

Cold comfort

The next generation of Antarctic research stations is now being designed and built. Quirin Schiermeier reveals the problems that architects, engineers and inhabitants must overcome in the Pole's unforgiving conditions.

The wailing sound of a saxophone can sometimes be heard echoing through the night on Dronning Maud Land in Antarctica. Anna Müller, a physician and the base commander of Germany's Neumayer research station, plays the sax to banish the loneliness and boredom that creep up during the dark, freezing polar winters.

Life in the narrow station has left its mark on the four men and five women who have wintered on the 12-year-old base, now buried under 20 metres of snow. During the long winter months there was little scientific work to do here, other than the daily checking of meteorological instruments. Spring has finally arrived, but during July and August some crew members did not leave the window-less tubes for weeks. Only in December, when the summer crew arrives, will life in this voluntary prison become more enjoyable again.

Neumayer is just one of about 100 permanent research stations that have been built in Antarctica since 1904, when the Scottish explorer William Speirs Bruce built a year-round meteorological observatory on the South Orkney Islands, at 60° south. Now several countries, including Germany, Britain, the United States and France, are busy building or planning the next generation of stations. These will offer tomorrow's polar researchers more comfortable living conditions, but they will also have to meet tighter environmental regulations.

There are currently 82 stations, maintained by 27 countries. About half of them are permanently occupied. These scattered outposts at the end of the world (see map) provide bases for a wide range of research,

from astronomy and climate sciences, to geology and marine biology. They are pretty much the only man-made structures in Antarctica — the Antarctic Treaty, first signed in 1959, ensures that the continent is used only for peaceful, non-military purposes, effectively reserving it for adventure, a little tourism, and a lot of science.

Many of the science bases on Antarctica are long overdue for rebuilding. Some are slipping off the edge of the continent. Others are buried by metres of ice, thanks to yearly snowfall. Only the tip of the 30-year-old US South Pole Station now pokes above the surface, forcing researchers to enter via a steep staircase in a snow well. Some stations are simply bare-boned shacks that leave

researchers prone to depression during the winter months.

Although a few of these ancient huts are being preserved for posterity — such as a British station built in 1944 on the island of Port Lockroy — most are being revamped. At the Pole, for example, the sinking Amundsen-Scott South Pole Station is set to be replaced by a US\$150-million complex, scheduled for completion next year.

Special delivery

Building at such sites is a mammoth logistical challenge and the new complex has taken almost 15 years to plan and construct. The Pole is about 3,000 metres above sea level, and the thousands of tonnes of material for the base and nearby research facilities — including IceCube, a new high-energy neutrino observatory — had to be delivered by cargo planes or bulldozer convoys battling their way over ice and crevasses from the US coastal base at McMurdo Sound more than 1,600 kilometres away.

The new station will be separated from the outside world by thick steel doors and airlocks. Before polar air enters its heating and air-conditioning systems, it will be raised to room temperature by passing it through a heated glycol solution. And should something go wrong, most of the station's life-sustaining systems — heating, electricity and medical facilities — are designed to be remotely operated and repaired, via a computer link, from institutes in the United States.

Ironically, these provisions for a frozen world were designed by the Hawaiian-based architect Joe Ferraro, who can see the



C. GILBERT/BRITISH ANTARCTIC SURVEY



Halley V (left) risks being washed away, and the South Pole Station (middle, right) is drowning in ice.

palm-tree-lined beach of Honolulu from his office window.

About 1,600 kilometres north — although every direction is north if you start from the South Pole — a smaller wintering station is currently under construction at Dome C, a high plateau ideal for ice-core drilling (see *Nature* 429, 596–597; 2004). Concordia, built jointly by France and Italy, consists of two octagonal buildings in which a 16-strong crew will conduct year-round experiments on everything from geomagnetism to cosmic background radiation, starting next year.

To beat the encroaching ice, Concordia's buildings rest on legs that can hydraulically lift the entire station, keeping it metres above the snow from year to year. Several stations already use such systems, including Britain's Halley V Research Station, and they look set to be a standard feature in the polar architecture of the future. The hydraulic legs prevent the accumulation of snowdrifts and allow for windows, although they also expose the crew to the loud noise and strong vibrations caused by polar storms.

Mobile homes

The Halley base faces an even tougher challenge than Concordia and the US South Pole Station: it sits on a coastal shelf ice that is moving at 100 times the speed of inland glaciers. Building on such mobile foundations certainly puts an architect's knowledge of ice and snow to the test. As snow accumulates inland, the ice flows towards the ocean at several hundred metres per year, eventually breaking off in icebergs, so each structure has a limited lifetime of no more than 20 years.

Britain and Germany are the only two countries maintaining such shelf stations, and both are currently designing new bases

in northern Antarctica: Halley VI on the Brunt Ice Shelf and Neumayer III on the Ekström Ice Shelf. The British Antarctic Survey warned in April that Halley V could be washed into the Weddell Sea the next time a massive ice sheet breaks off the shelf, which is due to happen around 2010. And at Neumayer II, snow pressure is already causing scary distortions and deformations of the existing tube-shaped building.

The new stations will be built on carefully selected sites to ensure the longest possible life before the ice slips into the sea. Both will be jacked up on extendable hydraulic stilts. And the German buildings will be enclosed in a large outer structure, creating a buffer zone between the living space and the outer skin for extra insulation and protection from storms.

But aside from these few requirements, the final designs for these buildings have yet to be finalized. The design for the UK station will be selected through a competition in September 2005, with entrants' proposals expected to encompass some of the most innovative — and most cost-effective — ways to ensure a happy, healthy crew.

To comply with strict environmental regulations introduced in 1998, the buildings will also have to restrict their use of water and fuel. Waste heat from diesel generators will be harnessed for extra warmth, and wind and solar power will be high on the list of desirable technologies for the new stations. At the moment, a station the size of those planned by Britain and Germany consumes some 200,000 litres of diesel per year.

Technology developed by the European Space Agency (ESA) could help, says Fritz Gampe, a senior officer in the agency's technology-transfer programme. An automated water-treatment plant developed for use on the International Space Station, for

example, could easily be installed in polar stations, he says.

And a prototype 'space house' that the agency developed for use in earthquake-prone regions or a possible future Mars colony would fit polar requirements perfectly, he adds. The solar-energy-powered structure, which looks like a futuristic igloo built of ultralight carbon composites, would also be easy to transport home once its lifetime on the ice had expired.

ESA has pitched just such a proposal for the Neumayer station. But Dietrich Enss, a consultant engineer with the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, which maintains Germany's Antarctic bases, is sceptical. "What we really need in Antarctica is maximum success at minimum cost," says Enss. "After all, this is not a beauty contest down here, but all about science."

Nonetheless, beauty and comfort are important on the insides of these structures. "Communal space is key for the team spirit in winter, so improving the human aspect of accommodation will be an important criterion," says Malcolm Reading of the London-based architecture firm Malcolm Reading & Associates, which is running the design competition for the British station. Viewing domes and adjustable interior walls for creating larger, temporary communal spaces, would be welcome features, he says.

Feathered friends

Reading recently asked staff who winter at British Antarctic bases what they miss most during their stay. "Pets" and "the laughter of children" were the most frequent answers. Although no children have yet been spotted in Antarctica, pets have. Tourists cruising the shoreline of the continent in summer occasionally report seeing budgies in cages outside the scattered stations, despite the fact that this is technically a violation of the Antarctic Treaty, which bans the import of all non-indigenous species to the continent in order to protect its fauna and flora.

Pets and new-fangled architecture aren't looked upon kindly by some of the veteran explorers of the continent. "A little bit of hardship is good for you," says Peter Clarkson, a geologist and executive secretary of the international Scientific Committee on Antarctic Research, who was base commander of Britain's Halley II station in 1968. "If you're sitting there inside a centrally heated building in T-shirt and sandals things just aren't right."

But for most of the younger scientists who live in Antarctica over the winter, including Müller, a new generation of stations complete with windows would be an immense relief from the winter blues. "My stay here was a totally unique experience," says Müller. "But I wouldn't do it again." ■

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