfield at Bunger Hills be used as an 'alternate' and that further monitoring be carried out of snow and ice conditions in the Davis area. The report recommends that smaller aircraft be used to transfer expeditioners from Casey to Davis, Mawson and remote field locations.

The next stage of the air transport investigation is to identify a provider or providers who could carry out the various tasks associated with the system. These tasks



*In whiteout conditions, company representatives inspect automatic weather station close to the proposed airfield site. One of the main concerns of air transport personnel is good meteorological data and forecasts for flights. Automatic weather stations are required at several locations to provide the necessary information.*

PHIL TRACEY

include construction of the airfield itself, provision of all the facilities that would be required (for example, accommodation at the airfields, fire fighting equipment,

navigation equipment and airfield marking) and of course, provision of the aircraft themselves. The tendering process for the facilities has commenced. It is a two-stage process, consisting of an 'expression of interest' stage and a final tender stage. Six companies that are tendering to provide the aircraft have been selected from the 'expression of interest' stage. These companies were invited to send representatives to visit Casey on Voyage 5 during the 2000–01 season, and three of the companies were able to take up this opportunity. They were shown the station, including an examination of the infrastructure available, and they visited two proposed sites for the compressed snow runway inland of Casey.

The second 'tender' stage will be carried out during 2001. Also during 2001 risk and cost benefit analyses, including environmental impact assessments, will be carried out, so that by the end of the year a final decision on the implementation of the system can be made. If the decision is to proceed, construction of the runway in the Casey area could commence next summer season.

*Jo Jacka, Air Transport Study Project Manager, AAD*

## Harnessing the power of the windiest continent



*Test wind turbine at Casey Station collecting operational and engineering data while producing power for the Casey grid.*

AAD PHOTO

STUDIES INTO THE POTENTIAL OF ALTERNATIVE ENERGY systems such as wind and solar energy have been undertaken at the Australian Antarctic Division since 1992. These studies have shown that the use of wind power at Mawson and Macquarie Island may be economically viable if engineering and logistical hurdles can be overcome.

At present, a total of approximately 2.1 million litres of diesel fuel is used annually to provide power and heating at Australia's three Antarctic stations and subantarctic Macquarie Island.

In addition to the financial benefits of alternative energy systems, a substantial reduction in the use of fossil fuels at the stations will result in a reduction in the emission of greenhouse gases, and a reduced risk of fuel spills and damage to the environment.

The present focus of the Alternative Energy Program is Mawson station. An analysis of the electrical and thermal loads of the station, combined with a minimum number of suitable sites for a wind turbine, have resulted in a preferred solution of three to four turbines in the size range of 230 to 280 kW .

Work is presently underway at Mawson to reduce the station load. This will not only have immediate impacts on the quantity of fuel used, (and hence on the costs of refuelling the station), but may also reduce the requirement for the fourth, and possibly the third turbine.

An analysis of the world market of suitably sized turbines indicated that there are a number of

# Safe and waterproof on Heard Island

WHEN PLANS FOR A FIELD SEASON FOR SCIENTISTS ON Heard Island were declared, the hunt was on for a sturdy hut that was waterproof, portable, cheap to produce and able to be transported by a variety of means.

Experience has shown that reliance on tents to accommodate field workers in the extreme weather conditions on Heard Island is a fraught business. It is guaranteed to involve frequent re-pitching, chasing of gear and constant attempts to dry clothing and sleeping bags in conditions that will try the most experienced expeditioner. To make the best of the time on the island, it was essential to ensure a better standard of accommodation and workspace for members of the 2000–01 Heard Island ANARE.

And so was born the water tank hut—brainchild of AAD Field Equipment and Training Officer, Rod Ledingham. After all, what better for a rainy climate than a watertight container adapted as a hut, and what could be more watertight than a rainwater tank?

The concept was trialled a number of years ago on Macquarie Island when a 2.7 metre diameter high-density polyethylene water tank was converted into a small hut for Davis Point as a refuge for a marine debris collection program. The hut was positioned by helicopter and has proven to be most effective.

The main problem with the early tank model was the great deal of condensation on the interior walls, which soaked bedding and fittings. This was partially solved by retrofitting closed cell foam matting on the walls. On investigating the possibilities of insulating, it was discovered there was a system whereby a secondary insulating layer could be cast on the interior during the rotary moulding process.

The trial tank came out like a melted gumboot, but on the second attempt a perfect specimen with approximately 12 mm of insulation was formed. This 3.4 metre prototype was fitted out and found able to hold 6 bunks which could be moved and used as shelves or workbenches. There was also enough room for a set of



*A tank hut is towed through the surf by rubber boat to Aurora Australis after housing glaciologists on the Brown Glacier at Heard Island during the 2000-01 summer.* DOUG THOST

60 cm wide shelves from floor to ceiling. Windows were doubleglazed with polycarbonate attached to the interior and exterior surfaces. A door was fitted about 40 cm up from the floor so that the base remained waterproof. Ventilators and roof hatches were fitted.

The polytank is virtually indestructible and therefore ideal for deployment in places like Heard Island. It is also relatively cheap (\$2,000 to \$3,000 with insulation) compared with the now famous fibreglass 'Apple' huts which are constructed as a series of panels and bolted together.

Fifteen tank huts have been used on Heard Island this season, delivered to Atlas Cove, Brown Glacier and Spit Bay by helicopter. Several were towed in the water by inflatable rubber boats and lifted onto the re-supply vessel, their self righting capability proven in trials before going to Heard Island.

Early reports from expeditioners are positive but we'll have more news on life in a water tank in the next edition of *Australian Antarctic Magazine*.

*Rod Ledingham, Field Equipment and Training Officer  
& Rob Easter, Field Operations Manager, AAD*

*from page 40*

manufacturers who have turbine designs which are of the correct output. However, the harsh environment and severe wind speeds at Mawson, along with some of the other design characteristics of the available turbines, meant that there was only one preferred turbine.

Coincidentally, similar sized turbines from the same manufacturer have been supplied to the township of Denham in WA under a Greenhouse Office showcase grant. In that case, the design criteria included the requirement for the township to run on 100% wind power when the environmental conditions are right.

The AAD is now working with the manufacturer and their Australian agent to jointly develop the world's first cold region turbine and control system—a system that is capable of running Mawson station without diesel fuel when the conditions are suitable. Wind modelling indicates that this could be as much as 80% of the time over the full year, and 100% of the time over winter.

An environmental impact assessment at the Initial Environmental Evaluation level is currently out for comment. If the project proceeds smoothly, the first work will occur on site in the 2001–02 summer.

*Chris Paterson, Chief Engineer, AAD*

# Australian Antarctic shipping program 2000-01

	Arrive	Depart	Activity
<b>Voyage 1 — Aurora Australis</b>			
Hobart	29 September 2000	01 October 2000	On hire, load
Marine science	02 October 2000	12 October 2000	
Davis ice edge	25 October 2000	29 October 2000	Over-ice resupply, deploy summer personnel
Mawson ice edge—fly off	04 November 2000	05 November 2000	Deploy summer personnel using S76A helicopters
Heard Island	09 November 2000	10 November 2000	Deploy and retrieve summer personnel
Fremantle	18 November 2000	20 November 2000	Discharge, load
<b>Voyage 2 — Polar Bird</b>			
Fremantle	05 October 2000	08 October 2000	On hire, load
Heard Island	19 October 2000	25 October 2000	Deploy summer personnel using AS30B helicopters
Hobart	05 November 2000	06 November 2000	Discharge, load
<b>Voyage 3 — Polar Bird</b>			
Hobart	05 November 2000	06 November 2000	Discharge, load
Macquarie Island	09 November 2000	14 November 2000	Winter personnel changeover, resupply using AS30B helicopters
Marine science	20 November 2000	25 November 2000	
Casey ice edge—fly off	26 November 2000	19 December 2000	Deploy summer personnel (delayed by heavy ice)
Hobart	26 December 2000	30 December 2000	Discharge, load
<b>Voyage 4 — Aurora Australis</b>			
Fremantle	18 November 2000	20 November 2000	Discharge, load
Heard Island	29 November 2000	30 November 2000	Deploy and retrieve summer personnel
Mawson	04 December 2000	7 December 2000	Winter personnel changeover
Davis	09 December 2000	11 December 2000	Winter personnel changeover
Sansom Island—fly off	11 December 2000	15 December 2000	Restock fuel depot, support Amery program
Davis	16 December 2000	16 December 2000	Complete winter personnel changeover
Hobart	27 December 2000	01 January 2001	Discharge, load
<b>Voyage 5 — Polar Bird</b>			
Hobart	26 December 2000	30 December 2000	Discharge, load
Casey	28 January 2001	01 February 2001	Resupply and winter personnel changeover (delayed by heavy ice)
Hobart	08 February 2001	11 February 2001	Discharge, load
<b>Voyage 6 — Aurora Australis</b>			
Hobart	27 December 2000	01 January 2001	Discharge, load
Marine science	12 January 2001	23 January 2001	
Mawson	24 January 2001	26 January 2001	Deploy winter personnel
Casey	01 February 2001	02 February 2001	Assist Polar Bird enroute Casey–Hobart
Marine science	03 February 2001	22 February 2001	
Davis	25 February 2001	26 February 2001	Retrieve summer personnel
Marine science	27 February 2001	01 March 2001	
Hobart	10 March 2001	12 March 2001	Discharge, load
<b>Voyage 7 — Polar Bird</b>			
Hobart	08 February 2001	11 February 2001	Discharge, load
Mawson	24 February 2001	03 March 2001	Resupply
Zhong Shan/Law Base—fly off	05 March 2001	06 March 2001	Deploy CHINARE personnel and equipment using AS30B helicopters
Davis	07 March 2001	08 March 2001	Retrieve summer personnel
Heard Island	14 March 2001	20 March 2001	Retrieve summer personnel and camp
Hobart	31 March 2001	01 April 2001	Discharge, off hire
<b>Voyage 8 — Aurora Australis</b>			
Hobart	10 March 2001	12 March 2001	Discharge, load
Casey ice edge—fly off	20 March 2001	22 March 2001	Retrieve summer personnel using S76 helicopters
Marine science	22 March 2001	22 March 2001	Deploy sea ice buoy
Macquarie Island	28 March 2001	31 March 2001	Supplementary resupply and retrieve summer personnel
Hobart	03 April 2001	04 April 2001	Discharge, off hire

**Voyage 1:** Leader: Suzanne Stallman; Deputy: Gordon Bain

**Voyage 2:** Leader: Rod Ledingham

**Voyage 3:** Leader: Ian Allison; Deputy: Michael Johnston

**Voyage 4:** Leader: John Brooks; Deputy: Jenny Whittaker

**Voyage 5:** Leader: Ross Jamieson; Deputy: Gerald Harwood

**Voyage 6:** Leader: Graham Hosie; Deputy: Andrew McEldowney

**Voyage 7:** Leader: Vince Restuccia; Deputy: David Moser

**Voyage 8:** Leader: Martin Betts; Deputy: Leanne Millhouse