Concordia: A new permanent, international research support facility high on the Antarctic ice cap.

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INTRODUCTION

While there is a continuously increasing awareness of the importance of Antarctic research, the 14 million square kilometres Antarctic continent still only houses two permanent inland research stations, Amundsen-Scott and Vostok opened in Nov 1956 and Dec 1957 respectively. Recognising the unique research opportunities offered by the Antarctic Plateau, the French and Italian Antarctic programmes have agreed in 1993 to cooperate in developing a permanent research support facility at Dome C, high on the ice cap. The facility is named "Concordia".

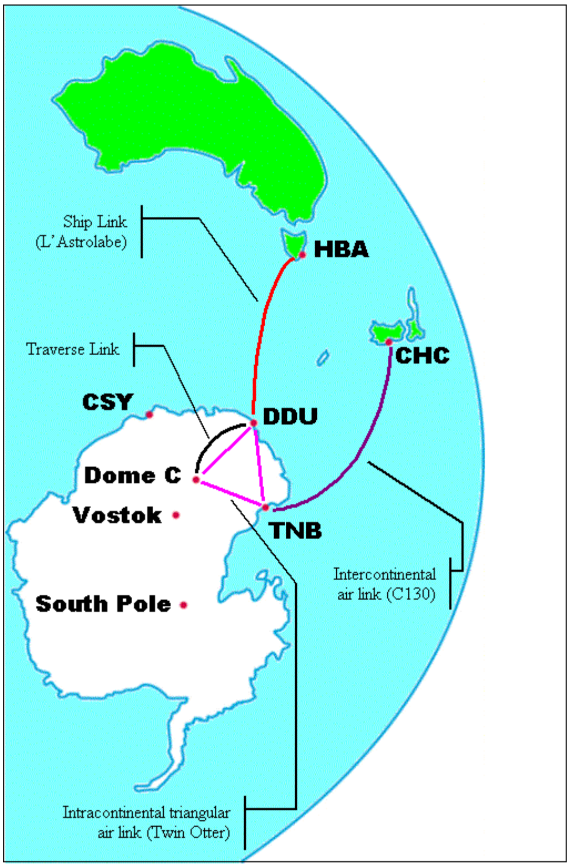

Figure 1: Map showing Antarctica, Australia, New-Zealand, Concordia Logistic Structure and Gateways (HBA=Hobart, CHC=Christchurch, CSY=Casey, DDU=Dumont d'Urville, TNB=Terra Nova Bay)

Concordia consists of a core group of three 'winter' buildings flanked by a summer camp doubling up as emergency camp. All structures are on or above ground. Access is by traverse tractor trains for heavy equipment and by light ski-equipped plane for personnel and selected light cargo. Jointly operated by France and Italy, Concordia is open for research to the worldwide scientific community. Officially open for routine summer operation in Dec 1997, Concordia should be open year round from 2003 upon completion of the core winter buildings. Facilities are designed for a winter population of 16 expeditioners, nine persons conducting scientific experiments and seven support staff. Concordia pioneers an advanced concept in Antarctic operations, the integral self-elevating building, and introduces a new generation of regular, long-range logistic traverses.

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WHY DOME C?

Dome C was originally selected for glaciological research: a substantial layer of ice, about 3,200m thick, offers great potential for climatic reconstruction of the last 500,000 years. But Dome C has other valuable characteristics that support the installation of a permanent scientific station:

- Dome C is located inside the polar vortex where the ozone hole can be detected in the austral spring.
- The Antarctic Plateau is a well recognised, favourable site for astronomic observations due to its geographic location and its extremely dry, cold and rarefied atmosphere.
- Dome C, far away from any marine perturbations, is an ideal place for studying Solid Earth Geophysics, especially seismology.
- Dome C, at 3,200m above the continental crust, is protected from any magnetic perturbations by earth crust anomalies and is an ideal place for studying magnetism.
- Dome C is as a very isolated site with severe climatic conditions. It will be an excellent site for evaluating techniques and procedures for future work on other planets. It is also an excellent site for studying small groups of people in conditions close to those encountered in space vehicles or orbital stations.

THE DOME C SITE

Dome C is located at 75°06'South and 123°23' East, 950 km inland from Banzare coast, at 3,200 m altitude on sub-horizontal ice ground with no crevasses. There is no local fauna or flora. While the closest station is Vostok (Russia) 560 km away, the closest coastal stations with good shipping access are well over 1,000 km away. Dumont d'Urville (France) and Casey (Australia) are about 1,100 km away to the North over the ice cap while Terra Nova Bay (Italy) is about 1,200 km away to the East behind the Transantarctic mountain range.

Meteorological conditions are characterised by low wind speeds, low precipitation and low temperatures. 14 years of Automatic Weather Station (AWS) records by the University of Wisconsin show an average wind speed of 2.8 m/s (5.4 knots) and an average temperature of –50.7°C (-59.3°F) with a minimum of –84.6°C (-120.3°F). Typical summer monthly average is around –30°C (-22°F) and typical winter monthly average around –60°C (-76°F).

SURFACE TRANSPORT SYSTEM

Construction of Concordia requires the delivery of some 2,000 tonnes of equipment while routine operation will require the annual delivery of some 300 tonnes. The success of the project is critically dependant on the capacity to deliver this large quantity of equipment reliably and in a cost effective manner. To achieve this, an efficient, regular long-range 'Traverse' surface transport system was developed between Dome C and Dumont d'Urville, a return trip close to 2,200km. Heavy cargo is shipped by sea from Hobart in Tasmania to Dumont d'Urville then transferred to the traverse convoys bound for Dome C.

Antarctic over-ice traverses have traditionally been slow trips conducting en route scientific work, except for the resupply operations of Vostok out of Mirny Station. Organising a fast, regular traverse transport system required a new, innovative approach and the selection, testing and validation of new vehicles and procedures. The traverse system is now fully operational with three return trips conducted every summer season between mid November and mid February.

Since Dumont d'Urville Station is on a small island a few kilometres away from the Antarctic continent itself, traverse convoys are formed at Cape Prud'homme, a nearby coastal site with easy access to the plateau. Cargo delivered to Dumont d'Urville is transferred to Cape Prud'homme either on sleds over the sea-ice in winter or on barges over the water in summer, then towed up to the convoys' formation area. Loading and unloading infrastructure, under-ice vehicle shelters, a workshop and a base camp have been set-up at and around Cape Prud'homme for the formation and support of the traverses.

A typical convoy is composed of nine tractors. Two Kassbohrer PB330 snow-grading tractor clear and level the ground for seven rubber-tracked Caterpillar Challenger tractors towing all cargo loads and traverse caravans. Excellent at handling snow, the PB is not designed to tow heavy loads and is usually not towing any load. Originally designed to tow heavy loads on loose ground in agricultural applications and first tested in Antarctica around Cape Prud'homme in 1990/91, the Challenger tractor was successfully modified for routine Antarctic traverse use. Each Challenger tows a combination of tank-sleds, cargo sleds and tracked trailers, most of them specially designed for the Concordia project. Diesel fuel for both traverse operation and Dome C delivery is transported bulk in $12m^3$ tank-sleds while most dry cargo is in 20 foot containers on sleds and trailers.

The traverse route takes the convoys from sea level to 3,200m altitude over 1,100km of ice. The first 250km (the 'coastal zone') bears noticeable slopes and uneven ground of up to several metres amplitude. It is also subject to weather turbulence with disrupting heavy snowfalls or temperature surges. The rest of the route (the 'plateau' zone) shows stable weather and fairly even ground rising slowly but the ground can be very soft with very dry snow not subject to much wind compaction. The average speed of the convoys is around 6.5km/h in the coastal zone and 9.5 to 11km/h in the plateau zone. A typical traverse round trip out of Cape Prud'homme takes 22 to 24 days and consumes 70 to $80m^3$ of diesel fuel to deliver some 130 tonnes of net cargo to Dome C, giving a net cargo output of 5.4 to 5.9 tonnes per day.

LIGHT-PLANE TRANSPORT SYSTEM

Personnel and selected light cargo are transported to and from Dome C by a ski equipped twin otter aircraft operating out of Terra Nova Bay on the triangular route Terra Nova Bay – Dome C – Dumont d'Urville. Travel in and out of Antarctica for Dome C personnel is primarily by air between Christchurch in New Zealand and either Terra Nova Bay or McMurdo station and secondarily by sea between Hobart in Tasmania and Dumont d'Urville. Some 40 twin otter flights are received each season at Dome C on a 3,000 m levelled snow runway.

BUILDING DESIGN CONCEPT

Concordia Station consists of one core of three 'winter' buildings flanked by a summer camp that also acts as emergency shelter. All structures are on or above ground. Two of the three winter buildings are unique integral self-elevating buildings forming the station's main living and working area. The third winter building housing the main energy and mechanical services, the summer/emergency camp and all satellite installations are modular units set low over ground on skids. These units can be towed away to avoid progressive burial by snow accumulation. Technical services use standard, reliable technologies in a simple, streamlined system. Only one of the three 140kVA generator sets will be needed at any time. Engine heat is recovered with boilers satisfying additional heating requirements. Annual fuel consumption is expected to be around $250m^3$ or 200 tonnes of Diesel fuel to meet average electrical and heating loads around 100 and 75 kW respectively.

Each of the two 'integral self-elevating buildings' is based on a roughly cylindrical body supported by six legs. Each leg is sitting on a large 'footing' pad spreading the load over the snow. Each leg can move up and down relative to the body of the building via a hydraulic jack. A leg can be jacked up relative to the building and snow packed under its footing. Once all six legs have been subject to this operation the body of the building can be raised above the new ground surface by jacking the legs back down relative to the body. This allows the entire structure to leapfrog its way up over the ice as the ground level rises with snow accumulation.

The originality of this design is to make the entire structure upwardly mobile to preserve its integrity. The usual jack-up building design is based on the body of the building sliding upward along fixed legs. As snow accumulates and the ground level rises, an increasingly longer section of the legs is entrapped underground and subject to differential movements of the ice. This progressively ruins the foundations and ultimately deforms the legs to the point of preventing further jacking-up operations. The self-elevating design adopted for Concordia requires a heavier, sturdier structure to allow for the variations in structural loads during elevation operations but guarantees the long term integrity of the building structure.

CONCLUSION

Concordia station will provide year-round research support to the international scientific community high on the Antarctic ice cap in a project pioneering the advanced concept of integral self-elevating buildings and introducing a whole new generation of regular, long-range logistic traverses. Already open for routine summer operation since 1997, Concordia should be open year round from 2003.